Biophysics, Rockets, and the State:

the Making of a Scientific Discipline in Twentieth-Century China

by

Yi Lai Christine Luk

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Graduate Supervisory Committee:

Ann Hibner Koblitz, Chair
Hoyt Tillman
Jane Maienschein

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ABSTRACT

This study takes biophysics—a relatively new field with complex origins and contested definitions—as the research focus and investigates the history of disciplinary formation in twentieth-century China. The story of building a scientific discipline in modern China illustrates how a science specialty evolved from an ambiguous and amorphous field into a full-fledged academic discipline in specific socio-institutional contexts. It focuses on archival sources and historical writings concerning the constitution and definition of biophysics in order to examine the relationship between particular scientific styles, national priorities, and institutional opportunities in the People's Republic of China. It argues that Chinese biophysicists exhibited a different style of conceiving and organizing their discipline by adapting to the institutional structure and political economy that had been created since 1949.

The eight chapters demonstrate that biophysics as a scientific discipline flourished in China only where priorities of science were congruent with political and institutional imperatives. Initially consisting of cell biologists, the Chinese biophysics community redirected their disciplinary priorities toward rocket science in the late 1950s to accommodate the national need of the time. Biophysicists who had worked on biological sounding rockets were drawn to the military sector and continued to contribute to human spaceflight in post-Mao China. Besides the rocket-and-space missions which provided the material context for biophysics to expand in the late 1950s and early 1960s, Chinese biophysicists also created research and educational programs surrounding biophysics by exploiting the institutional opportunities afforded by the policy emphasis on science's role to drive modernization. Biophysics' tie to nationalistic and utilitarian

goals highlights the merits of approaching modern Chinese history from disciplinary, material, and institutional perspectives.

For my parents,
without whose guidance and support I would have been lost years ago.

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I have accumulated many debts in the process of researching and writing this dissertation. Although my achievement is relatively small, these debts are immense and I want to take this opportunity to express my gratitude to those who have helped, inspired, encouraged, and assisted me along the way.

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PREFACE

In the late summer of 2011, I found myself at a faculty–graduate student potluck party. As I was walking down the hallway trying to make conversation, I stumbled across a middle-aged faculty member who taught general education courses at my university. After I had told him of my interests in doing a dissertation on the history of biophysics, he mentioned: “You know, I am trained as a biophysicist; I have a Ph.D. in biophysics from the University of Virginia.” He asked about my motives for studying biophysics because, unlike him, I did not have a degree in that field nor was I pursuing one.

“I am intrigued because it seems that no two biophysicists can agree on what biophysics is specifically, yet it is held that biophysics is important and worth doing.” To which he jokingly replied, “True. We don’t know what biophysics is exactly, but that’s what we do.”

Contemporary history of biophysics appears to be in a perpetual state of perplexity. In 1940, J. R. Loofbourow from MIT suggested that there is “no clear agreement, even among biophysicists, as to what the term biophysics means.”[1] He then took the liberty to expand the conceptual scope of biophysics to include the physics of life, the physical methods to study biological systems, and the physical intervention in life processes. What Loofbourow illustrated in 1940 was the broad scope of the field while lamenting the lack of a definable focus of biophysics.

The molecular revolution since the late forties and early fifties changed little about this picture. The discovery of DNA and the advancement of microscopic instruments did indeed improve the tricks of the trade but these scientific developments

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[1] John R. Loofbourow, “Borderland Problems in Biology and Physics,” *Reviews of Modern Physics*, 12 (1940), pp. 267-358, on p. 267.

still did not alter the fundamental set of questions regarding the conceptual problem of the focus of biophysics. By 1963, a *Nature* article kicked off a report on the organization of biophysics in the international realm with the following lines, "probably no two scientists would agree on a definition of 'biophysics', yet during the past five or ten years there has been a growing consciousness that in this ill-defined borderland where physics, physical chemistry, biology and medicine overlap, revolutionary advances are likely to be made in the next ten or twenty years."[2] In 1969, *Nature* continued to portray biophysics as an amorphous but attractive discipline: "even if nobody knows just what biophysics consists of, a meeting at Queen Elizabeth College earlier this week left most of the two hundred participants with the conviction that it has a bright future."[3]

Fast-forwarded to the 1980s, one would expect the definitional problem of biophysics to be a bygone issue, but that was not the case. One unanimous conclusion arrived at in the Eighth International Congress of Biophysics held in Bristol between 29 July and 4 August 1984 was that "there probably never was an adequate definition of biophysics. Perhaps there never will be."[4] The same year, a book reviewer commenced a review article of a biophysics textbook with the following sets of questions:

> What is biophysics? This question, asked by the editors of *Biophysics*, must also have been asked countless times of all of us who profess to be biophysicists. To develop a sense of unity and to delineate boundaries is perhaps the main obstacle to be surmounted by anyone who seeks to write

[2] G. B. B. M. Sutherland, "International Organization of Biophysics," *Nature*, vol. 198, iss. 4886 (June 22, 1963), pp. 1141-2, on p. 1141.
[3] "Interdisciplinarians: Bright Future for Biophysics," *Nature*, vol. 223, iss. 5213 (September 27, 1969), p. 1317.
[4] Maxine Clarke, "Many Guises in Bristol," *Nature,* vol. 311, iss. 5987 (October 18, 1984), p. 605.

> a core textbook on this discipline. Yet, the writing of such a text would in itself represent an essential stage in the definition of the subject. Biophysicists have long awaited such a statement—have the authors of *Biophysics* provided it?[5]

The reviewer concluded that the authors of the textbook under review gave a satisfactory attempt at defining the scope of biophysics but not a "definitive statement that we have been awaiting."[6]

In 1995, comparing definitions and coverage of biophysics in different textbooks, Marco Bischof from the International Institute of Biophysics in Germany concluded that he could not find a definition of the investigative range of biophysics that was common even to two of the many biophysics textbooks he surveyed.[7]

In other words, from the 1940s to the 1990s, no one had been able to offer a textual definition to adequately cover biophysics in spite of the proliferation of textbooks and handbooks dedicated to the subject itself. Instead, one article on *Nature* suggested that the question of the definition of biophysics should be approached by seeking what biophysicists do in practice.[8]

The motto "definition by doing" harkens back to the same sentiment echoed by the self-identified biophysics faculty member when he told me that not knowing what biophysics is does not prevent a biophysicist from doing biophysics.

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[5] Anthony C. T. North. "In Search of a Subject: Book Review of *Biophysics* edited by Walter Hoppe, Wolfgang Lohmann, Hubert Markl and Hubert Ziegler," *Nature* vol. 308, iss. 5961 (April 19, 1984), pp. 755-6, on p. 755.
[6] *Ibid*, p. 756.
[7] Marco Bischof, "Some Remarks on the History of Biophysics (And Its Future)," in Chang-Ling Zhang, Fritz A. Popp, and Marco Bischof eds. *Current Development of Biophysics: the Stage From an Ugly Duckling to a Beautiful Swan* (Hangzhou: Hangzhou University Press, 1996), pp. 10-21.
[8] Andrew Miller, "Definition by Doing," *Nature* vol. 317, iss. 6035 (September 26, 1985), p. 300.

This is a study about the history of biophysics—a subject that has fascinated me ever since the first semester of my doctoral program. I had no previous training in the science of biophysics nor did I have any familial, cultural, or personal predilection for biophysics. What fascinated me was that biophysics did not have a definite set of subfields or a university-wide department of its own in the United States. Different academic institutions invented their own rules to incorporate biophysics into different schools and departments, and different people used terms like "biophysics" and "biophysicists" to mean different things. Yet despite the lack of a formal definition in this field, there was nevertheless a great deal of optimism surrounding its future.

CHAPTER 1

INTRODUCTION

On 2 November 2009, Yang Liwei (杨利伟), China's first man-in-space, and Chen Shanguang (陈善广), director of the China Astronaut Research and Training Center and chief engineer for the Chinese manned space program, dressed in military uniforms to attend a funeral of a deceased scientist. The scientist to whom these two space celebrities paid respect was not a Werner von Braun type of figure in China, and not a typical space pioneer you would expect by any measure, because he was a cell biologist.[9]

The reason driving the first *taikonaut* (Chinese equivalent for astronauts) and the director for training *taikonauts* to pay homage to a cytologist-cum-biophysicist is actually simple. Forty-three years ago, Bei Shizhang (贝时璋), in his capacity as the founding director of the Institute of Biophysics at the Chinese Academy of Sciences (IBP-CAS), was responsible for launching the first biological sounding rockets carrying animals to the upper atmosphere. Although the Chinese space travel in the sixties only brought dogs and mice to reach a level not even close to low earth orbit, many Chinese regarded the endeavor as the *origin* of human spaceflight in modern China.[10] So the high-profile visit to Bei's funeral by lieutenant Yang and administrator Chen was a symbolic

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[9] "Representatives of the China Astronaut Research and Training Center Chen Shanguang and Yang Liwei Send Condolences to Academician Bei Shizhang's Family,"中国航天员中心陈善广、杨利伟一行吊唁贝时璋院士并慰问家属, available on <www.ibp.cas.cn>.

[10] Wang Xiji (王希季), former director of the China Academy of Space Technology (CAST), applauded the efforts of the biophysicists this way: "the research of cosmobiology and the launch of biological rocket flights at the Institute of Biophysics laid the cornerstone for developing China's manned spaceflight." See IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets* 小狗飞天记: 中国生物火箭试验纪实, (Beijing: Science Press, 2008), foreword.

act to acknowledge the role of Bei Shizhang and the IBP-CAS under his directorship in setting the precedent for China's human spaceflights.

The Problem: Biophysics, Rockets, and the State in Modern China

The history of biophysics in China seems to be a far cry from the debates about the definition of biophysics I discussed in the prologue. But if biophysics can only be captured through depicting what biophysicists do in practice, the Chinese experience of building biophysics by launching rockets is one of the many ways that gives a concrete meaning to biophysics. How has the practice of Chinese biophysicists shaped the definition of biophysics in China? What forms of knowledge are involved in articulating the subject matter of biophysics? For those who are relatively unfamiliar with Chinese history, this study will offer an opportunity to explore contentious issues regarding the history of a scientific discipline in a different socio-historical context. China scholars and Chinese readers, I hope, will find that Chinese history looks different when the issue of building a scientific discipline is placed at the center of the analysis.

In the history of science, it was Robert Kohler who advocated approaching the building of scientific disciplines from a socio-economical point of view. His compelling analysis of the historical growth of biochemistry in the U.S. indicates that the social and institutional contexts matter to the expansion of a scientific discipline as much as, if not more than, the intellectual contributions and conceptual underpinnings of a discipline.[11] As Kohler carefully justified the role of institution in shaping science, a bigger question remains as to whether my analysis of the Chinese history of biophysics adds anything to

[11] Robert Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline* (Cambridge: Cambridge University Press, 1982).

the scholarship. If the building of a scientific discipline depends on institutional backing, is the character of institutional shaping a universal attribute or does it exhibit distinct, tangible national difference?

Jane Maienschein has considered whether national setting might exert any discernable effect on the development of scientific activities. As she explained, although institutional studies that focused on personalities or major historic events have left out the intellectual or political origins of the institutions, they still offer considerable insights into what role the national setting has played in shaping the character of science. Thus it is possible and sensible to argue for a certain "self-consciously American biology" in its own right. [12]

Is there a distinctively Chinese biophysics? At various analytic points, I compare and contrast the Chinese efforts of building biophysics with the American historical counterparts in order to put the Chinese experience of instituting biophysics into perspective. Using the mid-century American history of biophysics as a control case, the comparative analysis shows that there are indeed notable differences in constructing biophysics in twentieth-century America and China.

Structural characteristics of disciplinary orientation and university opportunities shape the history of biophysics in twentieth-century China, but they played out in distinctive ways in the context of China apart from that of East Asia. Disciplinary orientation, and with it ways of ordering scientific knowledge and practice, came in mostly with the national mobilization of personnel and capital. Science stood for social progress and public good. Opportunities to promote organized activities of science, in

[12] Jane Maienschein, "History of Biology," in Sally Gregory Kohlstedt and Margaret Rossiter, eds. *Osiris* (vol. 1, ser. 2, 1985), pp. 147-162, on p. 147.

terms of creating research institutes and educational programs, became more available after the founding of a unified state in 1949.

A key difference from the history of science in East Asia, and Japan in particular lies in China's diverging pattern of modernization and with it the place of science in national priority. While the Meiji Restoration enabled Japan to become Asia's first and the only non-Western country to industrialize (and colonize) in the nineteenth century, it also encouraged a wholesale, undiscriminating embrace of Westernization. Although Japan's modernization is, in reality, a hybrid struggle oscillating between Japanization (*nihonjinron*) and Westernization, Martin Jacques asserts, "Japan would still prefer to see itself as Western rather than Asian."[13] The post-Meiji cultural attitude affects Japan's orientation to science policymaking. Since Japan was much more advanced than China and the rest of Asia in so many ways for so many decades, the Japanese did not attach as high a priority to "revitalize the country through science and education" (*kejiao xingguo*) as did the Chinese. One consequence of this difference was that Chinese scientists and leaders were more forceful in their efforts to institutionalize scientific research and education.

Another important difference was the way in which science (or some scientific artifacts) was seen as originating from Chinese civilization rather than from Japan. Since Japan does not have such strong ancient scientific roots as China, it was less eager to rise to its pre-modern glory through the venue of scientific endeavors, instead focusing on military conquest. This focus on the military capacity for territorial annexation is exemplified in the slogan "enrich the country, strengthen the army" (*fukoku kyōhei*) but

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[13] Martin Jacques, *When China Rules the World: The End of the Western World and the Birth of a New Global Order* (NY: Penguin Books, 2009), p. 80.

apart from the imperial ambition, it had little to lay claim to in the past and future of science (aside from its military applications). Chinese scientists and scholars, on the other hand, had been preoccupied with the psychological predicaments of the "century of humiliation" and "national salvation" for over a century.[14] Today, current debates about the value of China's past and its proper place in the post-modern, globalized world are often initiated by concerned citizen-intellectuals and scientists alike. Science think-tanks and policymakers in China spare no opportunity to remind the public that China was home to the first worldwide innovations in science and technology and that one day science and technology will unquestionably bring Chinese civilization back to a place it considers itself destined to occupy.

For example, a recent science policy document began with the following remarks uttered by Karl Marx in the nineteenth century:

> Gunpowder, the compass, and the printing press were the three great inventions which ushered in bourgeois society. Gunpowder blew up the knightly class, the compass discovered the world market and founded the colonies, and the printing press was the instrument of Protestantism and the regeneration of science in general; the most powerful lever for creating the intellectual prerequisites.[15]

What the Chinese policymakers implied here was that the three Chinese inventions gave the material conditions for revolutionary reforms to take place in the

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[14] For a classic socio-intellectual analysis of the psychological dilemmas of Chinese mandarins, see Joseph Levenson, *Confucian China and Its Modern Fate: A Trilogy, Vol. 1 The Problem of Intellectual Continuity* (Berkeley: University of California Press, 1968).

[15] Huadong Guo and Ji Wu, ed. *Space Science and Technology in China: A Roadmap to 2050* (Stuttgart: Springer Verlag, 2010), p. 5.

West, thus crediting ancient China for its (often under-acknowledged) role in Western social and cognitive development.

Added to these distinctive aspects of science in modern Chinese history is the position China has held in the field of space science. China was known for inventing gunpowder in the ninth century, firing the world's first rocket weapon in the eleventh century, and flying the first man to heaven with the use of a rocket-propelled chair in the sixteenth century—despite its unsuccessful outcome.[16] In 2003, China became the third spacefaring nation in the world. Despite a five-century delay in making progress in space science, aeronautics and astronautics are now invested with much hope and hype in China, especially since the rise of China's space efforts coincided with the economic crisis of the U.S. which forced many of the existing U.S. space programs to shut down.

Furthermore, there are several central themes in the Chinese narrative of biophysics that are unfamiliar to the majority of Western readers. Biophysicists pioneering human spaceflight through putting animals in the sky is one, for example, but there are many more. Chinese biophysicists could not have succeeded in launching the biological sounding rockets without the political patronage of the state and cooperation with other actors in the space-and-missile program, with one striking feature being the state's direct, sustained involvement in building the space establishment through mobilizing experts and laymen from many different areas.

There are some similarities between the Chinese space operations and those in the West. In both, the role of the state is critical, especially in the beginnings of space

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[16] Brian Harvey, *The Chinese Space Programme: From Conception to Future Capabilities* (Chichester: Wiley-Praxis, 1998), p. 1; Xu Dongmei 徐冬梅 "Wan Hu—the First Man Who Attempted to Fly a Rocket" 第一个尝试用火箭飞天的人——万户, available on <people.com.cn>

programs, as space science is inextricably intertwined with the development of missiles, nuclear weapons, and issues of national security in general. Oftentimes, the state plays an elemental role in unifying the various forces in the military and civilian sectors for doing rocket research. While similar in that respect to its Western counterparts, space operations in China have been more centrally organized with far-reaching political ramifications.

Spacecraft and statecraft are intertwined to the extent that technical advancement in spacecraft reflects the governing capabilities of the state. The state participation in China's rocket-and-space program led Qian Xuesen, considered the "father of missiles and rockets in China", to the belief that "our system can effectively integrate and unify our willpower. This is more conducive for conducting rocket engineering than in liberal America."[17] Qian was making not a scientific observation but a political statement on the credibility of the socialist system and the competence of the party-state in leading the country to extend the frontiers of science.

The explicit attention given to the political implications of space development is remarkable but hardly astonishing to Western scholars, being reminiscent of what Yaron Ezrahi has observed about the political appropriation of science and technology in both liberal and non-liberal political traditions. Regarding the function of science in non-democratic contexts, he wrote:

> The very science and technology which authorize decentralization by specialization, because they substantiate instrumental rather than arbitrary or political grounds for unifying parts of action, can also authorize centralization.

[17] Gong Xiaohua 巩小华, *Inside the Decision-Making World of Chinese Space Industry* 中国航天决策内幕 (Beijing: Chinese Literature and History Press, 2006), p. 26.

> In a totalitarian state where no autonomous private sector exists, the employment of science and technology to legitimate centralized political control in terms of necessary technical unity is not mitigated by the ideologically sanctioned decentralizing effects of specialization, the authority of nonpublic bodies, and the public nature of science as an intellectual enterprise.[18]

Ezrahi was talking about the politicization of science not in China *per se* but in countries he considered to be "totalitarian states" such as the Soviet Union, Nazi Germany, Franco's Spain, and fascist Italy. On the topic of seeking political legitimation through borrowing the authority of science and technology, H. Lyman Miller has considered the political manipulation of science and technology in modern China:

> One way in which science has had a significant political impact in modern China has been in its appropriation by intellectuals as a basis for comprehensive political ideologies. Because science has had spectacular success in explaining aspects of the natural world, it has laid claim to a uniquely reliable kind of knowledge and become a powerful source of ideas and values. Thus, science has acquired a sometimes intimidating prestige and authority, leading at times to attempts to extend its methods beyond its domain.[19]

Questions as to whether the People's Republic of China (P.R.C.) can be considered as a "totalitarian state" or the extent to which science justifies politics in the

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[18] Yaron Ezrahi, *The Descent of Icarus: Science and the Transformation of Contemporary Democracy* (Cambridge: Harvard University Press, 1990) p. 44.
[19] H. Lyman Miller. *Science and Dissent in Post-Mao China: The Politics of Knowledge* (Seattle: University of Washington Press, 1996), pp. 4-5.

P.R.C. are beyond the scope of this study. It is not my purpose to criticize either Ezrahi or Miller with these short quotations, but it is my intention to highlight some of the prevailing scholarly understandings of the function and value of science in an authoritarian/totalitarian non-Western country like China. While I do agree that science and technology sometimes serve as tools at the hands of the governing bodies to accomplish military and political goals, ideological legitimation is not sufficient to explain the gamut of activities of science and technology in China. To write off the efforts of Chinese scientists as constituting nothing more than a collusion with the state agenda to manipulate the public is to ignore many other central aspects in the science and technology sector.

The primary actor, sponsor, and orchestrator of the Chinese space program is undeniably the state and its many apparatuses. But the space program has also enjoyed substantial popular support from its early days, a trend which continues into the present. Nationalist sentiment (in various forms and brands) is a necessary factor here, though insufficient by itself since "it would be difficult to imagine nationalism succeeding without inspiring personal attachment" as Sigrid Schmalzer pointedly noted in her study of the popular roots of human fossils and human evolution in modern China.[20] Likewise, it is problematic to reduce the significance of the Chinese space program to factors like nationalism or cultural chauvinism alone. Starting from the very early days, Chinese rockets have been dedicated to the needs of the masses on a practical level. The *Fengyun* meteorological satellites fulfilled cultural responsibilities of weather monitoring and disaster management. Premier Zhou particularly emphasized the development of

[20] Sigrid Schmalzer, *People's Peking Man: Popular Science and Human Identity in Twentieth-Century China* (Chicago: University of Chicago Press, 2008), p. 278.

indigenous satellites and utilization of foreign satellite data; Deng Xiaoping encouraged the marketization of communication satellites. Stacey Solomone has recently identified the linkage the Chinese government has fostered between the aerospace industry and popular demands,

> For example, in order to serve the people, space programs were vectored toward communications, entertainment, and life science applications. These applications of the aerospace industry into the lives of the masses are how the Chinese maintain a direct connection to space technologies; this approach reaches beyond the goals of national defense and international prestige...Although the original goals of national defense and international prestige remain strong, the aerospace industry of China also seeks to serve the people and contribute to China's economic development.[21]

In addition to "serving the people" through providing forecasting and infotainment services, "serving the science" is also an implicit outcome of the space program. I argue that advancement of scientific disciplines is one of the oft-ignored contributions of the space-and-rocket missions. The space program created a political platform to facilitate the growth of space-related disciplines in China—biophysics being a case in point. From this awareness of the interplay between biophysics, rockets, and the nature of the state of modern China, we can move to the next focus, the biophysicists themselves.

[21] Stacey Solomone, "Space for the People: China's Aerospace Industry and the Cultural Revolution," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China,* pp. 233-250, on p. 245-6.

Who Are the Chinese Biophysicists?

In the prologue, I suggested that Western biophysicists have not arrived at a unanimous agreement as to what biophysics really is; rather, it is suggested that doing biophysics is more important than clearly defining it. That practice precedes definition might work for some practicing biophysicists; but a conceptual foundation is indispensable for a discipline to grow and develop as a profession.

It is not that there is a shortage of definitions of biophysics in the science literature, but biophysicists of different backgrounds and research orientations give different statements tailored for different audiences serving different purposes. For instance, an argument erupted in the "Correspondence" column in *Nature* magazine over the identity of the first biophysicist. A reader launched a complaint against an article that claimed that "biophysics began with Avery," on the grounds that it was a "subjective opinion" amounting to little more than the biases of the author. Besides giving potential nominees for taking the honor of being the first biophysicist such as the British scientist Francis Crick (the reader was affiliated with the biophysics department at the University of Leeds), the subscriber went on to suggest, "In this department, however, we have our own prejudice on the matter. Perhaps a prophet is indeed not without honour except in his own country (or even in his own country, it would appear)."[22] It seems that authorization of the first biophysicist rests on the credibility and background of the interlocutor more than the research contribution of the biophysicist under discussion.

Who is privileged to speak on behalf of biophysics and biophysicists? In China, some prominent Chinese biophysicists have taken up the task of defining biophysics, but

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[22] John E. Lydon, "First Biophysicist," *Nature,* vol. 235, iss. 5339 (February 25, 1972), p. 447.

this brings us to questions such as: Who are these Chinese biophysicists? How do they understand the disciplinary nature of biophysics? How do the perspectives of these biophysicists reflect their scholarly backgrounds?

I follow a small group of influential biophysicists who have voiced opinions about what biophysics encompassed in twentieth-century China. The most authoritative spokesperson of biophysics in China was Bei Shizhang, as the most respected leader in the community of Chinese biophysicists who is considered to have almost single-handedly founded biophysics in mid-century China. Throughout his professional career, Bei advocated biophysics as a biology-centric area of inquiry that required the cooperation of both biologists and physicists, with his conception of biophysics being correlated to his background as a cell biologist, the details of which will be explored later. [23]

Next to Bei Shizhang, Shen Shumin (沈淑敏)—deputy head of the department of biophysics at the University of Science and Technology of China (USTC) and editor-in-chief of a leading Chinese biophysics journal, *Progress in Biophysics and Biochemistry*, has made public attempts at defining biophysics. Unlike Bei, who received his doctoral degree from the University of Tübingen in 1928, Shen was a domestically-trained biologist. In 1963, Shen contributed a single-authored article to *People's Daily* introducing the discipline of biophysics to the Chinese mainstream audience. Titled "Biophysics—A Newfound Discipline in Biological Sciences," Shen's conception of

[23] Bei Shizhang, "Several Problems in Biophysics" 生物物理学中的若干问题, in *Selected Writings of Bei Shizhang* 贝时璋文选 (hereafter *SWB*) (Hangzhou: Zhejiang Science and Technology Press, 1992), pp. 205-206.

biophysics struck the same chord as that of Bei with her representation of biophysics as a biological science.[24]

Next in line is Xu Jinghua (徐京华), chairman of the Biophysical Society of China. Between 1963 and 1983, Xu raised questions about the theoretical issues in the epistemic construction of biophysics. Whereas Bei gave the basic framework for interpreting biophysics and Shen communicated biophysics to the public, Xu was interested in the philosophical contentions of biophysics. Xu was sensitive to the competing ideas involved in shaping the history of biophysics: vitalism, mechanism, organismic theory etc. Xu did not give a black-and-white definition to biophysics but rather pointed out the ambiguous position of biophysics, as it is situated at the crossroads between physics and biology.[25]

Despite dissimilar career paths and research interests, Bei Shizhang, Shen Shumin and Xu Jinghua shared one commonality: their commitment to shaping the disciplinary discourse of biophysics. They were concerned with the past, present, and future directions of biophysics. They could be considered as biophysicists with a shared passion in the history and philosophy of biophysics. At the heart of their efforts is the struggle to differentiate biophysics from other closely related disciplines such as biochemistry.

Yet not all leading biophysicists were interested in the epistemic aspects of biophysics. Zou Chenglu (邹承鲁) was a reputed biophysicist known for his contribution to synthetic crystalline bovine insulin in the late 1960s. His scientific achievement

[24] Shen Shumin 沈淑敏, "Biophysics—A Newfound Discipline in Biological Sciences" 生物科学中的一门新兴学科—生物物理学, *People's Daily*, August 06, 1963.
[25] Xu Jinghua 徐京华, "Some Theoretical Questions in Biophysics" 生物物理学中的一些理论问题, in The Chinese Society of Physiology ed. *Proceedings of the First National Biophysics Academic Conference* 第一届全国生物物理学学术会议汇刊, (Beijing: Science Press, 1965), pp. 72-78.

probably outstripped those of the previous biophysicists, yet he displayed no active interest in the theoretical and philosophical issues of biophysics. Zou received his doctoral degree in biochemistry from Cambridge University in 1948. Not only did he identify himself primarily as a biochemist rather than a biophysicist, he has written several articles celebrating notable biochemists and development of biochemistry in China, though he has remained silent on the intellectual matters of biophysics.[26] The only reason I am willing to categorize him as a biophysicist is his official affiliation with the Institute of Biophysics. Zou's academic profile indicates that not all biophysicists (or scientists working in the Institute of Biophysics) have a vested interest in shaping the epistemic paradigm of biophysics.

Biological Sounding Rockets & "Two Bombs, One Star": The Making of a Discipline

Western space observers have not normally grasped the connection between Chinese biophysicists and the Chinese space program. Although the first manned orbital flight in 2003 aroused much attention, there is considerable uncertainty as to what came before. Reviewers of space science recognized the launch of China's first communication satellite (comsat) in 1984, or the launch of the country's first satellite, *The East is Red*, in 1970, and perhaps the tale of Qian Xuesen who returned to China in 1955.[27] But a closer inspection reveals significant analytical gaps as a unique *biological* dimension was missing among the known space vehicles and dignitaries. The comsat has no living things

[26] Zou Chenglu 邹承鲁, *Essays of Zou Chenglu* 邹承鲁杂文集 (Beijing: Xue Yuan Press, 2008).
[27] Gregory Kulacki and Jeffrey G. Lewis, *A Place for One's Mat: China's Space Program, 1956-2003* (Cambridge: American Academy of Arts and Sciences, 2009), p. 4.

in it and only feeds electronic data back to earth; *East is Red* is bigger and heavier than the Sputnik, but it is nothing more than an empty vessel circling the earth making noise; Qian is undeniably a pivotal figure in China's aerospace industry but he is not primarily responsible for putting any forms of life into space as his expertise is not in biology. Although Qian was credited for founding the missile-and-space program in China and having written the popular textbook *An Introduction to Interplanetary Flight* (星际航行概论), the root of a manned spaceflight can be traced back to the large-scale bomb-and-rocket mission dubbed "Two Bombs, One Star" (两弹一星, referring to the detonation of an atomic bomb, a hydrogen bomb, and the launch of an artificial satellite).

A conventional view of "Two Bombs, One Star" is that political missions precede disciplinary interests. This aspect of the relationship between disciplines and mission was captured in the slogan "mission drives disciplines" (任务带学科). But the complementary aspect was usually overlooked, for "mission drives disciplines" was just the upper line in the slogan, to be completed by the lower line——"disciplines facilitate mission" (学科促任务).

Existing writings on the history and technology of "Two Bombs, One Star" have been mostly provided by retired rocket engineers, nuclear scientists and government officials. The focus is either on the technical capability or the political correctness of the program. Few looked at the program from the perspective of discipline building. Space missions came to fruition with a close interaction and cooperation among physical scientists, engineers, life scientists, mission planners, cadre members, officials, and technicians. Since mission planners and government officials dominated the narratives of the event, we have yet to understand and appreciate the role of biological scientists in the mission or what the mission meant to the biology-related disciplines.

The main focus of this study is to understand the ways in which "Two Bombs, One Star" generated the political momentum to integrate biophysical scientists into the overall mission and, in the process, created the operative condition for the active participation of life scientists in the space program, most notably in the launch of biological sounding rockets in the 1960s. Essentially, this is an examination of how the contribution of biophysicists to "Two Bombs, One Star" in the 1960s shaped the discourse and character of biophysics in China after the completion of the mission.

Consolidating a Discipline: the Institutionalization of Biophysics

If the space-and-rocket missions ("Two Bombs, One Star") opened a window of opportunity for Chinese biophysicists to build their discipline, the next questions surface: What was the actual process of discipline building? What does it mean to build a discipline in practice? What are the embodiments of a science discipline?

Biophysics shares considerable intellectual overlap with other biological disciplines. As biophysics is a "catch-all term" as Lily Kay dubbed it, it allows different groups of scientists to participate and claim professional interests. Both Lily Kay and Nicholas Rasmussen have noted the rivalries between American biophysicists and their colleagues in biochemistry, physics, molecular biology, and physiology.[28] If there is anything distinctive to biophysics that makes it stand out from other biological sciences,

[28] Lily Kay, *Molecules, Cells, and Life: An Annotated Bibliography of Manuscript Sources on Physiology, Biochemistry, and Biophysics, 1900-1960* (Philadelphia: American Philosophical Society, 1989), p. 13; Rasmussen, *Picture Control.*

it would be its primary emphasis on advanced technology. The science of biophysics is best exemplified in integrating sophisticated instruments with quantitative theory. This is evident in Delbrück's collaborative attempt to inaugurate a "physical biology" program in Germany in the 1930s.[29] The centrality of high technology is even more striking in the coalescence of the community of biological electron microscopists in America between 1940 and 1960.[30] These precedents highlight the fact that biophysics is a technology-oriented discipline: It is not an entrapment of technological determinism. Machines are what made biophysics what it is, but the problem is that powerful machines alone cannot sustain a discipline. The "burst of the biophysics bubble" in the mid-century United States testifies to the importance of institutional support to buttress a fragile discipline with flexible research areas and lucrative developmental promise.[31] If biophysics is to be put on a permanent footing as a fully mature discipline, its leaders must find a way to incorporate its technical advances into specific national and institutional contexts.

There are many methodological strategies to examine the construction of a science discipline. Kohler's study of the building of biochemistry considered the emergence of departments and institutions, founding and appointment of chairs, specialized journals and societies, standardization of degrees and certificates and academic markets for university graduates as indicators of the consolidation of biochemistry in the United States compared to the European counterparts. Gerald Geison highlighted the significance of institutional opportunities in shaping the intellectual

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[29] Philip Sloan and Brandon Fogel, eds. *Creating a Physical Biology: The Three-Man Paper and Early Molecular Biology* (Chicago: University of Chicago Press, 2011).
[30] Rasmussen, *Picture Control*.
[31] Nicholas Rasmussen, "The Mid-Century Biophysics Bubble: Hiroshima and the Biological Revolution in America, Revisited," *History of Science* 35 (1997): 245-293.

program in his study of the Cambridge School of Physiology.[32] In other words, analyzing the disciplinary formation of science from an institutional perspective is an appropriate method.

Institutional contexts provide material and political support for certain science disciplines to grow. The history of instituting biophysics in China can be assessed from the establishment of educational and research programs of biophysics. Chapters 4-7 look at how biophysics coalesced into a distinct discipline through the institutionalization of teaching and research in biophysics. For readers interested in the institutional history of science in non-Western countries, the history of launching biophysical educational and research programs sheds lights on how a science discipline takes root in different contexts; historians of education in modern China can determine the similarities and differences between the teaching of science and non-science disciplines in the twentieth century.

Overview of Chapters

The narrative that follows will cover Chinese history roughly from 1930 to 2005. Each of the ensuing chapters investigates the core components I identified as my focus of research. Chapter two gives an overview of the intellectual landscape of Chinese biophysics by reviewing three Chinese biophysicists' perspectives on biophysics. I also give a profile of Bei Shizhang, the founding father of biophysics in modern China, and I correlate his academic background with his scientific style and views of biophysics. Chapter three explores the institutional transition from experimental biology to

[32] Gerald Geison, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late Victorian Society* (New Jersey: Princeton University Press, 1978).

biophysics between 1949 and 1958; chapter four takes up the issue of the political patronage of biophysics by tracing the military-scientific negotiations in the early periods of China's rocket research; chapters five and six discuss the educational program of biophysics at USTC; chapter seven portrays the ups and downs of biophysicists and the biophysics program during the Cultural Revolution; finally, the epilogue gives a follow-up account of Chinese biophysics in the post-Mao era.

CHAPTER 2

VIEWS OF BIOPHYSICS: THREE CHINESE BIOPHYSICISTS IN SEARCH OF SUBJECT MATTER

On 16 January 2009, *Science* international news editor Richard Stone paid a visit to the Institute of Biophysics at the Chinese Academy of Sciences (IBP-CAS). Picking up on what Wen Jiabao, the then Chinese premier, had said about science being the fountain for innovation and development in China, Stone credited IBP-CAS as forceful evidence for fulfilling Wen's grand vision.[33] The fact that this science journalist chose to correlate science with the state through the example of biophysics demonstrates the political significance of the subject matter.

While Stone brought attention to the socio-political meaning of China's biophysics, Chinese biophysicists have offered a range of views about the disciplinary, historical, philosophical, and social meanings of biophysics in China. These scientists focus more on the value of the intellectual foundation of the discipline to which they are committed. This chapter explores the views of biophysics held by three leading Chinese biophysicists. It gives an overview of the dominant Chinese conceptions of biophysics by comparing the Chinese intellectual landscape against the state of knowledge on the history of biophysics. I suggest that Chinese scientists' views of biophysics are quite different from the interpretive frameworks in Western historiography. Finally, I assert that scientists' views of biophysics are inseparable from the intellectual history of biophysics and the academic, social, and personal background of individual scientists.

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[33] "*Science* News Editor Richard Stone Visits the Institute of Biophysics" "《科学》杂志新闻编辑理查德•石磊访问生物物理研究所," (January 19 2009), available on <www.ibp.cas.cn>.

Views of Biophysics I: Bei Shizhang

At the first national biophysics academic conference held between 7 and 15 August, 1964, Bei Shizhang—the first and the most well-known Chinese biophysicist who attempted defining and delineating biophysics—contributed a closing speech to mark an end to the first biophysics conference. There were four central themes in this nine-day workshop, namely "the physical chemistry of biopolymers," "theoretical biophysics," "photoreactions and photosynthesis," and "biophysical equipment." The program was designed in such a way that biochemistry and biophysics each accounted for half of the thematic attention. Bei drew upon the disciplinary background of biochemistry in his epilogue to reflect on the state of knowledge in biophysics and the prospects of biophysics in China. Entitled "Several Problems in Biophysics," the speech began with a discussion of "the meanings of disciplinary cross-fusion" (学科相互渗透的意义) based on a brief historical narrative of biochemistry:

> Biochemistry is one of the fastest growing disciplines in biological sciences in the last twenty years. It is a concrete example of disciplinary cross-fusion. Since every living process is closely related to biochemical changes, a sole reliance on concepts and methodologies from biology is not enough for research purposes. The participation of chemistry is needed for problem solving. As a marginal discipline, biochemistry has made considerable advancement in the research of the isolation, purification, structures and function, artificial synthesis of chemicals in living organisms, as well as addressing questions such as the activities of these chemicals *in vivo*, including how do (these chemicals) interact with the

> body? How do they constitute with body parts? How to conduct metabolism? How to relate to the environment? (Biochemistry) has solved many questions in the theory and practice of biology.[34]

Although Bei stressed the value of using chemical approaches to study biology, he expressed even greater concern about the positive outcomes of epistemic enrichment and methodological enhancement than about any supposed prevailing hierarchy of scientific knowledge. From the latter point of view, the chemical approaches to biological problems upset the positivist scientific order by disrupting what were then the normative disciplinary boundaries. While some Western scholars saw biochemistry as a case of the colonization of biological territory by the more "primal" discipline of chemistry,[35] Bei stressed the non-hierarchical, problem-oriented nature of disciplinary intersection upon which the development of biochemistry was founded. Biochemistry was constructed as a successful example of interdisciplinary science, not because of any pre-determined superiority of chemistry but out of the need for the trans-disciplinary knowledge and skills to solve complex problems in biology. What this suggested is that the positivistic causal chain was inadequate for dealing with the complexities of biological sciences and thus potentially undermined its absolute authority as not merely the greatest but the exclusive method of scientific inquiry.

The reciprocal exchange in "disciplinary cross-fusion" was underscored as Bei explained that "the function of disciplinary cross-fusion is not unilateral; it is (about)

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[34] Bei Shizhang, "Several Problems in Biophysics" *Proceedings of the First National Biophysics Academic Conference* (Beijing: Science Press, 1965), pp.13-14, also reprinted in *SWB,* pp. 205-206.
[35] Julie Thompson Klein, *Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities* (Charlottesville: University of Virginia Press, 1996), p.82.

reciprocal assistance, reciprocal enrichment and mutual improvement."[36] In particular, Bei did not share a cultural predisposition that accorded physical sciences higher epistemic value than biological sciences. He detailed the scope of correlative questions that biochemistry addressed and with which it was broadened. He presented biochemistry as a biology-centered inquiry, in a similar vein as biophysics. Bei used the case of biochemistry to build up his vision of biophysics as

> a discipline that investigates the basic nature of life. Biophysics measures the inter-relationship between the quality, energy, and informatics of life, and considers the factors of environmental influence in clarifying the nature of life in the micro and macro scales and theorizing about life, while contributing to agricultural production, medical health and national defense… The physical explanation of life depends on the mutual endeavors of biology and physics.[37]

The pivotal point in Bei's representation of biophysics was the basic commitment to unravel the nature of life with mutual efforts from physics and biology. The conceptual emphasis of investigating life overrides the physicist's presupposition of a universal theory of the universe and the biologist's preoccupation with observing and describing nature. Bei presented the future of biophysics as primarily a life science-oriented inquiry, but he welcomed the participation of physics in this joint venture, which was as much about the microscopic investigation of cells as it was the macro-mapping of the relationship between living organisms and the environment.

[36] Bei Shizhang, "Several Problems in Biophysics," *Proceedings of the First National Biophysics Academic Conference*, p. 15.
[37] Bei Shizhang, "Several Problems in Biophysics," *SWB*, p. 205.

Views of Biophysics II: Shen Shumin

At around the same time, a female Chinese biophysicist took actions to enhance the nation-wide profile of biophysics. On August 6, 1963, Shen Shumin (沈淑敏) contributed a six-page, single-authored article to *People's Daily* to advertise biophysics as "a newfound discipline in biological sciences" (生物科学中的一门新兴学科).[38] Both the length and topic of this article were unorthodox for the official newspaper of the P.R.C. In this extended essay intended for the general public, Shen introduced the discipline and research areas of biophysics, and reviewed its past historical connections and envisioned future relationships with other disciplines, primarily those in the biological sciences. The essay fit nicely into genres such as science textbooks, science popularization literature, and even academic journals, but not political newspapers. Yet the official mouthpiece of the Party chose to publish the article in full, which reflected the overall political importance of biophysics as a discipline in 1963.

The early 1960s witnessed the rapid growth of many new scientific disciplines in the P.R.C.; biophysics was hardly the only novel science that was considered worth promoting for public understanding. The unparalleled weight attached to biophysics by the editorial committee of *People's Daily* was more conspicuous in comparison to its sister discipline—biochemistry. Biochemistry appeared in *People's Daily* in an article entitled "New Things in Biochemistry" (生物化学中的新东西) in 1961.[39] However, not only was this piece half the length of the Shen article on biophysics, it was directly

[38] Shen Shumin, "A Newfound Discipline in Biological Sciences—Biophysics," *People's Daily*, August 06, 1963.
[39] S. E. Severin 谢维林, "New Things in Biochemistry" 生物化学中的新东西, *People's Daily*, October 12, 1961.

translated from a report penned by the Soviet biochemist S. E. Severin that was published in the leading Soviet newspaper *Pravda* (真理报).[40] The source news was written to mark the Fifth International Congress of Biochemistry held in Moscow in August 1961. Since the original article was written by a Soviet scientist addressed to a Soviet audience, the content covered the latest accomplishments by Soviet biochemists, with an exclusive focus on the structures of proteins and macromolecules to act as a counterweight to the American ground-breaking effort of stimulating the incorporation of phenylalanine into a polypeptide chain with poly-U amino acids. The latter achievement was one of the highlights in the 1961 Moscow meeting as summarized in a speech given by American Nobel laureate Marshall Nirenberg.[41]

Although both biochemistry and biophysics were publicized in China's journalistic domain in the early 1960s, the authorship, style of writing, intended audience, length, and even the political implications were diametrically different. Not only was biochemistry presented to Chinese readers by a foreign scientist, biochemistry was discussed in the 1961 article without any relationship to China or Chinese biochemistry. Not once was Chinese effort in biochemistry explored or any Chinese biochemist named.

One should remember the fact that the 1961 article was released at a time when the diplomatic relations between the P.R.C. and the U.S.S.R. were strained by ideological disputes and political rivalries that culminated in the collapse of the Sino-Soviet alliance in 1962. Even though the two communist states were still officially allies, many Soviet

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[40] For biographical information on S. E. Severin, see "Sergei Evgen'evich Severin (on his 60th birthday)," *Bulletin of Experimental Biology and Medicine,* Vol. 52, Iss. 6 (July 1, 1962), pp. 1448-1449.
[41] Marshall W. Nirenberg, "Draft of Speech Given at the International Congress of Biochemistry in Moscow," *Profile in Science: The Marshall W. Nirenberg Papers* (August 1961), available on <profiles.nlm.nih.gov>.

experts and equipment were already being withdrawn from China by 1960.[42] The end of the Sino-Soviet technical cooperation marked the turn of political discourse from "learning from the big brother" to "using national efforts to overcome difficulties", whereby Chinese leaders and scientists declared a domestic commitment in China's quest for national security and scientific capability. The paradigm shift from dependency or interdependency to self-reliance was partly reflected in the transition from biochemistry reportage in 1961 to biophysics reportage in 1963. Not only was biophysics brought to the attention of the Chinese people by a Chinese biophysicist, but in addition Shen's emphasis was placed on the Chinese approach in building biophysics.

Shen explored how biophysics could aid modernization efforts in agriculture and medicine. In the practice of agriculture, Shen considered the instruments and techniques of biophysics useful for the measurement and analysis of agricultural productivity. For example, she suggested that the variations in temperature, light intensity, humidity and acidity of crops could be captured and measured more accurately by the instruments used in bioelectronics. Another way in which biophysics could facilitate agriculture was through the biophysical understanding of cyclical changes in living organisms and their adaptations to biomes, also known as biological or circadian clocks. Although the study of the chronological variation of the biological realm usually fell under the field of chronobiology rather than biophysics per se, Shen situated knowledge of the variations of the timing and duration of biological activity within the discipline of biophysics.

[42] For example, the Ukrainian chemist Mikhail Klochko reminisced that he was ordered to leave China in 1960 despite his request to prolong his stay, see Mikhail A Klochko, (translated by Zhao Baohua) 赵宝骅译, *A Soviet Scientist in Red China* 一位苏联科学家在中国, (Changsha: Hunan Education Press, 2010); John Lewis and Xue Litai also reported the termination of Soviet aid in military equipment and atomic energy by August 1960, see John W. Lewis and Xue Litai, *China Builds the Bomb,* (California: Stanford University Press, 1988), pp. 35-72.

"Currently, one of the interesting research questions in biophysics is the periodic and rhythmic phenomenon in the biological kingdom, also known as biological clocks."[43] By incorporating the study of biological cycles into biophysics, Shen managed to connect the science at the intersection of biology and physics—something quite far-flung from agriculture—to one of the major modernization and collectivization projects in Red China. Relating a "newfound discipline" to a pragmatic area of immediate state commitment and interests was of strategic importance in the 1960s, when suspicion was starting to cloud over those scientific branches that were deemed to be too "abstract" without practical contribution to the real world.

As much as Shen was optimistic about the input and values of physics in biophysics, she was also cautious about the limitation of using only physical laws to study biological problems. Shen ended the article by envisioning the future development of biophysics in the following terms:

> Development in biophysics will incentivize biological science to equip itself as one of the most accurate and quantitative branches in modern science with new findings in modern physics. If modern physics is inadequate to explain the laws of motion in nature, that is, if physics cannot satisfactorily explain the most superlative laws of natural motion—the laws of life, then this mission shall fall upon the shoulder of biophysics. If one of the important research areas in current biophysics is to employ principles from engineering and technology to study living processes, it is not difficult to imagine that years later, the driving force of

[43] Shen Shumin, "A Newfound Discipline in Biological Sciences—Biophysics," *People's Daily*, August 06, 1963.

> development in engineering and technology will be the research results derived from the highly precise and flexible automatic control and adjustment systems in living processes.[44]

Shen's vision of the dialectics of biology and physics was embedded in the above statement of the prospects of biophysics. As of 1963, Shen subscribed to the view that physics could drive the development in biological sciences, including biophysics. Yet the dynamics were going to change as biophysics became more mature. As knowledge in organic processes accumulated, eventually it would be life sciences that drove the developments in physical sciences and engineering. Shen's definitive article in *People's Daily* was precedent-setting in two ways: First, it was the first time the subject of biophysics was introduced to the masses of Chinese people. None of Bei Shizhang's previous writing had put the epistemic content of biophysics under direct public scrutiny the way Shen's article did. Also evident here is the asymmetrical treatment the editorial board of *People's Daily* extended to other disciplines, as the comparative case of biochemistry revealed. Secondly, although Shen shared Bei's perception that biophysics was a biological science comprised of biologists and mostly biological subdivisions, she also drew upon the utilitarian values of concepts and methodologies in physics for biological study and genuinely considered using physics to study biological phenomena a promising new area for biophysicists. Bei Shizhang had never put into words the centrality of physics in the intellectual terrain of biophysics. Bei embraced the preference for making biophysics more quantitative by lending weight to the methodologies of mathematics and statistics, not physics per se. When he spoke of the role of physics in

44 *Ibid*.

biophysics, he stressed the importance of mutual cooperation and reciprocal exchange rather than a unilateral flow of labor and knowledge from physics to biology.[45]

Furthermore, Shen regarded the understanding of all living and organic systems as the primary mission of biophysics. After identifying the goal of biophysics, Shen attributed “the birth of modern biophysics” to “biologists’ interests in physics and the closer relationship between biology and physics as physical techniques that have broader applications in biology."[46] Even though Shen went to some length to discuss the applicability and relevance of physical concepts for studying biological problems, she maintained the baseline assumption that biophysics was a profession in biological science as the title indicated, and that it was initiated by and intended for those who were trained as biologists.

Views of Biophysics III: Xu Jinghua

On the same occasion that Bei was articulating the disciplinary mission of biophysics, a young biophysicist Xu Jinghua (徐京华) dedicated an article to address the theoretical and philosophical underpinnings of biophysics.[47] Unlike Bei Shizhang or Shen Shumin, Xu was less concerned with giving an authoritative statement about the subject matter or potential applications of biophysics than drawing attention to the competing views of biophysics as a consequence of the enduring conflict between physics and biology. Xu labeled biophysics as "a conflict-ridden discipline" (充满矛盾的学科) by

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[45] Bei Shizhang, “Several Problems in Biophysics,” *SWB*, pp. 205-214.
[46] Shen Shumin, “A Newfound Discipline in Biological Sciences—Biophysics,”*People’s Daily*, August 06, 1963.
[47] Xu Jinghua 徐京华, “Some Theoretical Questions in Biophysics,” in *Proceedings of the First National Biophysics Academic Conference*, pp.72-78.

virtue of the fact that biology itself is such "a conflict-ridden discipline" due to the divergent interpretations of life held by biologists and physicists.[48]

Xu considered the embodiment of physics–biology conflict in four styles of scientific thought: mechanism (机械论), vitalism (生机论), teleology (目的论), and organismic theory (组织论). The mechanical canon holds that life is nothing more than "a living automaton" (生物体机器) that is amenable to the Cartesian view. If life is no more than a complex and precise machine, it authorizes a mechanical approach to investigate life phenomena and blurs the boundary between machine and human, organic and inorganic. At the opposite end lies the doctrine of vitalism, the adherents to this principle argue that life cannot be reduced to automata due to the non-divisibility of life. Various branches of vitalist ideology might recognize the efficacy of using physico-chemical methods to enhance the understanding of the laws of life but deny the possibility of unlocking the innermost essence of the nature of life by physical laws alone. Somewhere in the middle between these two poles lies the belief of teleology. Xu did not elaborate on the foundation of teleological philosophy but rather chose to reproduce quotations on teleology by a few Western scientists: "Teleology is a lady without whom no biologist can live. Yet he is ashamed to show himself with her in public" by E. von Brücke; and "reflexes had to be goal-directed, and that the purpose of a reflex serves as legitimate and urgent an object for natural inquiry as the purpose of the colouring of an insect or blossom" by Charles Sherrington. Lastly, Xu identified proponents of "organismic theory" as antagonistic to mechanically reducing biological

[48] *Ibid,* p. 72.

organisms into parts without considering the order, organization, and the structure of the living body.

By briefly visiting these strands of philosophical thought on the history of biology, Xu's purpose was to bring these contentious issues to the attention of a Chinese audience and stimulate further discussion. He did not think the mechanism—vitalism distinction could capture the entire range of conflicts between physics and biology, but merely highlighted the controversy as a theoretical issue worthy of reflection among biophysicists whose subject matter is inescapable from such intellectual debate.

For Xu, the basic point of contention was the different views of life physicists and biologists were inclined to bring to the discussion table. Physicists and biologists were trained to see nature in different terms. The geneticist Jacques Monod proclaimed, "life is compatible with the laws of physics, but not controlled by the physical law," while the famous physicist Ernest Rutherford declared, "science is either physics or stamp collecting." By relegating biology and other associated scientific branches to the amateur hobby of philately, Rutherford rejected any possible types of scientific paradigm other than those of physics. His view is dramatically incompatible with the view expressed by Monod. Essentially, physicists carried to biology a particular way of viewing life, and although some physicists emphasized the complexity and diversity of life, they tended to see the difference between animate and inanimate matter in quantitative rather than qualitative terms. In their eyes, biological behaviors could be quantified with improved precision and eventually, the functional performances of living organisms could be captured, optimized, and immaculately modified by physical laws.

Bei Shizhang, Shen Shumin, and Xu Jinghua were passionate scientists who were dedicated to expounding on the academic status, public profile, and philosophical problems of this domain of inquiry known as biophysics. Despite slight variations among their conceptions of biophysics, they were united in their overarching vision of seeing it as a biologically-oriented specialty. They did not shy away from the thorny issue of the physics–biology divergence, but all of them argued that biophysics primarily consisted of biologists investigating life phenomena.

Now that the prevailing views of biophysics held by three leading Chinese biophysicists have been introduced, the next question to address is: how to make sense of their views? Here, history may have something valuable to teach us. Understanding the historical development of the views of biophysics can help put things into perspective.

A Historiography of Biophysics

Views of biophysics draw on a variety of interpretations because they often involve one discipline asserting a dominant status (physics) over another (biology) with the very epistemic notion of biophysics involving the contested academic relationships between these two disciplines. In fact, striking a proper balance between physics and biology had always been a concern even at the beginning when the concept of "biophysics" was first introduced in Western literature.

According to the Oxford English Dictionary (OED), the earliest usage of the term "bio-physics" appeared in Karl Pearson's *The Grammar of Science* in 1892 as "this branch of science which endeavours to show that the facts of Biology… constitute particular cases of general physical laws has been termed *Ætiology*. It would perhaps be better to call it *Bio-physics*."[49] In other words, "biophysics" in Pearson's conception was an etiological science that sought to describe life phenomena with physical laws. The OED formulation does not include Pearson's description of "biophysics" from *The Grammar of Science.* Furthering the suggestion of using "Bio-physics" to capture the relationship between organic processes and physical laws, he went on and suggested, "just as *Applied Mathematics* link *Abstract Science* to the *Physical Sciences*, so *Bio-physics* attempt to link the *Physical* and *Biological Sciences* together."[50]

Pearson envisioned that what he called "Bio-physics" would integrate physical and biological sciences, just as applied mathematics would link abstract and concrete sciences together. In earlier chapters of his work, Pearson drew upon the marked distinction between organic and inorganic motions and contended that there is "no definite link between the two branches of Concrete sciences, between the Physical and Biological Sciences."[51] Thus, "Bio-physics" was introduced as an initiative to bridge the gap between these two scientific branches.

What does it mean to blend two disparate and distinct branches in concrete sciences? Linking two fields is not as simple as connecting two dots on a sheet. Attempts to integrate two fields are often fraught with conflict and controversy because friction arises with the bringing together of two sets of theoretical worldviews, modes of inquiry, and frames of assumptions. To this end, it is noteworthy that Pearson devoted an entire chapter to consider the relationship between biology and physics before introducing the

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[49] *The Oxford English Dictionary*, online ed., "Biophysics," <www.oed.com>.
[50] Karl Pearson, *The Grammar of Science*, available at The University of Toronto Book and Texts Archive <www.archive.org/details/grammarofscience00pearuoft> accessed July 1 2011, pp. 528, italics in the original.
[51] *Ibid*, p. 527.

new term "Bio-physics" and his synthetic vision. In chapter IX "Life: The Relation of Biology to Physics," he articulated the similarities and differences between the two disciplines. The cornerstone of Pearson's theoretical view is that both physics and biology are descriptive, not explanatory sciences. Thus, both belong to the level of "concrete" rather than "abstract" sciences. Placing physics and biology on the same theoretical level is crucial to grasping Pearson's notion of biophysics. Contrary to many modern definitions of biophysics that seek to explain life through physical laws, Pearson never asserted that physics could explain biology:

> If the biologist gives us an accurate account of the development of the ovum and then remarks that the changes are *due* to "forces resident in the egg," he certainly cannot mean that the chemist and physicist are capable of *explaining* what has taken place. He probably considers that the conceptual shorthand of chemistry and physics would suffice to *describe* what he has himself described in other language.[52]

Pearson's message is that certain organic processes in biology can be captured by established laws and principles in physical sciences, but physical-chemical mechanisms cannot sufficiently explain life physiology: "organic phenomena may be described by aid of organic corpuscles constructed out of inorganic corpuscles," but "mechanism cannot explain life, mechanism does not explain anything."[53] Pearson's emphasis is placed on the non-explanatory role played by physics in relation to biology: "our object in biology is identical with that in physics, namely, to describe the widest ranges of phenomena in the briefest possible formulae, we see that the biologist cannot throw back life for an

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[52] *Ibid*, p. 332, italics in the original.
[53] *Ibid*, p. 344.

explanation on physics."[54] In short, both physics and biology, in Pearson's cognitive map, are concrete sciences dealing with the physical rather than the metaphysical realm. Physicists and biologists sometimes share their interests in the organic stratum of the natural kingdom but tools and knowledge in physics cannot adequately explicate organic phenomena.

Moreover, Pearson drew upon the differences between organic and inorganic forces to support his argument that physics is not capable of explaining life phenomena: "Before we assert that life can be described mechanically, we must determine whether the motion by which we conceptualize organic phenomena can be resumed in the same laws as the motion by which we conceptualize inorganic phenomena."[55] For Pearson, there is an inherent difference between the nature of forces governing organic and that driving inorganic phenomena. It is apt for inquisitive physicists to explore the wonders of life through chemical structure and atomic configuration, but these physical devices are simply mathematical shorthand to describe, rather than to elucidate the process of life.

"Does biophysics belong to biology or physics?" is one of the most commonly raised questions by biophysicists. It concerns the issue of territorial jurisdiction, or the state of autonomy of each field. Most biophysicists acknowledged that concepts and principles from biology and physics were incorporated into biophysics, and so it is difficult, if not impossible, to demarcate the boundary between the two. Glaser, author of *Biophysics,* suggested that it is equally justified to subsume biophysics under either biology or physics. Bialek, author of the recently released *Biophysics: Searching for Principles*, noted that "biophysics" can be used by people who subjectively think of

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[54] *Ibid*, p. 332, italics in the original.
[55] *Ibid*, p. 342.

themselves as either physicists or biologists. Bialek, a renowned biophysicist at Princeton, labeled questions such as "where is the boundary between physics and biology?” or "is biophysics really physics, or merely the application of methods from physics to the problems of biology?" as "naive." But are these questions really "naive" or simply too complex to come up with a single, numerical answer?

There is a historical context in which the relationship of physics and biology is situated. Likewise, the relationship between physicists and biologists did not take place in a historical vacuum. Almost none of the biophysicists bothered to take note of the history of disciplinary relationships as they posited the balance of physics and biology in biophysics. Without an appreciation of the historical circumstances in which physicists related to biologists, practicing biophysicists were bewildered by the contemporary heterogeneity of names for the field and its practitioners. Making sense of the present-day complexity descended into an exercise of conjecture and guesswork. It is understandable that questions regarding the disciplinary constitution of biophysics were stigmatized as "naive."

Naiveté or not, these questions point to the difficulty and complexity in blending scientific enterprises with an intricate historical relationship. While Pearson relegated both physics and biology to the same conceptual level of descriptive sciences with little explanatory power, he also offered his views on the dissimilarities between physics and biology. In Pearson's mindset, physics had a longer history than biology. The precedence of physics over biology marked their asymmetrical power relationship with uneven disciplinary credits ascribed to each branch:

> While on the one hand, however, physicists can get on very well without biology, at any rate within a certain limited field of observation, biologists, on the other, have not only adopted many of the physicist's notions as to *matter*, *force*, and *eternity*, as modes of describing biological facts, but they are further, whether they wish it or not, inevitably bound to physics by the fact that life is never found apart from physical associations. Mechanism, on its side, does not as a theory involve a discussion of biological phenomena, but biology without a discussion of mechanism is necessarily incomplete.[56]

The dependence of biology on physics is clearly conveyed in this quote. Biology was circumscribed by physical description because facts about life were intimately associated with physical components. While it may be that "physicists can get on very well without biology," biologists did not enjoy the same degree of disciplinary autonomy. We can use physical language to study and describe biology, but not the other way around. In Pearson's passage, biology was secondary to physics; it was incomplete without physical intervention; it was inevitably and involuntarily bound to physics.

Does this imply that physicists enjoyed unconditional privilege over biologists? This is rather unlikely, as Pearson cautioned that both physics and biology—irrespective of the inner hierarchy within academia——belonged to the same conceptual stratum. Notwithstanding the within-class order, neither physicists nor biologists had the intellectual currency to transcend to the abstract level:

[56] *Ibid,* p. 328, italics in the original.

> It is this transition from science as a conceptual description of the sequences of sense-impressions to metaphysics as a discussion of the imperceptible substrata of sense-impressions, which mars biological as well as physical literature. But the physicist is here to blame, for he has projected without perceptual evidence his molecule and atom into the phenomenal world, and the biologist only follows the physicist's example when he asserts the reality of gemmule or germ-plasm.[57]

In effect, Pearson berated physicists for metaphysical trespassing. He also bemoaned the lack of self-determination among biologists for blindly following the physicists. Because physics and biology were ultimately not capable of "explaining" life as Pearson assumed, both physicists and biologists were guilty of going astray. Pearson blamed physicists primarily for this disciplinary "misconduct:"

> But I want to point out, and this very earnestly, how the physicist too often entices the biologist into a metaphysical slough by postulating mechanism as the substratum and not as the conceptual description of certain groups of sense-impressions.[58]

The wish of physicists to "seduce" biologists into believing the metaphysical magic of physics has continued into the present. Modern textbooks on biophysics have been filled with enthusiastic calls from physicists to generate universal laws to quantify animate behaviors:

> Can we imagine a physics of biological systems that reaches the level of predictive power that has become the standard in other areas of physics?

[57] *Ibid*, p. 337, italics in the original.
[58] *Ibid*, p. 340, italics in the original.

> Can we reconcile the physicists' desire for unifying theoretical principles with the obvious diversity of life's mechanisms? Could such theories engage meaningfully with the myriad experimental details of particular systems, yet still be derivable from succinct and abstract principles that transcend these details? For me, the answer to all of these questions is an enthusiastic "yes."[59]

Biophysicists like Bialek are committed to teaching and lecturing about biophysics partly because of the lure of realizing physicists' long-standing dream of unifying organic and inorganic realms with grand theoretical principles derived from mathematics. The temptation of accurately measuring and predicting biological performance with physical formulae motivates physicists to transcend the disciplinary boundary which, according to Pearson, sets physics and biology apart from abstract sciences. This is the metaphysical "misdemeanor" Pearson referred to in his code of grammar.

In sum, these historical and contemporary visions associated with biophysics suggest that the intersection between physics and biology had always been fraught with conflict and controversy. In the late nineteenth century, Pearson demonstrated several subtle but asymmetrical aspects between physics and biology. Pearson's text thus provided a historical context to conceptualize the intersection of physics and biology in more concrete terms. Staged at the contested crossroads between physics and biology, biophysics was hardly intended as an equal exchange between physicists and biologists for knowledge advancement; it did not start off on an equal playing field. Physics was

[59] William Bialek, *Biophysics: Searching for Principles* (New Jersey: Princeton University Press, 2012), p. 4.

conceived as the *leitwissenschaft* (leading science) guiding biology in its ambitious movement to build a theory of pure motion.

Compared to the intellectual history of biophysics in the Western scholarship, the Chinese biophysicists' attitudes towards biophysics and the understanding of organic and inorganic, life and non-life are both familiar and simultaneously foreign. Bei Shizhang was similar to Pearson in the sense that both were concerned about cultivating a proper relationship between biology and physics in the formation of biophysics. Like Pearson, Xu Jinghua also discussed the philosophical dissonance between organic and inorganic systems. At the same time, Chinese biophysicists had offered a very different understanding of the disciplinary input in the making of biophysics. Both Bei Shizhang and Shen Shumin envisioned biophysics as a discipline of biologists, by biologists, and for biologists. Even though physical scientists might have had a role in the joint venture known as biophysics, it was biologists who were going to be in charge while physicists would only serve as supplementary figures. Deciding who was responsible for doing biophysics was a pivotal point upon which the issue of agency in biophysics rested. This is why Pearson had warned biologists about the metaphysical encroachment induced by the overly ambitious physicists. Contemporary American biophysicists like Bialek envisioned the future of biophysics as an inquiry driven by physicists leading the quest and followed by biologists, whereas Chinese biophysicists suggested the exact opposite.

What could explain the divergent views of biophysics across cultures? In what follows, I focus on the academic background and scientific contributions of Bei Shizhang—the first and arguably the most important biophysicist in modern China—in order to delve deeper beyond the superficial East-West contrast. It's not enough to say that biophysics in China is biologically-oriented; what is more important is to seek a plausible explanation for this epistemic predilection. If biologists and physicists, in general, will ask different questions when faced with the same biological phenomena, then it is worth asking: What kind of question did Bei ask regarding living organisms? What inspired his search for what comprises life?

Bei Shizhang: the Father of Biophysics in China

In 1903, Bei Shizhang was born to a fisherman's family in the coastal village named Zhenhai in Zhejiang province. Ying Youmei has chronicled the first stage of Bei's life stretching from his childhood to undergraduate education in China and graduate training in Germany.[60] For the purpose of the current analysis, the most important round of events in this stage was his graduate experience in Germany. Below I will reiterate only important milestones in his pre-German phase.

The primary and secondary schools Bei had attended, namely Jin Xiu School (进修学堂), Bao Shan School (宝善学堂), and De Hua School (德华学校) were run by German-based charities in China, so he had studied the German language for several years before going off to college. His father encouraged him to further study foreign language. But Bei was certain that his real interest was in life science. In 1919 he was admitted to Tongji Technical College of Medicine and Engineering, TTCME (同济医工专门学校), formerly the German-founded Tongji School of Medicine and Engineering (同济医工学堂). Bei graduated from TTCME and left for Germany with a pre-med

[60] Ying Youmei 应幼梅, "The Life, Work and Thought of Professor Bei Shizhang"贝时璋教授的生活、工作和思想, in *SWB*, pp. 1-39.

degree in 1921. He would go to the University of Tübingen and graduate with a doctorate by 1929, return to China in 1930 where he would become an influential scientist, cultiminating in his launch of the biophysics program in China in 1958 which would mark the beginning of his legacy.

On 24 August 1964, during his meeting with the Japanese physicist Shoichi Sakata in the company of Chinese physicist Zhou Peiyuan, Mao Zedong enunciated his intellectual interest in the origins of cells: "We should study the origins of cells. The cell has its nucleus, a mass of protoplasm, and a membrane. The cell is organic, and so there must have been noncellular forms (cytooes) before there was the cell. What was there before the cell was formed? How was the noncellular form changed into the cell?" Apparently, his interest in this biological area was partly triggered by the work of a Soviet scientist: "there is a woman scientist in the Soviet Union who has been studying this problem, but no result has been reported."[61]

The "woman scientist in the Soviet Union" in Mao's speech refers to the Soviet biologist Olga Borisovna Lepeshinskaya. At that time, Mao probably did not know that before his declaration of intent and even before China was governed by his regime, Bei Shizhang was already intrigued by Lepeshinskaya's work. In 1943, Bei published a Chinese research paper entitled "Yolk Granules and the Reformation of the Cell" (卵黄粒与细胞之重建). It was contained in the inaugural issue of the Chinese journal *Science*. It was also the first place in which his theory of "cell reformation" was introduced to the scientific community to explain the process of cell differentiation.

[61] Mao Zedong, "Talk on Sakata's Article," *Selected Works of Mao Tse-tung vol. IX*, 24 August 1964, available on <www.marxists.org>.

Nobody took him or his theory very seriously back in the 1940s, but things were drastically different by the time he passed away in 2009. At the age of 107, Bei Shizhang was recognized as the oldest academician in modern China. He was among the first batch of scientists to be elected to the *Academia Sinica* (中央研究院) in 1948, right before the Nationalist government retreated to Taiwan, which means that he was the last academician whose scientific membership straddled across the Nationalist and Communist regimes. After 2004, Bei became the only surviving academician who witnessed the transformation of modern China from the "Republic of China" to the "People's Republic of China."[62] Within the scientific community, he was lauded as the founding father of biophysics in China. People were told that Chinese biophysics could not have materialized without Bei Shizhang. Biophysics and Bei Shizhang were synonymous in China. Chinese biophysics was embodied in Bei's pioneering efforts in synthesizing physical and biological sciences.[63] One of the notable dignitaries who went to Bei's funeral to honor his contribution was China's first *taikonaut* Yang Liwei, as was mentioned in chapter one.

[62] There were many news reports, videos, and articles between October and November 2009 on Bei's death and legacy. Here I only included some of the most representative ones: Committee of funeral service for Bei Shizhang 贝时璋先生治丧委员会, "Mourning Bei Shizhang: An Obituary" 沉痛悼念贝时璋先生:讣告, 29 October 2009; Zhao Yahui & Chen Xingxing 赵亚辉, 陈星星, "The Oldest Academician Bei Shizhang Worked to the Last Moment, 'We Have to Fight for Our Country'" 最高龄院士贝时璋打拼到最后一刻, '我们要为国家争口气', *People's Daily,* 2 November 2009; "Various Sectors in China Wave Goodbyes to the Eldest Academician Bei Shizhang" 中国各界送别中院最年长院士贝时璋, *China News* 4 November 2009; "Thousands Farewell Bei Shizhang" 千人送别贝时璋, *Xinhua News* 5 November 2009.

[63] "Founder of Chinese Biophysics Bei Shizhang Died at 107" 中国生物物理学奠基人贝时璋逝世享年107岁, *Science Times* 30 October 2009; "Founder of Chinese Biophysics and CAS Academician Bei Shizhang Passed Away"我国生物物理学奠基人中国科学院院士贝时璋逝世 *People's Daily* 1 November 2009; Wang Jing 王静, "Remembering Academician Bei Shizhang: Opening the Field of Biology, Expressing the Passion of Science" 记贝时璋院士:创生物伟业 抒科学豪情, *Science Times* 2 November 2009; "Bei Shizhang: Researching Life Science With His Life" 贝时璋:用自己的生命研究生命, *Science Times* 11 November 2010.

In 2003, a *festschrift* commemorating Bei's centennial birthday was released.[64] Several of his students and colleagues enumerated his tremendous contribution to laying the groundwork of biophysics in China. The biographical narrative centered around the personal virtues of Bei as an indefatigable science educator, an institutional builder, and a visionary disciplinary leader. Yet despite much respect to his lifelong dedication to furthering the course of scientific enterprise in modern China, international renown was still missing from his list of accomplishments. "His biggest regret," according to a news article, was that he didn't succeed in advancing the cell reformation theory that he proposed in the early 1940s.[65] For more than seventy years, Bei's attempt at giving an alterative interpretation of cell differentiation is still resisted by the mainstream scientific community. The lack of international recognition of Bei's scientific achievement led some Chinese scientists to mock him as a "science centenarian" (百岁老人), insinuating that Bei was just an old codger without much scientific credibility other than his longevity.

Controversy over Bei's theory is of direct relevance to the history of biophysics as the theoretical viewpoint upheld by a disciplinary founder is indicative of its epistemic content. The extent to which Bei's conceptions of biophysics are embodied in his theoretical outlook behooves us to study their correlation and broader impacts.

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[64] IBP-CAS, *Bei Shizhang and Biophysics: A Festschrift* 贝时璋与生物物理学纪念文集, available on (www.ibp.cas.cn).

[65] "Bei Shizhang: The Last Academician from the *Academia Sinica*" 贝时璋:最后一个中研院院士, *China News Weekly* 20 November 2009.

Theory of Cell Reformation

In a nutshell, Bei's theory of cell reformation casts doubt on the prevailing cytological paradigm exemplified by the Virchowian motto *omnis cellula a cellula* (all cells come from pre-existing cells) by drawing on the result of his empirical study of the developmental morphology of an autochthonous prawn in China.

The story of Bei's iconoclastic research takes us back to 1932. The official story began with his finding of an intersex strain of an arthropod in the swampy field of Songmuchang (松木场) on the outskirts of Hangzhou. Indigenous to the Chinese southeastern shores, its unusual reproductive process captured the curiosity of this German-returned zoologist. *Chirocephalus nankinensis* (南京丰年虫),[66] as it was called, was a fascinating shrimp for Bei because of its unusual mechanism of cellular proliferation during sex change. The sample breed under his investigation was of hermaphrodite nature, setting *c. nankinensis* apart from other sexually dimorphic arthropods. Microscopic observations showed that characteristics of both sexes co-existed in a typical *c. nankinensis* strain. Although *c. nankinensis* combined within one organism both male and female characteristics, the distribution and proportion of these sex features were not uniform among all types. According to the relative sexual traits from the specimens he collected, Bei divided them into male and female intersex types. He noted that at certain developmental stages, both sexes underwent sex reversal. What Bei termed "the female intersex" transformed into the "male intersex" and male into female. He

[66] The English scientific name was coined to capture the fact that this insect is a Nanjing (aka Nanking)-originated species (*nankinensis)* in the family of *chirocephalus*. The Chinese name was given by a folklore belief that the appearance of this shrimp in wintertime, along with heavy snowstorms, is a harbinger of a productive year as summarized in the Chinese proverb "heavy snow forecasts a good harvest year" (瑞雪兆丰年).

further sub-divided the female intersex into weak, middle, and normal female intersexes while the male intersex was divided into weak and normal male intersexes by virtue of their secondary morphological features. Thus, there were altogether five types of intersex strains of *c. nankinensis.* When the weak male intersex (弱势雄原中间性) underwent gonad reversal, the germ cells disaggregated their cellular contents into yolk granules or substances similar to yolk—a process which he called "cell deformation" (细胞解形)—then reaggregated into an adult cell incrementally from these chromatin-bearing entities during the transformation of germ cells from weak female intersex (弱势雌原中间性) to weak male intersex. Bei argued that the genetic materials first broke down from the oocytes into yolk granules, and then "reformed" from the yolk granules into new germ cells. This is the process that he termed "cell reformation." The new germ cells were formed not by cytokinesis but rather generated from the corpuscular substances, i.e. the yolk granules. His conclusion was that it was possible for cells to reproduce by means other than cell division. "Cell reformation" was thereafter hailed as an alternative way by which cells multiplied.

Historically, some other scientists have come up with different ideas on the plausible mechanisms of cell formation. One prevailing view held that cells only came from other cells, which was captured by the idea of the production of cells occurring internally within cells.[67] The cell-from-cell thesis placed the emphasis on the continuity between daughter cells and mother cells, yet there existed debate over whether new cells

[67] The exact phrase Raspail used was *omnis cellula e cellula* (every cell is derived from another cell), slightly different from the prevailing Virchowian dictum that reads *omnis cellula a cellula* (every cell is separated from another cell). The transition of ablatives from "e" to "a" was first endorsed in *Textbook of Histology* in 1857.

"derived" or "divided" from existing cells. Scientists of this intellectual conviction were separated from their colleagues at the far end of the theoretical spectrum——those who believed in the *de novo* formation of cells.

It was not sufficient to argue that new cells emerged anew; cells could be generated *de novo* from different sources in different ways. The *de novo* idea harbored a number of theoretical positions, one of which belonged to Theodor Schwann. He suggested that new cells were produced from the cytoblastema: amorphous glutinous substances flowing in the intercellular space that possessed cell-generating capacity. What Schwann offered was a model of exogenous cell formation. He and his mentor, Matthias Schleiden, never denied the existence of cell division and the role of nuclei in cell proliferation, but they did not see cell division as the only means by which new cells were created. Sometimes cells came from other cells and sometimes they came from non-cell entities. The "cell-from-non-cell" credo was not seen as a contradiction against the "cell-from-cell" doctrine.

Schleiden had proposed an alternative cell doctrine, but what distinguished Bei's reformation theory from Schleiden's notion of crystallization was the use of terminology. Bei's use of "reformation" was a conscious decision to separate it from the concept of "remaking" as he reacted to Lepeshinskaya's theory in 1942:

> Lepeshinskaya's view that yolk spheres from chicken embryos could be remade into cells, in my speculation, was the well-nigh reformation of yolk spheres. As the meanings of remaking and reformation differ. Remaking means creation from anew, but reformation simply means

> revitalization. The latter must be easier to accomplish as the ingredients were all there (as inherited) from the historical background.[68]

It was clear that Bei was concerned about the connotation and interpretation of the keywords. He interpreted Lepeshinskaya's investigation of "*die entstehung von zellen aus dotterkugeln*" as "remaking" cells from anew. The "remaking" of new cells from yolk spheres in chicken embryos created an image of the *de novo* generation of cells which undercut the historical continuity of cells. Bei was unsure of this "ahistorical" implication signified by the word "改塑." He did not overrule Lepeshinskaya's choice of the word, but he was confident that the word "reformation" was more appropriate. Although there were other English equivalences to the Chinese word "改塑" such as remodel, reconfigure, or recreate, the point of contention was the historicity of cells. Bei was in favor of seeking words that would preserve the undertone of the historical continuity of cells. He was concerned that a complete severing from the genetic past would make regeneration difficult to occur: Reforming cells was more plausible and arguable than remaking cells.

Ever since Bei wrote the first research article on *c. nankinensis* in German, he had relentlessly cast his theory as an alternative to the traditional viewpoint held by Rudolph Virchow. He was determined to refute Virchow's claim that cell division was the only way by which new cells generated by upholding his cell reformation theory as undermining the *philosophia perennis* in cell biology.[69] However, there remained many

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[68] Bei Shizhang, *SWB,* p. 115.

[69] All of his three papers published in the 1940s were reprinted in *SWB*; "Diploide Intersexen bei *Chirocephalus nankinensis*," originally published in *Science Record* in 1942, was reprinted with the title "南京丰年虫的二倍体中间性," in *SWB*, pp. 99-100; "卵黄粒与细胞之重建," originally appeared in 《科

unaddressed questions as to what inspired him to pursue an alternative cell theory. His eureka discovery of *c. nankinensis* in besieged Hangzhou was one thing, yet how to determine what he saw under the microscope was another. It was not just a matter of instrumental conditions; translating empirical findings into a theory did not follow a linear pattern. Making sense of cellular activities required an agenda to determine the proper relationship among cellular and subcellular organelles, which entailed much more than the ability to optimize the quality of pictures and the extent of visualization. With advanced microscopes and the right techniques of preparation, a set of working assumptions is required in order to interpret the biological phenomena in a petri dish. In other words, what matters most is not how much one can see, but where to look for what one assumes is being seen and how to decide what to make of it. In Bei's study, why did he focus on the sexual metamorphisms and not other structural and functional aspects of *c. nankinensis*? What drove him to divide *c. nankinensis* into five categories? Where did he get the ideas of "deformation" and "reformation?" In short, what led him to such a particular cellular interpretation?

Some of these questions are explained by his relationship with Wilhelm Harms, who acted as his mentor when he studied in Germany. Before Bei departed China, he had already acquired foreign language training in German-run secondary and tertiary schools in China. The defeat of Germany in World War I brought about the currency depreciation which made graduate education in Germany affordable for Bei.

学》(*Science)* in 1943, was reprinted under the same title in *SWB*, pp.110-121, and "Ueber die Transformation der Genitalzellen bei den *Chirocephalus*-Intersexen," originally published in *Science Record* in 1943, was reprinted as "关于丰年虫中间性生殖细胞的转变" in *SWB*, pp. 122-123.

Initially studying at Universität of Freiburg and after a stint in Munich, Bei would eventually arrive at Tübingen where he met Wilhelm Harms, who would serve as his academic advisor and mentor during his doctoral study at the University of Tübingen between 1923 and 1929.

Wilhelm Harms

The key to these questions is the work of Wilhelm Harms, the academic advisor of Bei Shizhang during his doctoral study at the University of Tübingen between 1923 and 1929.

Wilhelm Harms, esteemed along with Voronoff and Steinach for their pioneering work on "rejuvenation" research, was one of the earliest surgeons in sex reassignment operations. The various methods of "rejuvenation" could be drawn from Harms' two-volume *Body & Germ Cells* (*Körper und Keimzellen*) published in 1926.[70] In the first volume, Harms reviewed the nature and history of germ cells and their interconnections with the body. Harms amassed evidence from his previous studies on the endocrinal secretions of sex glands and their relationship with the whole organisms in mammals.[71] According to Ying Youmei (应幼梅), a biographer of Bei's life and work, Harms' emphasis on the entire developmental cycle made an impression on Bei. Specifically, Harms divided the life cycle of a typical organism into three stages: *progressive periode*, *stationäre zustand*, and *regressive periode* (progressive period, stationary state, and regressive period, respectively) Harms had his eyes on the regenerative power of the

[70] Wilhelm Harms, *Körper und Keimzellen vol. 1 & 2* (Berlin: Springer, 1926).
[71] Wilhelm Harms, "Experimentelle Untersuchungen über die innere Sekretion der Keimdrüsen und deren Beziehung zum Gesamtorganismus" *Archiv für Entwicklungsmechanik der Organismen,* February 15 1918, Volume 43, Issue 3, pp. 385-387.

labile tissues and organs such as the primordial germ cells. Ying remarked that "Bei appreciated Harms' philosophy of addressing a problem comprehensively from a developmental point of view."[72]

Ying's analysis of Harms' influence on Bei's intellectual evolution captures the correlation between Harms' developmental philosophy and Bei's framework on cell reformation. Harms stressed sexual physiology and regeneration of germ cells whereas Bei studied morphological changes of germ cells during sexual metamorphosis; Harms looked at growth and developmental processes whereas Bei examined the cytoplasmic changes during differentiation. More strikingly, Bei adopted Harms' terms to illustrate the core concepts in the theory of cell reformation. Bei attributed the transition from male to female intersex to the "*regressive periode"* (退行性) while the female to male intersex to the "*progressive periode"* (前进性). Not only were "regressive period" and "progressive period" a direct importation of Harms' language; the ideas were the primary conceptual grounds for building Bei's theory. The "regressive period" corresponds to the "deformation" (解体) of germ cells and the "progressive period" to the "reformation" (形成) of reproductive cells.[73] Harms' work was the key to unlock Bei's philosophical foundation.

Even before Bei postulated the theory of cell reformation, Harms' scientific style already colored the topic, driving questions, and analysis of Bei's doctoral thesis. Using the nematode *anguillula aceti* (a type of vinegar eel) as the research material, Bei

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[72] Ying Youmei, "The Life, Work and Thought of Professor Bei Shizhang", on p. 5.
[73] Ying did not always use the same terminology as Bei. Ying explicated "deformation" as "解体" (disintegration) and "reformation" as "形成" (emergence or formation), rather than the standard terms "解形" and "重建" used by Bei. See Ying Youmei, *SWB*, p. 11.

embarked his doctoral research on "experimental–morphological investigations on nematodes" (*experimentell-morphologische untersuchungen an nematoden*).[74] He proposed to study the complete life cycle rather than just the embryonic stage. One of the objectives of his dissertation was "to follow the entire life cycle" (*den gesamten Lebenscyclus zu verfolgen*) of the nematode.[75] His analysis of the development of *a. aceti* followed the idioms of *progressive, stationäre,* and *regressive phasen* introduced by Harms. In addition, Harms' abiding interest in sex determination and germ layers left an indelible mark on Bei's discussion of the findings. Bei's dissertation incorporated a number of handwritten drawings on "the growth of sex cells and germ cells" (*wachstum der geschlechtszellen* and *keimzellen*).[76] "Germ-line and the determination of somatic cells in the formation of the germ layers" (*keimbahn und die determination der somazellen bei der bildung der keimblätter*) was a major theme in Bei's mapping of the morphological differentiation of *a. aceti*.[77]

We can now sufficiently answer the three questions that I raised in this section. The reason Bei focused on sexual metamorphisms rather than other physiological aspects of *c. nankinensis* is a legacy of Harms' enduring interest in sex transformation and reassignment. Harms' tripartite analytical structure also exhibited a discernable influence on Bei's framework and choice of words in categorizing the intersex strains of *c. nankinensis*. Harms and Bei had a lot in common as both were attracted to the

[74] Sitsan Pai (Shizhang Bei), "Die Phasen des Lebenscyclus der Anguillula aceti Ehrbg.und ihre experimentell-morphologische Beeinflussun,g" *Zeitschrift für wissenschaftliche Zoologie* vol. 131 (1928), pp. 294-344, also reprinted in *SWB*, pp. 46-96.
[75] Pai, 1928, p. 295.
[76] *Ibid,* pp. 314-316.
[77] *Ibid,* p. 300.

developmental mechanics of living organisms, with a special emphasis on the differentiation of germ cells.

After introducing some of Harms–Bei intellectual continuity, we can begin to assess possible influences of Harms' worldview on Bei's perception of biophysics. If Bei adopted Harms' conceptual framework in forming his theory of cell reformation, can the same thing be said about Bei's view of biophysics?

What characterized Bei's interpretation of biophysics is that he did not subscribe to a pre-existing hierarchical view of science in which biology was subordinated to physics. Without a presupposition of a fraught relationship between physics and biology, it was easier for Bei to see congruity rather than conflict in the junction between physics and biology—the very territory in which biophysics resides. The question is: what enabled him to see connections rather than contradictions at the physics–biology intersection?

Again, Harms' scientific perspective is enlightening here. In *Körper und Keimzellen*, Harms discussed the origin of germ cells from the dynamics of post-embryonic differentiation and particularly the likelihood of regeneration of germ cells from somatic cells. Harms drew upon his studies on the formation of germ cells of the opposite sex from the peritoneal epithelium (abdominal lining) to build an alternative theory of the regeneration of germ cells. He highlighted the acquired ability of regenerative capacities of germinal epithelium from which germ cells were derived. Noteworthy was the way in which he attributed the regeneration of germ cells to epigenetic manipulation (from transformed somatic cells) rather than pre-existing conditions (preformed germ-plasm), which was the primary explanatory variable in

Weismann-Roux "*Descendenztheorie*." What Harms rejected was the view that reproductive cells and hereditary materials are independent from the rest of the body (*soma).* From Harms' perspective, the origin of germ cells was an affirmative example in favor of the environmental cause of genetic changes. It was changes in the organism's somatic environment that triggered the proliferation of epithelial cells that lined up the sex glands.

This connection between germ cells and somatic cells led Harms to have Lamarckian convictions. As an outspoken "neo-Lamarckian," Harms maintained:

> The more we immerse ourselves into the thinking of Darwin, which includes the non-vitalist Lamarckism, the more we recognize that it has also nowadays unlimited validity: the formation of species and with it evolution is in its course mechanistic, it is determined by the environment […]. At first, it is of little importance whether the resulting, newly adapted form is only a permanent modification (somatic mutation) or a heritable one (idiomatic modification). Under correspondingly enduring and stable environmental conditions, the former will lead to genetic changes or the formation of new genes and radicals.) [78]

Harms' attempt to reconcile the Lamarckian and Darwinian positions was clear in this quote. In fact, Harms fit the archetypal "neo-Lamarckians" in David Hull's schema, in which "the neo-Lamarckians did not form a group but worked largely in isolation from

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[78] Wilhelm Harms, "Ders.: Lamarckismus und Darwinismus als historische Theorien. Ein Kampf um Überlebtes," *Zeitschrift für Medizin und Naturwissenschaft*, vol. 73 (1939), pp. 1–27, quoted in Thomas Potthast and Uwe Hoßfeld, "Vererbungs- und Entwicklungslehren in Zoologie, Botanik and Rassenkunde/Rassenbiologie: Zentrale Forschungsfelder der Biologie an der Universität Tübingen im Nationalsozialismus," in Urban Wiesing et al. (eds) *Die Universität Tübingen im Nationalsozialismus* (Stuttgart: Franz Steiner Verlag, 2010), pp. 435-482, p. 442.

each other. Instead of viewing themselves as renegades, they tended to see themselves as conservatives championing a wider view of evolution against the overly restricted position of the neo-Darwinians."[79] Harms saw the Darwinism–Lamarckism divide in terms of relative differences rather than absolute contradiction. As he framed it, although the Darwinian theory of natural selection might never be discarded, the Lamarckian theory was indispensable for explaining the emergence of functionally adaptive traits. Despite the fact that Harms was an adherent of the doctrine of "the inheritance of acquired characteristics" (*Vererbung erworbener Eigenschaften*), he was more articulate about the interplay of Darwinian and Lamarckian paradigms than about the exact mechanisms by which the acquired characteristics were inherited.

Like most neo-Lamarckians, Harms was a synthesizer who set himself the task of harmonizing seemingly contradictory systems. He wanted to bring the plausibility of environmental modification into the Darwinian program. Not just because Darwinian evolution was "cruel, wasteful, and opportunistic," but also because it ignored the possibility that evolution might not be as gradual as Darwin thought it was.[80] Harms followed the Lamarckian convention to call upon at least considering environmental influences in addressing how species change rather than just natural selection.[81] For Harms, recording adaptive responses to the environment and its philosophical implication for the Darwinian framework preceded answering specific questions in Lamarckian inheritance such as how mutation can be organically passed on to the next generation.

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[79] David Hull, "Lamarck Among the Anglos," in J. B. Lamarck, *Zoological Philosophy: An Exposition with Regard to the Natural History of Animals* (Chicago: The University of Chicago Press, 1984), p. l.
[80] *Ibid,* p. lv.
[81] Richard Burkhardt Jr., "The Zoological Philosophy of J. B. Lamarck," in J. B. Lamarck, *Zoological Philosophy: An Exposition with Regard to the Natural History of Animals* (Chicago: The University of Chicago Press, 1984), p. xxii.

Harms' scientific conviction may have inspired Bei's view of biophysics since it is possible that his commitment to integrating seemingly incompatible views shaped Bei's efforts in reconciling different knowledge traditions. From Bei's formulation of biophysics in 1964, it is clear that he refrained from a hierarchical doctrine of scientific disciplines. Bei displayed a tendency to see connections among closely related disciplines. His description of the disciplinary relationships between physics and biology was characterized by a type of holistic thinking that privileged the study of a system over a reductionist analysis of its parts. He was more driven to underline the correlations and intersections among disciplines, and it is not implausible that he was informed by an academic heritage of seeing continuities and promoting synthesis in the knowledge enterprise.

For my purposes, it is important to distinguish what Harms achieved from what he left open. While Harms tried to reconcile some aspects of the Darwinian-Lamarckian divide, he did not give an adequate elaboration of the mechanics for the Lamarckian inheritance, let alone the relative contribution of ancestral, inherited, and adaptive factors in shaping ontogenetic development. No one, not even J. B. Lamarck himself, has successfully accounted for the mechanisms of inheritance of acquired characteristics in persuasive and conclusive details, not to mention the inglorious attempts by some discredited Soviet geneticists like Lysenko.[82]

Even though Harms was sympathetic to the Lamarckian cause of inheritance, the truth is that he did not give sufficient details and evidence to support the Lamarckian interpretation. Apparently, this "intellectual trait" of dedication to knowledge synthesis

[82] *Ibid*, p. xvi.

but failure to account for internal mechanics he also inadvertently passed on to Bei. Although Bei was widely respected in the Chinese scientific community, he was hardly the most renowned or the most outstanding Chinese scientist; others took a more critical view of some of his claims. For example, Rao Yi (饶毅),[83] a young Chinese neurobiologist, recently expressed his skepticism of Bei and his work:

> The "centenarian" has made contribution to the development of Chinese science. However, compared to his contemporaries such as Feng Depei in physiology and Wang Yinglai in biochemistry, the quality of his academic achievement was less outstanding, and even quite below that of his contemporaries'. When I first came to visit the newly established research center of his, I was brought to the exhibition room in which his "cell reformation" results were on display. I said his research was inappropriate.....It was inappropriate as anyone can take a glance and see his limited "achievement".....When I expressed my concern, I did not know that academician Zou Chenglu had raised similar objections in the past and had paralyzed their interpersonal relationships...Perhaps because the issue is now timeworn, I have not been reprimanded. But things could not have been easy for Zou as Zou used to work under him...Those who did not know about developmental biology might regard Zou's objection

[83] Rao was trained at Harvard and UCSF. He had worked at the School of Medicine at Washington University in St. Louis before serving as the head of a scientific institute at Northwestern University. In 2010, his high-profile decision to give up not just his tenured professorship but also his American citizenship to return to China put him under the media spotlight. He is now the dean and chair professor of the School of Life Sciences at Peking University in China. See Sharon LaFraniere, "Fighting Trend, China is Luring Scientists Home," *The New York Times* January 6, 2010; Jaime FlorCruz, "'Sea Turtles' Reverse China's Brain Drain," *CNN World* October 28, 2010; and "Neuroscience Grows in China," *Nature Neuroscience* 11 (1), 2008.

against him as groundless. Reportedly Zou said his research in China was quite inactive over the years. He seldom published papers. Readers can check out bibliography to evaluate Zou's comment on their own. There is no need for other people to explain.[84]

When Rao's article was first published in 2007 in a Chinese periodical,[85] Bei Shizhang was still alive. This might explain Rao's indirect reference to him as the "centenarian" rather than spelling his name out directly. Yet there is no doubt that Rao was talking about Bei Shizhang. Besides invoking Bei's personal trademark—"cell reformation"—Rao's speculation on the glacial relationship between Bei and Zou was situated when Zou Chenglu was a biochemist at the IBP, thus explaining why Zou was allegedly "uneasy" when he worked with Bei at the same institute. Also, Feng Depei and Wang Yinglai were both scientists in Bei's cohort. If we accept that Bei Shizhang was indeed the target of allusion in Rao's essay, the next question is why did such a young and brilliant scientist publicly denounce Bei?

One of the main reasons for a lack of approbation of Bei's theory of cell reformation among the mainstream scientific community is his insufficient explication of details. What Bei called "cell reformation" encompassed primarily the principle that cells could be "reformed" from the yolk granules that enveloped the cells under suitable conditions. But "deform" and "reform" are vague terms in a scientific study, nor is the phrase of "suitable condition" specified with enough details. The biggest problem is that even if one observes an abnormal pattern of cell differentiation in *c. nankinensis*, is it

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[84] Rao Yi, *Rao Discussed Science* 饶议科学 (Shanghai: Shanghai Science and Technology Education Press, 2009), p. 159.

[85] Rao's article under the same title was contained in *Commentary on Science & Culture* 科学文化评论 Vol. 4, Iss. 2, 2007, pp. 38-45.

justified to generalize from this one isolated occurrence to the overall cytoscape? Even more so, since Mao's declaration of interest in the origins of cells, Bei began to sell his theory as offering a potential explanation for cell origins and even the evolution of life.[86] The problem is that issues as complicated as the origins of cells are very difficult, if not impossible, to replicate in an experimental setting. It is not that Bei was less attentive to scientific rigor but that sufficiently demonstrating the vast array of environmental and hereditary factors on short-lived organisms in a laboratory was almost inconceivable.

Bei's resemblance with Harms is striking: Both are motivated to integrate divergent fields by seeking the connections between what were perceived as unrelated systems. The connection of germ cells and somatic cells drove Harms to advocate not just an environmental cause of genetic change, but what could be considered in modern understanding an epigenetic cause for the origin of germ cells. However, even if Harms made a convincing case that the "transformed somatic cells" could be transmitted to the germ cells which later transmuted the reproductive organs, he did not prove that the environment was the principal force for heredity and evolution because those changes in the somatic cells were very likely the result of a selection process rather than environmental induction. In plain language, our bodies and genes change over time as we adapt to the environment, but these adaptations cannot pass over to the next generation immediately. As a species, we can only change slowly and over a long course of natural selection. We change gradually and somewhat accidentally, not inductively. Recently, most evolutionary biologists have argued that it was unfair to reduce the scope of Lamarck's thought to merely the mechanics of inheritance of acquired characters.

[86] Bei Shizhang, "Seventy-Year Research on Cell Reformation" 七十年的细胞重建研究 *PIBB* 2003: 30(5), p. VII.

Writing slightly before he died, Stephen Jay Gould championed a more broadly conceived landscape of Lamarck's evolutionary theory.[87] Perhaps these afterthoughts would stimulate a revived interest in Lamarck's natural philosophy.

To conclude, Harms' lifelong emphasis on the environmental conditions and organic development shaped Bei's views on biophysics and his formulation of scientific theory. On the one hand, Bei was cultivated to synthesize specialties with divergent methodological approaches and theoretical worldviews. Meanwhile, Bei's humble academic record also stems from the same intellectual commitment: he saw the big picture and the connection among previously separated fields, but did not attach enough weight to details and intricacies, and the details are important, especially when attempting to communicate the merits of a new theory to detail-oriented people that populate the scientific community, regardless of nationality.

Summary

Biophysics reflects problems associated with integrating scientific disciplines with hierarchical relationships. Thus, views of biophysics inevitably draw upon different ways of compromising or reinforcing these disciplinary conflicts. This is probably one of the reasons why biophysics had always been subjected to different interpretations about what the term meant and what its range of investigation encompassed, as noted in the prologue. Probably more than any other domain of scientific inquiry, biophysics allows for much bigger room for conceptual maneuvering and reconfiguration. Since there isn't a consensus among Western biophysicists as to what biophysics is all about, it is fruitful

[87] Stephen Jay Gould, *The Structure of Evolutionary Theory* (Harvard: Belknap Harvard, 2002), pp. 177-178.

to explore how biophysicists in other contexts understand and delineate this particular field of inquiry.

This chapter reviewed the ways in which three Chinese biophysicists approached biophysics in socialist China. Each of them had his or her own formulations of what biophysics encompasses, its applications, and theoretical underpinnings. Yet they generally portray biophysics as a biology-driven specialty, which is contrary to the mainstream historiography of biophysics in Western literature. The intellectual history of biophysics reveals ideas about how to order knowledge. What Karl Pearson revealed is the theoretical and methodological dissonances between physics and biology as a product of the way scientific knowledge is ordered in Western cultural cartography. The relationship between physics and biology reflects the Western worldview of scientific order, and at the core of Western epistemic order is the philosophical conception of objectivity according to which disciplines are ranked on a scale from the most mind-independent ones (physics) to those that are more intertwined with external influences (biology). This ideal of objectivity resides in the belief in the universal power of physics to encompass and explain any natural phenomenon. Behind this cultural order of scientific knowledge is the preference to reduce complex phenomena into calculable, quantifiable, and computable units of analysis. Compared to this historical context, the Chinese conception of biophysics turned the intellectual order of science upside down. Biology, rather than physics was interpreted as the *leitwissenschaft* that underlines biophysics in China. This appears to be largely due to Bei's relationship with his academic advisor Wilhelm Harms' intellectual influence on Bei's academic pursuits, in both a positive and negative light.

But the story of Harms and Bei stayed mostly in Germany. Since Bei returned to China in 1931, his cytological research would lie dormant for the next thirty years, during which he put the state-assigned administrative and organizational tasks before his own research agenda. In the post-1949 period, Bei would have to put his research interests on hold, as his duties would compel him to act as a discipline builder that would ultimately define him as a "founding father" of Biophysics in China.

CHAPTER 3

THE PRECURSORS OF BIOPHYSICS, 1949-1958

The last chapter introduced the founding figure of biophysics in China and his disputed academic achievement. The birth of Bei's theory of cell reformation took place before the Communist takeover of China and it was neither a communist invention, nor a critical biophysical one. Bei's unorthodox knowledge was predicated on a particular theoretical assumption rather than empirical experimental discovery. Cell reformation and Bei's developmental studies only became "biophysical" when he established an institute of biophysics after 1949. Bei's early life prior to 1949 was of significance as his overseas education shaped his views of biophysics and ultimately the intellectual foundation of the discipline in China. As influential as Bei and other biophysicists like Shen Shumin and Xu Jinghua were, their presence was not enough to encapsulate the range of factors that gave rise to building a scientific discipline in modern China. Having capable scientific leaders is only one of the many prerequisites for the development of a scientific discipline. In the case of biophysics, institutional shaping is also a critical factor: Institutions justify and finance scientific inquiry, and the blessing of institutions is an essential condition for robust scientific development.

This chapter explores the institutional building of biophysics before its inception in 1958. To trace the dynamic process of instituting biophysics, I begin with a normative survey of biological institutions in China before 1949, the experimentation with setting up the Institute of Experimental Biology between 1949 and 1953, and end with the establishment of the Institute of Biophysics in 1958. The organizing thread that underpins these narratives and institutional events is Bei's peculiar leadership style. At different analytical points, I have sought to compare and contrast the personalities and social capitals between Bei Shizhang and Francis Schmitt. As charismatic leaders for building biophysics in twentieth-century China and the United States respectively, Bei Shizhang and Francis Schmitt exhibited different styles in their leadership, and these stylistic differences affected the process and outcomes of institution building.

The state of Chinese biology before 1949

The discipline that would eventually be called biophysics was practically non-existent before 1949. This was not unique to biophysics or biology. Scientific research was meager and disorganized in pre-1949 China. This is not to wipe out any Nationalist legacy or some continuities between the Nationalist and Communist regimes.[88] But 1949 brought the dawn of a new age of disciplinary and institutional formation of science in China. Many scientific fields coalesced into disciplines only after the political turmoil had calmed down, and with new political patronage to pursue modernization and nation-building. Prior to 1949, the lack of stable conditions was highly undesirable and unconducive to the organization of formal and sustained scientific inquiry. This was best summarized by the distinguished meteorologist Zhu Kezhen (竺可桢) in the collection of his diaries. In addressing the lack of organized research endeavors before 1949, Zhu assigned blame not only to external military threats imposed by the Japanese troops but also to intra-mural fragmentation. In his words, "Many contradictions and shortcomings existed within scientific circles. Among the most prominent was the sectarianism which

[88] For thematic issues on pre- and post-1949 similarities and divergences in Chinese state-building and modernization, see Jeremy Brown and Paul Pickowicz, eds. *Dilemmas of Victory: The Early Years of the PRC* (Cambridge: Harvard University Press, 2007).

prevailed inside scientific organizations and the confused ideology of science for its own sake that was professed by most scientific workers."[89] Science is a collective enterprise, and the intervention of a strong state can be advantageous for managing internal strife among scientists, especially at a politically unstable time. Scientific visions had to be standardized and the marching-in of the Communist government offered an authoritative source for this goal.

But even within this politically volatile soil, the seed of biophysics was already budding. It is worth visiting some of the precursors to what came to be known as biophysics because Bei and his research activities were synchronic in the same period. Pre-biophysics arrangements in pre-1949 China could give us some clues so as to better contextualize the emergence of biophysics after 1949.

Laurence Schneider has surveyed some of the establishments of biological education and research in Republican China. His emphasis was put on the transmission of American models to China as in the adoption of the medical model of the Johns Hopkins University by the Peking Union Medical College under the auspices of the Rockefeller Foundation. These were examples of the transfer of pedagogical models and resources from America to China. Schneider attributed a large part of the domestic growth of biology in Republican China to the assistance of foreign foundations and their foreign policies rather than indigenous legacies.[90]

The dependence on foreign support was just part of the story of China's biology before 1949. The role of local-based foundations in promoting biology education and

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[89] Zhu Kezhen 竺可桢. *The Complete Collection of Zhu Kezhen, Vol. 5 竺可桢全集, 第五卷*. (Shanghai: Shanghai Science & Technology Education Press, 2005), pp. 376-377.
[90] Laurence Schneider, "Part I: Republican China, 1911-1949," in *Biology and Revolution in Twentieth Century China* (Lanham: Roman and Littlefield, 2003), pp. 33-114.

research should not be overlooked. An exemplar of domestic efforts in building biology is the establishment of The Beiping Fan Memorial Institute of Biology (北平静生生物调查所).[91] BFMIB was founded in 1928 with financial support from The China Foundation for the Promotion of Education and Culture (CFPEC, 中華教育文化基金董事會) and The Shang Chih Society (尚志學會). Its predecessor was The Biological Research Center of the Science Society of China (中國科學社生物研究所) created by a group of Chinese students at Cornell University in 1922. Most of the early executive members were science graduates of Cornell, such as entomologist Bing Zhi (秉志) and chemist Ren Hongjun (任鸿隽). When Fan Yuanlian (范源廉), also known as Fan Jingsheng (范静生) died in 1927, senior members of the Science Society of China decided to dedicate the biological institute to commemorate Fan. In 1938, BFMIB became the largest institute for organized biological research in China. According to Hu Zonggang (胡宗刚), BFMIB was operating as a small-scale local biological organization between 1938 and 1945 independently from the Nationalist government.[92] BFMIB suffered from a period of financial hardship as the sponsorship from CFPEC could not reach mainland China during the second stage of Nationalist-Communist Civil War. After 1949, the director of BFMIB, Hu Xiansu (胡先驌) wrote to the military managing committee that the board of regents would like to incorporate the institute into the Chinese Academy of Sciences (CAS). BFMIB was to merge with Institute of Botany of the Beiping Academy of Sciences (北平研究院植物所) to form the Institute of Botanical Taxonomy of CAS (中

[91] Hu Zonggang 胡宗刚. *A Historical Manuscript of The Fan Memorial Institute of Biology* 静生生物调查所史稿. (Jinan: Shandong Education Press, 2005).
[92] *Ibid,* p. 121.

科院植物分类研究所). Today, BFMIB continues to be part of what is now called the Institute of Botany of CAS (中科院植物研究所).

Was there any sign of Bei Shizhang and biophysics in BFMIB? Not exactly. First, there was the geographical segregation. In September 1937, the institution to which Bei belonged——*Zheda*—was forced to evacuate from Hangzhou. The *Zheda* crew joined the procession of universities to march southwest. They were en route for two years traversing over an area of 2600 kilometers across six provinces. A considerable part of this route overlapped with the first half of the Communist retreat during the heroic "Long March" from Jiangxi to Yan'an. This was sometimes dubbed "the long march of the intellectual army" (文军长征) to highlight the revolutionary symbolism of Chinese intellectuals during Japanese occupation.[93] As the head of biology of *Zheda*, Bei took responsibility for continuing the teaching and learning of biology during evacuation. From Chan Yuan Monastery (禅源寺) in Western Tian Mu Mountain (西天目山), to Confucian Temple (文庙) in Jian De (建德), and Tang's Family Temple (唐家祠) in Mei Tan (湄潭), Bei did his best to make sure classes could proceed in these religious venues as much as possible.[94] Trapped in the rural southwest between 1937 and 1945, there was no way for Bei to reach out to the major foundations and institutes that were concentrated in eastern and southeast China.

Even if Bei had not had to retreat to the southwest, there was still the disciplinary divide. Bei's doctorate from Tübingen was in zoology whereas BFMIB had a strong

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[93] The University of Zhejiang. *Centennial History of the University of Zhejiang* 浙江大学百年发展史 (Hangzhou: The University of Zhejiang Press, 2002).
[94] Wang Guyan, *A Biography of Bei Shizhang,* pp. 77-86.

focus on botany. Although Bei had no prior experience with botany, the zoology-botany gap was not an impediment for building a cross-disciplinary structure that encompassed both zoology and botany. When the *Zheda* biological department resided in a Chinese quadrangle in rustic Mei Tan, Bei strove to make room for the different biological specialties in the Chinese family hall. As a result of his leadership, morphology, botanical taxonomy, physiology, genetics, and developmental biology all were able to cohabitate under the same roof. He underlined the importance of having a balanced representation of teachers to support a comprehensive and systemic learning of biological knowledge.[95] Although his research during this period revolved around experimental biology and developmental embryology, he did not promote areas in which he had vested interests at the expense of competing fields such as genetics.

The philologist Fu Ssu-Nien (also romanized as Fu Sinian, 傅斯年) spoke of various ways in which people react towards rivals and rival intellectual claims. Those who express interest but do not understand *terra incognita* are uninformed sympathizers; those who understand the complexity but remain indifferent are informed onlookers; but the most precious are those who are both informed and sympathetic, especially when their sympathies come from their understandings.[96] Bei's attitude towards genetics fit nicely to the third archetype. He did not have a background in genetics, as he came from Tübingen's School of Zoology where he specialized in what might be considered as cyto-mechanics. Yet he was not hostile to geneticists; he was sympathetic to their cause because he understood the importance of genetics for developmental biology. In the six

[95] *Ibid,* pp. 86-7.
[96] Dorothy Needham and Joseph Needham, eds. *Science Outpost: Papers of the Sino-British Science Cooperation Office, 1942-1946* (London: the Pilot Press, 1948), p. 283.

years where *Zheda* was stranded in Mei Tan, he cemented his lifelong friendship with geneticist Tan Jiazhen (谈家桢). When Tan was indisposed in Shanghai in his senior years, Tan told reporters that he wished to see his old friend Bei Shizhang in Beijing because "Bei was a good guy with fine intellect" (他为人好、学问好). When Tan was hospitalized in 2004, Bei sent over one of his sons to Shanghai to visit him, which made Tan very happy that "my best friend's son came to see me."[97] The camaraderie between Bei and Tan stretched from *Zheda* all the way to the very end.

Tan was a student of Thomas Hunt Morgan at Columbia. He would become the most outspoken Morganist against Michurin biology at The Qingdao Genetics Symposium held between August 10 and 25 in 1956. The tale of confrontation between Morganists led by Tan and Michurinists led by Zu Deming (祖德明) has been detailed by Schneider.[98] Suffice it to say that Tan was a staunch supporter of Morgan's genetics and uncompromising in his hereditarian thinking. For Tan, the basis of heredity was unmistakably to be found in chromosomes, genes, and DNA, whereas Bei was different; he was not a geneticist. Bei's analytical interest in genetics came from his theoretical concern with the proper relationship between heredity and development. His own research on cell differentiation lay at the intersection between genetic inheritance and non-genetic development. Genetic and epigenetic factors converge in the developmental studies of embryos. Bei was like other developmental embryologists who were drawn to the possibility of "untangling the embryo's developmental complexities and understanding the embryo's development via a cellular interpretation of life," as Jane

[97] Wang Guyan, *A Biography of Bei Shizhang,* p. 88.
[98] Laurence Schneider, *Biology and Revolution in Twentieth Century China,* chaps. 5-6.

Maienschein has denoted.[99] Bei realized that heredity and development comprised the entirety of life. Bei's enthusiasm in the movement and reformation of cells in the process of differentiation did not overshadow his respect for the role of genetics in the course of organic development.

His knowledge of both genetics and developmental biology earned him not just a permanent friend but also trust from *Academia Sinica*. In spring 1947, Bei was delegated to attend the International Congress on Cell Biology in Copenhagen. In preparation for the upcoming trip, he met with several scientists at the *Academia Sinica* located at 320 Yueyang Road (岳阳路) in Shanghai at that time. Notable was his close interaction with Luo Zongluo (罗宗洛), director of the Institute of Plant Physiology; Wang Jiaji (王家楫), director of the Institute of Zoology; and Feng Depei (冯德培), acting head of the preparatory office of the Medical Research Center.[100] Bei knew how to cultivate cordial relationships with his colleagues in botany, zoology, and physiology (or biomedicine) before he created an institutional space for biophysics. A congenial relationship with leaders in biophysics-related disciplines paved the way for his subsequent efforts to institutionalize biophysics. In particular, Luo Zongluo was willing to assimilate the Institute of Plant Physiology into the biophysical framework under Bei's leadership.

Divergence in leadership styles

Bei's personality and leadership style stand in sharp contrast to that of Francis Schmitt, the all-intimidating leader of American biophysics at MIT. In Rasmussen's study

[99] Jane Maienschein, *Whose View of Life? Embryos, Cloning, and Stem Cells,* p. 35.
[100] Wang Guyan, *A Biography of Bei Shizhang,* p. 104.

of "the burst of the biophysics bubble" in the United States, he explored reasons why the biophysics programs in major American research universities did not continue from cultural and institutional points of views.[101] Biophysics failed to gain foothold at the University of California at Los Angeles (UCLA) because of the policies and entrenched domination of its School of Medicine that tended to overshadow non-service-oriented science programs such as biophysics. However, the story was quite different at non-medical institutes. At MIT, Francis Schmitt was once a national leader in championing biophysics, and in 1954, the National Institute of Health asked Schmitt to head a fund for extramural research in this field, which later crystallized into a large-scale conference featuring major luminaries in biophysics known as the "NIH Biophysics and Biophysical Chemistry Study Section." Despite this, Schmitt's biophysical program at MIT fell apart eventually as he could not draw support from colleagues in related disciplines, most notably biochemistry. In Rasmussen's analysis, the failure of Schmitt and his allies to establish biophysics as an enduring discipline had a lot to do with the competition with biochemists in the struggle for claiming intellectual and methodological ownership of the physical chemistry of macromolecules.

Bei was not a self-styled "iron-man" as Schmitt was.[102] Bei was known for his gentle character and good manners. He was polite not just to high-ranking officers and party leaders. His students, co-workers, friends, collaborators, and journalists all reported his easy-going personality in chorus. Two biographers were deeply moved by Bei's

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[101] Nicholas Rasmussen, "The Mid-Century Biophysics Bubble: Hiroshima and the Biological Revolution in America, Revisited," *History of Science* 35 (1997): 245-293.
[102] Nicolas Rasmussen, *Picture Control, The Electron Microscope and the Transformation of Biology in America, 1940-1960*. (California: Stanford University Press, 1997), pp. 154-196.

expressed courtesy towards those who were below him.[103] One of Bei's mottoes read "test your knowledge against those who are above yours but compare your circumstances to those who are less fortunate" (学问试看胜于我者，境遇要比不如我者).[104] Even in his marriage, he was the good-tempered one compared to his wife.[105] Some even attributed his longevity to his compassion and morality.[106] In a professional function to which I was invited in 2010, several senior Chinese scientists argued that Bei's prolonged life saga offered an evidential case to seek immortality from morality. They believed that moral behaviors rather than medicinal potions were the elixir of life.[107] Bei was a mortal man but the exemplary status of his moral reputation extended beyond his mortal limitations. Regardless of the figurative supernatural elements, the fact is that his character was so exemplary and winning of respect that people were willing to ascribe his longevity to his outstanding character and kindness.

However, scientists are people and people have their idiosyncrasies. It is hard to say which leadership style is better. But in the case of biophysics, the personalities of head scientists have an irrefutable impact on the ultimate fates of disciplines. Scientists of a strong and forceful disposition are usually destined to take up the lead for a discipline, but not always. In disciplines with flexible definitions and shifting interpretations such as biophysics, aggressive individuals can be perceived as a threat to those with equal stakes

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[103] Wang Guyan, *A Biography of Bei Shizhang,* p. iii-v, and Zhang Jianjun, "Epilogue," in *Bei Shizhang* (Ningbo Press, 2002).
[104] Wang Guyan, *A Biography of Bei Shizhang,* p. 90.
[105] *Ibid,* p. 307.
[106] Du Hao 杜浩, "The Way to Elixir of Bei Shizhang," 贝时璋的养生之道. *Science Regimen* 科学养生, 2010, (2), pp. 6-7.
[107] The event was an invitation-only memorial service for one of the earliest female physicists in modern China, namely Dr. Wang Mingzhen (王明贞先生). It took place in Main Hall at Tsinghua University on September 10, 2010. The function was attended by the president of Tsinghua University, representatives from the secretariat office, media press, former colleagues & students, retired Tsinghua scientists, and the invited public such as myself.

in the venture. The history of biophysics in twentieth-century America revealed that it was Schmitt's iron-fist persona more than anything that caused the demise of the biophysical empire he had longed to build. Schmitt had the financial backing from both NIH and MIT to pursue his biophysical dream; he was charismatic, knowledgeable, and visionary. Yet he failed to convince others of biophysics' niche in American biology. The situation was unambiguously identified by Nicolas Rasmussen who argued "Schmitt's ambitions for biophysics were not fulfilled in the form he envisioned largely because of competing efforts at redefinition and reform of biological disciplines."[108] Sometimes too much assertiveness only made things worse. Schmitt was not afraid of standing up to defend for biophysics. But his masterful speeches could not persuade other equally ferocious and ambitious biologists such as Linus Pauling.

Bei, in contrast, knew how to work *with* rather than *against* people. He was not associated with the kind of sabre rattling or adversarial competition in the arenas of science or politics. He was praised for his cooperativeness and loyalty to collectivities rather than individual gains. At times this perceived selflessness could yield serendipitous advances faster and more painlessly than otherwise. Former CAS deputy director Zhang Jingfu (张劲夫) once urged the secretariat office to disburse funding to Bei proactively because "old Bei is not after money or material, we would give him (what he wants) without his asking." (贝老是不争钱不争物的，我们应主动给他)[109] People tend to be kind and generous to those who are seen as harmless. The Bei–Schmitt contrast cast doubt upon the Machiavellian myth. It is not always better to be feared than loved.

[108] Nicolas Rasmussen, *Picture Control,* p. 186.
[109] Zhang Jianjun, *Bei Shizhang* (Ningbo Press, 2002), p. 79.

Sometimes perceived clemency rather than forceful tyranny could deliver what you want more quickly.

Yet Bei was hardly an ethereal or unmaterialistic figure. It is important not to paint an overly naïve picture of Bei's ambitions. Whether it was his doctoral dissertation on the developmental cycles of a vinegar eel or his attempt to construct an alternative cell theory, he was anything but a blind conformist. He might not have been an opportunist or a careerist, but he clearly had his own agenda. He wished to implement his vision to build an interdisciplinary structure for biophysics in China just like Schmitt had wanted to do in the U.S.. The question is how to put such an agenda into practice?

Wang Guyan recently published the most in-depth biography of Bei Shizhang. It stands in my opinion as the most encompassing and best-chronicled biography of Bei that has ever appeared in press. In Wang's detailed documentation, one of the *sine qua non* of Bei's success in building biophysics in China is his high standing and great renown in China's scientific community. As Wang elaborated, the first distinctive quality of Bei was that "he had long been an academician of *Academia Sinica* and a committee member of the academic division of CAS. Not only was he a well-respected and famous biologist, he was also equipped with a firm knowledge base in physics, chemistry, and mathematics. He was also good at interacting with experts in these disciplines...He continued to learn and broaden his lines of thought."[110] Science is a hierarchical and highly selective community; if one wants to get anything done in this meritocratic but exclusionary republic, one needs to demonstrate his or her elite status. This happens in America as well. As Paul Gross recognized, "Questions thought to be worth asking are

[110] Wang Guyan, *A Biography of Bei Shizhang,* p. 164.

usually the products of agreement by some sort of elite."[111] Gross was commenting on the ways in which elite scientists at the Marine Biological Laboratory (MBL) defined American biology at the turn of the twentieth century. There is no reason to think that science could be "defined" by the less privileged in other places. In China, one of the best ways to acquire elite membership in the scientific circle is by becoming one of the academicians (院士).

Becoming an Academician

The early history of Chinese academicians in modern China has been chronicled elsewhere.[112] In the volume entitled *Chinese Academicians*, the archivists divided the early cohort of Chinese academicians into three clusters. The first cluster was those who were born in or around 1890 and earned their doctorates in the first half of the twentieth century; the second generation was those who were born in or around the 1900s and went abroad in the 1920s; the third generation was those who were born in or around 1915 and went overseas in the 1940s. According to this typology, Bei belonged to the second generation of academicians. However, Bei was among the first group of academicians to be elected to *Academia Sinica*. Besides his outstanding scholastic background, the fact that a scientist of "*deuxième génération*" like Bei could rise to academicianship ahead of the previous generation also had a lot to do with the introduction of the system of academicians to China. Although *Academia Sinica* was founded in 1928, the system of academicians was not implemented until 1948. Part of the delay was due to conflicting

[111] Paul Gross, "Epilogue," in Jane Maienschein, ed. *Defining Biology: Lectures from the 1890s* (Cambridge: Harvard University Press, 1986), p. 337.
[112] Zhang Jianwei and Deng Congcong(张建伟, 邓琮琮), *Chinese Academicians* 《中国院士》 (Hangzhou: Zhejiang wen yi chu ban she, 1996) (杭州:浙江文艺出版社, 1996).

ideas about the appropriate rendering for the term "academician." Among the Chinese equivalents of "academician," the decision-makers finally settled on "院士" instead of other alternatives such as "学侣," "院侣," or "院员" as the standard translation for "academician."[113] The semantics for "academicians" remained a contested issue as it was a symbol of intellectual power vis-à-vis that of political leverage. Years later, the Chinese Communist Party would relinquish the term "院士" and opted for another Chinese equivalent "学部委员" for the same group of "academicians" because the former sounded too elitist.

In 1948, Bei was among the three scientists from *Zheda* to be elected to the first cohort of academicians at *Academia Sinica*. The other elected *Zheda* academicians were Zhu Kezhen and mathematician Su Buqing (苏步青). This national honor got him the invitation to partake in The Preparatory Committee of the National Congress of Workers in Natural Sciences (中华全国自然科学工作者代表大会筹备会) that was held in Beijing on July 13, 1949. There were altogether five scientists from *Zheda* sitting at the Preparatory Committee. Two hundred and eighty five selected representatives from various political and professional sectors attended this convention. The meeting predated the officiation of the People's Republic of China but the idea of creating a national academy of science had already been raised on this occasion. Bei was one of the conveners of the science panel (理科组). He, along with several panel members such as Yan Jici (严济慈) and Zhu Kezhen, proposed that the government should establish a

[113] *Ibid*, p. 19.

national academy of science. The panel then had an after-dinner session with vice-chairman Zhou Enlai to discuss plans for setting up a Chinese Academy of Sciences.[114]

Many open and closed-door meetings were held in the second half of 1949 to design and discuss details on how to further the scientific capacity in China. Many pending questions awaited strategic planning, not least of which was the appropriate name for a national academy of sciences. Clearly, the old name *Academic Sinica* could not stay as this institution was relocated to Taiwan along with the Nationalist Party. In a draft proposal entitled *A Draft Proposal for People's Academy of Sciences* ("建立人民科学院草案"), Qian Sanqiang (钱三强) and his colleagues recommended the appellation The People's Academy of Sciences (人民科学院) for the new academy so as to distance themselves from the notion of science for science's sake while stressing the need of using science to serve people. But this suggestion with an explicit proletariat overtone was not adopted.[115]

Bei's participation in the national congress in 1949 was a critical milestone both in Bei's life and the institutional history of biophysics. The journey to a national consortium in Beijing forecast his career transition from an inquisitive scientist to an institutional leader. He was going to spend the majority of his time from this point onward as an administrator and planner rather than a scientist working in the field. But what was asked in response was "why did he give up science for organizational service?" In addressing this question, he remarked that most scientists, including himself, enjoyed

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[114] Wang Guyan, *A Biography of Bei Shizhang*, pp. 116-118.
[115] Fan Hongye, ed. (樊洪业), *A Historiography of the Chinese Academy of Sciences 1949-1999* 《中国科学院编年史, 1949-1999》 (Shanghai: Shanghai Education Press, 1999) 上海:上海科技教育出版社, 1999), p. 2.

hanging out in the libraries and laboratories more than any places else. That was fine, but if every scientist is like this all the time, then who is left to take care of organizational and societal needs? Ying's documentation gave a sense of compromise in his decision to leave the laboratories behind for boardroom meetings, since "he did a lot of organizational, planning, and community work for the science sector after 1949. He did it not out of personal interest but as a service to the party and to the nation. The party and the country required some scientists to temporarily leave their beloved libraries and laboratories for these tasks." [116] Bei resigned himself to administrative chores because he was willing to give up personal pursuits for collective interest. Planning for research programs and new institutions take up a lot of time and sometimes these decisions were not entirely voluntary. When Bei was appointed to the title of academic secretary of CAS in Beijing, he expressed to the board of directors about his reluctance to take up the job. Yet the leaders at CAS convinced him that these organizational tasks were conducive for the overall interests of the academy. Therefore, Bei obeyed the order from the organization for the public good (贝为了顾全大局而服从组织安排).[117]

Yet Bei's deference to the central authority should not obscure his vision for instituting biophysics. The episode of Bei's proposal of establishing a Chinese Academy of Sciences was significant to the institutionalization of biophysics because it was indicative of Bei's political leverage in the scientific clique surrounding CAS. Before biophysics could find an appropriate niche in CAS, the father of biophysics was already an active participant in the planning and processes of decision-making in CAS. He was

[116] Ying Youmei, "The Life, Work and Thought of Professor Bei Shizhang," p. 31.
[117] Zhang Jianjun, *Bei Shizhang*, p. 159.

no rank-and-file member; his status as an academician with high visibility among the board of leaders was a *sine qua non* for building biophysics in China.

Experimental Biology, 1949-1953

After CAS was formally established in 1949, preparatory committees were set up along disciplinary lines to coordinate the overall structure of CAS. Bei was invited to sit on the preparatory committee for the zoology institute (动物学研究所筹备组). Also recruited in this committee were Bing Zhi (秉志) from BFMIB (静生生物调查所), Chen Zhen (陈桢), Tong Dizhou (童第周), Zhu Xi (朱洗), Shen Jiarui (沈嘉瑞), Wu Xianwen (伍献文), and Wang Jiaji (王家楫), all of whom he had met in 1947. In this committee, both Bing Zhi and Chen Zhen were versed in both zoology and botany. Working with leading biologists from both botany and zoology helped Bei accumulated knowledge and experiences for crossing the botany-zoology gap. In 1950, he seized the opportunity to present a bill for restructuring zoology and botany. The bill introduced by Bei was known as "Adjustment of the Institutes of of Zoology and Botany."[118] In this bill, he proposed a new institutional structure to accommodate both zoology and botany into the same fabric. His idea was to create a tripartite system for botanical taxonomy (植物分类), marine biology (水生生物), and experimental biology (实验生物) in order to balance the relative weights of zoology and botany.

Bei was particularly interested in getting experimental biology instituted in CAS. This was hardly surprising given the fact that Bei had been actively promoting

[118] Wang Guyan, *A Biography of Bei Shizhang*, p. 122.

experimental biology since *Zheda* was in evacuation. In China, he was the first one who coined the term "experimental biology" in Chinese.[119] At a time when the biological tradition in China was dominated by the sciences of morphology and physiology, Bei incorporated elements from the German *naturphilosophie* into the descriptive framework in biology. Bei did not really "transform traditions in Chinese biology" the way American biologists did at the turn of the twentieth century.[120] But his cytological approach added something new to the existing studies of biological forms and functions via pure description and classification. The new commitment was the investigation of causes underlying forms and functions as emphasized by the German cytological school.

It was no coincidence that experimental biology was the precursor of biophysics in China. The Institute of Experimental Biology (IEB, 实验生物所) was founded in 1950 in Shanghai. IEB was the amalgamation of physiological, zoological, and botanical divisions from both the Beiping Academy of Sciences and *Academia Sinica.* On August 1 1950, Bei was appointed as the incumbent president thus being permanently transferred from a higher-education institution to a research academy. From Hangzhou to Shanghai, this appointment was to close the *Zheda* chapter in his life forever. From that point on he was going to leave behind the swampy fields in Hangzhou where he discovered *c. nankinensis* and the primitive classrooms in Mei Tan where he wrote up the papers on the theory of cell reformation. He was transformed from a research scientist into a disciplinary builder and scientific leader.

[119] Ying Youmei, "The Life, Work and Thought of Professor Bei Shizhang," p. 18.
[120] Jane Maienschein, *Transforming Traditions in American Biology: 1880-1915* (Baltimore: Johns Hopkins Press, 1991).

Originally there were three research centers instituted under IEB: Center for Plant Physiology was headed by Luo Zongluo; Center for Entomology was chaired by Chen Shixiang (陈世襄); and Center for Developmental Physiology was led by Zhu Xi. Except for the entomology team, the plant physiology and developmental physiology teams were stationed in Shanghai. The Center for Developmental Physiology was the home base of Bei; here, he had his own laboratory in the developmental physiology group. Bei then took the initiative to continue his interest in cell development since experimental biology accounted for a large part of the research efforts in the Center for Developmental Physiology. In addition to Bei, other researchers in this team also engaged in the research of the embryonic development and cellular differentiation of animal cells.[121]

This narrow focus on cell development in animals had little crossover with the center for plant physiology. Even though plant physiology was brought into the institutional structure of experimental biology, a common platform could not erode disciplinary differences. Plant cells and animal cells are very different to begin with. Heterogeneous modes of cell multiplication and composition are found in animal and plant tissues. Bei's training in multicellular animal organisms did not prepare him to wrestle with the various types of nucleo-cytoplasmic interactions or morphological features in unicellular plants such as algae. In January 1953, plant physiology was separated from IEB and became the Shanghai Institute for Plant Physiology (上海植物生理研究所) under the leadership of Luo Zongluo. The six-year collaboration between Luo and Bei ended solemnly as Center for Plant Physiology was separated from IEB. It showed that an interdisciplinary infrastructure could not resolve entrenched disciplinary

[121] Wang Guyan, *A Biography of Bei Shizhang*, p. 133.

differences, especially when these differences stemmed from dissimilar epistemic commitments.

As for the entomology division situated at Beijing, the Center for Entomology had only superficial connections with the rest of IEB in Shanghai. When the plant physiology team left IEB in 1953, the entomology team seized the opportunity to merge with the entomology institute at the Beiping Academy headed by Zhu Hongfu (朱弘复). The recently amalgamated entomology institute remained in Beijing. Its director was Chen Shixiang originally from IEB and the associate director was Zhu Hongfu. Entomology was going to stay further away from IEB, therefore the tripartite institutional structure for experimental biology only lasted for less than three years from inception to termination. Plant physiology and entomology parted ways with experimental biology, leaving only developmental physiology to stick with IEB.

What did Bei learn from this episode of instituting experimental biology? How does it feature in the overall history of biophysics in China? We gather that Bei's acquisition of CAS academicianship in 1948 brought him the necessary political capital for becoming a scientific leader. He made good use of these privileges by joining the planning panels for CAS. The IEB was an administrative attempt to integrate botany, entomology, and physiology, but it did not work out quite as well as Bei had hoped. This is because making true inter-field connections entailed something more than administrative arrangement: Field coalescence requires genuine commitment from researchers of different intellectual traditions. Institution alone cannot eliminate rival epistemic norms. What institutions can offer is a space for previously separated scholars to mingle, but it is up to the people themselves to decide how they want to take advantage of the shared area.

Space and its use matter to the development of biophysics as well. Bei understood that creating an empty shell to integrate biological and physical sciences could not sustain interdisciplinary fusion. It took strategic effort rather than a mere institutional space to unite researchers of different disciplinary convictions. People from different backgrounds would only work together if they shared a common set of worldviews and strived towards a common goal. In the precedent IEB case, there was not a single overarching project that required pan-institutional cooperation. Plant physiologists did not have an urgent need to reconcile epistemic differences with entomologists or developmental physiologists. This made Bei realize that he needed to put forward a common project in the new institutional framework to legitimize and thus consolidate disciplines with flexible norms like biophysics. A big project can incentivize people to work out their differences and mobilize their skills for solving a common problem. In short, the IEB episode sowed the seed of planting mission-oriented research into the interdisciplinary soil of biophysics a few years later.

From Experimental Biology to Biophysics, 1954-1958

The restructuring of IEB in 1953 did not diminish Bei's political cachet. Bei was one of the twenty-six scientists of the CAS delegation visiting Moscow between February and May in 1953 in the name of "learning from the big brother." This Moscow trip gave him the rare opportunity to meet with the Soviet cytologist O.B. Lepeshinskaya.

As I revealed in the preceding chapter, Bei had been exposed to the existence and importance of Lepeshinskaya and her revolutionary claim of "vital substances" (活质学说) before his appointment as secretary of the CAS. Bei's enthusiasm in anticipating his meeting with Lepeshinskaya was guileless. In his first meeting with Lepeshinskaya, Bei asked her about the exact chemical components and methods of extraction of the so-called "vital substances." Lepeshinskaya was reported to have sidestepped these inconvenient questions.

The second time Bei met with Lepeshinskaya, she did not want to discuss any aspect of her work on the formation of blood islands from yolk spheres in chicken embryos. Instead, she wanted to broadcast her latest discovery on the rejuvenating power and crop-yielding potentials of soda baths.[122] Much to Bei's chagrin, Lepeshinskaya was not willing to share the details of her work or to clarify the confusions in her "revolutionary" cell study.

Lepeshinskaya was known as a rather arrogant scientist. Other scientists also reflected on the patronizing attitudes of Lepeshinskaya and Lysenko during the Moscow visit.[123] Bei sensed her condescending attitude, but he was relentless to know more about her alleged "ground-breaking" study—a claim that was lauded by Stalin and Lysenko as comprising "a socialist revolution in cytology." Yet Bei's eagerness to converse with his respectable Soviet colleague was unreciprocated. Lepeshinskaya wanted to dominate the dialogue unilaterally without expressing a tinge of interest in Bei's cellular studies.

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[122] Wang Guyan, *A Biography of Bei Shizhang*, p. 135-140; Yakov Rapoport, *The Doctor's Plot of 1953*, (Cambridge: Harvard University Press, 1991), p. 260.
[123] Zhang Jianwei and Deng Congcong, *Chinese Academicians* (Hangzhou: Zhejiang wen yi chu ban she, 1996), p. 77.

When one door of collaboration remained closed, another door opened. The Chinese government sent another delegation of scientists and engineers to Moscow in 1957 to discuss issues of cooperation on science and technology. Bei was a leading member of this delegation and between October 24 and November 13 in 1957, he led a discussion with Soviet experts regarding the project on “the foundation for building biophysics” (建立生物物理学的基础).[124] In the same session, Bei authorized four new areas in biology, namely microbiology, biophysics, biochemistry, and genetics.[125] This was one of Bei’s earliest moves for making “biophysics” known in the political sphere. It was a preparatory step for laying the groundwork of launching biophysics in China.

Besides theoretical deliberation, he also seized the chance to visit the research facilities in the Soviet Academy of Sciences and higher-education institutions in the Moscow area. Of particular interest to him were the research and teaching activities in radiobiology, biophysics, biochemistry, and medicine. As Wang Guyan suggested, “the (Moscow) visitation prepared for Bei’s effort in pioneering a new discipline and establishing the Institute of Biophysics and the Department of Biophysics at the University of Science and Technology of China in 1958.”[126]

Even before the Moscow trip, Bei had taken actions to legitimize biophysics in China. He was not testing the water with experimental biology anymore; this time he took concrete steps to integrate biophysics into the institutional structure of CAS. In 1955, the central government promulgated a twelve-year development blueprint in agriculture known as “A Draft Developmental Outline of National Agriculture between

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[124] Wang Guyan, *A Biography of Bei Shizhang*, p. 139.
[125] Ying Youmei, “The Life, Work and Thought of Professor Bei Shizhang,” p. 35.
[126] Wang Guyan, *A Biography of Bei Shizhang*, p. 156.

1956 and 1967." This policy document was said to inspire other bureaus to release similar twelve-year plans for their respective sectors.[127] In 1956, the CAS secretariat office prepared the "Key Scientific Research Projects for CAS to Undertake in Twelve Years (for Natural Science & Technical Science)." As the designated academic secretariat of CAS, Bei was a critical member in the drafting and consultation of the "Twelve-Year Plan." His role in the planning of this policy document was exemplified in his chairing of the session on "Several Important Questions in Basic Theories of Natural Sciences" in April 1956. Another co-chair of this session was the celebrated physicist Zhou Peiyuan (周培源).[128] He was also invited to sit on the committee that was responsible for finalizing the resultant policy document—"A Long-Term Outline of Planning for the Development of Science and Technology Between 1956 and 1967"—or simply "Twelve-year Long-term Plan for Science and Technology Development." After the "Twelve-Year Plan" document was disseminated, Bei was appointed as the head of the division of biological sciences in the planning committees of the State Council.

Where did biophysics feature in this policy domain? In the policy document entitled "The Second Five-Year Planning Outline for the Chinese Academy of Sciences (A Draft)" released in March 1957, biophysics was highlighted as a key marginal discipline awaiting further development.[129] This was a window of opportunity for Bei. Serving as the head of the biological planning committees of the State Council, Bei proposed to the State Council that CAS should establish a research institute for biophysics. The State Council approved his request right away. In the ninth executive

[127] *Ibid*, p. 152.
[128] *Ibid*, p. 153.
[129] *Ibid*, p. 248.

meeting of CAS, the executive committee licensed the plan for turning what was left of IEB into the Institute of Biophysics. By 1958, the residual team in IEB was the developmental physiology group led by Bei. This made it so that he was basically deploying the same group of people under his directorship to a new edifice under a new name. But it was exactly the act of naming that legitimized the disciplinary status of biophysics in China. Naming is as much a political decision as it is a scientific judgment. What an institute is called bespeaks bureaucratic justification as much as epistemic and methodological commitments. It also gives an important index for individuals working in the same specialty to claim professional identity.[130]

Summary

On September 20, 1958 the Institute for Biophysics at the CAS was formally established and China was one of the few places in the world where biophysics was legitimized and endorsed at the national and institutional levels. Now Bei finally got what he had wanted: an independent scholastic territory for biophysics. How did he make use of this institutional space? How did he align the manpower in biophysics with powerful machines after 1958? It is to these questions that we now turn.

[130] These aspects of names and labels of stabilizing interdisciplinary research and structure have been touched upon by Julie Klein. See Julie Thompson Klein, *Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities* (University of Virginia Press, 1996).

CHAPTER 4

BIOPHYSICS AND BIOLOGICAL SOUNDING ROCKETS, 1958-1962

The inauguration of the Institute of Biophysics (IBP) in the Chinese Academy of Sciences (CAS) in 1958 is a historic milestone in the development of biophysics in China. It was one of the world's few institutes dedicated solely to advancing the science of biophysics. How did Chinese biophysicists make use of this institutional platform? Institutional patronage for biophysics was not uncommon in other places, but the support often turned out to be sporadic and not sustained. In the same year that biophysics came of age in China, the American biophysicist Francis Schmitt organized a month-long national conference on "the study program in biophysical science" at Boulder, Colorado with generous funding from the National Institute of Health (NIH). His ambition was to solicit a national consensus on the disciplinary cause of biophysics. It did not turn out as well as he had wished. Nicholas Rasmussen has diagnosed some of the underlying causes.[131] One of the problems was that the institutional commitment to biophysics did not last long in the U.S.. With this in mind, it is useful to ask how the Chinese biophysicists managed to sustain institutional support for biophysics.

What this chapter discusses is how the technology that was available shaped what the individuals with knowledge of biophysics could do to meet the needs of their institutional benefactors. Ultimately meeting this need for their expertise is what granted them the resources to build and develop the discipline. The specifics of the institutionalization of biophysics in China are examined in this chapter through the history of the launching of the biological rockets between 1958 and 1966 In documenting

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[131] Nicholas Rasmussen, *Picture Control: The Electron Microscope and the Transformation of Biology in America, 1940-1960* (California: Stanford University Press, 1997), pp. 154-195.

how Chinese biophysicists built the discipline of biophysics through launching the rockets, two sets of questions were brought to the forefront: The first is how biophysicists interacted with other experts in the Fifth Academy—the chief unit responsible for putting together rockets and missiles in socialist China. The early history of the Fifth Academy and its predecessor, the Fifth Bureau, reveals how government bureaucracy restructured the academy in order to create a workspace for rocket and missile scientists. This introduces the question of how biophysicists positioned themselves in the Fifth Academy when it was populated by rocket engineers, and also of how they combined discipline building with the politics of scientific collaboration.

The second set of questions is how the Chinese space program contributed to the institutionalization of biophysics. Space and rocketry programs are usually mission-centered whereas scientific disciplines are more research- and teaching-oriented. A mission is a series of short-term operations while research and teaching involve long-term planning. So in what ways did the space program, directly or indirectly, enable the disciplinary growth of biophysics in socialist China?

In other words, the two overarching questions of this chapter concern how biophysicists negotiated their roles in the space program as well as what the space mission meant to biophysics as a discipline.

Mission 581 and "Two Bombs, One Star"

The emergence of IBP in 1958 coincided with one of the most important cross-disciplinary, trans-sectoral missions that ever took place in the history of socialist China.

Instigated by the Soviet launch of Sputnik in 1957, top leaders at CAS such as Zhu Kezhen (竺可桢), Qian Xueshen (钱学森), and Zhao Jiuzhang (赵九章) proposed that CAS should design a satellite project that went along with the military projects on atomic and hydrogen bombs. The then party secretary and vice president of CAS, Zhang Jingfu (张劲夫) conveyed this idea to the central government. The heat from Sputnik triggered a firestorm of research interest on artificial satellites by the Chinese scientists. On May 17, 1958, Chairman Mao announced at the second session of the Eighth Annual Meeting of the National Congress that "we are going to develop artificial satellites" (我们也要搞人造卫星).[132] Within the same month, the state secretariat sanctioned the artificial earth satellite plan. This was the first artificial satellite plan put forth by the Chinese government, and CAS was the major supplier of expertise to execute this project. The project was known as "Mission 581" (581 任务) to denote the fact that it was the mission of first priority devised in 1958.

An artificial satellite was prioritized as the key mission of CAS in 1958. An integral part of the satellite project was to develop sounding rockets (探空火箭). Sounding rockets are the most basic type of missile-based research vehicles. They can carry instruments and animals to the atmospheric and ionospheric strata but cannot penetrate into outer space. Sounding rockets are flown on missions of short duration and are not intended to reach orbit. Compared to the more powerful and advanced launch vehicles such as space shuttles, sounding rockets are not nearly as high tech, but they do have their advantages. They are much cheaper and less risky for geophysical and

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[132] Wang Guyan, *A Biography of Bei Shizhang,* pp. 247-249.

biophysical experimentations at high-altitude. The relatively low cost and low risks make them a popular instrument for upper atmospheric research. Accordingly, before 1968 the National Aeronautic and Space Administration (NASA) recommended that new instruments designed for satellite flight first test themselves on sounding rockets.[133] In other words, sounding rockets are the prerequisites for satellite flights.

In China, Deng Xiaoping was in favor of experimenting with sounding rockets in space research rather than lavishing resources on the more expensive and complex technology of earth satellites. This was captured by a slogan popularized by Deng, "turning thighs to calves, satellites to sounding (rockets)" (大腿变小腿，卫星变探空).[134] In view of the material shortages in the late 1950s, CAS focused on launching two types of sounding rockets, namely the meteorological sounding rockets (气象探空火箭) and the biological sounding rockets (生物探空火箭, hereafter bio-rocketry). IBP was an important and active participant in the bio-rocketry program, along with the Academy of Military Medical Sciences (军事医学科学院) and the Chinese Academy of Medical Sciences (中国医学科学院). The entire bio-rocketry project was supervised by the Fifth Research Academy of the Ministry of National Defense (国防五院, hereafter Fifth Academy) under the leadership of the famous rocket engineer Qian Xuesen.[135]

Here is our first glimpse into the role of biophysicists in the early history of the Chinese space program. Biophysicists were recruited into the bio-rocketry program in

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[133] William Corliss, *NASA Sounding Rockets, 1958-1968: A Historical Summary* (DC: NASA, 1971).
[134] "Turning thighs to calves" is a metaphor that means something akin to "shortening" and in this context refers to reducing expenses in the rocket decision-making process. Song Jian 宋健, ed. *Biographies of Pioneers of 'Two Bombs, One Star' vol. 1 & 2* '两弹一星'元勋传 (上下卷) (Beijing: Tsinghua University Press, 2001), p. 138.
[135] Brian Harvey, *The Chinese Space Programme: From Conception to Future Capabilities* (Chichester: Wiley-Praxis, 1998).

Mission 581, which was never just a civilian science project undertaken by CAS; rather, it was meant to be a joint civilian-military operation from the very beginning. This was evident in the close relationship between CAS and various military departments, most notably the Fifth Academy in Mission 581. Together with the hydrogen and atomic bombs, Mission 581 was part of the large-scale techno-military project called "Two Bombs, One Star" (两弹一星).[136]

Where did this military intervention come from? Technologically speaking, missiles and bombs are inseparable from satellites because a reliable carrying vehicle is the foundation for lifting bombs and satellites off the ground. The Missile is the major apparatus for propelling anything across a long range within a short time. Although atomic bombs, hydrogen bombs, missiles, and satellites are inter-related, developing missiles is the first step. Missiles are a core part of the strategic weapon program. The central unit overseeing the Chinese missile program was the National Defense Science and Technology Commission (NDSTC, 国防科学技术委员会). NDSTC was headed by Marshal Nie Rongzhen (聂荣臻) under the jurisdiction of the Central Military Commission. John Lewis and Xue Litai have related the role of the military-industrial complex in China's nuclear weapon programs.[137] Lewis and Xue told the story of Chinese bomb-making from the perspective of international politics of arms control as well as about the meanings of missiles and nuclear weapons to China's defense

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[136] Science Times 科学时报, ed. *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star'* 请历史记住他们: 中国科学家与'两弹一星' (Guangzhou: Jinan University Press, 1999); also Zhang Jun 张钧, ed. *Aerospace Industry in Contemporary China* 当代中国的航天事业 (Beijing: Chinese Social Science Press, 1986).

[137] John Lewis and Xue Litai, *China Builds the Bomb* (California: Stanford University Press, 1988).

modernization. What Lewis and Xue underlined was the strong military implication of missiles and nuclear weapons.

Most military officers and government ministers welcomed the strategic acquisition of a nuclear arsenal for the sake of national interest. The American nuclear threat was a fundamental driving force behind this strategic decision. Lawrence Freedman once remarked, "no country had been closer to a nuclear attack than the Chinese since Hiroshima and Nagasaki were destroyed."[138] It is therefore understandable that many high-rank revolutionary leaders embraced nuclear weapons for national security. But the focal figures in this chapter are not the military commanders and government bureaucrats as featured in the narrative of Lewis and Xue, but the scientists in the missile–cum–satellite program.

What did CAS scientists think of the strong military presence in Mission 581? The geophysicist Zhao Jiuzhang, who was in charge of launching the geophysical sounding rockets, emphasized the military value of satellites. In a corresponding letter addressed to Zhou Enlai in 1964, he wrote "almost all satellites are related to national defense. The CAS planning proposals for developing China's artificial satellites should also stress the military application of satellites."[139]

What about other scientists at CAS? How did they feel about the civilian-military nexus? It was reported that almost two thirds of all the personnel at CAS were mobilized to participate in "Two Bombs, One Star" at one point.[140] How did these scientists

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[138] Lawrence Freedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1981). p. 276.
[139] Li Chengzhi 李成智, ed. *A Draft History of the Development of Space Technology in China, vol. 1-3* 中国航天技术发展史稿 (上中下册) (Jinan: Shandong Education Press, 2005), p. 611.
[140] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star*,*'* pp. 23-24.

negotiate their roles and interests in this military-dominated program? Was there any jurisdictional dispute between specialists and commanders from different agencies?

Civilian-military conflict in space programs is quite common. Space science and technology is a sophisticated feat of engineering that requires multidisciplinary cooperation between experts, technicians, and administrators. Friction is mostly unavoidable in close interactions among people with heterogeneous backgrounds and values. Scientists are not accustomed to military styles of operation while military personnel are not trained to consider long-term research questions beyond their assigned tasks and missions. Both technical and operational factors are necessary to successfully execute a space program, for a sustainable space program has to carry out both high-risk missions in a timely and safe manner while also transferring some of the military benefits for civilian use. Striking a balance between these multiple factors can be difficult.

The private negotiation between Song Renqiong (宋任穷) and Zhang Jingfu exposed some of the dilemmas in civilian-military cooperation in "Two Bombs, One Star." Song was the bureau chief in charge of China's nuclear industry, first called the Third Ministry of Machine Building (Third MMB, 三机部) between 1956 and 1958, then the Second Ministry of Machine Building (Second MMB, 二机部) after 1958. Zhang was the vice-president of CAS at the time and was a pivotal figure in Lewis and Xue's account.[141] Before CAS and P.R.C. came into existence, Zhang had worked under Song in Communist guerilla battles. During the "Hundred Regiments Campaign" (百万大军过长江) in 1949, Zhang was the deputy commissar of the Anhui province while Song was

[141] Lewis and Xue, *China Builds the Bomb*.

the secretary of the provincial committee and the political commissar. Not only were they colleagues, they were close friends. When "Two Bombs, One Star" was underway in 1958, Song called Zhang's office one day saying that he wanted to make a home visit to go see him. It made Zhang uneasy to have his "older brother" come visit him; Zhang suggested that he should go see Song instead. But Song insisted he had to come to Zhang, not the other way round. Zhang then understood that Song approached him for soliciting support from CAS for the Second MMB. When Song saw Zhang, he dashed over and clutched Zhang's hands, "Jingfu, this is too important a matter. You have to help! I had hoped other departments would contribute, but the major support comes from CAS!"[142] They reached an agreement to transfer the Institute of Nuclear Science originally established in 1950 under CAS over to the Second MMB but maintained its official title as "INS-CAS" in the public domain. INS-CAS was under the dual leadership of CAS and the Second MMB. This arrangement was made to better align the nuclear expertise with the military needs of making weapons, and it represented a military overshadowing of civilian control of nuclear science. Zhang was well aware of the political overtones as he announced to scientists at INS, "After INS was handed over to the Second MMB, I order that you don't have to come to CAS meetings. Go to the meetings at Second MMB."[143]

But Zhang did not always give way to military encroachment. When Liu Youguang (刘有光), commissar of the Fifth Academy, invited Zhang to sit on the party committee of the Fifth Academy, Zhang resisted, realizing that Liu's purpose was to facilitate a further brain drain from CAS to the defense sector. Zhang opined, "I am with

[142] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star,'* p. 24.
[143] *Ibid,* p. 25.

CAS. How can I go to the army? This is not going to work" (我在科学院，怎么到军队? 这不行).[144] Since Marshal Nie also rejected Liu's motion, Liu had no alternative but to drop the idea. Accordingly, Zhang sought to balance civilian-military equilibrium by invoking the analogy of "walking-on-two-legs:"

> I propose (the strategy of) walking on two legs. On the one hand we cooperate with the Fifth Academy. At the same time we carry out our own project here at CAS …Nie agrees with this suggestion. CAS should also carry out missile research because most experts—except the elites that have been transferred to the Fifth Academy—remain in CAS. There are many research institutes in CAS. We have a comprehensive team. Therefore China decides to pursue missiles with two legs (i.e. from two avenues): the first one is the Fifth Academy. It is the central bureau specialized for this task with generous support from the state; another is CAS. We also do research and explorative work. We have our experimental sites.

The "walking-on-two-legs" trope in Zhang's quote is not a random metaphor. It is a widespread figure of speech in socialist China that is employed for striking a balanced relationship between binary opposites such as theory & practice, research & production, and experts & amateurs. It was inscribed in a field report put together by a team of radical American scientists and teachers visiting China in the early 1970s who witnessed the

[144] *Ibid,* p. 35.

grassroots infiltration and mobilization of national campaigns for "the benefit of the people."[145]

Although some socialist enthusiasts later reported their disillusionment with surreally optimistic portrayals of socialist science, not all aspects of socialist science were an ill-constructed Potemkin village. The dual civilian-military coordination and conflict in "Two Bombs, One Star" exemplifies the dialectical mode of incorporating practitioners from separate workplaces into a cooperative platform while retaining their independence. The "walking-on-two-legs" metaphor encourages scientific integration in a dialectical fashion. It is "dialectical" because it manifests the principle of the unity of opposites in dialectical materialism.[146]

The dialectical relationship between scientific organizations such as CAS and military agencies such as the Fifth Academy or the Second MMB is the backdrop against which the biophysicists' contribution to the space program can be critically assessed. It is imperative to remember that like all space endeavors, the Chinese space program is composed of a motley group of practitioners and politicians. It is a site of political struggle where at times one side would cave in for better overall coordination but at other times it strove for harmony and order by synthesizing opposing forces. Biophysicists represented the civilian force from CAS. Examining their interactions with colleagues in the military services such as flight surgeons and rocket designers can reveal more intricate details about the role and responsibility of biophysicists in the Chinese space program.

[145] Science for the People, *China: Science Walks on Two Legs* (New York: Discus Books, 1973).
[146] Loren Graham, "Chapter II Dialectical Materialism: The Soviet Marxist Philosophy of Science," in *Science and Philosophy in the Soviet Union* (New York: Vintage Books, 1974), pp. 24-68.

The Fifth Bureau and the Fifth Academy

Some scholars have attributed the origins of the modern Chinese space–and–missile program to the genesis of the Fifth Academy and the impeccable leadership of the Chinese "Father of Missiles" (导弹之父) Qian Xuesen (or Tsien Hsue-shen). Qian studied under Theodore von Kármán, director of the Guggenheim Aeronautical Laboratory at California Institute of Technology (GALCIT). Von Kármán was lauded as one of the most outstanding aerodynamicists of the twentieth century. Qian's biographer Iris Chang described Qian as von Kármán's favorite student partly because Qian was the only student to whom von Kármán devoted an entire chapter in his autobiography *The Wind and Beyond*.[147] Von Kármán had a high regard for Qian, nominating him for membership in the Scientific Advisory Board of the Air Force in addition to making arrangements to get Qian security clearance to work for classified military projects at Caltech. Qian was ranked as a temporary colonel of the U.S. Air Force in 1945 and became Robert Goddard Professor of the Jet Propulsion Laboratory (JPL) at Caltech in 1950. All the evidence suggested that Qian was an unusually gifted scientist who was invaluable to the U.S. aerospace industry.

Qian's celebrated achievement in aeronautical sciences and his close connection to the U.S. military services made his deportation in 1955 all the more shocking and mysterious. Dan Kimball, executive vice-president and general manager of the Aerojet Corp, warned the U.S. government at the dawn of Qian's departure in the strongest possible terms, "I'd rather shoot Qian than let him leave this country. It was the stupidest

[147] Theodore von Kármán with Lee Edson, "Dr. Tsien of Red China," in *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Space* (Boston: Little Brown, 1967), pp. 308-314; Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1995), pp. 47-60.

thing this country ever did. He was no more a Communist than I was, and we forced him to go…He knows too much that is valuable to us. He's worth five divisions anywhere."[148] Yet Eisenhower agreed to let Qian go at the Johnson-Wang Talks in 1955. Iris Chang characterized the episode as one of "the most monumental blunders the U.S. committed during its shameful era of McCarthyism."[149] Brian Harvey used Qian's deportation to epitomize the benefits China was reaping from America's distrust of Chinese scientists as he passionately argued, "China's most talented scientists were expelled from the U.S. at the very moment that the Chinese political leadership at home was anxious to modernize the country. China unexpectedly and suddenly inherited many of the best scientific experts in the world."[150]

These political discourses surrounding Qian's ungraceful expulsion from the U.S. heightened the analytical interests in how Qian kicked off the beginning of China's modern missile program. As Qian was such a towering figure in missile science, a big part of Chinese modern missile and space achievement was directly attributed to his legacies. The establishment of the Fifth Academy in 1956 was ascribed to his return to China in 1955. Brian Harvey even named the founding occasion of the Fifth Academy—October 8, 1956—as "the birthday of the Chinese space program."[151] Yet one should not use what Qian's departure meant to the U.S. as an *a priori* assumption to assess Qian's contribution to the Chinese space program, for the loss of Qian to U.S. is not necessarily commensurate with the gain of Qian for China. His scientific brilliance and military outreach in the U.S. prior to 1955 is one thing. This stage of his life may or may not have

148 Chang, *Thread of the Silkworm*, p. 200.
149 *Ibid*, p. xiii.
150 Brian Harvey, *The Chinese Space Programme: From Conception to Future Capabilities*, p. 12.
151 *Ibid*, p. 4.

had direct impact on the next stage of his life. We should not allow the political blunder of the U.S. to eclipse a proper analysis of the correlation between Qian and the development of the missile and space enterprise in China.

It is true that the Chinese space program was largely indebted to the organizational efforts of Qian, especially in the early days. Nevertheless, modern Chinese construction of missile and space technology originated in the establishment of the Fifth Bureau of the Ministry of National Defense (国防五局, hereafter Fifth Bureau) on August 9 1956, which predated the establishment of the Fifth Academy. The Fifth Bureau was born out of the lobbying efforts of Marshal Nie. In 1956, Nie submitted a policy outline to the Central Military Committee entitled "Preliminary Views on Establishing China's Missile Research." Drawing from Qian's report "The Construction of Jet and Rocket Technology," Nie proposed that the Committee of Aerospace Industry should set up a missile managerial bureau (导弹管理局). Zhou Enlai accepted Nie's proposal. The resultant bureau was the Fifth Bureau, to be directed by commissar Zhong Fuxiang (钟夫翔). Qian was appointed as the deputy director and the chief engineer of the Fifth Bureau. Under the framework of Fifth Bureau, a missile research institute (导弹研究院) was created and directed by Qian. This was the Fifth Academy. In other words, the Fifth Academy was encapsulated by the Fifth Bureau in the beginning.[152]

The distinction between the Fifth Bureau and the Fifth Academy revolved around institutional responsibilities. The Fifth Bureau was designed as a managerial bureau with an assortment of departments for managing missiles and other defense-related matters.

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[152] Li Chengzhi, *A Draft History of the Development of Space Technology in China*, p. 57.

Besides the Fifth Academy, the sub-units under the administration of the Fifth Bureau included the department of planning, a specialist work unit, the department of armaments, the department of technological cooperation, the department of basic construction, the department of finance, the department of equipment, the department of cadre, the department of administrative and economic management, etc. The Fifth Bureau was located in the former sanitariums of the Central Military Commission and the Department of General Armaments in Beijing.[153] Despite its official status as a research-cum-bureau institute under the joint helmsmanship of Nie and Qian, upon closer inspection the Fifth Academy was just a hollow institutional sub-unit in pressing need of missile and nuclear specialists. Shortly after the Fifth Academy began, Qian filed grievances to Zhong, "are we still going to conduct missile research at all? Are we going to do it or not? If yes, we should expedite the employment process. This cannot be postponed anymore!"[154]

On May 29 1956, Nie convened a meeting in the conference room of the Office of Central Military Commission. The objective of the meeting was to recruit specialists from key scientific agencies to work at the Fifth Academy. Besides CAS, representatives from the Harbin Academy of Military Engineering (HAME, 哈尔滨军事工程学院) and Tsinghua University were also present. Yet the leaders from these institutes were reluctant to transfer their in-house scientists and engineers to the Fifth Academy. General Chen Geng (陈赓) from HAME broke the deadlock by agreeing to dispatch ten engineers from HAME to the Fifth Academy, and other institutes followed suit. Altogether around a hundred engineering students and trainees were seconded to the Fifth Academy.

[153] *Ibid*, p. 75.
[154] Gong Xiaohua 巩小华, *Inside the Decision-Making World of Chinese Space Industry* 中国航天决策内幕 (Beijing: Zhong guo wen shi chu ban she, 2006), p. 17.

Conflicts of interests were evident from these institutional transfers of scientists and engineers. As Gong Xiaohua contended, "nobody is willing to let go of their own specialists."[155]

To streamline the bureaucratic structures of the missile branch, the Fifth Bureau and the Fifth Academy merged into one unit in 1957. The restructured institutional body retained the name "the Fifth Academy." Zhou Enlai issued the decree of Qian's appointment as the director of the amalgamated Fifth Academy. As the incumbent president of the Fifth Academy-cum-Bureau, Qian had heavy administrative duties. To relieve the burden from Qian's shoulders, Air Force commander Liu Yalou (刘亚楼) replaced Qian as the director of the Fifth Academy whereupon Qian was "relegated" to the title of deputy director.[156] As a war veteran, commander Liu was accustomed to day-to-day administrative tasks.[157] This bureaucratic decision allowed Qian to focus on missile research rather than military errands.[158] Qian understood that the institutional arrangement was intended to concentrate ammunition for doing missile and rocket research. In a speech he gave to the corps at the Fifth Academy, he said "our system can effectively integrate and unify our willpower. This is more conducive than the liberalized America for conducting rocket engineering."[159]

In 1937, Qian had joined the "Suicide Squad" along with three other graduate students to experiment with propulsive motors in the deserted periphery of Caltech. The

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[155] *Ibid,* p. 16.
[156] Song Jian, ed., "Qian Xuesen," in *Biographies of Pioneers of 'Two Bombs, One Star' Vol. 2*, p. 283.
[157] Liu Yalou was mentioned in a military writing of Zhou Enlai for his role in taking military stocks for the Air Force in 1950. See "Military Order and Hiring Air Force Consultants" 军事订货与聘请空军顾问, in Zhou Enlai, *Selected Military Writings of Zhou Enlai* 周恩来军事文选 (Beijing: Military Academy of Sciences of People's Liberation Army of China Press, 1997), pp. 3-4.
[158] Gong Xiaohua, *Inside the Decision-Making World of Chinese Space Industry*, p. 29.
[159] *Ibid,* p. 26.

Pasadena approach differed from its aeronautical predecessors with its emphasis on merging theoretical calculation and experimental flights. Contrary to the solitary works of Robert Goddard or Konstantin Tsiolkovsky, the GALCIT rocket research under the directorship of von Kármán was undertaken via teamwork and division of labor. Iris Chang suggested that the collective ethos of GALCIT exerted substantial influences on the later development of aeronautics.[160] As rocketry transformed from an amateur avocation into a scientific profession, the nature of rocketeering changed from individual tinkering into systems engineering. Therefore, Qian's remark on the comparative U.S.-China institutional capacities for pursuing rocketry research was at least partially drawn from his Caltech experiences of using systems oriented thinking to approach aeronautics. But we should ask—do vertically integrated institutions really offer more favorable environments for making missiles and rockets? Since Qian was deliberately comparing the Chinese system with the U.S. model, it seems intuitive to turn to some aspects of the U.S. space history for comparative insights.

Comparative Politics of Civilian-Military Alliance in Space Missions

Space operations are made up of a miscellaneous crew in which nuclear physicists and rocket engineers occupy a more central and exalted place than biologists and life scientists. This is hardly surprising given the fact that a large chunk of the space mission is attached to technical performance. The majority of this responsibility falls upon the shoulders of engineers and physical scientists. Life scientists are usually incorporated into the space program for the purposes of supervising manned operations in space. But this

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[160] Chang, "The Suicide Squad (1937-1943)," in *Thread of the Silkworm*, pp. 68-92.

"life" variable has to wait until the "mechanical" variable is tackled. In other words, only after the aircraft can be successfully lifted off the ground can anyone consider how to put living things into the capsule.

Since engineers and technicians dominate the space mission, the role of biomedical scientists at this stage is usually marginalized. The politics of resource competition and adversarial relationships between biomedical specialists, physical scientists and administrative officers in NASA Manned Space Program has been captured by John Pitts.[161] In NASA, life science as a discipline was perceived as subordinate and secondary to the agency's major space programs from the very beginning. NASA's first administrator T. Keith Glennan created the biomedical team as an adjunct to the Space Task Group rather than as an independent unit. After that, there was no direct effort to convert the adjunct division of life sciences into a permanent office. Nor was there political will to appoint a life scientist to a high-level deliberative position.

The marginalization of biomedical science led to internal factionalism among clinicians and technicians in the Space task force. As Pitts suggested, "the subordination and decentralization of the life sciences…would preclude the interaction among biologists, medical scientists, and the clinicians that is normal in biomedical research setting…many scientists questioned NASA's ability to provide adequate biomedical support for manned spaceflight."[162] NASA decision-makers reluctantly set up a Life Sciences Advisory Committee in preparation for the Mercury project, yet a staff report

[161] John Pitts. *The Human Factor: Biomedicine in the Manned Space Program to 1980* (DC: NASA, 1985).
[162] *Ibid,* p. x.

concluded after the Mercury operation that “NASA was underestimating the importance of biomedicine.”[163]

The domination of engineers in NASA top management is a primary reason for the lack of significance assigned to life science in the space program. But it also has a lot to do with the turf conflict over space biology (or space life sciences) between NASA and the U.S. Air Force. In many ways, the Air Force was ahead of NASA in its acquired capabilities of space biomedicine, in part because the Air Force antedated NASA in developing aviation medicine after WWII. As Maura MacKowski argued, “space medicine came into being as the product of several factors: first and foremost, the development of aviation medicine into a recognized professional specialty.”[164] The boundary between aviation medicine and aerospace medicine is not a scientific one, but a political one. During the interwar period, aviation medicine was under the exclusive control of the military services as aviation medicine was inseparable from combat medicine and flight surgery.[165] Space biomedicine lies somewhere along the military-civilian continuum. Essentially, the Air Force accounted for a sizable part in the professionalization of aerospace medicine in the U.S.. After NASA was founded in 1958, the Air Force continued to gain preeminence on biomedical expertise in orbital and sub-orbital spaceflight operations. The hesitation of NASA administrations to authorize an official and coherent life science program within the agency aligned with the Air Force’s political preference. Accordingly, the Air Force took concrete steps to prevent NASA

[163] *Ibid,* p. 16.
[164] Maura Philips MacKowski, “Human Factors: Aerospace Medicine and the Origins of Manned Space Flight in the U.S.,” PhD dissertation, Arizona State University, 2002, p. 2.
[165] For example, the first professor of aviation medicine, Hubertus Strughold maintained that the distinction between aeronautical and astronautical flights was as artificial and misleading as that between space and atmosphere. For Strughold, space medicine is a logical extension of aviation medicine. See “Hubertus Strughold and Avaiation Medicine in Germany, 1927-1945,” in MacKowski, “Human Factors,” pp. 79-140.

from strengthening its own biomedical facilities. For example, the Air Force teamed up with their lobbyists in the Congress to deny NASA funding for building an in-house biomedical program. As Pitts related, "a major expansion of in-house capabilities in the life sciences (at NASA) ran directly counter to the aspirations of the Air Force."[166] NASA did create a Division of Life Sciences in the mid-1970s but it "did not lead to a truly integrated life science program."[167] "How biology fits into and interacts with larger systems" remained a challenge in NASA well into the 1980s if not later.[168]

The clash between NASA and the Air Force crystallized the abrasive relationship between civilian agencies and military services in pursuing space-related sciences. The problem was further intensified by the historical contingencies that shaped the creation of NASA. In spite of Eisenhower's rhetoric of separating civilian space exploration from military activities, NASA was founded primarily not for scientific exploration but with the explicit goal of "beating the Soviets."[169] It was international politics rather than domestic scientific interests that gave rise to NASA. For this reason, John Pitts was conscious of the fact that "NASA was not primarily a science agency; it demanded a form of organization and management that reflected space program objectives and capabilities rather than scientific priorities alone."[170]

That NASA is a non-scientific construct disguised as a civilian agency complicates the recruitment of life scientists in its civilian space programs. If NASA was an ordinary scientific organization like the NSF or the NIH, efforts to launch a life-

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[166] Pitts, *The Human Factor,* p. xi.
[167] *Ibid*, p. 182.
[168] *Ibid*, p. 208.
[169] Wang Zuoyue, *In Sputnik's Shadow: The President's Science Advisory Committee and Cold War America* (New Jersey: Rutgers University Press, 2008), p. 99.
[170] Pitts, *The Human Factor,* p. 176.

science-oriented program would have met less resistance. However, NASA was not an agency designed to advance science for the sake of science. Hence, how to coordinate the biomedical team in a decentralized political culture while maintaining the agency's priorities to fight against the Soviets remained a headache.

In the previous section, I revealed some of the dialectical relationship between the civilian unit and defense sectors in China. It is noteworthy that the history of CAS is longer than that of NASA. Unlike NASA, CAS was created not with the doctrine of international combat in mind but with the objective of promoting domestic science and technology for national modernization. Thus, there had already been a cadre of scientists in basic research when the grandeur of Sputnik stunned the world in 1957. It is true that the overall scientific horsepower and facilities in China were not on a par with those in the U.S. in the 1950s but Chinese scientific brainpower was by and large concentrated in one centralized agency. Consequently, the Second MMB from the Ministry of Defense had to recruit and borrow from CAS for Mission 581——just as Marshal Song insisted on approaching Zhang, the deputy director of CAS, and not the other way around——because CAS was the national storehouse of scientific experts and expertise.

While the transfer of space-related scientists flowed from the civilian agency to the military sector in China, the reverse happened in the U.S.. The Air Force was the major employer of specialists in sciences pertaining to airpower and aviation services in the post-war U.S.. The monopoly of aviation medicine by the Air Force (and Army to a lesser extent) stemmed from the triumph of the U.S. as an air super-power in the Pacific battlefield. As MacKowski noted, "WWII turned aviation medicine into a combat mode."[171] It showcased the military prowess of the U.S. in the international aerosphere when "aviation medicine in Japan (and Asia in general) was well behind that of Germany or the U.S. during WWII."[172] The predominance and pre-existence of the Air Force outstripped NASA in biomedical capabilities for space operations. NASA was founded "in Sputnik's shadow"[173] while the military superintendence overshadowed the civilian control of space research. This specific civilian-military organizational arrangement was as much a historical happenstance as an institutional outcome of the decentralized responsibilities for undertaking R&D activities in the decentralized public system of accountability in the U.S. political culture.

Existing evidence suggests that a decentralized political system is not always conducive to optimize federal coordination. When there is a dire need for directing instrumental actions, a central unit of authority has the advantage of mobilizing resources and enforcing discipline in large-scale projects that require seamless cooperation among multiple agencies. The subordination of life scientists in NASA's space operation illustrates this point. In the late fifties and early sixties, U.S. biomedical capabilities for space operations were dispersed among different agencies and the related activities in aviation physiology were largely uncoordinated. Dr. Randolph Lovelace II, a reputable flight surgeon who chaired the pilot selection committee for Project Mercury, urged "a coordinated national program of research in space biology and medicine."[174] Building on Lovelace's opinion, an external advisory committee under the chairmanship of Dr.

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171 MacKowski, "Human Factors," pp. 141-187.
172 *Ibid*, p. 144.
173 "In Sputnik's shadow" is the book title of Wang Zuoyue. Wang used the metaphor to convey his thesis of a new storm of technological enthusiasm in Sputnik's aftermath. Wang Zuoyue, *In Sputnik's Shadow: The President's Science Advisory Committee and Cold War America* (New Jersey: Rutgers University Press, 2008), p. 99.
174 Pitts, *The Human Factor,* p. 10.

Seymour Kety from NIH issued a report pushing for a pro-integration view in managing NASA's biomedical programs. The "Kety's report" in 1960 recommended a "maximum integration of the personnel and facilities applicable to the space-related life sciences in the military services and other Government agencies."[175] The advisory report highlighted the lack of coordination between civilian agencies and military services in pursuing space biosciences. There were demands for a centralized life science division both inside and outside of NASA in the late sixties. In 1970, NASA had to address the widespread dissatisfaction and inefficiencies of its adjunct life science task force by programmatic restructuring. John Pitts saw the reorganization of NASA's biomedical program in 1970 as a reflection of "the value of centralized coordination of life science programs."[176]

The operational merits of centralized statecraft were presciently identified in seventeenth-century England by Thomas Hobbes, who maintained that "centralized definitions of reality are more effective and reliable as means of settling social disputes than decentralized definitions of reality which are based on collective witnessing."[177] Boyle's experimental philosophy would dominate the Anglo-American political tradition for the next three centuries while Hobbes's hortatory advice of the strength of having a strong sovereign to avert *bellum omnium contra omnes* (the war of all against all) was buried in his treatise *Leviathan*. Recently, however, there is revived interest in assessing the relevance of Hobbesian moral and political philosophy to contemporary political affairs. Hobbes's disagreement with Boyle three centuries ago continues to matter given the ongoing difficulties of guaranteeing public order and securing global peace in the

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[175] Mae Mills Link, "chapter 4 NASA Long-Range Life Sciences Program: The Kety Committee," in *Space Medicine in Project Mercury* (DC: NASA, 1965), available on <history.nasa.gov>.
[176] Pitts, *The Human Factor,* p. 175.
[177] Ezrahi, *The Descent of Icarus,* p. 93.

twenty-first century.[178] Hobbes's shrewd observation of the advantage of having an absolute sovereign to arbitrate disputes in the seventeenth century anticipated the need for having a centralized coordination of life science components at NASA in the 1960s.

The U.S. data was a test case for our inquiry in China. The historical circumstances of U.S. civilian-military struggles in the context of Anglo-American political philosophy were intended to sharpen the consideration of the role of biophysicists in the Chinese space program mediated by Chinese political culture.

Historical Context of Chinese Political Culture

The above historical juxtaposition of the space program and statecraft is intended to bring into perspective the interactions of biology-related experts in Chinese space operations. While the decentralized political structure in the U.S. could weaken the capabilities of federal cooperation and national deliberation, the centralized state in China had the bureaucratic capacity to offer a vertically integrated system for managing space activities. Did the Chinese centralized system really offer examples of better practices for disciplinary integration?

Skeptics would probably point to the infamous Anti-Rightist campaign that began in 1957 as counter-evidence. The mainstream characterization of the Anti-Rightist campaign is that it was mainly a hysterical witch-hunt against the "rightists" or "reactionaries" whom the Communist government unreasonably and unfairly identified as "enemies of the people" and severely punished with labor reeducation, imprisonment,

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[178] For example, see Luc Foisneau and Tom Sorell, eds. *Leviathan after 350 Years* (Oxford: Oxford University Press, 2004) and David Armitage, "Hobbes and the Foundations of Modern International Thought," in Annabel Brett et al., eds. *Rethinking the Foundations of Modern Political Thought* (Cambridge: Cambridge University Press, 2006), pp. 219-235.

or exile.[179] What triggered the Anti-Rightist campaign was the preceding "Double Hundreds" movements (The Hundred Flowers and the Hundred Schools Movements) in which Mao legitimized the view that science had no class character following the speech made by the director of the Central Propaganda Department, Lu Dingyi (陆定一).[180] Many saw Mao's rhetoric as a way to smoke out intellectuals with bourgeois ideologies. Mao's wariness against intellectuals intensified when some scientists publicly stated that "the Communist Party does not know science and it cannot lead scientific work"(共产党不懂科学，不能领导科学工作), and that "the leadership of the Communist Party is not beneficial for scientific development" (共产党的领导对科学发展没有好处).[181] Met with these explicit outcries of direct challenge to the ruling authority of the party rather than constructive suggestions of policy advice, Mao took actions to crackdown "those who had misunderstood the limits of the earlier invitation to debate" as the erstwhile diplomat Henry Kissinger aptly described.[182]

Some attributed the cause of the Anti-Rightist campaign to Mao's distrust and resistance against those who were more knowledgeable than he.[183] Mao's personal caprices and insecurity notwithstanding, the extent of the impact of the Anti-Rightist campaign has been disputed. Zuoyue Wang reckoned that around 300,000 people were

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[179] Zuoyue Wang, "Physics in China in the Context of the Cold War, 1949-1976," in Helmuth Trischler and Mark Walker, eds. *Physics and Politics: Research and Research Support in Twentieth Century Germany in International Perspectives* (Franz Steiner Verlag, 2010), p. 265.
[180] Hu Huakai 胡化凯, ed., *A Selected Collection of Documents on Animadvert on Science in China During 1950s-1970s vol. 1*20 世纪 50-70 年代中国科学批判资料选(上). Jinan: Shandong Education Press, 2009), p. 33.
[181] *Ibid*, p. 37.
[182] Henry Kissinger, *On China* (NY: Penguin Press, 2011), p. 182.
[183] Hu Huakai, *A Selected Collection of Documents on Animadvert on Science in China During 1950s-1970s Vol. 1,* p. 40.

branded as "rightists" whereas one source put that figure at 550,000.[184] The scope of influence on scientists at CAS was even more uncertain. It is true that some scientists were sent off to labor camps or criticized in one way or another,[185] but there were also explicit guidelines that demarcated the treatment of scientists—particularly those with significant achievement——from that of social scientists. For example, one policy document granted special prerogative to natural scientists during the Anti-Rightist struggle: "...the Anti-Rightist struggle in the scientific sector should not be carried out in the same fashion as in social sciences. Anyone with significant achievements or those who returned after the Geneva conference should be protected." [186] A few historians of rocket technology in China interpreted this policy as ensuring that a group of outstanding but 'problematic' scientific practitioners could continue to work on atomic bombs and missiles.

Merle Goldman has offered her views on various reasons behind the exemption of scientists from the spate of political attacks in twentieth-century China. The boundary between scientific and nonscientific intellectuals is one crucial factor. That science was perceived as less ideologically subversive was captured by the belief that "because scientists worked with slide rules and equations, their work was ostensibly less related to political issues than was that of writers and social scientists which, by its very nature,

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[184] Wang, "Physics in China in the Context of the Cold War, 1949-1976," p. 256; Hu, ed. *A Selected Collection of Documents on Animadvert on Science in China During 1950s-1970s vol. 1*, p. 40.

[185] Yao Shuping, "Chinese Intellectuals and Science: A History of the Chinese Academy of Sciences (CAS)," *Science in Context* 3, no. 2 (1989): 455.

[186] Liu Jifeng, Liu Yanqiong, and Xie Haiyan 刘戟锋, 刘艳琼, 谢海燕. *The Project of 'Two Bombs, One Satellite:' A Model of the Big Science* 两弹一星工程与大科学. Jinan: Shandong Education Press, 2005), p. 122.

challenged political control."[187] Besides the perception of science as politically neutral, differential attitudes towards scientists were associated with the pragmatic value science afforded to modernization and production. Even at the revolutionary height of the sixties, Goldman argued that Mao "wanted to shield [scientists] from the kind of violent attacks that hit nonscientific intellectuals."[188] Although the line separating scientists from nonscientists became fuzzier as the Cultural Revolution kicked into high gear, it is fair to say that scientists in general were not reviled on the same scale as nonscientific intellectuals.

Moreover, historical studies of individual institutes at CAS reveal that scientists from the specific institutes under examination suffered relatively less than the general body of CAS during the Anti-Rightist campaign. Both Zuoyue Wang and Sigrid Schmalzer contended that scientists at their respective institutes of investigation—namely the Institute of Physics and the Institute of Vertebrate Paleontology and Paleoanthropology—did not suffer as much compared to their colleagues from other institutes at CAS.[189] It seems that the negative impact of the Anti-Rightist campaign on the science sector should be evaluated on the specific level of individual research institutes rather than the generic level of CAS.

How did the scientific and engineering crews recruited in "Two Bombs, One Star" fare in the ostensibly anti-intellectual, anti-scientific political atmosphere of 1958? Some Chinese historians of combat and military sciences have argued that various

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[187] Merle Goldman, *China's Intellectuals: Advise and Dissent* (Cambridge: Harvard University Press, 1981), p. 136.
[188] *Ibid*, p. 138.
[189] Wang, "Physics in China in the Context of the Cold War, 1949-1976;" Sigrid Schmalzer, *People's Peking Man: Popular Science and Human Identity in Twentieth-Century China* (Chicago: University of Chicago Press, 2008).

political movements in the twentieth century had relatively minor impact on the conduct of "Two Bombs, One Star" because of its political significance. Since "Two Bombs, One Star" was presented as a matter of national security, it was packaged primarily as a political mission rather than as a scientific instrument. As Li, Liu and Xie incisively argued, "the project 'Two Bombs, One Star' figured high on the priority list of key political leaders because it was mainly considered as a (scientific) tool for achieving political ends. The project was given privileged treatment in many ways. This is why the project can be pushed forward successfully in the midst of the unstable political environments."[190] Or as Lewis and Xue summarily remarked, "China accommodated its technology to politics, rather than the other way around."[191]

This perspective was further corroborated by another veteran in the history of China's aerospace industry. Besides concurring with the previous points on national priority and determination to advance missiles research, Zhang Jun (张钧) approached the relationship between political tumult and the space program with an appraisal of the political trustworthiness of intellectuals in space sciences:

> From the latter half of the fifties to the antecedence of the "Cultural Revolution," the "leftist" ideological inclination led to discrimination against scientific practitioners, depreciation of knowledge, and distrust of intellectuals. These behaviors were seen as expression of a "strong standpoint of class conflict." Yet the circumstances were different in the aeronautic frontier…Party leaders and cadre members from various ranks

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[190] Liu, Liu, and Xie, *The Project of 'Two Bombs, One Satellite:' A Model of the Big Science*, p.123.
[191] Lewis and Xue, *China Builds the Bomb*, p. xviii.

> at the aeronautics outpost share a conception over time that rockets and orbital satellites are inseparable from intellectuals.[192]

It is interesting to note that Zhang Jun was not a China watcher from the outside, but an informed insider himself. He was the deputy director of the Seventh Ministry of Machine Building (Seventh MMB) between 1964 and 1968. The Seventh MMB was created in 1964 as the chief institutional body to oversee all bureaus in space science and technology, including the Fifth Academy. The Seventh MMB was the central unit in charge of the research, design, testing, manufacture, and management of missiles and rockets.[193] The Seventh MMB was renamed the Ministry of Aerospace Industry in 1982 and Zhang Jun was appointed as the director. Familiar with the military-civilian alliances in space operations, Zhang acknowledged that the space sector was inevitably involved in the array of political struggles in the second half of the twentieth century; yet Zhang also highlighted the extraordinarily high level of respect and care cadre leaders displayed towards intellectuals in the space industry. It is true that the revolutionary fervor did spread to the space sector, but party officials were highly concerned about the pragmatic reliance upon scientists for the research and manufacture of rockets and satellites—for these instruments were directly linked to national interests. Premier Zhou Enlai articulated the imperative of using advanced science and technology to consolidate national defense as a state priority in 1956.[194] The discourse paved the way for his later effort to insulate rocket scientists and engineers in the Seventh MMB from the attacks of

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[192] Zhang Jun, ed., *Aerospace Industry in Contemporary China* (Beijing: Chinese Social Science Press, 1986), pp. 482-483.
[193] *Ibid*, p. 494.
[194] Zhou Enlai, "Only With Advanced Science Are We Able to Consolidate National Defense"只有掌握先进的科学，才能有巩固的国防 in *Selected Military Writings of Zhou Enlai*, pp. 370-371.

radical factions by maintaining that the testing and launching of rockets is a matter of national security and reputation, and that anybody who interferes with the process is a traitor.[195]

Besides the Anti-Rightist campaign, the year 1958 is overcast with another political cloud that loomed over large-scale engineering projects; the ambitious Great Leap Forward was the next anthropogenic storm awaiting to unleash its calamity. Between 1958 and 1960, revolutionary optimism and production overestimation took a heavy toll on Chinese population. The extent of causality was compounded by the subsequent famine and an untimely drought. Judith Banister suggested that more than thirty million people died during the Great Leap Forward.[196]

The policy failure swiftly turned into an economic impasse. What is known as the "three hard years" forced the decision-makers in Beijing to put many state-led modernizing projects on hold. Much controversy flared up around the space-related projects, which were perceived as serving no immediate needs for the people's well-being. Whether to "continue" (上马) or to "abort" (下马) Mission 581 was a much disputed matter at the Bei Dai He Conference of National Defense and Industry (北戴河国防工业会议). As the principal architect and national advocate of 'Two Bombs, One Star,' Marshal Nie found himself besieged by an assembly of conference participants who were opposed to the continuation of the space program. Many of them felt that China simply could not afford such a lofty project with a flimsy connection to the sufferings on earth. The issue was brought to the Politburo and Central Military

[195] Li Chengzhi, *A Draft History of the Development of Space Technology in China*, p. 343.
[196] Judith Banister, *China's Changing Population* (California: Stanford University Press, 1987).

Commission meetings at Mount Lu in the summer of 1960 where it attracted the attention of Chairman Mao.[197] In the past, Mao had tauntingly called nuclear threats and atomic weapons "paper tigers" that were subordinate to what was fundamentally a "people's war."[198] Nonetheless, he understood the strategic implications of space research for advanced technology and national security. One does not need to be a space enthusiast to appreciate the fact that controlling space is a military asset for overseeing operations on the ground. Mao therefore endorsed project 'Two Bombs, One Star' in spite of the dissension from the party. As Mao proclaimed, "we must make up our minds to develop cutting-edge technology. We cannot cut back or abort" (要下决心搞尖端技术,不能放松或下马).[199] Mao's declaration is a manifesto of the national determination to pursue advanced science and technology regardless of financial realities. Some might call it an irresponsible or undemocratic policy that was achieved at the peril of public welfare. This is certainly one way of looking at the picture; another perspective posited that there are always some economic excuses or social opposition to hold back the development of basic science. Socialist China between 1958 and 1960 was arguably not the perfect time for launching space programs in view of the enormous domestic difficulties. But if the space program had to be postponed until every hungry person had been fed, it could take forever. From this standpoint, the political resolution to continue the space program gave it the necessary push to stay the course. The technocratic cliques in the party welcomed Mao's decision. His stubbornness translated into a national pertinacity to unify the space coalition.

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[197] Gong Xiaohua, *Inside the Decision-Making World of Chinese Space Industry*, pp. 62-63.
[198] Lewis and Xue, *China Builds the Bomb*, p. 242.
[199] Zhang, *Aerospace Industry in Contemporary China,* p. 16.

In short, the macro-political atmosphere of 1958, despite being haunted by anti-intellectual biases and budgetary constraints, was actually favorable for conducting space missions. True, the Anti-Rightist campaign and post-Great-Leap-Forward material shortages continued to cloud the space program. Yet the high priority bestowed upon the space program in general provided a strong political impetus for the actualization of space initiatives.

Biophysics and Mission 581

The political tone was settled——for the time being at least—as the space mission unfolded in earnest. In the foregoing paragraphs, I have briefly noted that biophysicists took part in Mission 581. I have also explored the nuanced dynamics between CAS and the military sectors. The complex civilian-military interactions offered the backdrop against which the role of biophysicists could be assessed. But what was the exact responsibility of biophysicists in Mission 581? And how did Mission 581 transform biophysics?

Mission 581 was organized to undertake the research and production of artificial satellites and sounding rockets. Researchers, experts and engineers from five sectors were enrolled in the planning and execution of Mission 581. Besides CAS and the Fifth Academy, workers, practitioners, and volunteers were mobilized from industrial sectors, higher-education institutions, and local research organizations to facilitate the project.[200] The tactic was to commission a "big corps" (大兵团) to manage an unimaginably

[200] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star*,*'* p. 14.

monumental task. It was a strategy of employing mass efforts to overcome extraordianry obstacles.

The reliance on collective strength and willpower was not just a legacy of the Great Leap Forward but also an emerging paradigm of science in socialist China. One of the principal proponents of this collectivized mode of operation was Marshal Nie, who endorsed the means of using centralized power for national coordination.[201] In this model, the ideology of self-reliance aligned with the principle of national cooperation to inform the general policy for science and technology in socialist China. For example, a similar big corps was set up in 1960 to create synthetic insulin under Mission 601.[202] The resultant synthetic bovine insulin with high vitality was lauded as a socialist achievement to crack the code of life.[203]

The “big corps” style of management symbolized the myriad of participating units in Mission 581. The Institute of Biophysics was part of the CAS team, but the participation and contribution of biophysicists should not be blown out of proportion to obscure the collective character of the mission. Among the CAS alliances in Mission 581 were the Institute of Mechanics, the Institute of Electronics, the Institute of Biophysics, the Institute of Geophysics, the Institute of Automation, the Institute of Physics, etc.

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[201] Zhang, *Aerospace Industry in Contemporary China,* pp. 490-491.

[202] Xiong Weimin, Wang Kedi 熊卫民, 王克迪, *Synthesize a Protein: The Story of Total Synthesis of Crystalline Insulin Project in China* 合成一个蛋白质:结晶牛胰岛素的人工全合成, (Jinan: Shangdong Education Press, 2005). However, the authors gave a negative portrait of the ‘big corps’ mode of administration in synthesizing bovine insulin. They argued that the successful synthesis of protein depended on delicate laboratory skills rather than the crude enthusiasm of volunteers. The ‘super big corps’ (特大兵团) was later broken down and only the trained and sophisticated laboratory scientists were allowed to stay. It was these biochemists and pharmacists that finally rescued the project. They concluded that Mao’s strategy of relying on the masses was not suitable for every line of work in science and technology.

[203] “China Achieves World’s First Total Synthesis of Crystalline Insulin,” and “Use Mao Tse-tung’s Thought to Open the Gate to ‘The Enigma of Life,’” *People’s Daily* January 1, 1967.

Scientists and engineers from CAS rallied a primarily research-, academic-oriented force for Mission 581. Within the CAS squad, the Institute of Biophysics was charged with the task of launching biological sounding rockets while the Institute of Geophysics under the leadership of Zhao Jiuzhang was charged with the making of geophysical sounding rockets.

Under the chairmanship of Qian Xuesen and the vice-chairmanship of Zhao Jiuzhang and Wei Yiqing, three institutes for general rocketeering were founded in 1958, namely the 1001 Institute of Satellites and Overall Design, the 1002 Institute of Control System Design, and the 1003 Institute of Satellite Payload Design. Of these, the 1001 Institute was the major apparatus responsible for the supervision of sounding rockets, which were non-orbital, non-recoverable small rockets that were intended for probing into the upper atmosphere for research purposes. Therefore, ground control, tracking and recovery—specialties of the other two rocket institutes—could be kept to minimum. The 1001 Institute was the chief partner unit working closely with the Institute of Biophysics and the Institute of Geophysics in launching the biological and meteorological sounding rockets respectively.[204]

The 1001 Institute was also known as the Shanghai Institute of Machine and Electricity Design (SIMED, 上海机电设计院) jointly administered by the Shanghai municipal government and CAS. Engineers from SIMED provided the mechanical shell while scientists from CAS determined the ends to which these probing rockets would be put. The partnership between SIMED and CAS worked this way: SIMED supplied rocket

[204] Brian Harvey, *The Chinese Space Programme*…pp. 1-12; Science Times, ed., *May History Remember Them*…pp. 176-186.

engineers and material physicists to design the hardware backbone of the rockets while scientists from CAS were left to take care of the interior systems and information-retrieval functions of the sounding rockets. The close cooperation between SIMED and the Institute of Geophysics revolved around the assemblage of a meteorological sounding rocket for the purpose of studying the geophysical phenomena of the upper atmosphere. SIMED handled the engines and the types of fuels for firing the rockets while the geophysicists figured out what kind of barometers should be used to measure the atmosphere's pressure, density, temperature, wind, speed, and direction.

As for the biological sounding rockets, SIMED basically recycled the same type of missiles and fuels (T-7 rockets with two stages of liquid-fuel and solid-fuel) that they had previously tested on the earlier sounding rockets for meteorological exploration. After several successful runs with the radar and sensor-carrying sounding rockets, the biophysicists joined the crew to experiment with the idea of carrying a payload of living creatures to the upper atmosphere. This is the origin of the biological sounding rocket in Mission 581, for which the objective was not weather forecasting but the physiological measurement of the effects of rocket flight and space travel on living organisms. Biophysicists were invited to join the team in order to expand the scope of sounding rockets beyond meteorological applications.

As biophysicists were assigned a biological space mission, two puzzling questions stood out. First, why was the IBP picked for overseeing biological rocket flights? The IBP was in no way the only biology-related institute under CAS for exploring the biological dimensions of space travel. In fact, IBP had just been inaugurated in 1958. Considering the newness of the institute and its staff, why would Chinese mission planners think IBP was capable of doing high-altitude biological testing? Secondly, how did IBP align itself for a task that fell more appropriately into the specialties of aviation medicine and space biology rather than biophysics? How did biophysics and biological rocketry find each other?

The answer is that biophysicists sought biological rocket designers out, not the other way around. The delegation of biological rocketeering to IBP was not a top-down decision from the central authority but a result of an unsolicited proposal from Bei Shizhang—director of the newly established IBP. Bei submitted a formal proposal to the CAS board of planners in May 1958.

In this policy document, Bei convinced his comrades of the capabilities of IBP to conduct high-altitude biomedical research.[205] Since biophysics was still a disciplinary blank slate, it offered more room to make the necessary preparations for a mission that required not just considerable expertise in atmospheric physiology but also seamless coordination with other units, primarily SIMED, in the design of the cockpit layout and life-support system in the flying capsule. Bei felt that IBP was up for this challenge due to the very interdisciplinary nature of biophysics. The launching of biological rockets incorporated in one flight both the physical aspect of testing rocket propulsion on factors of acceleration and deceleration and the biological aspect of measuring atmospheric effects on vital functions. Whoever ended up with the job would need knowledge in space flight and animal experimentation to satisfactorily execute the bio-rocketry mission.

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[205] Wang Guyan, *A Biography of Bei Shizhang,* pp. 247-249.

It would have been difficult to predict that the very same Bei Shizhang whose doctoral expertise was in experimental cytology would be entrusted with a mission in high-risk space biology. Bei had no proper training in rockets and aviation medicine. He was equipped with knowledge to deal with the smallest enigma of life but not the big question of flying animals into space. Neither Bei nor IBP under his leadership was the best candidate for the biological sounding rockets. But neither was anyone else in the rest of the nation. When Qian Xuesen returned to China in 1955, he saw the bleak reality that he had to do everything from scratch. Post-war China was at ground floor when it came to missile production and aerospace engineering. There were no launching pads, no observation consoles, no testing sites for any high-altitude task. Nor was there an existing pool of "missile-conscious" scientists in China.[206] There weren't a lot of "rocket-conscious" biologists for mission planners to choose from. Given the full extent of technological backwardness of postbellum China, delegating the bio-rocketry mission to a new institute with no existing space specialists was not necessarily an ideological decision.

IBP was not the sole contractor for flying biological sounding rockets. It was to share the obligation with two other institutes, namely the Academy of Military Medical Sciences and the Chinese Academy of Medical Sciences, both under the jurisdiction of the Ministry of Defense. It is worth mentioning that the equipment and manpower for military biomedical research in China were nowhere near the caliber of that in the USSR or the USA in late 1950s. The Air Force of the People's Liberation Army did not have a strong team of aviation surgeons and combat clinicians after WWII as China did not

[206] Chang, *Thread of the Silkworm*, pp. 191-198.

emerge as a post-war super air power. In the 1950s, many Chinese scientists and engineers with very little or no former training in rocket engineering signed up to be chief engineers and supervisors for managing 'Two Bombs, One Star.' For example, Wang Xiji (王希季) and Yang Nansheng (杨南生) reportedly knew little about rockets and satellites when they were appointed as director and deputy director of SIMED respectively. Wang recalled that everyone felt they were "crossing the river by feeling the stones."[207] Laymen transformed into experts as they learned about aerodynamics and biomedical aviation in the field with hands-on experience. In short, it was plausible and sensible for IBP to be chosen to direct the bio-rocketry mission in view of the crude conditions in mid-century China.

But why did Bei want to venture into the risky and esoteric field of space biology? What could biophysics possibly gain from sending animals into space? Bei's hope was to strategically drive the disciplinary growth of biophysics by completing a state-led mission. He was inspired by the prevailing slogan of "using mission to drive discipline" (任务带学科). The idea was to take core political missions as the organizing principle to coordinate all relevant disciplines and sub-disciplines in a systemic fashion. An editorial of *People's Daily* contended that "the research method of using mission to drive discipline has a clear objective of mobilizing mass interests. It is easy to organize, and also an important means of developing science." (任务带学科的研究方法,不仅目标明确, 鼓起干劲, 便于组织, 也是发展科学的一个重要手段) [208] More importantly, the

[207] Science Times, ed., *May History Remember Them...*p. 181.
[208] Mao Yisheng 茅以升, "The Science of Railroad Research in the Great Leap Forward" 跃进中的铁道科学研究工作 *People's Daily*, January 16, 1959.

deputy director of CAS, Zhang Jingfu, a close friend to Bei, also advocated the means of using political missions to drive disciplinary development. As Zhang elaborated,

> there were many positive aspects of driving disciplines with missions: 1) the research objective is clearly identified with a close correlation between theory and practice; 2) the details are concrete enough to draw mass support; 3) mission is like a red thread that connects all the beads of specialized knowledge together, with strong organizational vitality; 4) people with high and low operational levels could benefit from each other to enable public participation in science research activities.[209]

Even though rocket research and space administration were no longer carried out by IBP after Mission 581 was over, the bio-rocketry mission was important for the long-term disciplinary development of biophysics. The participation of IBP in the bio-rocketry program was important to IBP in at least two ways. First, the close collaboration with the Defense Ministry helped protect the scientists within IBP against revolutionary criticisms and persecutions. Although the army was not an absolute sanctuary for scientists, compared to the majority of scientists in CAS, scientists in IBP were rather well protected. This is evident from the first meeting of the division of biological sciences in 1979. The then chairman of the biological division, Tong Dizhou, also the vice-president of the CAS, died accidentally that year when he was giving a speech in Hangzhou University. The absence of Tong put Bei in charge of charing the meeting. Before 1966, there were sixty committee members in the biological academic division; the number

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[209] Zhang Jingfu 张劲夫, "The Great Leap Forward in Science Activities Should Be Pushed Forward" 科学工作的大跃进需要向前推进一步 in Zhang Zhihui 张志辉, *Selected Literature on China's Great Leap Forward in Science and Technology*, *vol. 1* 科技'大跃进'资料选（上) (Jinan: Shandong Education Press, 2009), p. 55.

dropped to 36 when the first meeting in biological academic division was re-summoned after the Cultural Revolution in 1979. Over half of the members were from the IBP.

Secondly, it is not an overstatement that the close collaboration offered the financial support and legitimation for this new discipline to flourish. Between 1958 and 1960, IBP received a special subsidy from the Defense Ministry to purchase new equipment. From 1958 to 1966, IBP-CAS was heavily involved with national military programs in rockets and missiles. The peak of its engagement with the techno-nationalistic program in Maoist China was its central role in the launch of biological rockets, T-7A (S1 and S2) between 1963 and 1966. The first bio-rocket T-7A (S1) was successfully launched in July 1964. T-7A weighed 1145 kg and stood 10.32 m tall, carrying 40 kg of payload and reaching 115 km.

On July 14, 1966, a male dog named Xiao Bao (小豹) was clad in a protective garment installed in a biological cabin equipped with a life-support system, a shock absorber, a safety belt and a waste container, along with recording and electronic control devices in the T-7A (S2) rocket and was projected into the ionosphere. Joining Xiao Bao in the biological space mission were other biological specimens: a box of albino rats and test tubes containing fruit flies, actinomycin, parenzyme, lysozyme, pepsin, penicillin, phycomycin, bacteriophage etc. The launching and landing were successful. Two weeks later, Xiao Bao's female buddy Shan Shan (姗姗) rode on the same rocket; the same cycle was repeated and the biological effects of space conditions on living organisms were recorded for further study of physiological and behavioral responses to the conditions of spaceflight and the space environment. This successful news attracted the attention of the central government officials such as then-vice premier Li Fuchun (李富

春) and the member of the Central Special Committee Zhang Jingfu. In the next year, team 651 was lined up for further space exploration activities. The key mission for team 651 was a T-7A (S2) rocket for carrying dogs. After the three successful launches of T-7A (S1) rockets, then-president Guo Moruo, then-vice president Zhang Jingfu， and member of the biological academic division Tong Dizhou made a visit to IBP in the company of Bei Shizhang. In January 1966, Bei chaired the First National Forum on biological satellites, and a conference on aeronautical medical science organized by the Ministry of National Defense. A report titled "the biomedical plan for a manned spaceship" was submitted to the Central Planning Committee. Details of this bio-rocketry mission were spelled out in the booklet *Flying Dogs in the Sky* issued by IBP in 2008. [210]

Mission 581 opened a new page for the launch of the biological rockets; it was the first time biology-based scientists were actively engaged in the national missile program in China. The pioneering study of animals in spaceflight laid the necessary groundwork for manned space flight in the years to come.

Summary

The short answer to the first driving question underpinning this chapter——the relevance and contribution of biophysicists to the Chinese space program—is that the biophysicists were part of Mission 581. But this terse reply conceals more than it reveals. As I have indicated, the successful execution of Mission 581 depended on the intimate cooperation between scientists dispatched from CAS (of which biophysicists were simply

[210] Institute of Biophysics of Chinese Academy of Sciences 中国科学院生物物理研究所, ed. *Flying Dogs in Sky: A Documentation of Chinese Biological Experimental Rockets* 小狗飞天记: 中国生物火箭试验纪实. (Beijing: Science Press, 2008).

one sub-group) and military officers appointed by the Second MMB and later the Seventh MMB. Some of the dialectical exchanges between CAS and the Second MMB exposed the fact that the civilian-military components of Mission 581 were neither perfectly dovetailed nor completely misaligned. It is important to consider the bigger historical and political contexts in which the civilian-military alliance was situated in China as opposed to the U.S.. The transformation of the civilian-military relationship was embedded in each country's specific historical matrix and bureaucratic orthodoxy. In particular, the intertwining of military services and civilian agencies illustrated the intricate relationships between states and sciences. The rivalry between NASA and the Air Force in managing its biomedical capabilities is not a coincidence but a reflection of the normative political structure in the U.S..

The more informed answer is that the intersection between biophysics and the Chinese bio-rocketry program offered a case study to interrogate the relationship between sciences and the state in socialist China. In socialist China, the relationship between science and the state that evolved as a result of the missile-cum-space program proved to be a determining factor in the growth of new or otherwise marginal sciences. Biophysics in particular profited from the opportunities for expansion and innovation provided by the military-defense programs. The next chapter explores the establishment of a new department of biophysics between 1958 and 1966 and a new biophysical curriculum—the very first of its kind in contemporary China——at the University of Science and Technology of China.

CHAPTER 5

BUILDING A DEPARTMENT OF BIOPHYSICS, 1958-1962

As much as the bio-rocketry mission justified the new institutional role of biophysics, biophysics was still a rather ambiguous and under-appreciated discipline for many Chinese scientists in the late fifties and early sixties. Although there was a new institute and new projects lined up for the self-identified "biophysicists," scientific recognition of biophysics as a distinct discipline did not come about immediately. Among the more learned biologists in socialist China, it was still the case that few of them knew what "biophysics" was, and many did not even make an effort to know. The indifference and even opposition to biophysics was best summarized by an acerbic voice at the time: "There was only physiology, no biophysics" (只有生理学，没有生物物理学).[211] Not only did physiology have a longer tradition in modern China, it had rallied to itself a better academic understanding and reputation in biological circles.[212] Biophysics, on the other hand, was relatively unknown to biologists and physicists. Bei Shizhang realized that the mere adoption of the term "biophysics" was not enough to promote its academic profile: He saw educational campaigns as the key to raise awareness of biophysics as an independent discipline and to attract able and ambitious students to this newfound profession.

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211 Wang Guyan, *A Biography of Bei Shizhang,* p. 163.
212 One of the indicators of the leading disciplinary status of physiology in China is the early history of its professional journal, *The Chinese Journal of Physiology* (中国生理学杂志), which was inaugurated in 1927 by four distinguished physiologists and medical biochemists under the auspices of the Rockefeller Foundation. The journal was renowned for publishing research papers of exceptionally high quality in Republican China. See "In Commemoration of the Eightieth Anniversary of *Acta Physiologica Sinica*" 纪念《生理学报》创刊 80 周年, available at <www.actaps.com.cn/history>.

This chapter documents the effort of building a department of biophysics at the University of Science and Technology of China (USTC, 中国科学技术大学) from 1958 to 1962. As the biophysicists were working on the bio-rocketry mission, they were simultaneously engaged in putting together a university department with specialized study programs. They were eager to introduce an educational framework for biophysics and the success of this endeavor rode upon the coattails of the bio-rocketry mission. During this period the founding of biophysics as a department was a strategic move to stabilize and strengthen the disciplinary status of biophysics in two essential ways: First, it offered an institutional site for training a new cadre of biophysicists. The school drew scores of young Chinese eager to learn a style of biophysics that was broadly biological and with a service role in the biological missions of the space program. Second, the invitation to launch an educational program at USTC was not simply an occasion for the learning and teaching of biophysics; it afforded Bei Shizhang a perfect opportunity to introduce and institutionalize a specific study plan for biophysics students. It served Bei's aim as a discipline builder by allowing him to define a style and a territory for the discipline that he advocated. Biophysics was available at USTC in the fall of 1958, but identifying what aspects of biophysics were being taught and how the curriculum conformed to the disciplinary vision of biophysics is more important than the institutions of biophysics alone. The central theme of the following chapter is the convergence of the institutional impetus and intellectual ambitions in establishing a broadly conceived, non-reductionist program of biophysics.

The University of Science and Technology of China (USTC)

One of the notable features of USTC is that it is not just another higher-education institution in China with a specialization in science and technology. Most universities, including the prestigious Peking and Tsinghua Universities, are under the administration of the Ministry of Education (MOE). By contrast, USTC–from its establishment until this very day– falls under the jurisdiction of the Chinese Academy of Sciences (CAS).[213] Although CAS is an academy *de jure*, its organizational nature does not resemble that of the National Academy of Science in the U.S. CAS adopts the institutional model of France and Russia in which the national academy is not just an honorific society but also a major headquarters for research and teaching activities. CAS was known as the "head of the train" of national R&D activities when it was founded in 1949, but it wasn't clear whether CAS should assume leadership in scientific and technical education. In 1950, a controversy erupted between Guo Moruo (郭沫若), then president of CAS, and Yang Xiufeng (杨秀峰), then secretary of Higher Education at MOE, regarding whether CAS or MOE should act as the center of scientific education and training. Mao stepped in and asked both parties to set aside their jurisdictional interests and make collective contributions to the common cause of national modernization.[214] Although Mao brought about an immediate resolution to this particular conflict, the undertones of the quarrel

[213] As of 2013, seventy-two universities and higher education institutions are under the jurisdiction of MOE while only three are under CAS. Besides USTC, the other two CAS-managed universities are the University of the Chinese Academy of Sciences (中国科学院大学) and the Shanghai University of Science and Technology (上海科技大学). See "A List of Higher-Education Institutions Under the Direct Jurisdiction of the Ministry of Education of the People's Republic of China" 中华人民共和国教育部直属高等学校名单, available at <www.moe.edu.cn>.

[214] Zhang Jianwei, and Deng Congcong, *Chinese Academicians* (Ningbo: Zhejiang wenyi chubanshe, 1996), pp. 83-84.

remained, and it would foreshadow the entanglement of CAS in educational affairs in 1956.

In 1956, the policy document entitled "Twelve-Year Long Term Plan for the Development of Science and Technology, 1956-1967" was announced. The policy highlighted higher education in natural science and advanced technology as one of the *sine qua non* for socialist construction. The legislative imperative created an instant demand for advanced training in science and technology.[215]

Reformists and board members at CAS felt that given the pivotal role of CAS in carrying out the "Twelve-Year Plan," it should take the initiative to improve college education in science and technology. CAS leaders saw their organization as an agenda-setting body in responding to the pressures for science instruction in order to meet the goals of national modernization. The motion was first proposed by then president of CAS, Guo Moruo, in the third executive meeting of CAS on March 18, 1958, where he raised the possibility that CAS could consider developing an affiliated educational institution to facilitate the training of cadres. Guo's idea was supported by Nie Rongzhen with the endorsement of Zhou Enlai. On May 21 1958, Nie submitted a formal proposal to then Secretary General of the Politburo, Deng Xiaoping, who passed the motion of constructing a CAS-directed university of science and technology.[216]

The driving force behind CAS's desire to secure a role in training students in science and engineering was the requisite human resources for implementing the "Twelve-Year Plan." The immediate concern of CAS leaders and scientists was the need

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[215] Xu Liangying, et al., ed., *Science and Socialist Construction in China* (New York: M E. Sharpe, 1982).
[216] Zhu Qingshi ed. *A Draft Edited History of the University of Science and Technology of China* (Hefei: University of Science and Technology of China Press, 2008), pp.1-14; for an abridged history, see "Founding background and preparation process" at <arch.ustc.edu.cn/history>.

to prepare a cohort of scientists and engineers who could meet the practical requirements of the many modernization projects articulated in the "Twelve-Year Plan." However, there were ulterior motives: Members of academic divisions in CAS also recognized that educational programs in advanced science and technology could advertise the devotion of scientists to public service. Publicity meant a better reputation and the wider socio-political influence of scientists. Serving advanced science education could further highlight the political reliability of scientists as an elite class by "encouraging people to orient toward the Academy" (人心向院).[217]

It is evident that the founding of USTC was inseparable from the institutional mission of CAS, as not only was USTC under the leadership of CAS from the very beginning, it was established primarily as an instrument to fulfill the service role envisioned by CAS leaders. Federal projects for socialist modernization incentivized the proliferation of systemic education and apprenticeship by offering a utilitarian thrust to fortify the enfeebled educational base in science and technology.

The political economy of science education does not capture the full range of co-evolution between CAS and USTC. The genesis of USTC illustrated how the principle of "taking missions as the longitude, disciplines as the latitude, and using missions to drive disciplines" (以任务为经, 以学科为纬, 以任务带学科) was put into practice.[218] A critical motif in the mission-drive-discipline principle is the interweaving of missions and

[217] Zhang Li 张藜, "The Economic Livelihood and Social Status of Scientists: 1949-1966—The Case of the Chinese Academy of Sciences" 科学家的经济生活与社会声望：1949-1966 年—以中国科学院为例, *Studies of the Contemporary History of China* 中国当代史研究, (Beijing: Jiuzhou Press, 2009), pp. 104-142.
[218] Fan Hongye, ed., *An Edited Historiography of the Chinese Academy of Sciences, 1949-1999* 中国科学院编年史, 1949-1999 (Shanghai Education Press, 1999), p. 66.

disciplines. The symbiosis between USTC and CAS is crystallized in the policy motto of "running the university with the resources of the entire CAS and integrating departments with relevant CAS research institutes" (全院办校，所系结合). Partly drawing from the Soviet experience of merging the Novosibirsk State University with the Siberian Division of the USSR Academy of Sciences, the objective was to furnish an integrative program of science education by marshaling human and instrumental resources from all over CAS.[219] Thirteen major research institutes of CAS begat a department at USTC with the director assuming the role of department chair. In this way, each academic department of USTC would correspond impeccably to the same specialty of the respective institutes at CAS. The CAS-USTC interplay closed the gaps between teaching and research, theory and practice, basic and applied sciences, and academic ideals and civil service.

On September 20 1958, USTC was inaugurated in the western suburb of Beijing. At the inauguration ceremony, then vice premier Nie Rongzhen delivered the opening speech, entitled "planting the red flag on the summit of science" (把红旗插上科学的高峰).[220] Following the practice of dual superintendence, Guo Muoruo assumed the presidency of USTC while thirteen directors of CAS institutes were appointed as the respective chairs of departments at USTC. One of these founding departments was biophysics and Bei Shizhang was the incumbent chair.

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[219] Wang, *A Biography of Bei Shizhang,* p. 167.

[220] Ding Yixin 丁毅信, and Ding Zhaojun 丁兆君, "The Establishment-cum-Opening Ceremony of USTC" 中国科学技术大学成立暨开学典礼, *Information and Research of University History* (*IRUH*, 校史资料与研究), Issue 1, (October 15, 2007): 11, available at <arch.ustc.edu.cn/news>.

Department of Biophysics at USTC, 1958-1961

For those who are unfamiliar with the history of USTC, it is easy to brush aside the department of biophysics as just another department in this "New Chinese University." Yet among the founding thirteen departments at USTC, only one department was invested with subject matter in biology, namely the department of biophysics. The rest of the "USTC Thirteen" were specialized areas in physical sciences, engineering, and electronics with no crossings into the biological sciences. Table 1 gives a summary of the founding departments at USTC in 1958:

Table 1

Founding Departments at USTC in 1958[221]

Department	系
Nuclear Physics & Nuclear Engineering	原子核物理和原子核工程
Technical Physics	技术物理
Physical Chemistry	化学物理
Thermal Engineering	物理热工
Radio & Wireless Electronics	无线电电子学
Automation	自动化
Mechanics & Mechanical Engineering	力学和力学工程
Radiochemistry & Radiation Chemistry	放射化学和辐射化学
Geochemistry & Rare Elements	地球化学和稀有元素
Polymer Chemistry & Polymer Physics	高分子化学和高分子物理
Applied Mathematics & Computer Technology	应用数学和计算机技术
Geophysics	地球物理
Biophysics	生物物理

Why was there only one department with specialization in biology? This is because all of the "USTC Thirteen" were expected to provide strategic service to the

[221] Ding Yixin and Ding Zhaojun, "University Preparatory Committee Convenes the First Departmental-Chair Meeting" 校筹备处召开第一次系主任会议, *IRUH*, Issue 1, (October 15, 2007): 6.

CAS-run project, "Two Bombs, One Star." All of the thirteen disciplines were in direct relationship to the making of atomic bombs, hydrogen bombs, and artificial satellites. The defense-oriented philosophy of USTC was unambiguously articulated in an internal reference document:

> The purpose of establishing the University of Science and Technology of China is to accommodate the research mission in areas of national defense and advanced science by educating scientific practitioners in these classified areas for national defense. The configuration of departments and specialties basically revolves around the needs for the nuclear energy and rocket industries.[222]

Biophysics was included because it was a core unit in the satellite project, of which Mission 581 was one part. Biophysics was also of strategic interest to the atomic team for assessing the biological effects of radiation. The connection with bombs and space missions enabled the biophysicists to align themselves with the CAS-USTC consortium as the only biology-related discipline in USTC.

Although the CAS-USTC partnership was an *ad hoc* arrangement driven by the need for undertaking the state-supervised missions, it granted Bei Shizhang a rare opportunity to further the disciplinary cause of building biophysics. In 1958, Bei had achieved something beyond the wildest dreams of most disciplinary builders: he had procured enough institutional support to establish a research institute and a university department for biophysics within the same year. Few could imagine a better orchestration

[222] "A Configuration Plan for the Departments, Specialties, and Specialization of USTC (Classified)" 中国科学技术大学系、专业、专门化设置计划表(绝密), in the Office of University Archive (OUA), USTC, Box 1960-WS-Y-21.

of the teaching and research of an emerging discipline than this. When Otto Warburg became the director of the Kaiser Wilhelm Institute of Experimental Biology at Berlin in the 1920s, he was in terrific shape to institutionalize Germany biochemistry. His laboratory in Berlin was equipped with state-of-art apparatus and advanced theories to study cellular metabolism and oxidation. But as Robert Kohler's comparative analysis revealed, Warburg's Institute offered enormous promise for doing innovative research but little incentives for discipline building partly because of Warburg's eccentric temperament but mostly as a result of "the gulf between a privileged avant-garde and the official academic discipline in German biochemical institutions."[223] The separation of cutting-edge research from disciplinary commitment and the lack of a suitable market to absorb graduates in biochemistry reflected a structural problem inherent in the German system that eventually led to a precipitous collapse.

As Bei's biographer and long-term apprentice, Wang Guyan suggested that the establishment of the department of biophysics at USTC was a celebrated event in the world history of biophysics. Wang claimed that the department of biophysics at USTC was the first independent department dedicated to biophysics in the world. There were organized courses or degree programs in biophysics in other parts of the globe, but the world's first *bona fide* department of biophysics, according to Wang, was born in USTC in 1958.[224]

But was USTC really the birthplace of the first department of biophysics in modern times? Wang argued as such; to evaluate his claim, it is informative to compare

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[223] Robert Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline* (Cambridge: Cambridge University Press, 1982), p. 39.
[224] Wang Guyan, *A Biography of Bei Shizhang,* p. 168.

and contrast USTC with other institutions. The Johns Hopkins University (JHU), for example, had a similar history during that time period.[225] In 1949, thanks to a donation by Mrs. May Jenkins, JHU was able to offer its first course in biophysics; in 1957, her death helped the university to endow the Thomas C. Jenkins Department of Biophysics with "fundamental studies" in biophysics instituted in the Faculty of Philosophy, and in the medicine and health studies in biophysics placed under the Schools of Medicine and Public Health. The divide between the basic and clinical studies of biophysics continue to the present where only the "fundamental studies" of biophysics remained in the department of biophysics. The JHU experience casts doubt upon the claim that USTC is the world's first institution to have founded a department of biophysics. JHU preceded the Chinese efforts in instituting a department of biophysics by a margin of at least one year,[226] yet judging from the fragmented character of the department of biophysics at JHU, it is likely the case that China did pioneer in creating a more *holistic* department of biophysics without an ostensible split among different branches.

To ascertain the "unified" character of Chinese biophysics, it is necessary to probe into the departmental structure of biophysics at USTC. The department of biophysics was the smallest unit at USTC in terms of student enrollments and departmental size. The enrollment figure of the biophysics department was the lowest throughout USTC. The university registrar reported that only fifty students were enrolled in biophysics in 1960, comprising less than four percent of the total student population.

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225 See <biophysics.jhu.edu/history>.

226 The obituary of Dr. Francis "Spike" Carlson, *de facto* founding father of the department of biophysics at JHU, put the establishment year of JHU's biophysics department in 1956, the year Carlson "began efforts to improve the biophysics department." Therefore, the department of biophysics at JHU most likely emerged in the 1956-57 academic year. See Frederick Rasmussen, "Francis Carlson, 77, Biophysics Professor," *The Baltimore Sun,* February 11 1999, available at <articles.baltimoresun.com>.

Other departments admitted an average of a hundred students in the 1960-61 academic year.[227] The enrolment number for biophysics shrank to twenty-five in 1963.[228]

Secondly, the department offered only one program from 1958 to 1961, namely the program in biophysics (生物物理专业). During the same period, each of the other twelve departments provided a range of two to five programs. As of 1960, there were altogether thirteen departments offering a total of forty-three programs as printed on the course catalogs, with only one department and one program dedicated to "biophysics."[229] Not only did biophysics achieve outer correspondence between departments and research institutes (系所对口), it also maintained an inner linearity among departments and programs. This one-department-one-program arrangement allowed Bei to concentrate teaching resources and to inculcate new students with an integrated curriculum of biophysics.

An Integrated Curriculum of Biophysics at USTC, 1958-1961

Was the department of biophysics at USTC a site in which disciplinary goals and mission service reinforced the programmatic growth of biophysics? How did the pedagogical content of biophysics converge with the epistemic visions of Bei Shizhang? Did it really offer a more integrated curriculum?

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227 "Enrollment Quota and Distribution for Each Department in 1960 (A Draft)" 各系 1960 年招生名额分配方案(草案), OUA, USTC, Box 1960-WS-Y-21.

228 "A Developmental Plan for Each Specialties of USTC, March 1963" 中国科学技术大学各专业发展规划 1963 年 3 月, OUA, USTC, Box 1970-WS-Y-14.

229 "A Corresponding List of Departments and Programs at USTC"中国科学技术大学系与专业设置方案对照表, OUA, USTC, Box 1962-WS-Y-24.

One way to approach these questions is by inspecting the biophysics' course plan and analyzing what was in the curriculum and what disciplinary input was retained. Table 2 presents a course plan in the biophysics program at USTC in 1961:

Table 2

A Biophysics' Course Plan at USTC, 1961[230]

Course			Hour/year
General		Marxism-Leninism	360
		Physical Education	120
		Foreign Language I (Russian)	315
		Foreign Language II (English)	120
Sub-total			915
Professional			
	Physical Sciences	Applied Mathematics	360
		Physics	548
		Electronics	120
		Inorganic Chemistry	360
		Isotopes	80
		Organic Chemistry	135
		Physical Chemistry	195
	Biological Sciences	Biochemistry	127
		Biology	315
		Radiobiology	120
		General Biophysics	112
		Instruments & Techniques of Biophysics	50
		Microscopic & Molecular Structures	20
		Technology & Equipment	60
Sub-total			2,602
Total			3,517

The *general* section of the study plan was designed in accordance with the school's overarching emphasis on "foundational studies" in science education. Qian

[230] "A Course Plan of the Biophysics Program (5812) of the Department of Biophysics, June 15 1961" 生物物理系生物物理(5812)专业课程计划表, 1961 年 6 月 15 日, OUA, USTC, Box 1963-WS-C-67.

Xuesen, in his capacity as the chair of the Department of Mechanics & Mechanical Engineering at USTC, contributed an article to *People's Daily* in 1959 expressing the curricular philosophy of USTC:

> USTC aims at training cadres in advanced science and research technology. Hence, the students must develop a solid foundation for doing research in the future. What constitutes the foundation for doing research? It is of course multi-faceted: political consciousness, professional knowledge, health, reading ability of foreign languages etc; all of these are foundational.[231]

The stress on building a sturdy "foundation" justifies the mandatory components of Marxism-Leninism, physical education, and foreign languages in the course plan for improving political consciousness, physical health, and language acquisition. Foreign languages I and II designate Russian and English respectively. The *general* module of the curriculum was pre-approved in the second departmental-chair meeting before classes commenced in fall 1958 and was intended for every program—biophysics was no exception.[232]

Yet the *general* module only accounted for approximately one quarter of the course hours; the majority of the curriculum was assigned to *professional* education. The *professional* module consisted of coursework in two big areas: physical sciences (including applied mathematics, electronics, and chemical sciences), and biological sciences (including technology and instruments of biophysics). The allotted hours were

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[231] Qian Xuesen, "Fundamental Studies at USTC" 中国科学技术大学里的基础课, *People's Daily*, May 26 1959.
[232] Ding Yixun and Ding Zhaojun, "University Preparatory Committee Convenes the Second Departmental-Chair Meeting" 校筹备处召开第二次系主任会议, *IRUH*, Issue 1, (October 15, 2007):7.

1798 and 744 for physical and biological sciences respectively. In view of this study plan, one might ask: why did the physical sciences receive a larger chunk of teaching hours than the biological sciences?

In a blueprint submitted by the party-committee of CAS to the State Council for running USTC, basic science and theories were singled out as a top priority in the curriculum. This was revealed in a document drafted by Zhang Jingfu, vice president of CAS, in which he wrote "the first priority after class commenced was the training on basic studies, and particularly the development of a robust foundation in areas such as mathematics, physics, chemistry, and mechanics."[233] In this memorandum, Zhang sent a clear message to Nie Rongzhen that the above areas of basic science were going to be prerequisites in the curriculum, irrespective of the specialties and programs. Given the predominant presence of disciplines in the physical sciences and nuclear engineering at USTC, this pedagogical emphasis on "basic science" was convenient for most incoming students because these classes were simultaneously the core classes in their majors.

From the compulsory *general* education to the prerequisites in "basic science," the school's preoccupation with foundation or "basics" (*jichu* 基础) was crystal clear. Yet what exactly was considered as "basic" or "foundational" was less obvious. Supra-scientific programs and political education appeared to be as relevant to the building of a good "foundation" as courses in basic science. Essentially, biology was not regarded as "basic science" or part of the "foundation" in the discourse. Again, one should look at the disciplinary distribution of the curriculum from the big picture of USTC's organizational

[233] Zhang Jingfu, "A Referendum of Test Running a New University Proposed by CAS Party-Committee" 科学院党组建议试办一所新型大学的请示, *Ibid*:13.

chart: Since none of the "USTC Thirteen" dealt with biology except biophysics, it was perhaps understandable why biological sciences were not featured in the programmatic visions of the university leaders.

However, to regard the omission of biology from "foundational" education as a sign of subordination of biophysics is premature. Although Qian Xuesen conceded that "fundamental studies" (*jichu ke* 基础课) consisted of extra-scientific components such as political and physical education, the preponderance of "fundamental studies" resided in what he called "basic theories" and "basic technologies." The former was made up of physics, chemistry, and mathematics. Qian explained that the education in "basic theories" was designed to underline the inter-connection between physics and chemistry and to advance a comprehensive understanding of mathematics. His formulation of "basic theories" was consistent with Zhang's articulation of "basic science" as university prerequisites in which physics, chemistry, and mathematics received the lion's share of attention.[234]

On top of the "basic theories," Qian also put forth "basic technologies" as another building block of "fundamental studies." His expertise in theoretical aerodynamics and his CalTech years shaped his perception that hands-on experiences with machines were also "basic" in the educational program. For example, he argued that aerodynamic research was inseparable from supersonic wind tunnels, just as the study of particle physics was indivisible from accelerators and detectors. What comprised "basic technologies" was quite specific to the nature of individual disciplines, but one of the indispensable courses in "basic technologies" was "engineering drawing" (工程画). In

[234] Qian, "Fundamental Studies at USTC," *People's Daily*, May 26 1959.

fact, how to implement the "engineering drawing" course was on the agenda of the second departmental-chair meeting before enrolment began. According to Qian's estimation, the teaching of "basic theories" would make up one third of the curriculum while that of "basic technologies" would occupy some ten percent of the total study hours. This schedule was expected to apply to all majors. This schedule was expected to apply to all majors and while it might not have seemed important at the time, "engineering drawing" was introduced to all programs except biophysics, which was notably exempted from the adoption of "engineering drawing" in its course plan—the only department receiving such special treatment.[235] Judging from the special consideration given to biophysics, one could hardly conclude that the board of regents at USTC and CAS ignored biophysics or denied its disciplinary legitimacy.

Until the end of 1961, the biophysics course plan as tabulated in Table 2 was the only program offered by the biophysics department. But this one-department-one-program package deal would change soon: A university-wide reform began to take place in 1960 to restructure the department-program alignment.

Biophysics and Program Reform, 1960-1962

On January 23 1960, the Office of the Party Committee of USTC reported to the Office of University Science Work of the Municipal Committee about a few administrative changes that the party-committee had discussed, but had not been approved by the managerial board of CAS in 1959. One of the proposed changes was to

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[235] Ding Yixun and Ding Zhaojun, "University Preparatory Committee Convenes the Second Departmental-Chair Meeting," *IRUH*, p. 8.

append a biochemistry program to the existing department of biophysics.[236] Biochemistry was not the only adjunct program proposed to the biophysics department. On March 15 1960, the Institute of Mechanics at CAS recommended a biomechanics program (生物力学专业) to be added to the biophysics catalogs.[237]

Nevertheless, the Chinese Communist Party's Committee for USTC did not adopt these suggestions. The directive issued by the CCP committee of USTC dated April 3 1960 advised against adding the biochemistry program to the existing department. The committee felt that the low enrollment figure of the biophysics department would hamstring the prospects of the new program, not to mention the side effect of distracting the focus of the department. The committee also vetoed the biomechanics motion on the grounds that the biophysics program already encompassed the content of biomechanics, which obliterated the effort to deploy another unit just for biomechanics.[238]

What implications can we draw from these unsuccessful experiences of incorporating biochemistry and biomechanics into the department of biophysics in 1960? On the generic level, these episodes indicated that party intellectuals regarded biophysics as a rather distinctive and full-blown discipline by 1960. It was "distinctive" in the sense that it was the smallest and most vertically integrated department offering only one program within the department. Nevertheless, other research institutes saw the "distinctiveness" of biophysics as a precious opportunity to expand their disciplinary interests. The strategic recommendation from the Institute of Mechanics was a case in

[236] OUA, USTC, Box 1960-WS-Y-21.
[237] "Institute of Mechanics at CAS Recommends Training Professionals in Mechanics-Related Areas in Proxy"中国科学院力学研究所建议代培养有关力学专业人才, OUA, USTC, Box 1960-WS-Y-21.
[238] "About the Referendum of Program Structures" 关于专业设置的请示, OUA, USTC, Box 1960-WS-Y-21.

point. The disciplinary ambitions of the Institute of Mechanics were manifested in a flurry of institutional changes it submitted to the USTC party-committee. In addition to proposing the biomechanics program, they also put forward ideas to create "Hydrodynamics" (水动力学) and "High-speed-high-pressure Mechanics" (高速高压力学) programs in the Department of Mechanics and Mechanical Engineering, as well as an "Operations Research" (运筹学) program in the Department of Applied Mathematics and Computer Technology. All of the above suggestions were endorsed by the USTC party-committee except the proposition of adding biomechanics to the biophysics department.[239] This relates to the second disciplinary characteristic of biophysics. The institutional smallness did not deprive biophysics of its disciplinary richness. Not only was biophysics a uniquely compact department, it was regarded as a unified discipline that encompassed biomechanics. Biophysics was recognized as a self-sufficient discipline capable of standing alone and absorbing other sub-fields.

As to the biochemistry dispute, evidence showed that it was the biological division of CAS which initiated the biophysics–biochemistry coalescence. The biological division was a large academic division consisting of all institutes in bio-related disciplines at CAS, in which biophysics was just one of the many. The elected members of an academic division are institutionally equivalent to academicians in other countries. One might ask whether the Institute of Biophysics was behind this bill. One might also ask to what extent Bei Shizhang was involved in the decision-making process. There are no easy answers to these questions. If Bei was ever a part of this motion, it is not

[239] "Institute of Mechanics at CAS Recommends Training Professionals in Mechanics-Related Areas in Proxy," OUA, USTC, Box 1960-WS-Y-21.

discernible in his own work. The paradox is that even though USTC implemented a close correspondence between departments and institutes, this administrative tactic did not necessarily grant autonomy to individual institutes for making macro-level decisions regarding departmental affairs. Despite his appointment as the department's chair, Bei did not necessarily have the power to alter institutional decisions on his own. The final decision invariably came from the institutional board beyond his domain of authority.

This power dynamic helps explain several interim amendments to the biophysics department between 1960 and 1962. The biochemistry idea came up again in 1961 in spite of the previous bureaucratic objection. A biochemistry major appeared on the course catalog of the biophysics department briefly in the 1961-2 academic year on the grounds that "only by applying theories and methodologies in biophysics and biochemistry simultaneously can we acquire a deep understanding of the processes and activities of living organisms."[240] The wording of this rationale skillfully avoids challenging bureaucratic authority while preserving the overall unity of biophysics. The opposition from the party-committee in 1960 had to do with the administrative statistics of student enrollment rather than the intellectual matter of biophysics or biochemistry. Incorporating biochemistry into the department of biophysics did not violate the official protocol so long as the focus was put on how biochemistry could enrich biophysics.

Yet despite this, there still is the matter of a shrinking student population in biophysics between 1960 and 1963: The enrollment number dropped from fifty in 1960 to twenty five in 1963. How did the school reconcile the stark reality of low recruitment rates with the disciplinary promise of biochemistry? To wrestle with this question, one

[240] "Appendix: Details of Program Structures of USTC" 附件:中国科学技术大学专业设置情况, OUA, USTC, Box 1962-WS-Y-24.

needs to temporarily zoom out of the department of biophysics and place under the lens a preceding inter-university affair.

In September 1959, an establishment known as "The University of Science Intelligence" (科学情报大学) blended with USTC by setting up the Department of Science Intelligence at USTC. Due to the clandestine nature of the discipline of science intelligence, DSI failed to recruit any student in both the 1959 and 1960 academic years. DSI received an administrative order from the CCP party-committee of USTC, dated August 9 1960, to disaggregate the establishment into three majors and delegate these programs to the Department of Technical Physics, the Department of Polymer Chemistry and Polymer Physics, and the Department of Biophysics, which were responsible for managing the intelligence studies in physics, chemistry, and biology respectively.[241]

With the department of biophysics hosting the bio-intelligence specialty, the administrators of USTC subsequently put bio-intelligence in the biophysics catalog as of January 11, 1962, in the wake of the biochemistry interlude. But one should bear in mind that the planning and consultation began in 1960, which put the contemplation of biochemistry and bio-intelligence at the same year. The difference is that the biochemistry recommendation came from the biological division from CAS, while the bio-intelligence program was supported by the university administrators at USTC. The bio-intelligence proposition differed from the former in that it affected not just the biophysics department but also other departments. The disintegration of DSI created a demand for other units to absorb its branches. Although there were other candidates for taking in the intelligence studies in physics and chemistry, the department of biophysics

[241] "USTC (60) Official Notice No. 0052" 科大(60)校教字第 0052 号, OUA, USTC, Box 1960-WS-Y-21.

was the only viable option for administering the bio-intelligence major at USTC. As much as the executive committee of the biophysics department wanted to preserve its singular programmatic structure, it was not in a position to reject this inter-departmental arrangement.

To recapitulate, the department of biophysics only registered one program from its founding in 1958 to 1961. Biochemistry was listed on the program inventory between 1961 and 1962 and bio-intelligence was put on the record in 1962. The one-department-one-program pact was no longer in place after 1961. Did these administrative exercises signify a declining status of biophysics?

One should not overestimate the importance of these administrative arrangements, which were usually made on an *ad hoc* basis for managerial convenience. These organizational policies signify little for the status of biophysics until we probe into the intellectual and pedagogical contents of these new programs. What was taught in the biochemistry and bio-intelligence programs? Did the epistemological claims of biochemistry and bio-intelligence contradict the core principles of biophysics, or were they interpreted as congruent with the conceptual mainstay of biophysics?

Biochemistry and Bio-intelligence: Contradiction or Congruity?

Let's begin with the examination of the biochemistry curriculum. Table 3 is a schematic representation of a biochemistry syllabus in 1961:

Table 3

A Biochemistry's Teaching Outline, 1961[242]

Chapter	章
1: Introduction	绪论
2: Protein Chemistry	蛋白质化学
3: Nucleic Acid Chemistry	核酸化学
4: Vitamins	维生素
5: Enzymes	酶
6: Hormones	激素
7: Glucose Metabolism	糖代谢
8: Fatty Acids Metabolism	脂类代谢
9: Protein Metabolism	蛋白质代谢
10: Nucleic Acid Metabolism	核酸代谢
11: Bio-oxidation	生物氧化
12: Energy Metabolism	能代谢
13: Water and Inorganic Salt Metabolism	水及无机盐代谢
14: Respiration and Neutralization	呼吸化学及酸碱平衡

The teaching outline of biochemistry was centered on the chemical mechanisms of living systems, as evident from the discussion of metabolisms to enzymes and hormones. But before these lectures on technical chemical knowledge came the introductory chapter, which consisted of four sections, namely "the research subject and mission of biochemistry," "a brief developmental history of biochemistry," "the relationship between biochemistry and other scientific disciplines," and last but not least, "the relationship between biochemistry and biophysics." When addressing the relationship between biophysics and biochemistry, it was posited that "this teaching outline was designed with the understanding of biochemistry as one of the fundamental

[242] "An Exposition of a Biochemistry's Teaching Outline" 生物化学教学大纲说明, OUA, USTC, Box 1961-WS-C-3.

studies in biophysics."[243] The phrasing pointed to compatibility between the subject matters of biochemistry and biophysics without necessarily reducing one to the other. As the earlier analysis showed, "fundamental studies" (基础课) was a rather flexible construct. Ideological awareness, physical constitution, and foreign languages were all considered as "fundamental" to biophysics and other disciplines, but it did not follow that the subject matter of biophysics was reducible to these components. On the contrary, the discourse implicitly suggested that biochemistry was below, not above, biophysics. The biochemical themes of study were likely to supplement rather than subjugate the subject of biophysics.

Biochemistry's teaching outline exhibited a conspicuous correlative tendency to relate its subject matter to other disciplines, notably biophysics. The interplay between biochemistry and biophysics revealed an absence of competition or even animosity that characterized the parallel dispute in the West. There was no demonstrated resistance from leading Chinese biochemists in questioning the disciplinary merit of biophysics. There was no Chinese Linus Pauling who stood up against biophysics and suggested that biochemistry take command of biophysics.[244] While the hostile relationship between biochemistry and biophysics in the U.S. occasioned an instance of disciplinary saber rattling, biochemistry and biophysics in China were more congruous with each other as neither side invoked the logic of "first principles" to dominate and devalue the other side. Chinese scientists did not resort to a doctrine that reduced one body of scientific knowledge to another in order to justify disciplinary existence. As Benjamin Schwartz

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[243] *Ibid*.
[244] Nicholas Rasmussen, "The Mid-Century Biophysics Bubble: Hiroshima and the Biological Revolution in America, Revisited," *History of Science* 35 (1997): 245-293.

shrewdly observed, to the extent that the conceptual base of Western science was foregrounded upon a certain form of reductionist materialism, the lack of reductionist impulse was a dominant and non-negligible feature in Chinese modes of thought.[245] What observations like this suggest is that biophysics in China was not predicated on a Cartesian mode of thinking. It wasn't so much determined by a rejection of Cartesian reductionism so much as it was uninhibited by that reductionist bias: Biophysics had no impetus to develop along the lines that reductionism spelled out for the development of academic disciplines in other parts of the world.

Besides biochemistry, Bei's unified vision of the knowledge landscape was manifested in the course layout of bio-intelligence. As indicated, the study of bio-intelligence was introduced as an official program at the department of biophysics in early 1962. Unlike the proposition of biochemistry from the biological division of CAS, the bio-intelligence recommendation came directly from the university's committee of party cadres. How did Bei and other biophysicists reconcile this new major with biophysics? How could they unify the epistemic elements of bio-intelligence with that of biophysics?

The science intelligence program consisted of intelligence studies in physics, chemistry, and biology that aimed at training cohorts of graduates to work for intelligence services, publishing houses and libraries. The erstwhile "University of Science Intelligence" was a Cold War establishment for collecting and translating foreign information pertaining to science and technology. The educational emphasis in the science intelligence program was placed on the reading and writing competencies in

[245] Benjamin Schwartz, "On the Absence of Reductionism in Chinese Thought," *China and Other Matters* (Cambridge: Harvard University Press, 1996), pp.81-97.

technical materials. A majority of the science intelligence curriculum was dedicated to surveying and summarizing literature in science and technology. Compared to the curriculums in biophysics and biochemistry that were more professionally oriented, bio-intelligence required a less discipline-centered module to provide the students with a more comprehensive exposure to a spectrum of fields. The overriding mission of the bio-intelligence program was to cultivate students in a broad repository of eclectic, instead of specialized, knowledge.[246]

The specific instructional mission of the bio-intelligence study created a favorable circumstance for the biophysics curriculum planners to integrate the existing biophysics content into the bio-intelligence teaching outline. Before the bio-intelligence program was officially instituted in the department of biophysics in 1962, it was already noted that the students from the University of Science Intelligence lagged behind their peers at USTC in terms of professional aptitudes. Thus, the university administrators anticipated that it might take up to a full year to season these students to the professional training modules in the destination departments at USTC. The home departments were allowed and even encouraged to amend the curriculum for these science intelligence students both to cater to their specific needs and to assist them in gradually adapting to mainstream study.[247]

Putting this administrative advice into practice, the department of biophysics put together a prospective course plan for the bio-intelligence program on June 16, 1961 as compiled in Table 4:

[246] "USTC (60) Official Notice No. 0052," OUA, USTC, Box 1960-WS-Y-21.
[247] *Ibid*.

Table 4

A Bio-intelligence Course Plan at USTC, 1961[248]

Course	Hour/week (hour/year)*
General	
Marxism-Leninism	3 (360)
Physical Education	2 (120)
Foreign Language I	2-4 (NA)
Foreign Language II	4-6 (NA)
Chinese	3 (90)
Professional	
Physics	4-7 (NA)
Organic Chemistry	3-6 (135)
Biochemistry	3-5 (112)
Microbiology & Cytology	6 (90)
Histology & Embryology	4 (60)
Plant Physiology & Evolutionary Biology	4 (64)
Human & Animal Physiology	5 (75)
Radiobiology	2-6 (112)
Materials & Publishing	2-6 (32)
Biological Seminar	3 (48)

Compared with the normative biophysics' course plan in Table 2, there were several outstanding characteristics of the bio-intelligence course plan in both the *general* and *professional* modules. On the *general* front, "Chinese" was introduced as a

248 "A Course Plan of the Bio (5812(:1) (Intelligence Program) of the Department of Biophysics, June 15 1961" 生物物理系生物 (5812(:1) (情报专业) 课程计划表, 1961 年 6 月 15 日, OUA, USTC, Box 1963-WS-C-67.

* Unlike the previous document "A Biophysics Course Plan at USTC, 1961" as shown in Table 2, this archival page is regrettably broken and incomplete. The parenthetical number denotes the total hours per year (总学时) as printed on the original document while the parenthetical letters "NA" denotes cases where the hour/year cells are empty. Since there is no explanatory page attached to these course plans, the correlation between the weekly hours and the annual hours is unfathomable, nor is it possible to compute the sub-total hours for each module as well as the total hours for the entire course plan as provided in Table 2.

compulsory course in addition to foreign languages for the bio-intelligence students. This was in line with the translational needs of the program for which command of both native and foreign languages were requisite. What is more eye-catching is the *professional* module in which the course load was significantly reduced from what it was in the physical sciences. Besides physics, nearly all of the *professional* courses were in biological sciences. The preponderance of the *professional* module was dedicated not even to biophysics, but rather to hardcore biology. In particular, courses like "microbiology & cytology" and "histology & embryology" were most likely imported due to Bei's sphere of influence because those were his areas of expertise. The only biophysics-related course in this outline is radiobiology—the study of the biological effects of radiation and cosmic rays on the living cells and tissues of both human and animal subjects in high-altitude flights. Radiobiology was a spinoff program from Mission 581 initiated by Bei in early 1961. The course was deemed relevant to the bio-intelligence students for its close connection with the nuclear and space industries. Radiobiology was also listed as a required course in the biophysics' course plan in the same year.

The case of bio-intelligence opened the door to better understand the changing institutional status of biophysics at USTC. Juxtaposing the course plan for bio-intelligence in Table 4 with that for biophysics in Table 2, one can see Bei's leverage and the department of biophysics at USTC more clearly. While physical sciences outweighed biological sciences in the course plan for biophysics, the reverse pattern was demonstrated in the bio-intelligence program. The compulsory component of physical sciences in the biophysics' course plan was a result of the university's prevailing interests in the "basic sciences" and "foundational studies" which pivoted around physical and mathematical sciences. But if biophysics was not exempted from this pan-university edict, why was the bio-intelligence program an exception?

The answer is likely to be found in the distribution of the student population. As of January 1962, there were altogether 219 students at the department of biophysics, of which only 37 students were enrolled in the bio-intelligence program, accounting for less than 17% of the total student population.[249] In other words, the bio-intelligence course plan was only available for a minority group of students while the course plan designed for biophysics major was applied to the main body of students. In this way, the department of biophysics could ensure that a certain mass of students complied with the instructional criteria laid out by the university leadership before experimenting with a new teaching module.

The bio-intelligence program was not closely scrutinized as other programs partly because its close association with the intelligence service which put it into the hands of the defense ministry---a higher position on the chain of command. In addition to bio-intelligence, the study of science intelligence as a whole did not fall under the normative disciplinary territory as it was not one of the founding departments and programs at USTC. Although the entire field of science intelligence was transferred to USTC for administrative expedience, the intended learning outcomes of the science intelligence study coincided with the university's long-cherished emphasis on basic knowledge. More specifically on the alignment between bio-intelligence and biophysics, the former's quest

[249] "Office of University Registrar: Reports, Opinions, and Blueprints About Department-and-Program Adjustment at USTC" 教务处:中国科技大学关于系与专业调整的报告、意见、方案, OUA, USTC, Box 1962-WS-Y-24.

for eclectic knowledge matched Bei's comprehensive and cross-disciplinary vision. Bei grasped this opportunity to alter the disciplinary equilibrium. While retaining physics in the bio-intelligence' course plan, he introduced a much heavier workload in biology, and particularly biological subject matter that was not covered in the biophysics' course plan such as cytology and embryology. Given that biophysics was conceived as a biology-oriented discipline from the very beginning, this tactic was advantageous to reinforce the disciplinary goal of building biophysics and prepare the educational ground to rekindle the discourse of cell continuity in the post-Mao era.

Infusing biological areas into the bio-intelligence course plan is another concrete example of the manifestation of the policy of "mission-drives-discipline" as mentioned in the foregoing chapters. Both bio-intelligence and biophysics shared a similar service role to the defense and space industries and this mission-oriented commonality surely helped justify Bei's effort to integrate elements of biophysics as a biology-centered subject into the bio-intelligence curriculum that appeared on the biophysics department's course catalog.

Summary

The preceding chapter discussed how Bei Shizhang led the Institute of Biophysics at CAS to volunteer and complete the bio-rocketry mission delegated from the highest authority. This chapter picked up the narrative threads and described the disciplinary benefits of the service role of biophysics beyond CAS. The mission connection helped biophysics to gain space in the newly established USTC in 1958 as the only biology-related department among the "USTC Thirteen." The department of biophysics administered only one program between 1958 and 1961. If the one-department-one-program alignment offered a more integrated teaching-and-learning team, as I contend, this arrangement was rather short-lived. The assimilation of biochemistry and bio-intelligence in 1961 and 1962 respectively altered the departmental structure. But as I argued, biochemistry was presented in the teaching outline as congruous with and even subordinate to biophysics. As for bio-intelligence, the above analysis showed that the course plan for bio-intelligence was structured along the axis of Bei's own areas of specialty in orthodox biology. All of these changes indicate that biophysics, just like other disciplines, were constantly reinventing themselves at a time when the institution and the state was in flux. The disciplinary growth of biophysics after 1958 did not follow a linear progressive chart from zero to the infinite. In reality, it was a rather rocky experience. However, biophysics as a department and a discipline managed to adapt to the waves of institutional changes by preserving and even expanding its core intellectual commitments.

The foregoing analysis covers the brief period from 1958 to 1962, but there is still not enough information to determine how unified and biologically oriented biophysics was. Therefore, we continue from 1962 to the eve of the Cultural Revolution in 1966 to follow up on its developmental trajectory.

CHAPTER 6

BIOPHYSICS ON THE EVE OF THE CULTURAL REVOLUTION, 1962-1966

Between 1958 and 1962, biophysics coalesced into a *bona fide* department encompassing biophysics, biochemistry, and bio-intelligence programs at the newly constructed University of Science and Technology of China (USTC) in Beijing. Not only was it a blossoming sign of the disciplinary development of biophysics in China, its impact was even more far-reaching: more than two hundred graduates of biophysics between 1958 and 1960 formed the backbone of the early efforts of biophysical research and missions; as of 2009, four Chinese academicians were USTC biophysics graduates.[250] In other words, the biophysics program at USTC was quite a national success quantitatively and qualitatively by training both mainstream and elite biophysicists in the contemporary People's Republic of China (P.R.C.).

The disciplinary triumph of biophysics was situated in the early institutional history of USTC; 1960 was an *annus mirabilis* for USTC administrators. Everything was on the rise: the university asked for 190 additional incoming students from the nation's best colleges and high-schools, accompanied with 375 teachers to be allocated to USTC. The optimism was exhibited in the forecast report prepared by the university for the academic years 1960 through 1967. In this document, the student body was envisioned to rise from 3145 in 1960 to 10,145 in 1962, reaching 20,000 by 1967, while the teaching staff was predicted to escalate from 1858 in 1962 to 2500 by the end of 1967.[251]

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[250] Wang Guyan, *A Biography of Bei Shizhang,* p. 168.

[251] "A Developmental Outline for the Teaching Staff, 1960-1967"1960-1967 年教学人员发展规划, in Zhu Qingshi 朱清时, ed. *A Draft Historiography of the University of Science and Technology of China* 中国科学技术大学编年史稿, (Hefei: University of Science and Technology of China Press, 2008), p. 23.

Yet behind these rosy figures came subtle countercurrents. The soaring of the student and staff population between 1960 and 1962 in the first three years aroused bureaucratic concerns on the need to control the drastic increase of teaching crew and resource management. The Science Council of CAS and the Higher-Education Administrative Board of the Ministry of Education issued instructions and memoranda to streamline the institutional structure of USTC between 1962 and 1964. The effect of these changing policies on the scale and status of biophysics at USTC were significant, and had far-reaching implications.

In documenting the university reform since 1962, this chapter reveals the contests between biophysicists and physicists at a time when the disciplinary investment of biophysics was at stake. Essentially, the responses of biophysicists and physicists to the top-down order of integrating biophysics into the department of physics illuminates the *de facto* disciplinary relationship between physical scientists and biology-oriented scientists in China and the politics of integration between physical and biological sciences.

As the destiny of the department of biophysics was in flux between 1962 and 1964, biophysics graduates from USTC undertook critical tasks in the biological sounding rocket mission(s). A major research thrust of the mission was on the biological problems associated with high-altitude flights; biophysicists were responsible for designing the biological rockets that propelled the first Chinese passengers to the sky: Two canine *taikonauts*[252] named *Xiao Bao* and *Shan Shan*. USTC graduates utilized and

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[252] The term *taikonaut* is the anglicized version of *taikongren* 太空人. Brian Harvey suggested that this term has the merit of symmetry with "astronaut" and "cosmonaut" used in the U.S. and Russia, and was favored by the western media over the transliterated term *yuhangyuan* 宇航员. However, both terms refer

applied the knowledge they learned from the biophysics program to the actual tasks in the field, culminating in launching the T-7A biological sounding rockets that took off between 1964 and 1966. Upon completing the mission, biophysicists left the launch site in the township of Shijiedu 誓节渡 at Guangde 广德 county in Anhui province. When the USTC was relocated from Beijing to Anhui during the Cultural Revolution, some of the biophysics students and alumni would help with navigating the area. Due to their prior famililarity with the local geography they had acquired while working on the biological sounding rocket mission, they were optimal candidates for assisting with the relocation.

From the changing institutional status of biophysics at USTC to the research-conducting capability of biophysicists in the space mission, the purpose of examining the shifting institutional policies and research missions from 1962 to 1966 is to depict the ebb and flow of biophysics on the eve of the Cultural Revolution. Both institutional support and material practices of biophysics during this period reflected the uncertainties and ambiguities before the advent of the Cultural Revolution. The vignettes portrayed in this chapter foreshadow the unfolding tumult of events from 1966 to 1976—the topic of the next chapter.

USTC Reform, 1961-1962

One of the early signs of university downsizing was the visitation of the party committee from CAS to USTC between January 17 and February 9 in 1961. A CAS

to men in space. In the context of animals in space, original Chinese sources usually describe the animals as "passenger" 乘客 or "explorer" 探空者. See Brian Harvey, *China's Space Program: From Conception to Manned Spaceflight* (Springer: Praxis, 2004), p. 251.

delegation consisting of twenty-seven bureaucrats and cadre representatives was dispatched to inspect the progress USTC had made in accordance with the principle of "adjustment, consolidation, substantiation, and enhancement" deliberated by the central authority. When USTC was founded in 1958, CAS leaders anticipated a timeframe of "three years erecting the foundation, five years shaping it up" (三年打基础, 五年成型). The 1961 site visit was planned to evaluate how much USTC had advanced in foundation-building in the first three years since its inception.[253]

The CAS inspection team was perturbed by the ever-expanding number of departments and programs at USTC. In 1960, the study of "science intelligence" (科学情报) was introduced to USTC as a single department, pushing the total number of departments to fourteen.[254] Backed by the policy orientation of "adjustment, consolidation, substantiation, and enhancement," the delegation recommended the "adjustment" of certain departments and programs in order to "consolidate" and "substantiate" teaching forces and resources for "enhancing" the quality of learning. On what basis did CAS reformers decide what departments were to be "adjusted?" And how was the "adjustment" plan carried out in practice?

The perceived association of disciplines and programs in relation to the state-directed missions constituted the grounds for departmental "adjustment." Under the guiding principle of "mission-drives-discipline," those majors and programs that clustered around a pilot mission but were assigned to different departments were going to

[253] "CAS Party Committee Came to the School to Inspect Work Progress"中国科学院党组来学校检查工作, *Ibid*, p. 29.
[254] "Appendix: Details of Program Structures of USTC" 附件:中国科学技术大学专业设置情况, OUA, USTC, Box 1962-WS-Y-24.

be combined. An example was the transfer of the computing program from the department of applied mathematics to that of automation; another was the combination of departments of thermal engineering and mechanics and mechanical engineering, forming a new department of modern mechanics.[255] The former change was to align the automation and computation forces at USTC with the Research Center of Computing Technology (计算技术研究室) at the Fifth Academy of the Ministry of National Defense; the latter to affiliate the applied mechanics team at USTC with the Research Center of Technical Physics (技术物理研究室) at the Fifth Academy.[256] By May 9, 1961, the institutional size of USTC was reduced from thirteen departments and forty-six programs before the adjustment to twelve departments and thirty programs post-adjustment. But both the program and the department of biophysics remained intact in this twelve-department institutional configuration in 1961.

However, 1961 was by no means an uneventful year for biophysics. On September 9, the university affairs committee convened the first plenary meeting to discuss matters regarding enrollment quotas and outcome assessment. Bei Shizhang attended the meeting in his capacity as a permanent committee member, along with forty-four other faculty members. The university concern on the declining learning outcomes as a result of the expanding student population was reflected in the central theme of the meeting—"(to do) everything for the quality of teaching" (一切为了教学质量).[257]

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[255] "The Adjustment of Departments and Specialties"系与专业调整, in Zhu Qingshi, ed. *A Draft Historiography of the University of Science and Technology of China*, p. 31.
[256] Li Chengzhi, ed., *A Draft History of the Development of Space Technology in China, vol. 1*, p. 76.
[257] "The University Affairs Committee Convenes the First Plenary Meeting"第一次校务委员会全体会议召开, in Zhu Qingshi, ed. *A Draft Historiography of the University of Science and Technology of China*, p. 32.

Concrete measures were put forth during the plenary session to improve the overall quality of education. A standing committee of the University Affairs Council was set up to monitor the political consciousness, physical health, and intellectual progress of the students. Sub-committees taking care of students' needs in areas such as campus dining and amenities were outlined in the policy paper "About the Recommendation of Setting Up a Committee of (Student) Life Management and Cancelling the Office of Infrastructure." This document indicated that the administrative priority had shifted momentarily from building infrastructure to bettering students' welfare.[258]

The university-wide concern with the quality of teaching prompted a series of changes in the biophysics department. The pruning exercise in 1961 resulted in twelve departments and thirty programs—an outcome with which CAS leaders were not particularly pleased. It was felt that the institutional size of USTC could use some further trimming. On August 3 1962, the vice-president of CAS, Zhang Jingfu, organized a party symposium at USTC to discuss adjustment proposals to reduce the number of departments to less than nine and that of programs to less than thirty. The symposium was open to cadre members, administrative officers, and secretariat staff only.[259] After attending the symposium, Yan Jici (严济慈), vice president of USTC, met with all the department heads to exchange views on the forthcoming reform, including Bei Shizhang, the *ex officio* head of the department of biophysics. Most scientists agreed with the basic rationale behind the 1962 adjustment: not only did a perceived over-specialization go against the mission-oriented statue of USTC, the national conditions of P.R.C. after the

[258] "The University Sets Up Life Managerial Committee and Office"学校成立生活管理委员会和生活处, *Ibid*, p. 35.
[259] "University Conducts Adjustment of Departments and Programs"学校进行系和专业调整, in Zhu Qingshi, ed. *A Draft Historiography of the University of Science and Technology of China*, p. 42.

Great Leap Forward and the concomitant natural disasters simply did not afford USTC (or any higher-education institution) the luxury to professionalize individual disciplines, no matter how legitimate the disciplines appeared to be. CAS leaders felt it very necessary to curb the professionalization and specialization trends at USTC by capping the number of departments and programs.

Several options were entertained in contemplation of the departmental cutbacks. One was an "8-department-29-program" model, another a "9-department-31-program" scheme. In both plans, the program of biophysics was preserved but not the department itself. Essentially, the department of biophysics was integrated into the department of nuclear physics in both options.[260] As the department of biophysics offered three programs—biochemistry, biophysics, and bio-intelligence—at the end of 1962, USTC was already considering closing it down. The school's resolution to terminate the department of biophysics was displayed in other alternative motions the reform committee put forth. In the "5-department-21-program" and "6-department-21-program" plans, biophysics was placed under the department of modern physics and the department of technical physics respectively.[261] It seemed pretty obvious that regardless of the final number of departments, biophysics was going to be incorporated into physics—be it nuclear, modern, or technical physics.

There were many possible reasons why biophysics was merged with other departments. The same set of qualities that initially made biophysics stand out from the rest of the founding departments——small student population, low department-to-program

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[260] "Adjustment Plans For Departments and Programs at USTC" 中国科技大学系和专业调整方案, OUA, USTC, Box 1962-WS-Y-24.

[261] "A Corresponding List of Departments and Programs at USTC" 中国科学技术大学系与专业设置方案对照表, OUA, USTC, Box 1962-WS-Y-24.

ratio——now became the compelling reasons to justify its abolition. At the time of budget cut and institutional slash, the low enrollment figure and thin course catalog of the biophysics department seemed to indicate that biophysics did not merit a separate department of its own and that it was more dispensable than other departments.

Nevertheless, physicists and biophysicists viewed the stakes involved in the biophysics assimilation plan differently from policy makers. Physicists at USTC and CAS objected to integrating biophysics with physics. Shi Ruwei (施汝为), head of the department of technical physics at USTC, commented that the overall adjustment plan of department and programs was sensible as the amalgamation of unrelated disciplines in a big physics department was just an administrative tactic. But he warned that an expanded department of physics would become difficult to manage, since coordinating a big department to various institutes at CAS would be quite challenging.[262]

In the written comments solicited by vice-president Yan with regard to the above merger, the Institute of Nuclear Physics (INP) reported that they concurred with the recommendation of offering new programs in atomic-and-nuclear physics as well as radioactive engineering physics, but disagreed with the idea of incorporating the biophysics program into the department of nuclear physics.[263] Zhao Zhongyao (赵忠尧), widely regarded as the father of nuclear physics in China, spoke on behalf of INP that "it

[262] "A 1962 Compiled Opinions from Some Leaders and Comrades from Related Research Centers on Our School's 14 Departments and Programs Adjustment Draft" 1962 各有关研究院所部分领导同志对我校14 系与专业调整草案的意见汇集, OUA, USTC, Box 1962-WS-Y-24.

[263] "Opinions from Related Research Centers on Departments and Programs Adjustment" 有关研究所对系和专业调整的意见, OUA, USTC, Box 1962-WS-Y-24.

is inappropriate to combine nuclear physics with biophysics as their subject matters have no similarities."[264]

Meanwhile, the Institute of Biophysics also acknowledged the general principle and orientation of the reform. Under the practical circumstances of IBP, difficulties abounded in the past three years of running the biophysics department. Therefore, IBP was in favor of reducing the size of the department and especially cutting the number of programs.[265] Yet, it opposed the idea of closing down the department of biophysics because "the news of the establishment of the biophysics department has already spread to outside the country; terminating the department is a matter of (China's international) reputation" (国外已知我校设有生物物理，撤消后与名誉有关). Yet if the dismissal of the biophysics department was absolutely inevitable, IBP suggested that USTC should at least consider changing the name of the program from biophysics to radiobiology (放射生物学) in order to ensure that USTC biophysics graduates could work at IBP.[266] This is because radiobiology was the only required *professional* course in both biophysics and bio-intelligence course plans by 1961. Therefore, the existing course plans could accommodate the name modification without putting the program and already-enrolled students at a big disadvantage.

Chinese physicists and biophysicists held different views on the disjunction of the disciplines they represented. The above juxtaposition indicates that the administrative strategy of attaching biophysics to physics was not well received by physicists or

[264] "A 1962 Compiled Opinions from Some Leaders and Comrades from Related Research Centers on Our School's 14 Departments and Programs Adjustment Draft," OUA, USTC, Box 1962-WS-Y-24.
[265] *Ibid*.
[266] "Opinions from Related Research Centers on Departments and Programs Adjustment," OUA, USTC, Box 1962-WS-Y-24.

biophysicists alike, albeit for different reasons. Physicists were more concerned about the lack of epistemic commonalities between nuclear physics and biophysics than about what would become of biophysics, while biophysicists were preoccupied with the international and academic consequences of dissolving the biophysics department. In particular, biophysicists viewed the suspension of the biophysics department as a matter of China's international image. The biophysicists' attempted justification of international standing and national prestige reflected the profound impact of the Cold War on scientific disputes in China.

Radiobiology as a Keystone

In reality, the recommended name alteration from biophysics to radiobiology was inseparable from the wider political discourse in the summer of 1962, when the U.S. launched a high-altitude nuclear weapon test some 250 miles above the Pacific Ocean. The so-called "Starfish Prime" event would lead to outrage among the Chinese scientific community, and figures such as Bei offered their own scathing commentary on the matter. Bei Shizhang was featured in an op-ed on *People's Daily*, inveighing against the U.S. "imperialists" for their "barbaric" action in total disregard of the safety and well-being of the rest of the world in the strongest possible terms:

> That American imperialists ignore the opposition from people all over the world and conduct a barbaric nuclear blast in space is a signal of their outrageous preparation for a nuclear war. We know that a nuclear explosion in space endangers not just a country or a region but the entire globe. One can see clearly now that it is American imperialism that poses

a threat to world peace. To defend world peace and to fight for happiness for humanity, we are raising the strongest protest against American imperialism.[267]

Comments such as this exemplified the kind of anti-american furor that occurred with the Chinese scientific community as a result of the incident. I copied Bei's quotation in full here because his unusually acrimonious tone was suggestive of the disciplinary interests of biophysics in high-altitude rocket flights in the early sixties. When this article appeared, the biological sounding rocket was still in the experimental stage and therefore away from public view. The average reader of *People's Daily* in the sixties was more or less accustomed to the abundant use of certain Cold War parlance such as "American imperialism;" but what made this op-ed unconventional was the person by whom these politically-charged phrases were uttered. Bei was reported in this article as not just a renowned biologist and the director of IBP of CAS, but as a representative of Chinese scientists as a whole. Considering the authoritative voice of *People's Daily* in Maoist China, it was not an over-statement that Bei and his trademark——biophysics——had acquired certain political sway on nuclear politics and particularly the biological hazards of atomic hegemony.

Bei's political leverage was particularly conspicuous in comparison with the other two scientists featured in the same article. Zhao Jiuzhang 赵九章, director of the CAS Institute of Geophysics, also criticized the U.S. "imperialist" action as a nuclear blast in lower outer-space was 100 times more powerful and potentially destructive than the

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[267] "Scientists in Our Country such as Bei Shizhang and Others Spoke Out Angrily against the United States for Scaling Up on Preparing a Nuclear War" 我国科学家贝时璋等发表谈话, 怒斥美国加紧准备核战争, *People's Daily*, July 13, 1962.

Hiroshima bomb. The electromagnetic pulse resulting from the nuclear explosion created an artificial radiation belt that significantly reduced the shielding of earth from solar radiation. The high-altitude explosions exposed the hypocrisy of the UN hype on the "peaceful use of outer space."

Zhao and the Institute of Geophysics under his leadership was another CAS team in the Mission 581, next to Bei Shizhang and his IBP team. The geophysical sounding rocket series predated the biological sounding rocket series in the launch history of T-7 rocket flights. The first geophysical sounding rocket was fired in February 1960 and the first biological sounding rocket prototype was not ready until 1963. In many ways, Zhao's expertise and experiences outshone Bei's on the topic of nuclear space bursts and their hazards. Zhao's knowledge was demonstrated in his more fact-based illustration of the effects of nuclear detonation and radioactive fallout on atmospheric integrity. Yet Bei was highlighted in this article as the spokesman of atmospheric radiology, not Zhao, whose academic capital eclipsed Bei's, who had nowhere near Bei's.

The last scientific figure in this article was Lin Rong (林熔), deputy chairman of the Biological Academic Division and associate director of the Institute of Botany at CAS. He condemned the "crazy" behavior of the U.S. on the grounds that the nuclear test affected the natural habitat on earth by wrecking the ionosphere. As veteran biologists, Lin and Bei were among the first fifty academicians to be elected in the Biological Academic Division of CAS in 1955.[268]

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[268] "Executive Summary of the Meeting of Establishing Academic Divisions" 学部成立大会工作总结报告, *A Compiled and Edited Historical Materials of the Chinese Academy of Sciences* 中国科学院史料汇编 September 14, 1954, pp. 211-215.

More importantly, Bei's public stance in *People's Daily* reflected his continued interest in promoting radiobiology as a legitimate field and career for biophysicists. Right after the sounding rocket operations were included in Mission 581, Zhao and Bei appeared in a news article praising the Soviet effort in pioneering high-altitude space travel with dogs and rabbits.[269] A large part of the article was dedicated to Zhao's comment on the technological advances of Soviet rocketry in terms of their propulsion horsepower, payload-carrying capacities, and types of scientific instruments for measuring ionospheric components and cosmic radiation. Bei received much smaller coverage than Zhao in this 1959 news report. Bei underlined the Soviet accomplishment of carrying biological passengers and specimens in suborbital flights, commending the tremendous scientific value of these cosmobiological missions for supplying requisite data for the further studies of space travel. Bei even claimed that "such a great scientific achievement could only take place in socialist countries."

What these two pieces of news in *People's Daily* suggested was Bei's concerted effort to procure political credibility and popular advocacy in preparation for biophysicists' strides into radiobiology in the late fifties and early sixties. These journalistic discourses shaped the developmental trajectory of radiobiology from primarily a small laboratory in nuclear physics to a nationally recognized core field in biophysics. In 1957, Bei agreed to construct and supervise a radiobiology laboratory within the Institute of Nuclear Physics upon the invitation of physicist Qian Sanqian. The emergence of radiobiology was partly triggered by the growing urgency to measure and

[269] "Scientists in Our Country, Zhao Jiuzhang and Bei Shizhang, Pointed to the Soviet High-Altitude Rocket Flights as an Important Creation" 我国科学家赵九章、贝时璋指出，苏联高空火箭是重大的创造, *People's Daily*, July 09, 1959.

prevent nuclear threats to living creatures in the Space Age. The radiobiology laboratory was established to further the study of biological effects of nuclear bombs and radioactive fallout on the environment and living organisms. In this radiobiology laboratory, an isotope measurement unit and eighteen monitor stations for detecting ash precipitation were set up to study the long-term small-dose radiation on animals and early diagnosis of radioactive-related diseases.

But Bei was not satisfied with leaving radiobiology in the hands of nuclear physicists. As soon as biophysics was institutionalized in 1958, he immediately constructed a radiobiology research group within the brand new IBP to offer more investigative branches in radiobiology, from studies of radiation measurement, radiation dosimetry, radio ecology, radio genetics, radiation protection background radiation, to biological impacts of internal radiation exposures etc. The elaborate organizational scope of radiobiology made it the largest in-house research group in IBP and a top collaborative partner with the Defense Ministry.[270]

Bei's ambition in furthering the course of radiobiology was manifested in the "National Radiobiology Workshop" that he organized in Beijing's *Xiang Shan* Hotel between February 7 and 11 in 1960. As the convener and member of the "steering committee of the national radiobiology research," he reported on the current state of research in radiobiology in addition to issuing a "National Blueprint for the Research on Radiobiology and Radiotherapy." Three years after this agenda-setting workshop, the

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[270] Li Gongxiu 李公岫, "Professor Bei's Trailblazing Contribution in Radiobiology in Our Country" 贝师对我国放射生物学的开创及其贡献, inInstitute of Biophysics of the Chinese Academy of Sciences ed., 中国科学院生物物理研究所, *Bei Shizhang and Biophysics: A Festschrift* 《贝时璋与生物物理学》纪念文集 <ibp.cas.cn>.

National Defense Science and Technology Commission (NDSTC, 国防科委) coordinated a "National Radiobiology and Radiotherapy Academic Exchange Conference" between August 28 and September 12 in 1963. The conference organizing committee received a total of 684 papers from all over the country, attesting to the national mobilizing impact of the 1960 workshop Bei put together.

In the closing speech of the 1963 conference entitled "current status and prospects of radiology and radiotherapy in our country," Bei reviewed the short history of radiobiology and radiotherapy in the P.R.C. as measured against the international benchmark. He compared the number of research papers submitted to the 1963 conference with the average number of publications contained in two major radiobiology academic databases at the time, *Nuclear Science Abstracts* and *Excerpta Medica*, to evaluate the advances China had made from 1960 to 1963. The 684 papers averaging some three hundred papers per year accounted for about one-tenth of the thirty six hundred and three thousand articles indexed in NSA and EM respectively in 1962. His preliminary bibliometric analysis of the quantity and quality of Chinese publication in radiobiology and radiotherapy highlighted not just China's share of the world's research output but also the qualitative distinctiveness of Chinese efforts in these two areas. As Bei argued, "Compared with international research, not only does the development of radiobiology and radiotherapy in our country cover a more comprehensive scope, a balance is maintained among the five research areas." The five research areas he referred to were radiobiology, radio-therapy, radio-hygiene, radiation dosimetry, radiation measurement, and biomedical applications of isotopes. To Bei, the notion of a balance of disciplines was desirable, as he followed a holistic view of science in which the interplay between wholes and parts is stressed:

> It is imperative to possess a holistic concept in order to study living organisms. But judging from the present level of technical capability, it is difficult to penetrate and solve problems if we only limit ourselves to studying the whole organisms without using *in vitro* experiments as supplements. The connections between wholes and parts, macro and micro, and structures and functions, are the three aspects of the basic patterns of living behaviors.[271]

In his tireless campaign to promote new disciplinary interests—in this case, radiobiology——Bei maintained a basic commitment to a biology-centered conception of disciplinary configuration. His primary interest in understanding living organisms does not preclude obtrusive experimental methodology in favor of a vitalistic approach for preserving the integrity of the organism. A holistic view of nature does not necessarily translate to an unenlightened obstinacy against new technology and methodology for more precise mechanical demonstration. It simply means a more balanced and systematic approach that seeks to relate those new methods with other parts within the broader purview of life science.

Bei's systematic thinking also showed in his comprehensive efforts to promote radiobiology as a subset of biophysics. Bei's political rhetoric in *People's Daily* and his national conference-organizing endeavor was matched by the educational campaign at USTC. When the biophysics department was going to be slashed by USTC administrators

[271] Wang Guyan, *A Biography of Bei Shizhang,* p. 232.

in 1963, Bei sought to anchor the disciplinary significance of biophysics to other national developments and missions via the conduit of radiobiology and cosmobiology:

> Certain areas in the terrain of biophysics have direct impact on the development of other disciplines. For example, research in radiobiology not only offers efficacious prophylactic and diagnostic measures in radiation-related diseases, but also facilitates the further development of the nuclear industry. Meanwhile, research in cosmobiology paves the way for manned space exploration and contributes to inter-planetary flight service. Therefore, building this program (biophysics) is of paramount importance.[272]

In this internal reference document, Bei justified the importance of biophysics from the standpoint of the service-role of both radiobiology and cosmobiology. Before 1963, most of the service discourse of biophysics orbited around the bio-rocketry mission and cosmobiology by the virtue of Mission 581. Radiobiology only appeared in the public arena as a legitimate realm for biophysics in or around 1960. The radiobiology connection to the military service was a timely venture to rescue the biophysics outpost at USTC. The "Starfish Prime" event came at a critical moment which ultimately furthered the importance of radiobiology in biophysics as concerns over radioactive fallout was fresh in everyone's minds. As the institutional clout of biophysics diminished at USTC, Bei and the IBP-CAS proposed a damage control measure by changing the name of the program from biophysics to radiobiology at the same time when radiobiology benefited enormously from the national concern that was a result of the recent event. Considering

[272] "Adjustment Plan for Seven Departments and Specialized Groups (Classified)" 七个系专业、专门组调整方案(机密), OUA, USTC, Box 1963-WS-Y-33.

the impact that it had upon both the public and officials, it came as little surprise that Bei's proposal was immediately accepted. Radiobiology would serve as a strategic keystone upon which biophysics would use to enter its next transitional stage.

Shen Shumin and Biophysics, 1961-1964

While Bei was busy traveling around the country to champion radiobiology as a new domain for biophysics, he left most of the managerial tasks of biophysics at USTC in the hands of a female biophysicist—Shen Shumin.

Shen Shumin was the second-in-command in the circle of Chinese biophysicists, next to Bei Shizhang. She had always been a devotee of Bei even before biophysics was instituted in 1958. She was employed as an assistant researcher in the developmental physiology laboratory in the Institute of Experimental Biology (IEB) back in 1950 when Bei acted as its founding director.[273] (The history of IEB as an institutional stepping-stone for the Institute of Biophysics (IBP) has been delineated in chapter four.) After IEB dissolved as the plant physiology and entomology teams left the institute in 1953, only the developmental physiology team continued to follow Bei's leadership. Shen was one of the core members who helped Bei with the founding of IBP and the subsequent transfer of personnel and equipment from IEB in Shanghai to IBP in Beijing. After the department of biophysics was created in USTC in 1958, Bei appointed Shen as the associate head to manage most of the day-to-day affairs. Not only was Shen in charge of setting up the overall course outlines, development goals, and staff deployment on behalf of Bei, she was the critical link that bridged teaching resources from IBP at CAS with

[273] "In Woeful Mourning of Professor Shen Shumin"沉痛悼念沈淑敏先生, *Progress in Biochemistry and Biophysics* (*PIBB)* 生物化学与生物物理进展 23, Issue 6, (1996): 482.

demands at the biophysics department at USTC. Shen acted as *de facto* department head as Bei Shizhang—the *de jure* head—was simply too busy to supervise the day-to-day operation of the department.[274]

In 1961, Shen took the liberty to split the teaching and research units along the physics/biology dividing line. The *physics* teaching and research unit was presided over by Shen Shumin, acting head of the department of biophysics, whereas the *biology* unit was headed by Ma Xiuquan (马秀权), who was then a supplemental teacher.[275] Juxtaposing Shen's ranking as a right-hand (wo)man of Bei Shizhang, who entrusted her with the task of overseeing the department of biophysics since 1958, with that of Ma, who was not even a regular faculty member, one could see rather clearly the level of significance ascribed to the *physics* teaching and research unit over the *biology* unit.

Existing evidence suggests that Shen mostly followed Bei's disciplinary vision in managing departmental affairs. She was particularly keen on fostering cross-fertilization between the physical sciences and biological sciences through prescribing mandatory coursework in mathematics, physics, and chemistry for all biophysics majors in the first three years of their undergraduate studies.[276] As the last chapter revealed, the compulsory courses in physical sciences were in compliance with the university's educational policy. It is hard to determine, however, how much the biophysics' course plan was designed as

[274] "An indefatigable Journal Founder Delights in the Mission of Education—Celebrating the Eightieth Birthday of Professor Shen Shumin"办刊育人, 乐此不倦—沈淑敏先生八十寿辰致庆, *PIBB* 22, Issue 1, (1995): 2-4.
[275] "The Department of Biophysics Creates Two Teaching and Research Units"生物物理系设立两个教研室, in Zhu Qingshi, ed. *A Draft Historiography of the University of Science and Technology of China*, p. 37.
[276] "An indefatigable Journal Founder Delights in the Mission of Education—Celebrating the Eightieth Birthday of Professor Shen Shumin" *PIBB* 22, Issue 1, (1995): 2-4, on p. 3.

a political stratagem. Was it to satisfy top-down requirements or as a bottom-up strategy to fulfill the disciplinary wishes of Shen backed with the endorsement of Bei?

Yet one thing was certain: the idea of creating bifurcated teaching and research units in the department of biology was not a mandatory order from above, but a voluntary action emerging from below, with its chain of authority traced all the way to Shen Shumin and ultimately Bei Shizhang. It was puzzling as to why Shen and Bei split the department into two units, but in retrospect, this seemingly contradictory action at the time would prepare the biophysics department to better cope with the next round of reforms at USTC in the coming years.

In retrospect, this seemingly contradictory action at the time was possibly a preemptive move to prepare the biophysics department to better cope with the next round of reforms at USTC in the coming years as the department of biophysics ceased to be a self-contained department. In 1964, Shen turned to articulate the applied values of biophysics in her op-ed that appeared in *People's Daily*.[277] In this article, she underlined advances made in radiobiology for diagnosing and treating tumors. She did not specify the clinical mechanism or effectiveness for treating radiation-induced tumors, but merely suggested possible avenues of treatment, such as "using radiation to cure tumors, or isotopic treatment for targeting tumors, or ultrasonic and microwave thermal therapies et cetera." Her intention was to draw attention to radiobiology and radiotherapy as biophysics-circumscribed areas with practical value. After identifying the medical benefits of biophysics via the channel of radiotherapy and radiobiology, Shen enumerated the areas of study that she considered as constituting biophysics. These included

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[277] Shen Shumin, "A Newfound Discipline in Biological Sciences—Biophysics," *People's Daily*, August 06, 1963.

biomechanics, acoustic biology, thermal biology, electro-biology, photo-biology, radiobiology, cosmobiology, theoretical biophysics, and instrument and technology in biophysics. Among these subdivisions, the incorporation of biomechanics in the profile of biophysics was derived from the decision reached by the Party's Committee for USTC in April 1960 that the study content of biomechanics was part and parcel of biophysics; the episode that was chronicled in the previous chapter of this book. Radiobiology and cosmobiology were the pillars of biophysics in 1963, when the department of biophysics at USTC disintegrated and journalistic campaigns for radiobiology and cosmobiology were in full swing. The rest of the study areas are all suffixed with "biology," affirming the biology-centered disciplinary underpinning of biophysics.

Shen's perspective on the character of physics in her narrative of biophysics was in line with her 1961 decision to administer the physics teaching and research unit under the biophysics department, as well as her efforts to increase the teaching hours of physics classes for biophysics students at USTC. The picture we get is that a leading biophysicist, in her capacity as the acting department head, was working step-by-step to gradually promote the participation of physics in biophysics. Her endeavor paid off in 1964, when the Party's Committee of CAS appointed her as the associate head of the department of physics——the very department into which biophysics was incorporated.[278]

This arrangement was noteworthy for three reasons. First and foremost, Shen had no training in physics. She was a biology graduate from Dongwu University in Suzhou in 1937. Her biology background prepared her for her many lectures in medical colleges all

[278] "Several Organizational Adjustment and Personnel Appointment" 部分机构调整和人事任免, in Zhu Qingshi, ed. *A Draft Historiography of the University of Science and Technology of China*, p. 75.

over China before she joined the Institute of Experimental Biology in 1950.[279] But she had no previous apprenticeship or academic positions in physics whatsoever. Therefore, her appointment was not a matter of expertise-borrowing but a political arrangement involving the balancing of disciplinary power. In terms of academic membership, not only was Shen the only biophysicist sitting in the executive committee of one of the six standing departments after the biophysics department was dismantled, she was the only appointee with her disciplinary affiliation labeled next to her post, signifying that Shen was a non-physicist on the committee that presided over the department of physics. The executive committees in the other five departments consisted of well-known scientists from their own disciplines: The department of mathematics was chaired by the renowned mathematicians Hua Luogeng (华罗庚) and Guan Zhaozhi (关肇直); the department of modern chemistry by Liu Dagang (柳大纲) and Wang Baoren (王葆仁), the department of modern physics by Zhao Zhongyao (赵忠尧) (who was opposed to the motion of placing biophysics under the institutional umbrella of modern physics due to a lack of perceived commonality in the subject matter), and Zheng Lin (郑林); the department of modern mechanics by the notable Qian Xuesen, and the department of wireless electronics by Ma Dayou (马大猷) and Lu Yuanjiu (陆元九). All of the above appointees were luminaries in their respective disciplines, meaning that there was no need to identify Hua Luogeng from the Institute of Mathematics or Qian Xuesen from the Institute of Mechanics because their disciplinary affiliations were supposed to be self-evident. Only in the department of physics under the directorship of Shi Ruwei, the disciplinary

[279] "In Woeful Mourning of Professor Shen Shumin," *PIBB* 23, Issue 6, (1996): 482.

background of the associate head Shen Shumin as a biophysicist was specified. It is possible that Shen was not as famous as other scientific dignitaries in the new cabinet or that the disciplinary recognition of biophysics was still low among the team members. Regardless of the reason, Shen made it into the rank of decision-makers at USTC by 1964 as the associate head of the department of physics.

What this signified was that biophysics still enjoyed a certain level of respect in the university even though it was robbed of its independent institutional space. That a leading biophysicist was still in a position of academic authority after the department of biophysics was dissolved shows that the discipline still enjoyed some of its former prestige. One should not lose sight of the fact that over half of the original "USTC Thirteen" departments were curtailed by 1964. It is true that biophysics did not maintain its initial status as a self-contained department after 1962, but it was premature to conclude that a diminishing institutional visibility equals the decline and fall of biophysics. Rather, the institutional clout of biophysics continued and with it the legitimacy of biophysics as a subject of inquiry. It would remain pertinent despite the setbacks that it had endured during the period of 1962-64, and though it lacked an official departmental space, it was still regarded as an independent discipline, thus revealing its level of importance.

Cosmobiology as the Origin of China's Manned Spaceflights

While the department of biophysics was experiencing an overhaul at USTC, Bei Shizhang was busy supervising an unprecedented space mission. Bei's interest in high-altitude and space biology had already crystallized by 1958, when he proposed to the standing committee of CAS that the newly established IBP should undertake the bio-rocketry program in Mission 581.[280] Under the auspices of political patronage and institutional blessing, he expanded the "581 biology team" (581 生物小组) into a "cosmobiology research unit" (宇宙生物学研究室) to turn a temporary state-led mission into a legitimate area of study within the institutional framework of biophysics.[281] The "cosmobiology research unit" was a specialized unit dedicated to the study of the bio-dynamics of spaceflight. The establishment of this unit was undoubtedly fueled by Mission 581, but Bei's hope was for cosmobiology to take root in biophysics after the completion of the mission. This was a manifestation of how mission could drive discipline beyond the mission itself.

The political momentum was there, and so was the institutional sponsorship for the formation of cosmobiology. Cosmobiology, or space biology, refers to the study of life in space. In order to study how living things function and react in space, one has to make it to (outer) space first. But leaving the earthbound environment is a step-by-step skyward journey facilitated by better technology. With more powerful propulsion systems and more enduring fuel supplies in place, one could reasonably hope to explore higher elevations off the ground. It might seem that before one could reach space, talking about studying life in space is futile and even ridiculous. Yet people have been concerned about human well-being in the air since well before the age of space exploration. Vertical distance distinguishes what is called aviation or aerospace medicine from space or

[280] Wang Guyan, *A Biography of Bei Shizhang,* pp. 248-9.
[281] Wang Xiubi 王修璧, "Professor Bei Shizhang is the Pioneer of Cosmobiology Research in Our Country" 贝时璋教授是我国宇宙生物学研究的开拓者, in *Bei Shizhang and Biophysics: A Festschrift*<ibp.cas.cn>.

cosmobiology. The main difference is height, but the general concern is similar: what are the effects of space environments such as low atmospheric pressure and oxygen deprivation on airborne living creatures? Flight physiology was a high priority during WWII, when military interest in the health of pilot crews was heightened by air warfare. Early attempts in studying the physiological effects of extreme altitude could be traced to the antebellum period of Himalayan expeditions in the 1890s, when the hazardous effects of extreme climatic conditions on mountaineers and climbers were not particularly well understood.[282]

The abiding interest in the limits of human tolerance to the hazards of extreme natural environment culminates in what is called "the human factor" in high-altitude or space flight.[283] "The human factor" in space exploration recognizes that sending any non-living machine into orbit is not an engineering feat until the empty vessel is filled with a living space passenger as "the human factor" is the critical variable and the ultimate barrier for realizing the dream of space travel.

Researching the near- and long-term biological effects of spaceflight and the space environment in preparation for manned space exploration was Bei's expressed orientation and mission for cosmobiology. The cosmobiology research unit took its initial research agenda from 581's bio-rocketry program to experiment with putting living organisms and specimens on rocket flights. The unit became the home for a long-term

[282] Maura Philips MacKowski, "Human Factors: Aerospace Medicine and the Origins of Manned Space Flight in the U.S.,"PhD dissertation, Arizona State University, 2002.
[283] John Pitts. *The Human Factor: Biomedicine in the Manned Space Program to 1980* (DC: NASA, 1985).

effort to investigate the physiological hurdles in spaceflights with animals as a proxy that could feed valuable data for future manned space exploration.[284]

Brian Harvey was right to suggest that "the idea of a manned space flight had always been in Chinese thinking from the very start."[285] Although China did not send the first man into orbit until 2003, the Chinese ambition in a manned space program had its origin in this humble cosmobiology research unit back in 1958. Wang Xiji, former director of the China Academy of Space Technology (CAST), applauded the efforts of the cosmobiology group in 2006: "the research of cosmobiology and the launch of biological rocket flights laid the cornerstone for developing China's manned spaceflight."[286] Next to Wang's calligraphic script lies Bei Shizhang's inscription that reads, "flying dogs to the sky marks the beginning of cosmobiology in our country." We can see the trajectory here: manned spaceflights began with cosmobiology, and cosmobiology kicked off with the task to "fly dogs to the sky." But what was the beginning point of "flying dogs to the sky?" How and when did those in the cosmobiology team start engaging in this program?

Coursework and Fieldwork in Cosmobiology, 1963-1966

Cosmobiology could not have flourished without the necessary supply of scientific manpower. Considered the critical shortage of talent in most areas in science and technology in the late 1950s, expanding the domestic S&T talent pool through

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[284] Bei Shizhang, "Commencing the Research in Cosmobiology in Preparation for Manned Space Exploration" 开展宇宙生物学研究为载人航天作准备, *Science Times*, November 15, 2006.
[285] Brian Harvey, *The Chinese Space Programme: From Conception to Future Capabilities* (West Sussex: Wiley-Praxis, 1998), p. 146.
[286] IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets* 小狗飞天记:中国生物火箭试验纪实, (Beijing: Science Press, 2008), foreword.

education was the key. Particularly in areas of scientific study that involved politically sensitive materials, the hopes of technological transfer were flimsy at best. Cosmobiology, with its close connection to the earth satellite program in the defense enterprise, was one of the advanced S&T areas in which foreign acquisition of technology and specialists was virtually impossible in the age of the Space Race. In the context of cosmobiology, the policy mantra of "self-reliance" meant offering domestic cosmobiological courses in order to ensure an indigenous supply of S&T talent. Where was a better place to run a study program of cosmobiology than the biophysics department at USTC?

Although cosmobiology was instituted in 1958, the first course in cosmobiology was not introduced to USTC biophysics students until 1963, after the biophysics program fell under the department of physics. The cosmobiological courses were offered between 1963 and 1966, until the "Cultural Revolution" put a halt to the normal operations of USTC.[287] Of course, no one could have predicted the unfolding of the cosmobiology program in 1963, but from the inception of the program, the time frame to demonstrate the pragmatic values of the cosmobiological coursework was reckoned to be very short under the stringent demands of Mission 581. The "T-7A" biological sounding rocket was listed as the key mission for both CAS and IBP between 1963 and 1965.[288] In other words, students in the cosmobiology program did not have much time to muse over books in the classroom; they had to convert what they learned from the classroom into

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[287] *Ibid*, p. 8; also see Ding Yixin 丁毅信, and Ding Zhaojun 丁兆君,*Information and Research of University History* (*IRUH*, 校史资料与研究), Issue 2, (December 10, 2007) available at <arch.ustc.edu.cn/news>.

[288] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star'* (Guangzhou: Jinan University Press, 1999), pp. 342-343.

the skills and techniques for solving practical problems in the field almost immediately. Given the mission expectations of launching the first T-7A rocket no later than 1965, what was required was not just a close cooperation between the teaching crew and the students to coordinate the teaching and service responsibilities but almost a simultaneous orchestration of classwork and fieldwork: what was learned in the school had to be immediately applied to see if the knowledge worked in practice or otherwise the mission could not be completed as planned.

In the institutional context of USTC in which "basic knowledge" was given extraordinary attention, this meant the implementation of cosmobiology courses would somehow violate the general pedagogical policy of USTC as visited in the previous chapter. It was a delicate matter of how to appeal to the university's board of leaders to consider loosening their long-cherished emphasis on "foundation" and "basics" for a program (cosmobiology) that was a subdivision of a discipline (biophysics) which no longer enjoyed the status of an independent department. For this purpose, Bei persuaded the USTC administrators to sponsor a scheme of "sounding technology specialty" which was dedicated solely to the study of instruments and technologies for space exploration:

> This specialty studies the instruments for measurement and detection, sensing devices and methods for ground-based remote measurement and control in high-altitude exploration launched by artificial satellites or rockets. The orbit route and speed of rockets and satellites, as well as radar technologies for tracing long-distance target positioning are also subjects of research. Since it is closely related to national defense and requires a

larger pool of talents, creating this specialty is of paramount importance.[289]

The "sounding technology specialty" was packaged as a purely technological program without anything to do with biology. The deliberate downplaying of biology in the above wording made sense given the circumstances of USTC in 1963, where none of the six remaining departments had any perceptible relationship with biology. Being framed as a study program for space technology rather than space biology was more agreeable with USTC's positioning and overall interests than otherwise. The underlined connection with national defense justified the strategic exemption from the university's strict requirement on "basic knowledge."

Be that as it may, the crew responsible for teaching some of the courses in the "sounding technology specialty" was directly appointed from the cosmobiology research unit at IBP. The cosmobiology curriculum was designed to expose students to basic ideas that were necessary for putting together the biological sounding rockets. As instructors and graduates showed their appreciation in reminiscences, many commented that the cosmobiology course module knit together knowledge and practice in the interests of mission-completion and self-improvement (既完成了任务, 又锻炼了自己).

Deng Jiaqi (邓家齐) and Li Zhenxiang (李祯祥) led the teaching staff of cosmobiology and were instrumental in pioneering the combination of coursework and fieldwork. Deng taught three courses, namely "Cosmobiology in closed environments," "The problems of radiation in perigee altitude," and "Explosive Cabin Decompression;"

[289] "Adjustment Plan for Seven Departments and Specialized Groups (Classified)" 七个系专业、专门组调整方案(机密), OUA, USTC, Box 1963-WS-Y-33.

Li was responsible for two courses, namely, "Biomechanics in space" and "Uranobiology" or "Exobiology."[290] We can see an emerging pattern in which these five core courses were categorized along the dividing line of the two instructors: Deng specialized in the service-oriented, rocketeering courses while Li lectured mainly on the theoretical aspects of space biology. Yet this classificatory scheme was deceptive; in addition to their teaching duties, both Deng and Li were also in charge of on-site experimental classes. Deng supervised the preflight and postflight medical assessments of animals' physiological responses to hazardous conditions and stress factors of rocket flights. He taught students how to measure and record the "four physiological signs" of pulse rate, respiration rate, maximum and minimum blood pressure, and body temperature.[291] Deng's expertise in monitoring the physiological effects of high-altitude exposure was noteworthy. In the meantime, Li was hardly an armchair professor; he was experimenting with ideas about means to reduce shock impact and vibration extremes in the cabin,[292] as well as a series of joint experiments involving launch rundown and bailout systems simulation with parachutes.[293] Li was equally competent in the technical part of the cosmobiological work. Just like American field biologists crossing the lab-field border with their new line of work in natural history at the border zone, the mixed

[290] Deng Jiaqi, "Remembering the Days of Teaching 'Cosmobiology'" 回忆讲授'宇宙生物学'的日子 in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 216-217; Li Zhenxiang, "Cosmobiological Courses in USTC" 中国科技大学的宇宙生物学课程, *Ibid*, pp. 218-219.

[291] Deng Jiaqi, "Some Vignettes of Temperature Experiments" 关于温度实验的一些情况, *Flying Dogs in the Sky*, pp. 142-143.

[292] Li Zhenxiang, "Vibration Experiments in Mice"鼠的振动实验, *Ibid*, pp. 144-146.

[293] Li Zhenxiang, "Joint Experiments, Launch Rundown, and Bailout Impact Experiments"联合试验、进舱流程、空投冲击试验, *Ibid*, pp. 150-152.

practices of Deng and Li resembled a type of border-crossing in which the approaches of coursework and fieldwork blended in the education of cosmobiology.[294]

The direct learning outcomes of the Deng-Li teaching and experimental efforts could be ascertained by surveying some of the thesis topics of the biophysics graduates in the 1964-1965 academic year. For instance, Jia Kepu (贾克朴) finished a thesis entitled "the effects of vibration on the physiological functions of mice' (振动对小白鼠生理功能影响), and Pei Jingchen (裴静琛) finished a dissertation on "biological effects of rocket flights" (火箭生物效应).[295] Due to the clandestine nature of the rocket and space missions, many of the original research and dissertations were not fully uncovered until recently. The sense of frustration and patience for hiding research efforts and outcomes in secrecy was captured by a Chinese poem distributed among practitioners and enthusiasts in the aerospace sector:

> Seeking innovation in the depth of mathematics and physics,
>
> 数理深处寻创见
>
> We made use of the tattered and disposed to compete with time;
>
> 修废利旧抢时间
>
> Anonymity was with us for some twenty years,
>
> 隐姓埋名二十载
>
> The blue sky was where our dissertations were published.

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[294] Robert Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (University of Chicago, 2002).

[295] Yang Tiande 杨天德, "The Early Training of Talents in Aerospace Biomedicine by the Institute of Biophysics"生物物理所对航天医学生物学人才的早期培养, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 219-222.

论文发表在蓝天[296]

Although the poem targeted primarily practitioners in mathematics and physics rather than biology per se, it was perfectly applicable to the young biophysicists working in cosmobiology in the mid-1960s. First, most of the cosmobiological crew was transferred from the cosmobiology research base at the IBP-CAS to either The Astronaut Center of China or Space Medical Engineering Research Institute on or before the Cultural Revolution.[297] Either way, the early cosmobiologists became an integral part of China's space program. Secondly, since the institutional circumstances of the USTC in 1964 placed both biophysics and sounding technology firmly under physics, it further legitimized the inclusion of biophysicists and cosmobiologists into the physics-dominated territory of space and rocket science.

The assertion that those involved in space and rocket engineering had to endure some twenty years of anonymity was no exaggeration. Oral histories from spouses and offspring of scientists who participated in the making of bombs and satellites testified to the secrecy of the programs to which they were assigned.[298] Many key scientists and engineers were required to keep their job titles, responsibilities and work locations hidden from their significant others. Qian Xuesen, in his capacity as the chief architect and

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[296] Zhou Benlian 周本濂, "The Blue Sky Was Where Our Dissertation Was Published" 论文发表在蓝天, in Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star'* (Guangzhou: Jinan University Press, 1999), pp. 256-259.

[297] For memoirs of the cosmobiological team instituted to the Astronaut Center of China, see Wang Youyun 王友云, "In Remembrance of the Participating Experiences of Cosmobiological Work" 参加宇宙生物学工作经历中的点滴回忆, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 223-228; for depiction of the cosmobiological team that were integrated into the Space Medical Engineering Research Institute, see Gong Wenyao 龚文尧, "Unforgettable Memories and Regrets" 难忘的记忆和遗憾, *Ibid,* pp. 235-238.

[298] For example, see Gu Xiaoying 顾小英, Zhu Mingyuan 朱明远, *Our Father Zhu Guangya* 我们的父亲朱光亚, (Beijing: Renmin Press, 2009); also see Cai Hengsheng 蔡恒胜, Liu Huaizu 柳怀祖, *Memories of Zhongguanucun* 中关村回忆, (Shanghai: Shanghai Jiaotong University Press, 2011).

commander of the space and missile program, was away from his Beijing residence for months without telling his wife his whereabouts, reportedly causing much distress to her.[299]

What does it mean to have one's graduate dissertations published in the blue sky beyond the scope of poetic imagination? The "blue sky" in the last stanza was not a figure of speech, but a literal point of reference: turning the sky into an auditorium for academic performance. In the scholarship and practice of cosmobiology, the open sky was the theater where cosmobiology was transformed into a mode of knowledge in which the theory of animal physiology in upper air met the practice of biological sounding rockets.

The performance of sounding rockets kicked off with the T-7 rockets as the orchestral instruments in the theatre analogy. The letter "T" in the appellation is short for *tan kong* (探空), which means that all rockets in this family belong to the sounding rocket series. T-1 and T-2 rockets were untested models reverse-engineered from the German V-2 (*Vergeltungswaffe*-2) rockets; T-3 and T-4 were tested with liquid fluorine and methanol as the propellant; T-5 was launched with liquid oxygen and ethanol as the propellant. All previous experiments of the T-family rockets were unsuccessful until the second launch of T-7M rocket ("M" denotes "model") on September 13, 1960. T-7A (S1) and (S2) rockets (探空 7 号甲生物 I 型、II 型火箭) used the same T-7M rocket (T-7 模

[299] Iris Chang, *Thread of the Silkworm*, (New York: Basic Books, 1995), pp. 231-260.

型火箭) prototype but modified it with an animal capsule inserted into the nose cone section of the rocket.[300]

As illustrated in chapter 5, the responsibility of assembling and fueling T-7 sounding rockets largely fell on the shoulders of SIMED (Shanghai Institute of Machine and Electricity Design). But the modeling of T-7A rockets was a result of the deliberation between the biophysicists from IBP and rocket engineers from SIMED. The participation of biophysicists was important because the T-7A rocket was the first time a Chinese rocket was designed to carry biological payloads into space. The ancestors of T-7A—T-7 and T-7M sounding rockets—were only intended to carry meteorological equipment such as radars and radiosondes. Engineers from SIMED needed input from biophysicists to devise ways of putting living things in the T-7A rockets. Table 5 presents the type of vehicles and the corresponding participation of biophysicists in the launch history of T-7 rocket flights.

Table 5 displays the active participation of biophysicists in the T-7 rocket flights spanning two years from 1964 to 1966. Were these practicing biophysicists from IBP-CAS or cosmobiology students from USTC? The answer was both. Most cosmobiology students from USTC were directly allocated to IBP-CAS upon graduation. Besides Jia Kepu and Pei Jingchen, five other USTC graduates were assigned to the bio-rocketry mission between 1963 and 1965: Yang Tiande (杨天德), Ma Zhijia (马治家), Xue Yueying (薛月英), Chen Mei (陈湄), and Teng Yuying (滕育英). Therefore, the

[300] See Li Dayao 李大耀, "Cherish the Memory of the 45th Anniversary of the First Successful Launching a Series of the T-7 Sounding Rocket"为中国开发太空探路, 创中国首飞太空记录—纪念 T-7 系列探空火箭首次发射成功 45 周年, *Spacecraft Recovery & Remote Sensing* 航天返回与遥感, vol. 26, iss. 3, (September, 2005): 1-4.

biophysics team in Mission 581 was comprised of both veteran biophysicists and fresh graduates from not just USTC but other higher-educational institutions as well.[301]

Table 5

A Launch History of Chinese T-7 Rocket Flights (emphasis my own)[302]

Launch Date	Vehicle	Launch Site	Status	Participation of biophysicists
2/19/1960	T-7M	Laogang	Successful	No
7/1/1960	T-7	Guangde	Successful	No
9/12/1960	T-7	Guangde	Successful	No
12/1/1963	T-7A	Guangde	Successful	No
7/19/1964	**T-7A(S1)#**	**Guangde**	**Successful**	**Yes**
6/1/1965	**T-7A(S1)#**	**Guangde**	**Successful**	**Yes**
6/5/1965	**T-7A(S1)#**	**Guangde**	**Successful**	**Yes**
7/15/1966	**T-7A(S2)***	**Guangde**	**Successful**	**Yes**
7/28/1966	**T-7A(S2)***	**Guangde**	**Successful**	**Yes**
8/8/1968	T-7/GF-01A	Jiuquan	Unknown	No
8/20/1968	T-7/GF-01A	Jiuquan	Unknown	No

* Rockets carrying dogs, mice, and biological specimens

Rockets carrying mice and biological specimens

As the second flight of T-7A (S2) blasted off and landed safely in rural Anhui, biophysicists were about to leave the Chinese space program. The scorching summer in 1966 marked their last research journey to the Shijiedu launch pad situated at the county of Guangde. After successfully completing the mission, the biophysics team was

[301] For example, Zhang Jingxue 张静雪 was a biology graduate from Peking University who in 1960 was assigned to the cosmobiology research unit at IBP-CAS, see Zhang Jingxue, "Remembering the Work Days and Life Vignettes at the Cosmobiology Research Unit"忆我在宇宙生物研究室的工作和生活片段, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 229-234.

[302] Zhu Zhiping 朱治平, "Historical Review"历史回顾, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, p.66; Colin Burgess and Chris Dubbs, "Appendix E," in *Animals in Space: From Research Rockets to the Space Shuttle* (Springer: Praxis, 2007). .

prepared to leave the hilly hinterland of Anhui and returned to the capital city of Beijing, where IBP-CAS and USTC were located at the time. Little did the USTC graduates in the crew know that their alma mater was going to be permanently relocated from Beijing to Anhui in the next couple years as the fervor of Cultural Revolution was unleashed. USTC remains in Anhui to this day.

Summary

The political consensus that had given biophysics an independent institutional space began to disappear in the early 1963, and this directly impacted the biophysics program for the next several years at USTC. Bei Shizhang had taken an anti-imperialist, anti-nuclear war image as his public persona between 1959 and 1962 whereas Shen Shumin had taken steps to increase and highlight the disciplinary values of physics in biophysics to maintain the political clout of biophysics in the USTC directorial bureaus.

Apparently, the "golden age" of biophysics stretching from 1958 to 1962 came to an abrupt end in 1963. It is tempting to conclude that the lack of academic authority of biophysics—or any discipline for that matter—signified an intrusion into scientific autonomy by the party-state. Yet it was more likely the case that the vignette of biophysics in this chapter showcased the embeddedness of biophysics within a cultural and historical context shared by most intellectual disciplines rather than a disembodied subservience of biophysics to the state. As I have shown in the foregoing pages, the community of biophysicists was not a passive victim, but was actively inventing ways to adapt itself to the new wave of institutional and technocratic reform that settled over USTC by 1963. This was made possible through strategic measures both in and out of the university: intramurally, additional teaching and research units and a new specialty were created to adapt biophysics to the host department while still maintaining some political leverage; extramurally, a number of high-profile media exposures on nuclear war reminded the public of the linkage between biophysics and radiobiology as well as the recognition of biophysics as an independent discipline vis-à-vis other disciplines such as biochemistry.

As if the series of changes hovering over China were not enough, the next round of political movement was about to take place. As the Cultural Revolution dawned, the community of biophysicists—old and young, working at IBP or USTC——found themselves with more uncertainties. Ahead of them in the civilian world was a political maelstrom characterized by a distrust of scientific expertise and intellectuals in general. The story of how the biophysics community fared in the institutional and political context of the Cultural Revolution between 1966 and 1976 is the subject that follows.

CHAPTER 7

BIOPHYSICS IN FLUX, 1966-1976

This chapter asseses the impact of the Cultural Revolution on biophysics and biophysicists from the standpoints of young biophysicists who participated in the defunct "Peace I" mission and of the senior biophysicists who pursued new areas of research and professional communication. Contained within this chapter are the stories of how the energies of young biophysicists such as Ma Fenglin and Fan Silu were spent on completing the mission of "Peace I" as much as possible. Concurrently, Senior biophysicists represented by Bei Shizhang championed a study on the origins of the cell and the origins of life by seeking refuge under Mao's stated interest on this matter. During the same period, H. Ti Tien, a Chinese-American biophysicist, also highlighted the "origins of life" in his work on membrane biophysics before and after his 1970s visit to China. Another notable Chinese biophysicist—Shen Shumin—continued her earlier attempt at promoting professional dialogue and the exchange of scientific updates around biophysics as a biology-oriented discipline.

These activities of junior and senior biophysicists were possible partly because of biophysics' connection with the military sector. Biophysics was folded into the science–military complex by drawing on the connections it had fostered before 1966, yet absolute safety was not guaranteed by military supervision. This chapter explores the impact of some of the gang violence in the military controlled bureau that was described in a General's diary and a widow's memoir regarding the death of Yao Tongbin.

The chapter then turns to the institutional changes with regard to IBP-CAS where it handed the cosmobiology team to NDSTC while the main office maintained its *de facto* status in CAS—one of the ten institutes officially affiliated with CAS in 1972. The last thing that will be discussed is what happened to the biophysics department at USTC, where most of its students and staff followed the order from the central government to arrive at the school's new designated campus in Hefei. By 1973, biophysics would remain one of the twenty programs with formal correspondence to the research institutes at CAS.

The purpose of this chapter is to examine the science–state relationship during the Cultural Revolution through the lens of biophysics. Biophysics was among the scientific disciplines that experienced continuous patronage and protection from the state in various ways between 1966 and 1976. How biophysicists managed to maintain institutional momentum and negotiated interagency restructuring with other ministries will cast light on the relationship between biophysics and a state in turmoil.

In relating the individual experiences of Chinese biophysicists of different ranks and genders during the Cultural Revolution, I harbor no illusions that these discrete scenarios and sporadic vignettes can give a complete picture of the interaction between scientist-intellectuals and government officials, let alone yield a sufficient explanation for the causes and consequences of the Cultural Revolution. The intention is to supply more stories and integrate them into my overall storyline in which the Chinese biophysicists—from notable biophysicists like Bei Shizhang and Shen Shumin to young cosmobiologists and fresh graduates from USTC——have been the main characters in my story.

The fortunes of biophysics and biophysicists during the Cultural Revolution can be assessed from the institutional changes and initiatives of IBP-CAS and those of the biophysics department at USTC. In this regard, this chapter differs from the previous chapters by combining the histories of research divisions with the educational establishment of biophysics in one analytical framework. Chapters three and four were dedicated to the emergence and flourishing of IBP-CAS; chapters five and six focused on the founding and adjustment of the biophysics department at USTC; this chapter considers the practice of *both* research and teaching simultaneously in order to explicate how the biophysics community is interwoven into the fabric of the state during a tumultuous period.

The Rise and Fall of the "Peace I" Space Mission, 1966-1967

Although the official record of the Great Proletarian Cultural Revolution dates the duration of the movement from 1966 until Mao's death in 1976, the actual time frame is contested. Controversy continues among historians and ordinary people who lived through this period. A Chinese interviewee in Barbara Mittler's study of Chinese propaganda arts recalled, "the real Cultural Revolution was between 1966 and 1968. After 1969 things were not the same…It was very strange to continue to call what followed a 'Cultural Revolution.'"[303] Some historians consider the period between 1966 and 1969 as "the nominal years of the Cultural Revolution"[304] in light of the velocity and intensity with which political events unfolded, culminating in the purge of Liu Shaoqi in April 1969; some regard 1966-1970 as one unit because these four years overlapped with

[303] Barbara Mittler. *A Continuous Revolution: Making Sense of Cultural Revolution Culture* (Cambridge: Harvard University Press, 2012), p. 381.
[304] Darryl Brock. "The People's Landscape: Mr. Science and Mass Line," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China*, pp. 41-118, on p. 42.

the duration of the nation's Third Five-Year Plan.[305] Mittler posited that the periodization of the Cultural Revolution was relative to individuals' experiences and knowledge of the movement. Individuals' perceptions of the timing of an event vary according to what they consider to be the epoch-changing element and how they connect these historical milestones to the contexts of their own lives. What was known to some as a "ten-year" catastrophe was both polyvocal and relativistic in individuals' memories.[306]

Given the flexible interpretation of the Cultural Revolution, an instructive way to assess the experiences of biophysics and biophysicists is to evaluate the reviews and reflections given by practicing biophysicists against the mainstream narrative. How did the Chinese biophysicists that were educated at USTC and working at IBP understand their own circumstances during these chaotic years? Did they describe anything different from the predominantly negative accounts that emerged in the post-Mao years? What happened to notable biophysics leaders like Bei Shizhang and Shen Shumin? Were they attacked or mistreated in any way?

When Mao expressed suspicions of impending security threats from "counterrevolutionaries," "revisionists," and "capitalist roaders" in February 1966,[307] biophysicists were engaging in a national conference on aerospace medicine organized by the Ministry of National Defense. Conference participants were representatives from CAS, Academy of Military Sciences, Academy of Medical Sciences, and several Ministries of Machine Building. Of the nine delegates from CAS, six were from IBP. Thus, biophysicists made up the largest body of the CAS delegation. The conference

[305] Roderick MacFarquhar and Michael Schoenhals. *Mao's Last Revolution* (Cambridge: Harvard University Press, 2006), p. 308.
[306] Barbara Mittler. *A Continuous Revolution: Making Sense of Cultural Revolution Culture*, pp. 380-382.
[307] MacFarquhar and Schoenhals. *Mao's Last Revolution,* p. 50.

lasted from the 25th of January to the 6th of February in Beijing's west suburb with the objective of delineating a plan for launching a new aerospace medical program for the 1966-1975 budgetary years. Bei Shizhang was one of the major signatories of the policy proceeding, titled "The Biological Aspect of Manned Spaceflight's Medical Plan (Draft)," that was subsequently submitted to the Central Committee. This policy paper was regarded as the first detailed biomedical plan in China's manned space program.[308]

It is important to remember that IBP carried out its planned meetings and day-to-day operations throughout most of 1966 and early 1967 as if the institute was insulated from the inflammatory political climate besieging CAS. After the aforementioned conference in Beijing's west suburb, concrete plans were laid out to realize the dream of sending a man into space as soon as possible. Following the successes of launching the dog-carrying T-7A (S2) biological sounding rockets in July 1966, leaders from the First Academy and the Eighth Academy of Space Technology were pushing for a new series of rocket missions to shoot primates into high altitude, seeing them as another step forward.[309] Dubbed "Peace I" (和平一号), the new mission was intended to carry a chimpanzee to the upper atmosphere. The launch vehicle would be equipped with even greater propelling force to carry a rocket with a bigger body mass to reach the near sub-orbital flight range. Joining these two space academies in the "Peace I" mission was IBP-CAS, which was charged with the tasks of the selection of chimpanzee-pilots as well as

[308] IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets* (Beijing: Science Press, 2008), p. 12.
[309] The First Academy is now known as the China Academy of Launch Vehicle Technology (CALT), 中国运载火箭技术研究院; the Eighth Academy as the Shanghai Academy of Space Flight Technology (SAST) 上海航天技术研究院. Both academies are currently under the administration of China Aerospace Science and Technology Corporation (CASC) 中国航天科技集团公司, one of the biggest state-owned enterprises in China's contemporary missile and space industry.

the testing and measuring of the behavioral responses of the short-listed animal-nauts. Since the physiological structure of chimpanzees is more complex than that of dogs, the cosmobiological team from IBP-CAS spent the latter half of 1966 designing experiments and acquiring the necessary materials and parts to measure the behavioral responses of chimpanzees in space.

Ma Fenglin(马凤林), an erstwhile participant in the "Peace I" mission whose work was about the experimental designs for capturing the higher-order neurological activities of chimpanzees in anti-gravitational conditions, recalled "at that time, despite the commencement of the Cultural Revolution, our work had not been disturbed yet" (当时, 文化大革命已经开始，但还未影响到工作).[310] Another biophysicist described his work in planting electrodes and an electroencephalograph amplifier on the scalp of chimpanzees for measuring neuro-electrical activity in flight, as part of the plan to realize the dream of a "flying brain-computer interface in the sky" (脑电上天).[311] The space neuro-electrical research was in full swing in 1966.

A technical drawing of a conditioned-reflexes-recording-system (reflexometer) that was specially designed to fit into the biological cabin of "Peace I" was completed on the 29th of December, 1966, along with another drawing showing the modeling device for capturing the signals of conditioned reflexes dated the 8th of December, 1966.[312] Rather than being the exclusive brainchild of cosmobiologists, these drawings represent a

[310] Ma Fenglin 马凤林, "The Budding Cosmobiological Projects" 萌芽中的宇宙生物学工程, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 180-184, on p. 182.

[311] Fan Silu 范思陆, "The Neuroelectrical Research of Monkeys" 猴子的脑电研究, in IBP-CAS, ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets*, pp. 207-210, on p. 209.

[312] Ma Fenglin, "The Budding Cosmobiological Projects," p. 183.

collective achievement out of the cooperation between scientists from CAS and workers and technicians from the machine factories outside of CAS. Ma deliberated over the technicality of vibration reduction of reflexometers and overall adjustment issues with the Eighth Academy. But to implement these technical adjustments, he had to seek help from the factory workers, who were the ones processing metals into desirable shapes and textures for holding the animal-pilots in the rocket. In other words, research and production was functioning quite well between IBP and other units beyond the Academy in late 1966.

Eventually the Cultural Revolution would reach IBP, and interfere with the work of the biophysicists, although it had not done so initially. Ma Fenglin detected the first sign of trouble when a fellow member of the Instrumental Shops of CAS (中科院仪器) told him over the phone that the production schedule of "Peace I" was likely to be postponed because the person in charge was planning to leave the R&D office for a while. In January 1967, a rumor denouncing the "Peace I" mission as a "black operation" (黑任务) was circulating among a few radical elements but the overall atmosphere remained calm. According to Ma, the young researchers in the mission were adamant that the mission should proceed even after project managers and superintendents retreated from the field of operations. Unlike the mission commanders or chief engineers who were vulnerable to Red Guard censure, young people like Ma were immune from being attacked as "anti-revolutionary" because their youth and low rank were supposedly indicators of "redness" and political reliability. They could join the Red Guard in uniforms but Ma and some of his teammates chose to invest their time by continuing to work for the "Peace I" mission. They spent the Labor Day holidays by making more modular parts and revising earlier rocket plans as they believed in "pushing forward as much as one can; even one step forward is a victory" (能推进一点是一点，能多走一步也是胜利).[313] Yet more difficulties awaited them as the productivity at the Instrumental Shops of CAS was greatly reduced. Ma sought solace from factory workers—another prominent social group usually exempted from ideological questioning[314]—who continued to support their research and production for the "Peace I" mission. The assistance extended by a few experienced metalsmiths brought to Ma not just convenience but "a taste of freedom" in the midst of the political maelstrom.[315] A foreman named Jin Fengming (金凤鸣) entrusted Ma with a key to the foundry so that Ma could spend as much time as he wanted in the steel mill. Sometimes foreman Jin would accompany Ma to work overnight at the foundry and Ma would buy Jin a simple breakfast at the cafeteria as a token of gratitude. Yet these sincere but isolated efforts were not enough to set the wheels in motion. The "Peace I" operation was officially aborted in the summer of 1967, and Ma and his team finally gave up on the project in October 1967.[316]

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[313] *Ibid,* p. 184.
[314] Not all workers were free from questioning and imprisonment. A worker in a machine factory spoke of his ten-year prison life during the Cultural Revolution and how his bitter life behind bars affected his wife and their son. See "The 3,650 Days of a Couple," in Feng Jicai ed. *Voices from the Whirlwind: An Oral History of the Chinese Cultural Revolution* (NY: Random House, 1991), pp. 105-127.
[315] Barbara Mittler has reported a similar surge of unfettered freedom among young people who grew up in the Cultural Revolution: "the Cultural Revolution is a time that created traumatic experiences for a great portion of the population but also a time of unknown freedoms and possibilities, especially among young people." See Barbara Mittler. *A Continuous Revolution: Making Sense of Cultural Revolution Culture*, p. 92.
[316] Ma Fenglin, "The Budding Cosmobiological Projects," p. 184.

A Military Representative, a Missile Scientist, and a Mourning Widow, 1967-1970

The setback of the "Peace I" mission highlighted the link between the Cultural Revolution and defense-related science missions. On the one hand, science and technology in relation to national defense and national prestige were given special protection against revolutionary interruption by the People's Liberation Army (PLA); on the other hand, the defense ministry was not a sanctuary for all scientists and all lines of scientific projects under its umbrella. At times, the Military Affairs Commissions (MAC) were ineffective in their supposed duty to "keep revolution in check and keep production in place" (抓革命，促生产).[317]

Scholarly debates erupted regarding the Janus-faced nature of military research and missions during the Cultural Revolution. Darryl Brock observed "there is a broad sense among scholars that defense scientists enjoyed protection from the Cultural Revolution due to the national security considerations related to their work,"[318] but in the same academic volume, Cong Cao quibbled, "those members of the scientific community who worked on the military research projects were spared of the worst of the turmoil, but they were not completely safe. The Cultural Revolution soon spread to the military as

[317] "抓革命，促生产" was one of the most widely known slogans popularized during the Cultural Revolution. It was Zhou Enlai who first disseminated the idea "to promote Mao Zedong's thought, to mobilize the masses to control the orientation of the class struggle and to swiftly restore the order of revolutionary work and production." See "Consigning Several Key and Provincial Military Districts to Supervise Spring Agriculture and Production" (委托各大军区、省军区抓好春耕生产), in *Selected Military Writings of Zhou Enlai* (Beijing: Military Academy of Sciences of People's Liberation Army of China Press, 1997), pp. 547-550.

[318] Darryl Brock. "The People's Landscape: Mr. Science and Mass Line," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China*, pp. 41-118, on p. 82.

well, with research, development, and production coming to a standstill because of Red Guards' rampages."[319]

The abortive "Peace I" mission highlighted some of the difficulties the state and in particular, the PLA, had faced in coming to grips with the factional strife in and out of the military establishment. While pitched battles between various groups of Red Guards and PLA have been explored at some lengths in the literature, struggles between scientists and military officers working in the Defense Ministry were seldom the subjects of analysis.[320] We know that the PLA were called in to restrain the Red rebels and to restore order in universities and high schools but we are not well informed about the role of scientists and their interaction with the PLA officers. The PLA-civilian interaction is one thing;[321] but for the purpose of this study, what piqued my interest is the extent of the military-science interplay. What was the nature of the struggles between missile and bomb-making scientists and the PLA in missile bureaus and factories? Did defense scientists enjoy *de facto* protection? How effective was the sheltering? How did biophysicists fit into this military-science regimen?

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[319] Cong Cao, "Science Imperiled: Intellectuals and the Cultural Revolution," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China,* pp. 119-142, on p. 127.

[320] Esherick, Pickowicz and Walder gave a historiographical review on the changing modes of scholarship pertaining to the Chinese Cultural Revolution. One of the most commonly pursued themes of analysis in the aftermath of the Cultural Revolution, according to the authors, was the conflicting interests among different social groups. "The first wave of scholarship on the Cultural Revolution," as the authors call it, portrayed the Cultural Revolution as a window of opportunity for different interest groups—notably student red guards, worker rebels, and officers in mass organization—to engage in factional struggles to further group interests that were usually couched in ideological terms. The genre of "interest group politics" was prevalent in the Cultural Revolution scholarly landscape from the mid-1970s to the early 1980s. However, scientists and engineers did not appear to be among the social groups that sought the revolutionary occasion to further their private interests. See "The Chinese Cultural Revolution as History: An Introduction," in Joseph Esherick, Paul Pickowicz and Andrew Walder, eds. *The Chinese Cultural Revolution as History* (California: Stanford University Press, 2006), pp. 1-28.

[321] For example, a former Red Guard described the prolonged standstill and subsequent fistfights between the "Red Rebels" student-led faction and "East-is-Red Corps" members from the army in a small town in Hebei province between 1967 and 1968. See Gao Yuan, *Born Red: A Chronicle of the Cultural Revolution* (California: Stanford University Press, 1987), pp. 206-282.

One common point of reference for reporting the PLA-science misalignment is the misfortunes at the Seventh Ministry of Machine Building (Seventh MMB). The Seventh MMB was one of the worst hit agencies in the defense sector during the Cultural Revolution. The damage to the Seventh MMB by the Red Guards, and in particular the torture of metallurgist Yao Tongbin, has been extensively noted in both Chinese and English writing.[322] MacFarquhar and Schoenhals in their study of the elite politics of the Cultural Revolution noted, "the Seventh Ministry of Machine Building, responsible for missile and satellite development, was also riddled with problems. Disruptive factional infighting had been endemic since the very beginning of the Cultural Revolution."[323] A Chinese source on the history of space science and technology in China also stated, "the scientific research of the Seventh MMB has been interfered with and damaged immensely by the 'Cultural Revolution'"(七机部的科研工作受到'文革'的很大干扰和破坏).[324] Even a celebratory volume on the heroic achievement of nuclear and missile scientists and engineers suggested that "factionalism of the Cultural Revolution wreaked havoc on the Seventh MMB"（七机部是文革派性干扰的重灾区).[325] Yet the devastation of the Seventh MMB is typically only mentioned but not examined. A recent scholarly work offered a rationale for the paucity of analysis of defense-related aspects of

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[322] Selected English scholarship that has referenced the Seventh Ministry of Machine Building between 1966-1970 include John Lewis and Xue Litai, *China Builds the Bomb* (California: Stanford University Press, 1988); Iris Chang, *Threads of the Silkworm* (NY: Basic Books, 1995); Brian Harvey, *The Chinese Space Programme: From Conception to Future Capabilities* (West Sussex: Wiley-Praxis, 1998); Paul Neushul and Zuoyue Wang, "Between Devil and Deep Sea: C.K.Tseng, Mariculture, and the Politics of Science in Modern China," *Isis,* vol. 91, no. 1 (2000), pp. 59-88; Cong Cao, "Science Imperiled: Intellectuals and the Cultural Revolution," in Brock, Darryl and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China,* pp. 119-142.
[323] MacFarquhar and Schoenhals. *Mao's Last Revolution,* p. 385.
[324] Li Chengzhi, *A Draft History of the Development of Space Technology in China, Vol. 3*, p. 343.
[325] Song Jian, ed., *Biographies of Pioneers of 'Two Bombs, One Star' II*, p. 405.

the Cultural Revolution: "the classified nature of defense science rendered documentation relatively unavailable to reporters… and modern historians. It is thus not surprising that relatively little analysis has been conducted related to S&T of national defense related to the Cultural Revolution."[326]

Indeed, the literature gap is largely due to a lack of access to sources and documentation that were not open to the public until recently. Scholars in China Studies have noted that what distinguishes the new wave of Cultural Revolution scholarship from the first generation of research is precisely the steady increase in the availability of once-scarce official and unofficial sources of information.[327] Historians now enjoy the luxury of the voluminous primary and secondary materials that were not available to the previous generation.[328] The exponential growth of documentation allows for a more concrete and substantial portrayal of aspects that were obscure in the first wave of research. What happened at the Seventh MMB between 1966 and 1969, perhaps, is a case in which newly released evidence could enable a more elaborate analysis beyond the line of interpretation established by those who worked with more limited sources.

In light of the widely noted but thinly examined mishaps at the Seventh MMB, one could benefit from the personal accounts of key participants in the struggles on the spot. The diary of Yang Guoyu (杨国宇) chronicled some of the conflicts and

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[326] Darryl Brock, "The People's Landscape: Mr. Science and Mass Line," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China*, pp. 41-118, on p. 83.
[327] Joseph Esherick, Paul Pickowicz and Andrew Walder, "New Trends in Cultural Revolution Research," *The Chinese Cultural Revolution as History*, p. 6.
[328] The rank of available materials include official histories of provinces, counties, districts, cities, oral histories of organizational and community participants, local gazettes and specialized newspapers, bureaucratic and ministerial histories and chronologies, diaries and biographies of key officials and intellectuals, transcripts of speeches, collected manuscripts of major figures, and even reprints of formerly internal reference materials.

confrontation between PLA officers and various cliques based on his firsthand knowledge and experiences at the Seventh MMB.[329] Although biophysicists were not depicted in Yang's recollections nor were biophysicists directly involved in the armed struggles at the Seventh MMB, Yang's diary commands attention as the circumstances at the Seventh MMB reflected the overall happenings of defense science—of which biophysics is a part—during the Cultural Revolution.

All personal accounts and statements of oral histories should be treated with circumspection and skepticism. The methodological pitfall of relying on this type of literary evidence is that sometimes the author masquerades fictional accounts as ostensible facts by the virtue of his or her authorship. As Stephen Pyne has cautioned, a memoirist's offense is where "the author claims the authority and gravitas of nonfiction, stating that what he or she says is true, but in reality fictionalizes the story or in some cases invents it out of whole cloth."[330] Nonetheless, personal recollections afford an opportunity to assess the Cultural Revolution as experienced at an individual level. In what follows, I do not take Yang's depiction at face value and as fully credible; rather, I inspect its authenticity by comparing his account with other testimonies. I believe these potentially flawed, yet integral materials, if handled carefully, could further illuminate the organizational dynamics of defense science and technology in revolutionary China.

A long-time lieutenant of Zhou Enlai and a Long March survivor, Yang oversaw the military takeover of the Seventh MMB during the period from March 1967 to

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[329] Yang Guoyu 杨国宇, "Information of Local Literature: Diary No. 24—A General's Diary during Military Control I (1967-1969)" 民间语文资料:日记 024 号—将军军官日记(上)(1967-1969) , in *Frontiers* 天涯 (2000), vol. 5, pp. 1-8; the *Encyclopedia of the History of Chinese Communist Party* 党史百科 dedicated an entry to the biography of Yang, available at <dangshi.people.com.cn>

[330] Stephen J. Pyne, *Voice and Vision: A Guide to Writing History and Other Serious Nonfiction* (Cambridge: Harvard University Press, 2011), p. 36.

November 1969. On 22 March 1967, Yang received a direct order from the NDSTC authorizing the twenty-third military base of the PLA to preside over the Third Research Institute of the Seventh MMB. Yang and his military unit were specifically chosen to take control of the Seventh MMB—the bureau responsible for the research and development of missiles and spacecraft—due to his earlier participation in the missile and space program. Yang reported his chairing of the initial meeting between the two major factions dated 19 May 1967. Over 10,000 protestors attended the meeting and expressed their revolutionary energy by constantly interrupting Yang's speech and challenging the authority of the military control committee. Yang reacted by reiterating the orientation of the general policy of the military control committee as serving public interest and aligning with Mao Zedong's thought. After an overnight sit-in, the mobs began to disperse after they realized that the military control officers were not going to budge. Although there were sporadic disputes and verbal attacks, bloody feuding was kept under control according to Yang: "we are were to contain some events because we came from the outside, so they thought we were simple-minded and had no interaction with capitalist-roaders or minority leaders within the military" (有些事我们制止还能制止，因为我们是外地来的，他们认为我们很单纯，与走资派、军内一小撮来往不多).[331] The strategy Yang utilized to control the mass emotion was three-fold. First, the military control committee would not take sides in any matter despite being charged by the mutinous crowd. Second, the military control committee adopted a firm stance by expressing its unswerving loyalty to the thought and leadership of Chairman Mao when

[331] Yang Guoyu, "Information of Local Literature: Diary No. 24—A General's Diary during Military Control (1967-1969) I," p. 2.

faced with opposition and disobedience. Third, the military control committee would allow criticism through Big Character Posters or other written channels but not in the form of physical assaults. When bitter fighting paralyzed the Second Research Institute of the Seventh MMB on 30 August 1967, Yang tried every means to prevent the bellicose flame from reaching the Third Institute.[332] Occasional armed struggles notwithstanding, the prevention of large-scale violence and bloodshed at the Third Institute of the Seventh MMB reflects the partial success of the tripartite strategy Yang had devised.

But the personnel turnover of the military control committee quickly altered the course of events. The existing military control committee was replaced by a new committee (新军管) on the 4th of April, 1968. Yang was seconded to the post of assistant commander but was still sitting on the new military control committee. He ended up in a quarrel with the young officers in the new committee over the new practice of singing selected quotations of Chairman Mao before breakfast (among other issues.) Refusing to join the mandatory quotation-reciting sessions each morning, Yang lost his sway in the new military control committee, and on the 16th of May, Yang's secretary Jiang Changying (蒋昌应) was badly beaten as he tried to stop a brawl between the notorious "915" and "916" gangs.[333] This was an alarming sign of the escalating interfactional antagonism, which would result in tragedy on the 8th of June, 1968, when Yang was informed of the death of Yao Tongbin (姚桐斌), the Birmingham University-trained metallurgist and director of the Third Institute of the Seventh MMB (703 所所长), as a result of a severe beating by some of the "915" members.

[332] *Ibid,* p. 4.
[333] *Ibid,* pp. 7-8.

Immediately after Yao's death, Yang was busy making logistic arrangements for transporting Yao's body. Apparently, many state-run hospitals including the Beijing Municipal Hospital and the Air Force General Hospitals were reluctant to collect the corpse for fear of an attack by the mob at the Seventh MMB. Ultimately, Yang had to force the Navy Hospital to accept the cadaver by means of military order. Meanwhile, Yang had to seek consent from Yao's wife in order to proceed with an autopsy of the body. Yang's diary depicted initial resistance, but eventual compliance to his request by Peng Jieqing (彭洁清), the widow of Yao Tongbin who was grieving over the loss of her husband, father to her three young daughters.[334] Three decades later, Peng Jieqing published a memoir expressing her love and devotion to her husband.[335] Peng's reminiscence of the events after the killing of Yao mentioned her encounter with Yang Guoyu for negotiating Yao's postmortem arrangement. Madam Yao characterized Yang as a middle-aged, round-faced military officer dressed in Navy uniform who spoke with a Sichuan accent. Peng was opposed to the idea of cutting open her husband's body at first but finally acknowledged the importance of performing a proper medical investigation in order to dispel rumors of Yao committing suicide or dying of a heart attack. As the medical team carried Yao's body away, Peng composed and distributed a Big Character Poster illustrating Yao's life and the gut-wrenching story of his death. She was later told that many people burst into tears as they read her poster.[336]

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[334] Yang Guoyu, "Information of Local Literature: Diary No. 24—A General's Diary during Military Control (1967-1969) I," p. 8.
[335] Peng Jieqing 彭洁清, *A Passion for Space: Boundless Love and Yearning* 航天情: 永远的眷恋 (Beijing: Tsinghua University Press, 2002).
[336] *Ibid,* pp. 24-27.

Besides lending support to Yang's documentation, Peng's recollection also casts light on hidden aspects of the Cultural Revolution and even contemporary Chinese history. David Apter and Tony Saich uphold the view that Chinese widows' oral history can open a new avenue for revisiting modern Chinese history:

> A rich, and indeed large, resource for uncovering actual events rather than myths are the many widows. China is a country of angry widows. Each shift in the party line produced its own legacy of such widows whose husbands were pulled down, humiliated, subjected to trials, committed suicide or died of beatings, or were atrophied by long prison sentences.[337]

Peng was among the ranks of Chinese widows who lost their husbands to various kinds of unfair sanctions in the twentieth century. Through relating mundane aspects of everyday life, Peng's memoirs, like Anne Frank's diary, revealed the horror and devastation an overzealous mob could inflict upon an ordinary soul. But her writing was also interspersed with discussion of the many patriotic deeds of Yao and his enthusiasm for the future of China's aerospace industry, of which her deceased husband was a crucial member. On the 2nd of December, 2005, Peng gave an invited lecture at a middle school in her husband's hometown. When asked whether the victimization of her husband caused her any disillusionment in the party-state, she answered with an absolute "no!" and said it was a few malicious people, rather than the state, that were responsible for her husband's death.[338]

[337] David Apter and Tony Saich, *Revolutionary Discourse in Mao's Republic* (Cambridge: Harvard University Press, 1994), p. 20.
[338] "Former Residence of Yao Tongbin, a 'Two Bombs, One Star' Pioneer, Is Open to the Public After Renovation" '两弹一星'元勋之一姚桐斌故居修复对外开放, *Xinhua News* (November 13, 2005).

Although some may cast doubt on the veracity and objectivity of Peng's publicly captured remark, I suspect that part of the reasons for her persistent faith in the state has to do with the ways in which the authorities handled Yao's case. When the news of Yao's death reached Zhou Enlai, Zhou was reportedly shocked to his very core. He dropped his teacup on the floor and exhibited indignation about the loss of a brilliant scientist—all the more so because Yao was personally appointed by Zhou to work in missile research in 1958.[339] The death of Yao impelled the Premier to issue a special protection plan for a small group of scientists and engineers in cutting-edge science and technology projects.[340] Decades after the Cultural Revolution, an unnamed veteran space engineer applauded the effort of Zhou Enlai this way, "I suffered quite insignificantly because a colleague of mine sacrificed his own life, and a widely-respected leader took action to protect the scientific community." The former referred to Yao Tongbin and the latter to Zhou Enlai.[341] Song Jian, a notable cyberneticist and a high-profile military scientist, elaborated on the positive consequence of Yao's sacrifice: "Yao died for a noble cause, because his unfortunate death prompted Premier Zhou to enforce the protection of many other scientists and ensured their safety."[342] This point was echoed by Stacey Solomone recently: "Without Yao's sacrifice, Premier Zhou may not have extended protection to fellow aerospace scientists and engineers."[343] In the spring of 1976, Peng expressed her deepest condolences at Zhou's passing and praised Zhou's attention to her and the family

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[339] Peng Jieqing, *A Passion for Space: Boundless Love and Yearning*, p. 146.
[340] Zhang Jun 张钧, ed. *Aerospace Industry in Contemporary China* 当代中国的航天事业 (Beijing: Chinese Social Science Press, 1986), p. 65.
[341] Peng Jieqing, *A Passion for Space: Boundless Love and Yearning*, p. 185.
[342] Song Jian, ed., *Biographies of Pioneers of 'Two Bombs, One Star' I*, p. 88.
[343] Stacey Solomone, "Space for the People: China's Aerospace Industry and the Cultural Revolution," in Darryl Brock and Chunjuan Nancy Wei, eds. *Mr. Science and Chairman Mao's Cultural Revolutions: Science and Technology in Modern China,* pp. 233-250, on p. 243.

since Yao's murder.[344] Recently in China, Yao has been honored with a posthumously awarded medal for his contribution to the bomb and missile program, along with a museum with the name "Former Residence of Yao Tongbin" in his birthplace in Zhejiang.[345]

Although unofficial sources of information like Yang's diary or Peng's memoir are susceptible to personal caprices and vagaries of individual memories, it is possible to test the accuracy of these personal recollections from documentation in other references. Peng Jieqing's memoir authenticates some of Yang's statement. A volume on the inside story of Chinese space policy-making also verifies the identity of Yang Guoyu as the chief officer in charge of the military control committee of the Seventh MMB by order of Zhou Enlai.[346] Translating what is singular and arbitrary to a collective and more plausible account, these new sources of material could fill a historiographical gap in the science—military intersection during the Cultural Revolution. As more relevant writings are released from the military sector in the future, one could even hope to elucidate more unknown aspects of the Chinese strategic missile and space program.[347]

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[344] Peng Jieqing, *A Passion for Space: Boundless Love and Yearning*, p. 186.

[345] Song Minyi 宋敏毅, "An Interminable Passion for Space: The Consort of 'Two Bombs, One Star' Medalist Yao Tongbin Visits *Tian Yi* Middle School,"悠悠航天情:'两弹一星'功臣姚桐斌的夫人彭洁清在天一, *Xi Shan Jiao Yu* (December 7, 2005), available on <www.xsjy.com.cn/>

[346] Gong Xiaohua 巩小华*, Inside the Decision-Making World of Chinese Space Industry* 中国航天决策内幕 (Beijing: Zhongguo wen shi chu ban she, 2006), p. 184.

[347] Esherick, Pickowic and Walder identified the same methodological hazard of using interviews with former red guards or other participants in the Cultural Revolution as oral histories of a tumultuous period "are inevitably affected by the vagaries of memory and often colored by self-serving reconstructions internalized over the course of decades of political study." But they opined that these deficiencies are amenable to corroboration and triangulation with other interviewees and additional testimonies about a single place or event. In the end, they justified and augmented the use of unofficial sources for new interpretations of the Chinese Cultural Revolution. See Joseph Esherick, Paul Pickowicz and Andrew Walder, "The Accumulation of Unofficial Sources," *The Chinese Cultural Revolution as History*, p. 11.

Biophysics at the Science-Military Interface, 1967-1972

The saga of Yao Tongbin and the untold (at least in English literature) story of Yang Guoyu are related because biophysics was at the forefront of the science-military interface between 1967 and 1970.

In March 1967, Nie Rongzhen, in his capacity as the vice premier and former head of the now defunct State Science and Technology Commission (SSTC) and National Defense Scientific and Technology Commission (NDSTC), proposed institutional reforms in the science and technology operations at the civilian–military intersection. Since many defense research projects relied on the cooperation between the defense industries and the civilian research institutions—CAS in particular—it became a priority for Marshal Nie to issue a special plan for the sustained development of military science at times of political perturbation.[348] The proposal, entitled "On the Institutional Adjustment and Restructuring Schemes of the National Defense Ministry" (关于国防科研体制调整、改组方案的报告), was introduced to reduce the level of disruption of scientific research in the defense establishment. Under the section heading of "Biomedical Aspects of the Manned Spaceflight Program"（载人宇宙航行规划—医学生物学部分) in this document, Nie proposed setting up a "Cosmomedical and Cosmobiological Research Center" (宇宙医学和宇宙生物医学研究中心) in the defense establishment by transferring the cosmobiology unit of IBP from the CAS framework to

[348] In his memoir, Nie Rongzhen acknowledged that the defense industries owed many of its scientific and technical advances to the contribution of the Chinese Academy of Sciences. See "On the Scientific and Technological Front," in Nie Rongzhen, *Inside the Red Star: The Memoirs of Marshal Nie Rongzhen* (Beijing: New World Press, 1988), pp. 659-727.

the NDSTC infrastructure.[349] Chairman Mao endorsed Nie's plan on the 25th of October, 1967.[350] In April 1968, around one hundred researchers and technicians from three research centers in IBP—The Cosmobiology Center (宇宙生物室), the Space Animal Testing Center (空间试验动物室), and the Cosmobiological General Control Center (宇宙生物总体室)—along with all the equipment and libraries, were handed over to the Space Medical Engineering Research Institute (SMERI, 航天医学工程研究所) under the administration of NDSTC.[351] Also recruited into the SMERI were operative units from the Academy of Military Medical Sciences (军事医学科学院) and the Chinese Academy of Medical Sciences (中国医学科学院)—partnering the units with IBP in Mission "581."[352] The cosmobiologists have remained in the military-industrial complex ever since. Between 1992 and 2012, the former biophysicists in the SMERI were responsible for the selection and training of the first cohort of *taikonauts* in China's first comprehensive manned spaceflight program (known as project "921"). Several biophysicists assumed high-ranking posts in China's manned space program: the principal designer-in-chief and the second chief commander of the "*yuhangyuan* system" ('航天员系统'首任总设计师和第二任总指挥), the chief designer of the 1/3 "subsidiary system," (1/3'分系统'主任设计师) and the chief designer of the "environmental control

[349] IBP-CAS ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets,* p. 15.
[350] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star'* (Guangzhou: Jinan University Press, 1999), p.120.
[351] IBP-CAS ed. *Flying Dogs in the Sky: A Documentation of Chinese Biological Experimental Rockets,* p. 221; also see Li Chengzhi, *A Draft History of the Development of Space Technology in China, Vol. 3*, p. 794.
[352] See "Mission 581 and Two Bombs, One Star" in chapter 5 for more information.

and life support subsidiary system" in the "spaceship system" ('飞船系统'的'环境控制生命保障分系统'主任设计师).[353]

IBP and CAS, 1966-1972

One of the indicators of the backlash against science and technology during the Cultural Revolution was the erosion of CAS. Existing writing suggests that the institutional legitimacy and integrity of CAS were severely undermined during the Cultural Revolution. According to H. Lyman Miller, the number of institutes and research centers of CAS shrank from more than 100 in 1966 to fewer than 40 in 1972. By 1973, the joint efforts of Zhou Enlai and notable science adviser Zhou Peiyuan managed to increase the number of CAS institutes to 53. That number had grown to 117 by 1981. Furthermore, the Academy's Scientific Council—the highest policy-making body in the Academy—was completely shut down and was only restored in early 1979. Miller gave the above bleak analysis of the overhaul of CAS by the Cultural Revolution both quantitatively and qualitatively.[354]

Nonetheless, the 60 or so institutes and centers that were allegedly expunged from CAS actually included both institutes that were abolished by the revolutionary forces as well as those that were transferred out of the Academy to other bureaus. The question becomes, just how many institutes were eliminated as opposed to relocated?

Available evidence from the official chronology of CAS indicates that the majority of the CAS institutes were transferred to military establishments or local

[353] Wang Guyan, *A Biography of Bei Shizhang,* pp. 263-265.
[354] H. Lyman Miller, *Science and Dissent in Post-Mao China: The Politics of Knowledge* (Seattle: University of Washington Press, 1996), pp. 88-89.

governments between 1970 and 1972. In the policy papers entitled "Report on the Institutional Adjustment of Existing Research and Development Units in CAS and NDSTC" and "Follow-up Report on Implementing 'Report on Opinions of the Institutional Adjustment Issued to the Party Committee of NDSTC from the State Council and the Central Military Commission,'" the central government ordered 78 out of 84 institutes and centers of the CAS to be consigned to either provincial governments, industrial agencies or the defense bureaus.[355] The official logbook of CAS suggested that the number of institutes that remained in the direct jurisdiction of CAS dropped from 18 in 1970 to only 10 in 1972.[356]

In other words, over 92% of CAS institutes were relocated to other sectors rather than eliminated. Nevertheless, the impact of institutional adjustments on the status and authority of the CAS was largely negative. The officially-sanctioned viewpoint is that such a rash institutional arrangement—a special product of the Cultural Revolution—— severely impacted China's science and technology capability.[357] Zhang Jinfu, vice-president and deputy director of CAS, sternly reprimanded the Cultural Revolution for threatening the lives of individual scientists and jeopardizing the entire scientific enterprise. Zhang lamented, "were it not for the Cultural Revolution, the contribution of the CAS would have been greater and the nation-wide scientific and technological development would have been better."[358]

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[355] Fan Hongye, ed., *An Edited Historiography of the Chinese Academy of Sciences, 1949-1999*, p. 204; the official chronology is also available on CAS homepage at <www.cas.cn>

[356] *Ibid,* p. 212.

[357] *Ibid,* p. 204.

[358] Science Times, ed., *May History Remember Them: Chinese Scientists and 'Two Bombs, One Star'* (Guangzhou: Jinan University Press, 1999), p.46.

While I am not an apologist for the Cultural Revolution, I think it is necessary to differentiate between institutional dislocations within CAS and the imperilment of science and technology. Was the apparent disintegration of CAS equivalent to the extermination of science and technology activity? In the case of biophysics, the cosmobiological units from IBP-CAS continued to thrive and made important contributions to the manned space program in their new institutional home, thus falsifying the assumption of a linear relationship between institutional transferal and the termination of science and technology.

Specifically in the circumstances of biophysics, the cosmobiological units that were handed over to NDSTC only accounted for around one third of the manpower of IBP-CAS. A substantial group of biophysicists stayed with CAS throughout the Cultural Revolution. IBP was one of the 10 institutes that remained under the jurisdiction of CAS in 1972. The other nine CAS-administered institutes at this time were the Institute of Mathematics, the Institute of Physics, the Institute of Chemistry, the Beijing Observatory, the Institute of Microbiology, the Institute of Genetics, the Institute of Geology, the Institute of Atmospheric Physics, and the Institute of Vertebrate Paleontology and Paleoanthropology.[359] To put it another way, one arm of IBP was transplanted to the military-industrial complex while the main body of IBP was still in the civilian system throughout the entire period when civilian science was discredited by proletarian distrust. This is not a small matter if one considers the scale of reduction of CAS. Many important institutes, like the Institute of Mechanics, were ordered to separate from the Academy,

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[359] Fan Hongye, ed., *An Edited Historiography of the Chinese Academy of Sciences, 1949-1999*, p. 212.

but biophysics managed to stick with CAS during the stormy years. The question to ask, of course, is why.

Bei Shizhang and the First U.S.-China Biophysics Contact

Among the many plausible reasons that might have contributed to the lenient treatment of biophysicists during the Cultural Revolution, the political standing of the leading scientists seems to be a critical factor. If the political credibility of a scientific leader was undermined, it could cripple the institute under his or her directorship. This is the infamous practice of "guilt by association" which incriminates people who are in an alleged affiliation with the person in question. The inverse side of this disreputable formula is that those affiliated with a scientist in good political stature were usually spared the political attacks occurring elsewhere. In the case of biophysics, what was the level of political trustworthiness of Bei Shizhang during the Cultural Revolution?

Bei's biographer and follower Wang portrayed Bei's experience during the transitional years of the Cultural Revolution as "very lucky. Not only was he not subject to criticisms, there were many people protecting him" (贝时璋是十分幸运的，他不仅仅没有挨过批斗，而且有许多人保护着他).[360] Wang's source of evidence drew from Bei's interactions with a working group hoping to resume research on cell reformation in 1970. Wang suggested that Bei was determined to rekindle the research on cell reformation during the Cultural Revolution when he had more time at his discretion after the many state-run projects were suspended. After he submitted a prospectus titled "The Origin and Transformation of Cells in Hemopoiesis and Some Related Issues" (造血系统

[360] Wang Guyan, *A Biography of Bei Shizhang,* p. 270.

中细胞起源和细胞转化以及其他一些有关问题), Bei spent many hours explaining the premise, hypothesis, and expected outcomes of his proposed study to audiences comprised of trained scientists, uninformed cadres, and the lay public. But unfortunately, his efforts fell on deaf ears; nobody expressed consent or dissent despite several attempts. The apathy among the audience could have been a sign of indifference or ignorance of the subject matter, but Wang contended that Bei's proposal was not construed as another "anti-revolutionary or a bourgeois" science project because Bei framed the investigation as a study of "cell origins" rather than "cell reformation." At the center of the representational difference is Chairman Mao's 1964 endorsement to study the origins of cells. Upon hearing Mao's announcement, Bei thought it was more appropriate and acceptable to change his research agenda from "cell reformation" to "cell origins," thereby drawing political currency from Mao's rhetoric. In addition to the prospectus, Bei also wrote an article entitled "Research on the Origins of Life and the Origins of the Cell" (生命起源和细胞起源的研究) in 1970.[361] It was the first time Bei adopted the phrase "cell origin" in his academic writing. In this article, he put forward the proposition that the purpose of studying the origins of life and the cell was to investigate the material conditions for the emergence of life and to "expound on the dialectical relationship between parts and whole, structure and function, micro and macro, time and place, individual and system."[362] This is a direct response to the philosophy of biology articulated by Mao, who posited that the origins of life, like the structure of elementary particles, must be understood as a dialectical process in which the micro-parts were

[361] Bei Shizhang, *Selected Writings of Bei Shizhang,* pp. 218-225.
[362] *Ibid,* p. 223.

indivisible from the macro-structures. In the cytological realm, the principle of "unity of Nature" in dialectical materialism was translated into an assertion of not exhausting the analytical structure of cells per se, but studying the transformation of "qualitative modes of existence of matter:"

> Searching for the origin of life would not stop somewhere on a "brick", a cell, or whatever. It would simply never stop, because each level is the production of a qualitative step—a step of a layer of our universe, that we may compare to an onion.[363]

Since Mao declared that the quest for the origin of life should not restrict itself to the level of cells but should expand to other biological units, Bei underscored the investigation of the relationship between life and non-life, cell and non-cell as a core objective, in addition to studying the differentiation and dedifferentiation of tumor cells.

The support from the state was evident from the scope of attention Bei's prospectus drew in the subsequent years. Bei's proposed research was listed as a key project in the Fourth Five-Year Plan released in 1971,[364] and highlighted by the CAS biological research council in 1972.[365] The political endorsement of Bei's work meant that not only was the political stature of Bei untarnished, his research was considered significant to social needs in the latter half of the Cultural Revolution.

If the above record is only circumstantial evidence of Bei's political credentials during the Cultural Revolution, Bei's appointment as the leader of the first scientific exchange orchestrated by the Mao-Nixon diplomacy is a direct expression of his political

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[363] Mao Zedong, "Talk on Sakata's Article," *Selected Works of Mao Tse-tung vol. IX*, August 24 1964.
[364] The Fourth Five-Year Plan was planned for the nation's economy and development from 1970 to 1975. See "Major Points of the Fourth Five-Year Plan (Draft)" (四五计划纲要(草案)) for more.
[365] Wang Guyan, *A Biography of Bei Shizhang,* p. 270.

sway in this period. In 1972, Bei led a seven-scientist delegation to visit the U.S. following the table-tennis tournament initiated in 1971.[366] The visit marked the ushering in of a new era of development and exchange of scientific and technological affairs between China and the countries within the U.S. "Western" sphere of influence. The 1972 delegation was the first sent by China to visit the U.S. and its allies since the onset of the Cultural Revolution. Between 6 October and 17 December, the delegation toured university laboratories and research facilities in areas such as high-energy physics, plasma physics, controlled thermonuclear reaction, computer science, environmental science, and biophysics in the U.K., the U.S., Canada and Sweden.[367]

In the U.S., the Chinese science delegation was cordially received by the Federation of American Scientists and the Committee on Scholarly Communication with the People's Republic of China (CSCPRC)—a committee jointly founded by the National Academy of Sciences (NAS), the American Council of Learned Societies (ACLS), and the Social Science Research Council (SSRC) in response to the Shanghai Communiqué issued on 27 February 1972.[368]

Besides acting as the titular head of the Chinese delegation, Bei Shizhang's visit to the U.S. in the fall of 1972 bore disciplinary significance to the first trans-Pacific exchange between native Chinese and Chinese-American biophysicists. Hsin-Ti Tien (田心棣), chair of the department of biophysics at Michigan State University, wrote to Bei

[366] Xinhua News, "Embarking on a Friendly Visit to the United Kingdom, Sweden, and Canada: Bei Shizhang Leads A Chinese Science Delegation Departing from Beijing, Guo Moruo, Liu Xiyao, Zhang Wenjin, Wu Youxun, Zhou Peiyuan etc. Come to the Airport to See Them Off" 前往英国、瑞典、加拿大进行友好访问:贝时璋率中国科学家代表团离京，郭沫若、刘西尧、章文晋、吴有训、周培源等到机场送行, *People's Daily,* October 7, 1972.
[367] Fan Hongye, ed., *An Edited Historiography of the Chinese Academy of Sciences, 1949-1999*, p. 271.
[368] CSCPRC, ed. *A Relationship Restored: Trends in U.S.-China Educational Exchanges, 1978-1984* (DC: National Academy Press, 1986), pp. 69-70.

Shizhang in early 1973 expressing his interest to visit IBP-CAS and other biophysics-related establishments in China after Tien learned of Bei's ambassadorial role in the first Chinese science delegation.[369] Tien departed for China in 1973 as an official representative of the Biophysical Society upon the invitation of Bei Shizhang and with the endorsement of the U.S. Biophysical Society Council.[370]

Under the auspices of the U.S. Biophysical Society, Tien visited several major biophysics-related research institutes and university departments. In addition to IBP at Beijing, Tien also traveled to the Institute of Plant Research at Beijing, the Institute of Plant Physiology at Shanghai, Sun Yat-sen University at Guangzhou, Wuhan University, Central China Normal University at Wuhan, and Peking University. After giving a general profile on the basic history and circumstances of each research institute, Tien considered "the effects of the Cultural Revolution on scientific research" particularly pertaining to the IBP and CAS.[371] Tien reached the conclusion that "During the Cultural Revolution research activities at the Institute (of Biophysics) were either completely interrupted or greatly curtailed."[372] The interruption, as Tien elaborated, was due to the participation of members of the institute in the "May 7th" cadre schools, factories, or peoples' communes, thus diverting attention away from laboratory science. In the meantime, the biophysics community suffered another blow with the retrenchment of educational programs at major universities. Tien describes Bei as saying that he could

[369] H. Ti Tien, "Biophysical Research in the People's Republic of China," *Biophysical Journal,* vol. 15, iss. 6 (1975), pp. 621-631.
[370] Tien was elected to the Biophysical Society Council in 1974. Other elected members serving on the Council during the 1974-75 term were Bernard Abbot, Alice Burton, J. Woodland Hastings, Lester Packer, Clifford Patlak and Thomas Thompson. Available on <www.biophysics.org> accessed 10 Dec 2013.
[371] A separate column was devoted to discuss the impacts of the Cultural Revolution on the research at CAS and IBP respectively. See H. Ti Tien, "Biophysical Research in the People's Republic of China," pp. 626-629.
[372] *Ibid*, p. 627.

only discuss with Tien the biophysics program he had launched before 1966 as universities were completely shut down between 1966 and 1969. What Bei reportedly disclosed to Tien reflects the circumstances of the biophysics program at USTC, which will be assessed towards the end of this chapter.

Available biographical information on Tien suggests that he had left China before 1949, became a U.S. citizen, and did not return to China prior to 1973.[373] Therefore, Tien's perception of the Cultural Revolution was mostly based on what he saw and what the Chinese scientists told him during his two-and-a-half month sojourn in China. Given his lack of prior knowledge of science and society in P.R.C., one is left pondering: Is Tien's portrayal reliable? Does Tien's report really capture the influence of the Cultural Revolution on the Chinese biophysics community?

Recent scholarship in the history of science has problematized the deliberate act of constructing models of national difference while concealing pre-Nixon years of transnational scientific exchange and the distasteful aspects of Cultural Revolution science in the 1970s U.S.-Chinese scientific exchanges.[374] It was found that the American Insect Control Delegation visiting Chinese entomologists and entomological facilities in

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[373] Tien was known in the American scientific community for his research on experimental bilayer lipid membranes. He published 6 research articles on *Nature* between 1966 and 1970 on this subject. Tien held a bachelor degree in chemical engineering from the University of Nebraska in 1953, and M.A. and Ph.D. degrees in chemistry from Temple University in 1961 and 1963 respectively. After obtaining tenure from Northeastern University between 1963 and 1966, he undertook a professorship at the Membrane Biophysics Laboratory at Michigan State University in 1966 and remained there until his death in 2004. See Zhang Zongrang 章宗穰, "Introducing *Advances in Planar Lipid Bilayers and Liposomes* Series–In Commemoration of the 45 Anniversary of the Publication of Research in Artificial Bilayer Lipid Membranes"《平面类脂双层和脂质体研究进展》丛书简介—纪念人工类脂双层膜研究工作发表 45 周年, *Chemical Sensors* 化学传感器, vol. 27, no. 1 (Mar. 2007), pp. 66-68; also see Zhuang Yanlin 庄炎林 and Wu Jie 伍杰, eds. *A Dictionary of Overseas Chinese and Foreign Affairs* 华侨华人侨务大辞典 (Jinan: Shandong Friendship Press, 1997), p. 579.

[374] Sigrid Schmalzer, "Insect Control in Socialist China and the Corporate United States: The Act of Comparison, the Tendency to Forget, and the Construction of Difference in 1970s U.S.-Chinese Scientific Exchange," *Isis*, vol. 104, no. 2 (June 2013), pp. 303-329.

1975 were engaged in what Sigrid Schmalzer called "the act of comparison, the tendency to forget, and the construction of difference," as the Chinese, Chinese-American and European-American entomologists were all too keen to portray socialist Chinese efforts in insect control as fundamentally different from those of corporate America. As Sigrid Schmalzer argued, "in 1975, socialist China was expected to serve as an inspirational other; its differences being celebrated for what they could teach the U.S. and the world."[375] Since Chinese science was assumed to be different and better at delivering public oriented goods than the U.S. corporate interest-driven science, the American pressure to construct otherness and the Chinese eagerness to highlight its uniqueness and self-sufficiency necessitated the downplaying and even erasure of commonality and prior history. Schmalzer's article issued a felicitous warning against taking the discourse of U.S.-Chinese scientific exchange as constituting a *prima facie* reflection of the actual status of post-Cultural Revolution Chinese science.

Compared to the U.S.-Chinese entomological exchange, what is remarkable in the synchronic biophysical communication is the somewhat more balanced depiction of socialist biophysics in Tien's field report. On the one hand, the high level of scientific competence in P.R.C. certainly left a good impression on Tien:

> From my observations during my two and one-half months' visit, it appears that the scientific work being done in the P.R.C. is of very high quality. My general impression of the laboratories I saw at the Institute of

[375] *Ibid,* p. 318.

> Biophysics and elsewhere is that they are staffed by dedicated and hardworking scientists and technicians.[376]

Besides commending the work ethic of scientists and the quality of their laboratory settings, Tien also praised the professional knowledge of locally-educated biophysicists and in particular their readiness to help translate technical terms in bilayer lipid membranes from English to Chinese during his lecture that was given in Chinese. It led Tien to reach the conclusion that "familiarity with recent scientific developments (in my specialty at least) is not limited to the few specialists trained abroad" and that "it was evident during the question-and-answer period following my talk that the Chinese investigators were quite up to date with the latest research in membrane biophysics done abroad."[377]

At the same time, Tien did not hold back from asking Chinese biophysicists about the negative impact of the Cultural Revolution on their research, nor did Chinese biophysicists appear to evade Tien's questions. Tien made no attempts to mask the disruption of the Cultural Revolution to the research and teaching of biophysics. At one point, Tien unabashedly acknowledged, "from the talks I had with scientists both at the Institute and elsewhere, my impression was that the Cultural Revolution has had many profound effects."[378] Tien was aware of the suspension of scientific journals and other scholarly activities during the Cultural Revolution (although he recognized that two core journals—*Scientia Sinica* and *Science Bulletin*—had resumed publication by the time of his writing) and the mandatory requirement of scientists from all ranks and all disciplines

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[376] H. Ti Tien, "Biophysical Research in the People's Republic of China," p. 629.
[377] *Ibid*, p. 630.
[378] *Ibid*, p. 629.

to engage in intense ideological study and practice. While Tien did not report scenarios of scientists being attacked or killed, one could sense from his writing an underlying tone of frustration and trepidation about the undesirable revolutionary effects on scientific practice.

For their part, the Chinese biophysicists responded to Tien's questions with as many details as they could disclose. They did not disguise their discontent with the policy of compulsory participation in manual labor and curtailment of college education of biophysics. Yet neither side mentioned any biophysicist being humiliated or assaulted. Even during the post-Mao years in which scientists were encouraged to publicly denounce the Cultural Revolution through discussing personal accounts of suffering, none of the narratives of victimization emerged from the biophysics community. Therefore, it appears that neither the Chinese biophysicists nor Chinese-American biophysicists like Tien were complicit in romanticizing the science of biophysics in the first U.S.-Chinese biophysics meetings.

Shen Shumin and *Progress in Biochemistry and Biophysics*

Bei Shizhang was fully occupied with his involvement in activities of science diplomacy in 1972. In the same year, Shen Shumin withdrew from the research frontline as she went on a hiatus to prepare for her next project. In spite of the stormy social atmosphere, Shen launched a journal called *Progress in Biochemistry and Biophysics* (*PIBB* 生物化学与生物物理进展) in 1974 with the help of cadres in IBP-CAS like Liang Peikuan (梁培宽). Shen acted as editor-in-chief for the journal between 1977 and 1987. Shen's biographer contended that founding an academic journal was a "difficult undertaking" due to the sensitive nature of academic publishing in the shadow of the Cultural Revolution; also, the handful of scientific journals and diminishing research output had made peer review and calls for papers an outstanding hurdle in running a journal.[379]

It was estimated that there were only 20 academic journals in science and technology in 1969. The number of scientific and technical journals rose to 400 in 1978,[380] and this number again increased by sevenfold towards the end of the 1980s.[381] *PIBB* was one of the 380 journals founded between 1969 and 1978 and was a major achievement of Shen. It is true that she was the acting chair of the biophysics department at USTC, but she did not found the department itself or the Institute of Biophysics.[382] *PIBB*, on the other hand, was her own brainchild rather than that of Bei Shizhang.

PIBB is not to be confused with another journal with a somewhat similar name in Chinese—*Acta Biochemica et Biophysica Sinica* (生物化学与生物物理学报). *ABBS* was founded in 1958 and run by the Institute of Biochemistry in Shanghai (presently known as the Institute of Biochemistry and Cell Biology within the administration of the Shanghai Institute for Biological Sciences). *ABBS* was initially under the leadership of Wang Yinglai (王应睐), director of the Institute of Biochemistry in Shanghai and a

379 "An indefatigable Journal Founder Delights in the Mission of Education—Celebrating the Eightieth Birthday of Professor Shen Shumin" 办刊育人，乐此不倦—沈淑敏先生八十寿辰致庆, *PIBB* vol. 22 (1995), pp. 2-4.
380 Jia Xian, "The Past, Present, and Future of Scientific and Technical Journals of China," *Learned Publishing* vol. 19, no. 2 (April 2006), pp. 133-141, on p. 134.
381 *Ibid,* p. 135.
382 See "Shen Shumin and Biophysics, 1961-1964" in chapter 6 for more information.

leading biochemist in China.[383] Shen was well aware of the existence of *ABBS* when she launched *PIBB*. To avoid professional overlap, she insisted that *PIBB* would put the emphasis on "comprehensive review" (综述) and "technology and methodology" (技术与方法); the former column would introduce the latest progress and research breakthroughs from the international community while the latter would provide a platform for domestic scientists and scientific workers to exchange views with each other; these two columns thus became the mainstays of *PIBB.*

Establishing *PIBB* in the midst of the Cultural Revolution is a testimony to Shen's political standing and a reflection of her application of a comprehensive approach to organizing professional communication among biophysicists. The previous chapter mentioned some of the ways in which she implemented her holistic vision into the curriculum of biophysics by prescribing compulsory coursework in mathematics, physics, and chemistry for all biophysics majors at USTC before 1966.[384] Clearly, Shen's commitment and dedication to promoting biophysics as a comprehensive field of science carried over into the post-1966 period.

Twenty years later, "comprehensive review" and "technology and methodology" remained core components of the journal, and stood alongside new columns such as "research reports" (研究报告), "research quick news and summary" (研究快报与简报), "news of science and technology and information service" (科技消息和信息服务), and

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[383] For an abridged history of biochemistry in modern China, see Dong Guangbi 董光璧, *History of Science and Technology in Modern and Contemporary China* 中国近现代科学技术史 (Changsha: Hunan Education Press, 1997), pp. 725-739.

[384] See "Shen Shumin and Biophysics, 1961-1964" in chapter 6 of this disquisition for more.

"exchange of experience" (经验交流).[385] The editorial office of *PIBB* highlighted the column "comprehensive review and professional papers" (综述与专论) as "specializing in publishing the latest news in this discipline, and has become the indispensable information for preparing biology classes in various higher-education institutions, a good companion of topic selection in related science and research institutes, and predominantly a readers' favorite."[386] Not only does Shen's editorial philosophy stand the test of time, she also created an enduring role for *PIBB* as a principal source for teaching biology in college education. This goes along with her previous efforts to advertise and advance biophysics as "a newfound discipline in the biological sciences" (*People's Daily* dated August 6 1963). From 1963 to 1974, Shen moved from writing a news article to launching a new journal to promoting biophysics as a biology-centered field of inquiry.

Meanwhile, one critic has implied that the accomplishment of publishing a scientific journal in 1974 was perhaps not so impressive if one considers the contents pages:

> When journals resumed publication around 1971, not only did most of their contents strictly address applied research, but the papers also attributed their research to the influence of Marxism-Leninism-Mao Zedong Thought. The research findings and quotations most frequently

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[385] Liang Peikuan 梁培宽 et al. "Fostering Cooperation, Marching Forward—In Commemoration of the Twentieth Anniversary of *Progress in Biochemistry and Biophysics*" 加强合作, 继续前进—纪念《生物化学与生物物理进展》创刊二十周年, *PIBB* vol. 21 (1994), pp. 7-8.
[386] *Ibid,* p. 8.

presented by scientists amounted to little more than truisms recognized as valid by any research scientist.[387]

Thus, it is imperative to delve beyond the surface of editorial ambition and evaluate the substance of the journal because the character of the journal lies in the content of its issues rather than what the editors declared it to be. Did *PIBB* only address applied research? Were the research findings and quotations published in *PIBB* nothing but party rhetoric ? To assess how biologically oriented *PIBB* really was—particularly in its early years—one must examine the content of articles published in *PIBB* in its maiden year of operation.

There were a total of 4 volumes and 53 articles contained in 1974. In January, *PIBB* commenced the journal with an inaugural article entitled "Digging Deep into the Scientific and Technological Battlefront of the 'Criticize Lin Biao, Criticize Confucius' Campaign to Thoroughly Conduct the Socialist Revolution" (深入批林批孔把科技战线的社会主义革命进行到底). This was a propaganda article in line with the "Criticize Lin, Criticize Confucius" campaign launched in 1973 after Lin Biao's airplane crash in 1971.[388] Although the two-page editorial had very little to do with biology or science per se, the editors consciously highlighted the inseparability between dialectical materialism and inquiry in biological sciences: "Biological sciences have always been a serious bone of contention between dialectical materialism, reactionary idealism and metaphysics" (生物科学从来就是辩证唯物主义与反动的唯心主义、形而上学激烈争夺的阵地). Political phraseology was tossed around to establish the ideological purity of the

[387] Cong Cao, "Science Imperiled: Intellectuals and the Cultural Revolution," p. 128.
[388] For the details of the "Lin Biao Affair" and its aftermath, see Qiu Jin, *The Culture of Power: The Lin Biao Incident in the Cultural Revolution* (California: Stanford University Press, 1999).

newfound journal. For example, the inaugural editorial pledged allegiance to "proletarian interests" by claiming that *PIBB* was determined to "rid itself of the influence of 'purely academic' perspectives of the bourgeoisie and make itself into a combative journal with proletarian politics as the guiding force in order to unify politics and scientific operation, to criticize bourgeois and exploitative ideologies of all kinds, and to facilitate the development of scientific enterprise."[389]

The second article published in 1974 reported the symposium on "Criticize Lin, Criticize Confucius" co-organized by the editorial committees of *ABBS* and *PIBB*. Participants of the joint symposium reached a consensus that "both *ABBS* and *PIBB* should be a battlefield for the 'Criticize Lin, Criticize Confucius campaign" ('学报'和'进展'都应成为批林批孔的一个阵地).[390] Thus, *PIBB* and *ABBS* were joined in their efforts to publicize their loyalty to the mainstream political campaigns in early 1974.

When one examines the content of the first two articles, one might be disheartened by the spillover of politics into the intellectual sphere, but one would discover that the next eleven articles published in the first volume were all about biological science rather than revolutionary politics. The third article, titled "Research on the Relationship between Spatial Structure and Functions of Biological Macromolecules in Solution—Minutes of a Discussion Group" (生物高分子在溶液中的空间结构与功能关系的研究概况—讨论会纪要), was the first piece in the "comprehensive review" column. This article summarized existing research and techniques for determining the

389 Editorial, "Digging Deep into the Scientific and Technological Battlefront of the 'Criticize Lin Biao, Criticize Confucius' Campaign to Thoroughly Conduct the Socialist Revolution" 深入批林批孔把科技战线的社会主义革命进行到底, *PIBB* vol. 1 (1974), pp. 1-2, on p. 1.
390 Editorial, "News on 'Criticize Lin, Criticize Confucius' Symposium" 批林批孔座谈会简讯, *PIBB* vol. 1 (1974), p. 3.

backbone spatial structure of protein molecules, from optical rotatory dispersion and circular dichroism (旋光色散与圆二色性) to hydrogen isotopes exchange (氢同位素交换), ultraviolet differential absorption (紫外差吸收), fluorescence (萤光方法), laser Raman spectroscopy (激光雷曼光谱), and NMR (核磁共振). The article then reviewed the biological significance of measuring macromolecular structure and envisioned the applied values of macromolecular research. Unlike the previous editorials of less than two pages, this article was six pages long and was devoid of propaganda; there was no attribution of the macromolecular research to the influence of Marxism-Leninism-Mao Zedong Thought.

Likewise, the rest of the essays in volume one were all about biology in one way or another, including the bioactivity of enzymes; the origins and development of mitochondria; bio-holograms and acoustic holography; the measurement of low-level Beta exposure dose in radioactive fallout; water-soluble protein injections; the digestive enzymes in *cyclophorus pyrostoma moellendorff*, a mollusk native to southern China; the experimental techniques to determine the molecular weight of protein molecules by gel filtration; the development and application of electron microscopes for biological research; the preparatory procedures of biological samples to be viewed under electron microscopes; and the preparation of water-insoluble enzyme derivatives and their application in biochemical analysis and separation. Basically, only two out of the thirteen articles published in the first volume of 1974 did not touch on the research, instrumentation, and application of biological science.

The other three volumes in 1974 exhibited similar patterns to the first volume: the first two articles were editorials in support of the "Criticize Lin, Criticize Confucius" campaign or letters pledging allegiance to the Great Proletarian Cultural Revolution, while the rest of the articles were dedicated to advances in biological science. Considering the fact that political commentaries made up less than 10% of the total length in each volume, it is reasonable to draw the conclusion that *PIBB*——even in its first year of operation—did in fact concentrate on disseminating news and research updates on biological science, though doing so while paying lip service to the revolutionary cause.[391]

PIBB was one of some three hundred journals that came into existence between 1969 and 1978. From the above content analysis, it is evident that not only was it permissible to launch a scientific journal during the Cultural Revolution, but more importantly, it was possible to devote the majority of the content to scientific knowledge and technical matters without jeopardizing the political credibility of the editorial committees or the founding members. Contrary to the skepticism of the journalistic practice (which resumed after 1971) that it only served to recycle political blather, it is clear that the bulk of the content of *PIBB* in 1974 concerned itself with scientific inquiry rather than political rhetoric.

From Beijing to Hefei: The Relocation of USTC, 1966-1973

The foregoing pages narrate the individual experiences of young cosmobiologists and senior biophysicists during the Cultural Revolution. However, the story is incomplete without examining what happened to the biophysics department at USTC.

[391] All of the current and past issues of *PIBB* are available on <pibb.ac.cn>.

Judging from the ubiquitous Big Character Posters on the campus of Peking University and the endless criticism sessions and revolutionary meetings at Tsinghua University, the overall impact of the Cultural Revolution on higher education was largely negative and even destructive. As one scholar lamented, “the Cultural Revolution paralyzed China’s educational system. Having been denounced as a system for cultivating revisionist seedlings, formal higher education was abandoned in 1966.”[392] USTC was unique not just because it was able to escape from the revolutionary reforms, but rather because it was USTC’s intricate relationship with CAS and the defense ministry that rendered its experience distinct from that of other higher education institutions.

The intertwining of USTC and CAS has been explored in this chapter and the previous one; CAS founded USTC in 1958 to promote higher education in science and technology, especially in areas with corresponding research institutes at CAS. In the case of biophysics, the USTC biophysics department was created in order to offer an educational program for supplying manpower to work at IBP-CAS, so many USTC biophysics graduates were assigned to work at the cosmobiological unit at IBP-CAS upon graduation.

The USTC–CAS symbiosis ran smoothly until July of 1966, when the CAS working team stationed at USTC was dismissed and replaced by a revolutionary committee, during which the USTC board of directors tried unsuccessfully to take back the school from the revolutionary committee. In 1967, as the “New Technology Office” and many defense-related research institutes of CAS were transferred to NDSTC, USTC

[392] Cong Cao, “Science Imperiled: Intellectuals and the Cultural Revolution,” p. 128.

leaders proposed that those departments corresponding to defense science should also be taken over by NDSTC. USTC was under the guardianship of the defense establishments for a brief period between 1967 and 1968 until NDSTC and Nie Rongzhen became targets of criticism for encouraging a "multi-center" institutional structure, which pressured NDSTC to relinquish control of USTC.[393] Was this a sign of civilian rebels overriding the authority of the military-defense complex? It could have been, but perhaps not to Zhou Enlai, who commented that it was unrealistic for NDSTC to lump everything into its framework. His speech dated 18 August 1968 read: "The industrial infrastructure of National Defense should proceed incrementally and moderately. It should not expand too quick in too short a time."[394]

On August 1968, after NDSTC had abandoned USTC, the Workers' and the PLA Mao Zedong Thought Propaganda Teams swiftly occupied the campus. The revolutionary education commission of USTC was inspired by the examples set by the Jiangxi Communism Labor University (JCLU), Peking and Tsinghua Universities to set up a "base for revolutionary education" at USTC. According to the policy document titled "Preliminary Opinions on Taking the Roads of JCLU, Rebuilding a New Proletarian USTC" dated July 9 1969, a core objective was to "take JCLU as a role model, to learn from Tsinghua and *Beida*, and to found a base for revolutionary education in Jiangxi."[395]

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[393] Guo Hanbin 郭汉彬, "Questions About the Sent-down and Relocation of USTC" 有关中国科技大学下放、搬迁的问题, Office of University Archive (OUA), USTC, Box 1974-WS-Y-4.
[394] Zhou Enlai , "National Defense Industrial Infrastructure Should Build from Small to Large" 国防工业建设应该从小到大, *Selected Military Writings of Zhou Enlai* (Beijing: Military Academy of Sciences of People's Liberation Army of China Press, 1997), p. 557.
[395] Ke Zineng 柯资能, and Ding Zhaojun 丁兆君, *Information and Research of University History* (*IRUH*, 校史资料与研究), Issue 2, (December 10, 2007) available at <arch.ustc.edu.cn/news>.

The students' movements at *Beida* and Tsinghua were triggered by the "May 7 Notice" (五七指示), named in honor of the date in 1966 on which Mao wrote to his successor Lin Biao authorizing the PLA to act as an instructional base for cadres in party, government, industrial, military, civilian, and educational sectors in order to facilitate criticism of the bourgeoisie through uniting with local forces in villages and factories.[396] Inspired by Mao's call to leave urban areas for the most remote, dilapidated rural districts, students in Peking and Tsinghua Universities decided to make their campuses "bases for revolutionary education." In 1969, the revolutionary committee of USTC followed in the footsteps of Tsinghua in drafting a "Consultative Report on Establishing 'an Experimental Base for May 7 Revolutionary Education'."[397] The report was subject to discussion and revision after several rounds of meetings between the Propaganda Teams, the standing committee of the revolutionary council and the CAS representatives. The finalized version of the "Consultative Report" adopted the suggestion that was raised by CAS representatives to align USTC with the institutional reform of CAS and make USTC a part of the CAS system.

The original plan was to spend two or three years preparing and looking for a suitable location in Jiangxi. Yet the occurence of a national security event expedited the relocation of USTC. In March 1969, the military skirmishes over Zhenbao Island between the USSR and China convinced Mao that a Sino-Soviet war was in the offing. National defense was stipulated as the first priority in the Third Five-Year Plan running from 1966 to 1970. Besides military preparedness, Mao twice warned of the need for the

[396] MacFarquhar and Schoenhals, *Mao's Last Revolution,* p. 160.
[397] Ke Zineng and Ding Zhaojun, *IRUH*, Issue 2, (December 10, 2007), p. 13; also see <arch.ustc.edu.cn/history.htm>.

civilian sector to prepare for the upcoming war.[398] The perceived Soviet aggression catalyzed the view that urban populations should be dispersed from the city-centers in order to avert danger. On the 26th of October, 1969, the State Council issued a mandatory evacuation order of thirteen higher education institutions in preparation for the potential war.[399] This is known and recorded as the "Emigration of Beijing Universities" (京校外迁).

Nevertheless, many USTC students and teachers resisted the evacuation order as the real purpose of the evacuation was not made clear. Liu Xiyao (刘西尧), chief of the Science and Education Commission of the State Council, who carried the message of the evacuation to USTC, spoke of the interchangeability between evacuation and relocation: "to relocate is to evacuate, to evacuate is to relocate" (搬迁就是疏散，疏散就是搬迁).[400] Zhao Xiangpu (赵湘濮), vice-commander of the PLA Mao Zedong Thought Propaganda Team stationed at USTC, also urged USTC staff to immediately leave Beijing: "the Soviet army can set foot in the capital in a few hours, and drop a missile in Beijing within three minutes" (苏军几个小时能打到首都，导弹三分钟能落到北京).[401] Under the fear of imminent Soviet attack and ubiquitous pressures to proceed with dispatch, between 17 and 30 December in 1969, a host of 900 USTC students and staff flocked to the city of Anqing (安庆) in Anhui province.

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[398] MacFarquhar and Schoenhals, *Mao's Last Revolution,* p. 308; for a more anecdotal portrayal of the Zhenbao (Treasure) Island incident, see Li Zhisui, *The Private Life of Chairman Mao* (NY: Random House, 1994), p. 513.

[399] "Notification About the Relocation of Higher Education Institutions" 关于高等院校下放问题的通知, October 26 1969, The State Council Information Office of the People's Republic of China 国务院新闻办公室, available at <scio.gov.cn>

[400] Ke Zineng and Ding Zhaojun, *IRUH*, Issue 2, (December 10, 2007), p. 18.

[401] *Ibid*.

When they first arrived at the inland city of Anqing, the freezing temperatures of December and a lack of heating supplies in southern China made their lives miserable. The regional government directed the group to purchase charcoal in Guangde——the launch site at which biophysicists had launched the biological sounding rockets in 1966. Among the detachment, the biophysicists stepped forward to volunteer to transport the charcoal from this mountainous locale with which they were familiar.[402]

The relocation project began in December 1969 and lasted until October 1970. After a temporary stay in Anqing, USTC moved to the city of Hefei and acquired the original site of Hefei Normal Institute as their campus. Meanwhile, most of the teaching staff of USTC were "sent-down" to inner rural regions in Anhui such as Huainan (淮南), Ma An Shan (马鞍山), and Tong Ling (铜陵). Fang Lizhi, then vice president of USTC and a physicist-turned-dissenter, remembered spending some time in a coal mine in Huainan before classes resumed in Hefei.[403] Fang was one of the 6000 USTC members who followed the emigrating horde from Beijing to Hefei. Half of the teaching materials, instruments, books, devices, and records were lost in the process, and it went without saying that many USTC teachers and students were frustrated and disappointed with the relocation order and outcome.[404]

The popular demand to move USTC back to Beijing reached the ears of the USTC leaders, and in 1972, the school convened a meeting attended by the USTC party

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[402] Cai Youzhi 蔡有智, "History and Commentary of Relocating the School" 迁校经历与评说 in *Attachment to USTC—Forty Years of Staying in School for the Class of 1959* 心系科大——五九级毕业留校四十年, pp. 15-17, available at <alumni.ustc.edu.cn>.

[403] Fang Lizhi, *Bringing Down the Great Wall: Writings on Science, Culture, and Democracy in China,* trans. and ed. James H. Williams (NY: Alfred Knopf, 1990), p. 70.

[404] Wang Xipeng 王锡鹏, "Some Updates About the Relocation of USTC" 有关科大外迁的一些情况, OUA, USTC, Box 1974-WS-Y-4.

secretary, the associate director of the revolutionary committee, representatives from CAS, the Second MMB, the Third MMB, and the associate director of the Education Bureau of the Anhui province to discuss the possibility of returning to Beijing. Qin Lisheng (秦力生), principal representative of CAS, dismissed the notion of returning USTC to Beijing or the CAS umbrella as CAS had its own burdens. One should not forget the generally dismal conditions of CAS in 1972 where more than half of its institutes were transferred or eliminated, undermining its overall authority and leadership. Three conclusions were reached from this meeting: first, USTC would continue to operate; second, the jurisdiction and configuration of programs and specialties, as well as the institutional structure would await further discussion; and finally, it was unrealistic to move USTC back to Beijing.[405]

The year 1972 was tumultuous for USTC; many study programs were discontinued because the institutional structure of USTC broke down. Between 1971 and 1972, USTC was co-administered by Anhui provincial government and the Third MMB. CAS shied away from the question of jurisdiction regarding the USTC until 1973 when the Office of the Secretariat of CAS issued a memorandum titled "Notice About Restoring the CAS Administration of USTC" stating that USTC would be returned to the jurisdiction of CAS starting in January of 1974. The decision was backed by an earlier document released by the State Council dated the 19th of March, 1973 in which the State Council announced the following points regarding the governance of USTC: 1) USTC would remain in Hefei; 2) since USTC had a historical relationship with CAS in terms of

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[405] "USTC Demands Returning to the Leadership of CAS" 学校要求归口中国科学院领导, in Zhu Qingshi 朱清时, ed. *A Draft Historiography of the University of Science and Technology of China* 中国科学技术大学编年史稿, (Hefei: University of Science and Technology of China Press, 2008), p. 122.

research-education correspondence, USTC would be under the dual leadership of CAS and the Anhui provincial government; 3) the program configuration, course plan, funding, and equipment acquisition would be jointly managed by the Science and Education Commission of the State Council, along with the CAS and Anhui provincial government.[406]

After the adjustment of programs, there were altogether 29 programs in 1973, 20 of which corresponded to the respective research institutes at CAS. Biophysics was among the twenty corresponding specialties (对口专业) at USTC; the remaining non-CAS corresponding specialties, such as aerodynamics, microwave technology, and explosive mechanics were handed to the Third, Fourth, and Seventh MMB respectively.[407]

Summary

Writing two decades after the onset of the Cultural Revolution, Lucian Pye wrote, "time has not made it easier to assess the Cultural Revolution. Partly because it was such a multi-dimensional event, touching people in so many different ways, no established form of analysis is capable of embracing its totality."[408] Besides pointing out the lack of comprehensiveness in the scholarly efforts to interpret this multifaceted political upheaval, Pye also urged scholars to admit prejudice and subjectivity in their analyses of the Cultural Revolution: "in looking back now and reassessing the Cultural Revolution, scholars must acknowledge that even as they strived for historical objectivity, they have

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[406] "USTC Returns to the Leadership of CAS" 学校重新归口中国科学院领导, *Ibid*, p. 132-133.
[407] "The Configuration and Adjustment of Specialties" 学校专业设置和调整, *Ibid*, p. 137-138.
[408] Lucian W. Pye, "Reassessing the Cultural Revolution," *The China Quarterly*, 108 (Dec 1986), pp. 597-612, on p.597.

been decisively, then and now, influenced by what the Chinese have had to say about the event."[409]

Another two decades have passed since Pye's article was published. Pye's admonition on the methodological biases in reassessing the Cultural Revolution remains as valid to the present analysis as it was more than twenty years ago. As the stories of the biophysicists and biophysics institutions unfolded in the foregoing pages, my examination is inevitably colored by the selected vignettes and vicissitudes the few Chinese biophysicists who chose to share their experiences with me and the public. I make no attempt to disguise my scant knowledge when it comes to the profundity of this decidedly emotional event. To amend these shortcomings, I have tested the rigor and veracity of some of the personal accounts by crosschecking with other sources and references to which I have access. I do not deliberately downplay or ignore evidence of violence or testimony of hardship.

In the end, what I have sought to produce in this chapter is not an exhaustive or impartial analysis of the Cultural Revolution but merely a story of Chinese biophysics and biophysicists against the backdrop of the Cultural Revolution.

This chapter has assessed the impact of the Cultural Revolution on biophysics and biophysicists from the local standpoints of young biophysicists who participated in the defunct "Peace I" mission and of the leading biophysicists who pursued new areas of research and professional communication within the limits of political acceptability. The energies of young biophysicists such as Ma Fenglin and Fan Silu were spent in completing the mission of "Peace I" as much as possible. Bei Shizhang championed a

[409] *Ibid*.

study on the origins of the cell and the origins of life by seeking refuge under Mao's stated interest in this matter. Concurrently, H. Ti Tien, a Chinese-American biophysicist, also highlighted "origins of life" in his work on membrane biophysics before and after his 1970s visit to China. Lastly, another notable Chinese biophysicist—Shen Shumin—continued her earlier attempt at promoting professional dialogue and the exchange of scientific updates around biophysics as a biology-oriented discipline.

These activities of junior and senior biophysicists were possible partly because of biophysics' connection with the military sector. The military was granted a larger degree of autonomy during the Cultural Revolution, and by association, military science and technology enjoyed some of the benefits of this autonomy as well. Biophysics was folded into the science–military complex by drawing on the connections it had fostered before 1966, yet absolute safety was not guaranteed by military supervision: Some of the gang violence in the military controlled bureau were described in a General's diary and a widow's memoir regarding the death of Yao Tongbin.

Institution-wise, IBP-CAS handed the cosmobiology team to NDSTC while the main office maintained its *de facto* status in CAS—one of the ten institutes officially affiliated with CAS in 1972. As to the biophysics department at USTC, most of the biophysics students and staff followed the order from the central government to arrive at the school's new campus in Hefei. By 1973, biophysics remained one of the twenty programs with formal correspondence to the research institutes at CAS.

These individual and institutional experiences of biophysics took place in one of the most controversial and abhorred periods in contemporary China. It has been widely assumed that many scientists and intellectuals were killed, humiliated, assaulted, and traumatized by party politics. But as several scholars have recently noted, factional politics (as significant as it is) does not encompass the range of lived experiences of the Cultural Revolution. As one reviewer perceptively argues, "if we look beyond the *realpolitik* among the elites and take seriously some of the ordinary people's commitment to socialism, we can then begin to grasp the coexistence of progressive political practices with turmoil."[410]

In the final analysis, the Cultural Revolution did hamper the research and education of biophysics. The "Peace I" mission was aborted after many months of hard work; the biophysics department was forced to discontinue teaching and learning and only resumed in 1970. But biophysicists, like many ordinary individuals, were not passively victimized by top-down manipulation but rather actively sought opportunities to survive and thrive in spite of the hardships they endured. The ability of the party-state to control the populace was less absolute than often assumed, and history shows that scientists were quick to invent ways to carve a niche for themselves and their discipline.

[410] W. K. Choi, "Book Reviews—*Mao's Last Revolution,* by Roderick MacFarquar and Michael Schoenhals," *Science and Society* vol. 73, iss. 2 (2009), p. 261-263, on p. 263.

EPILOGUE

In many ways, *PIBB*—the Chinese biophysics journal that was launched during the second half of the Cultural Revolution—continued to serve as a medium for Chinese biophysicists to exchange ideas about the foundation of their discipline in the post-revolutionary years. Subsequently, how to professionalize biophysics became a serious topic; the seeds sown by *PIBB* in the mid-1970s gave rise to a wider ongoing discussion on the professional orientation of biophysics in the post-Mao era.

Moreover, discourse on "the origins of the cell" and "the origins of life" that was generated during the Mao era, as discussed in the previous chapter, continued to arouse scholarly and popular interest in post-Mao China. The enormous changes from pre-1949 to post-Mao eras should not obscure the ways in which some trends that began before and during the Mao era have continued to exert influences in post-Mao China. This postscript looks at some of these discourses in the post-revolutionary period and discusses the connection with debates in the previous chapters.

The Biophysical Society of China

The 1979 *PIBB* issue opened with a review article that considered points of convergence between physics and biology.[411] Fueled by the latest advances in molecular biology, this author recognized the current trend of seeking physical knowledge and methods to explain biological phenomena. The author listed several areas in which concepts and theories in physics have made revolutionary inroads in biophysical research such as mechanical forces in intermolecular analysis, electronic configuration and

[411] Chen Runsheng 陈润生, "Several Biophysical Problems" 几个生物物理学问题, *PIBB* vol. 6 (1979), pp. 35-40.

bonding structures of macromolecules, and biological application of nonequilibrium thermodynamics.

Most of the efforts reviewed in this article involved pursuing physics as an analytical strategy to cast light on the molecular structures in biological systems. Unlike previous Chinese biophysicists, this author asserted that the physics-biology connection was expressed in the ways in which physics penetrated into biology, and that many biological problems relied on skillful physicists to tackle.

Biophysics as a specialty of using physics to study biology is a notion that had not hitherto taken root in China, at least not among mainstream Chinese biophysicists. During the Mao era, both Bei Shizhang and Shen Shumin adopted an explicitly biology-oriented conception as the foundation of biophysics. They recognized the methodological significance of physics for elucidating some of the mechanisms and problems in living organisms, but what they underscored was the equally important role of biologists with their knowledge of the connection between parts and wholes, individuals and systems. In 1964, Bei highlighted the cooperation and mutual efforts of physicists and biologists as the underpinning of biophysics rather than a one-way flow of physical knowledge into biological investigation.

By 1980, Bei had slightly modified his view on the physics-biology relationship. Instead of directly appraising the relative significance of physics and biology in constituting biophysics, Bei placed the emphasis on the research missions and purpose of biophysics:

> On the one hand, biophysics investigates the interplay between quantum effects, information processing, and changes in matter and energy; on the other hand, it connects these microscopic mechanisms with the higher performance of life at the macro level for further analysis and elaboration.[412]

This is not a new concept. In 1964, he identified the investigation of the basic properties of life as the purpose of biophysics, in which the study of the relationship between energy, matter, and information exchange was critical. However, Bei's formulation of biophysics in the post-Mao period did not consider biophysics' unique contribution to national defense or agriculture as contained in his 1964 article. Compared to 1964, Bei in 1980 was more concerned with the professional development of biophysics rather than the instrumental role of biophysics for state-led missions.

Bei's view of biophysics underwent a transformation in the late 1970s from portraying biophysics as a mission-oriented service science into a more specialized profession geared toward academic audiences. His changing attitude towards biophysics reflects the overall institutional priority of the biophysics community in the late 1970s.

PIBB in this period was dominated by reports on the professional development of biophysics at both domestic and international levels. In a 1979 issue of *PIBB*, representatives from IBP-CAS gave a summary report on the sixth International Biophysics Congress that was held in Kyoto between the 3rd and the 9th of September

[412] Bei Shizhang, "Hopes and Prospects For Biophysics in Our Country" 对我国生物物理学发展的几点希望, *Selected Writings of Bei Shizhang,* pp. 237-245, on p. 238.

1978.[413] In 1980, *PIBB* continued this trend with a follow-up article on the recent development of biophysics in Japan.[414] In the spring issue of 1980*, PIBB* made two announcements concerning an important milestone in the domestic development of biophysics—the founding of the Biophysical Society of China. In February, *PIBB* featured the preparation leading to the inauguration of the Biophysical Society of China;[415] and in June, it published a post-event update on the inauguration and annual meeting.[416] What this all makes evident is the surge of interest surrounding the professionalization of biophysics during this time period.

In his analysis of the making of biochemistry in the U.S., Robert Kohler asserted that "organizing professional societies was the most overt political means of consolidating biochemical interests."[417] Founding a professional society was political in the sense that it helped foster a sense of disciplinary identity among members by reinforcing the boundaries with other specialties and claiming a particular area of academic territory. The difference between China and the U.S. is the different contexts in which the professionalization of science took place. Whereas the medical service role in the U.S. provided an institutional incentive for medical chemists to market themselves as biochemists, Chinese biophysicists were moving away from a space-mission service role

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[413] IBP-CAS, "A Summary Report on the Sixth International Biophysics Congress" 第六届国际生物物理会议概况介绍, *PIBB* vol. 6 (1979), p. 17.
[414] Li Hua 李哗, "Development of Biophysical Research in Japan" 日本生物物理学研究的发展, *PIBB* vol. 7 (1980), pp. 78-80.
[415] Editorial, "The Biophysical Society of China Will Inaugurates in the Second Quarter Together With the Third Academic Symposium" 中国生物物理学会成立大会将于二季度召开，第三次学术讨论会同时举行, *PIBB* vol. 6 (1980), p. 27.
[416] Liu Rong 刘蓉, "Inauguration of The Biophysical Society of China in Beijing Coincided with the Third Annual Meeting of Biophysics in China" 中国生物物理学会成立大会在京召开，第三届全国生物物理学学术会议同时举行, *PIBB* vol. 6 (1980), p. 88.
[417] Robert Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline*, p. 198.

into a full-blown specialized discipline. The question is: what enabled this transformation of biophysics in the late 1970s?

The emergence of professional societies in science and technology in post-Mao China was facilitated by the policies of economic liberalization introduced by Deng Xiaoping in 1978. Deng's administration was marked by a profound optimism surrounding the engine of market reforms to fuel the Four Modernizations program that he advocated. In the scientific community, the beginning of Deng's era was sometimes called the "springtime for science" to underline its libertarian attitudes to scientific affairs compared to the earlier regimes. While attempts to claim elite status for scientists or specialized knowledge were greeted with skepticism in Mao's China, such endeavors were permissible and even desirable in the eyes of Deng Xiaoping. Since science is a pillar of the Four Modernizations, advancing the professional interests of scientists is considered acceptable as long as the ultimate goal of science is to realize the dream of the Four Modernizations.

For Chinese biophysicists, this presented a window of opportunity to further strengthen the disciplinary coherence of biophysics. In his opening speech at the inauguration of the Biophysical Society of China, Bei Shizhang was reported to have declared: "the founding of the [Biophysical] Society opens a new page in the enterprise of biophysics in our country. It will certainly catalyze the professional development of biophysics."[418] Organizing a professional society departs from the previous model of "mission drives discipline, discipline facilitates mission." In post-Mao China, Chinese

[418] Liu Rong, "Inauguration of The Biophysical Society of China in Beijing Coincided with the Third Annual Meeting of Biophysics in China," *PIBB* vol. 6 (1980), p. 88.

biophysicists were less concerned with facilitating space missions than cultivating a collective sense of professional identity.

Also characteristic of Deng's "open-door" policy is the increased leeway given to the dissemination of foreign information. Greater access to international updates in science and technology sharpened Chinese scientists' sensitivity to the organizational infrastructure of science and technology abroad. The growing appetite for knowledge about the development of biophysics in foreign countries was reflected in the content of *PIBB* in the early 1980s. Readers of *PIBB* were exposed to an increasing number of reports on the research, teaching, and organizational practices of biophysics in other countries.

The most notable account of biophysics' international developments covered in *PIBB* is probably the report on H. T. Tien's return visits in post-Mao China. In 1978 and 1979, the Chinese-American biophysicist returned to China for academic exchanges. In the latter visit, he met with Fang Yi—vice premier of P.R.C. at the time—along with a Chinese-American chemistry professor from the University of Chicago.[419] More important than the formal state reception is Tien's public lecture on the international updates of the teaching and research of biophysics, which was captured in the 1980 issue of *PIBB*. In his lecture, Tien used the example of the development of biophysics at his home institution, Michigan State University, to illustrate the teaching of biophysics in the U.S. The department of biophysics at Michigan State was founded in 1962 and grew into a full-fledged department by 1980 (but later was absorbed by the physiology department). Tien also shared his view on what biophysics is: "biophysics is the study of the

[419] "Fang Yi Received (Chinese) American Scholars Nien-Chu Yang and Hsin-Ti Tien" 方毅会见美籍学者杨念祖、田心棣, *People's Daily* August 30, 1979.

mechanisms of energy transfer in the living process and its relationship with the origins of life. It encompasses concepts from classical physiology and mathematical biophysics."[420] If we are to trust the editors of *PIBB*, this was the first time an American biophysicist ever echoed the notion of "origins of life" in the definition of biophysics.

Whether it was the journal editors or Tien himself who incorporated the element of "origins of life" into the formula of biophysics is unclear. If it was a result of an editorial decision, it was likely based on considerations to draw connections to Bei's research agenda and even Mao's rhetoric. If it was indeed Tien's own idea, it was consistent with his discussion of the relationship between bilayer lipid membrane (BLM) and the origin of life in a textbook that appeared in print shortly after his first visit to China in 1973.[421] In 2000, he and his collaborator published a revised version of the textbook, in which a subsection was dedicated to the consideration of "what is life and its Origin?"[422]

Tien's visits to China appear to have marked the beginning of biophysics transnationalism and cultivated a shared professional interest in the "origins of life." Essentially, the idea of the "origins of life" is not just an esoteric concern among domestic and foreign biophysicists. The popular interest in the controversies surrounding the "origins of life" is another post-Mao phenomenon.

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[420] Bian Zhe 边哲, "The Research and Teaching of Biophysics in the U.S. and the World" 国际与美国生物物理科研及教学, *Progress in Biochemistry and Biophysics (PIBB)*, vol. 6 (1980), pp. 77-78, on p. 78.

[421] "IV. BLM and the Origin of Life," in H. Ti Tien, *Bilayer Lipid Membranes: Theory and Practice* (NY: Marcel Dekker, 1974), pp. 457-460.

[422] "1.2. What is Life and its Origin?" in H. Ti Tien and Angelica Ottova-Leitmannova, *Membrane Biophysics: As Viewed from Experimental Bilayer Lipid Membranes* (Amsterdam: Elsevier, 2000), pp. 2-3.

“Continuity” or “Creation” of cells?

On the 8th of November in 2005, a Chinese blogger sent an excerpt of Bei’s cell reformation theory to Fang Zhouzi (方舟子), who is known for writing science popularization literature and exposing academic misconduct in China.[423] The sender was hoping Fang would publicly denounce Bei’s theory as fraudulent. Fang re-posted the excerpt to the website www.xys.org but did not add further comment.[424]

Registered and based in the United States, www.xys.org (the URL was derived from its Roman initials of its Chinese name 新语丝 (the *New Threads*) is a Chinese website launched and maintained by Fang. The website provides mainland Chinese and Chinese expatriates a virtual space to share and discuss topics related to science and society in China.

After the post appeared on The *New Threads*, a web user picked up the excerpt and waged an online war with Fang over the credibility of Bei’s theory. Under the alias *Tomoe,* this user did not regard Bei’s cell reformation theory as bogus. *Tomoe* argued that some aspects in Bei’s theory were consistent with the embryonic development in *Drosophila.*[425] *Tomoe* suggested that “a special form of division” would be a more

[423] Fang is an outspoken science writer known for his relentless drive to monitor the scientific community in activities such as uncovering fake CVs, plagiarism, and practices of pseudo-science in China. His efforts recently earned him the inaugural John Maddox prize sponsored and administered by *Nature.* See “John Maddox Prize: Two Strong-Minded Individuals Are The First Winners of An Award For Standing Up For Science,” *Nature*, vol. 491, iss.160 (8 November 2012), available at <http://www.nature.com/>.

[424] 8 November 2005 <http://www.xys.org/xys/ebooks/others/science/dajia6/beishizhang.txt>.

[425] *Tomoe* pointed out that the embryos of *Drosophila* do not undergo transcription and cytokinesis in the first two hours but the nucleus divides once every nine minutes and results in hundreds of nucleuses after the ninth division. The nuclear DNA comes from cell division but the nucleus constituents such as proteins and nuclear membranes come from material deposit. The enzymes, energy, and nucleic acids necessary for replicating DNA also come from the mother cells. The newly formed cells are built on the basis of cytoplasm from these mother cells. The phenomenon is consistent with one of the tenets in Bei’s cell reformation theory, which states that new cells are generated on the basis of existing materials from old cells.

felicitous term to describe this mechanism rather than "cell reformation." But whatever it is called, *Tomoe* claimed that there is a considerable overlap between the developmental embryology of *Drosophila* and Bei's theoretical assertion. What *Tomoe* objected to was a premature and sweeping deprecation of Bei's cell reformation theory.

Tomoe benchmarked Bei's theory against external criteria in developmental genetics. He did not uncritically glorify Bei, but he found Bei's vision both prescient and precious: "What I admire is the phenomenon he has observed some 70 years ago" and concluded that "his theory is now common sense, but it was a breakthrough at that time." Yet Fang and his followers were not ready to grant Bei this special acclaim of prophetic insight. Fang maintained, "All, not just some, viewpoints of old Bei are 'mistaken'." Fang regarded Bei as a vitalist and interpreted Bei's theory as advocating the *de novo* generation of new cells by denying the historical continuity of cells: "regardless of what materials are utilized, 'cell reformation' denies the genetic continuity of cells. It suggests that environmental condition alone (without the need of genetic order of the old nucleus) is enough to generate new cells and nucleus from scratch..."[426]

At the heart of this debate lies the question regarding the historical continuity of cells. Fang rejected Bei's theory on the grounds that cell reformation defies the historical continuity of cells, in contrast to *Tomoe* who suggested otherwise. For Fang, what was at stake was not Bei's experimental sophistication or his choice of research substrates; nor did Fang display much interest in the cytomechanical similarities between *Drosophila* and *c. nankinensis*. Fang was skeptical of Bei's theory because he considered the theory of cell reformation a heresy against the doctrine of cell continuity.

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[426] 9 November 2005 <http://www.xys.org/forum/db/208/210.html>.

The paradigm of cell continuity is a core theme that has run through much of the history of biology in twentieth-century China. Scientists have been concerned with the lineage of cells ever since Virchow, if not earlier. Western scientists had been preoccupied with the question of how new cells were formed and where cells came from ever since the establishment of cells as the fundamental unit of life. In republican China, Bei dedicated much time and energy into investigating the formation, constitution, and interpretation of how cells arose. By advocating a cell-from-yolk cause of cell generation, Bei was among many scientists of the world who offered a cell-from-X hypothesis before and during the twentieth century. Specifically, Bei Shizhang postulated "reformation" as a theoretical explanation of some of the transformation of cells. While once sympathetic to Lepeshinskaya's cytological theory, Bei was insistent upon choosing the right term in order to not sound ahistorical.

Under Mao, the "origins of life" were placed in the framework of dialectical materialism. To demonstrate relevance of his work to state-approved agendas at the height of the Cultural Revolution, Bei aligned his theory on cell lineage to Mao's known interest in cell origins. What Mao offered was a justification for Mao-era scientists to work on issues related to cell lineage. Finally, in the post-Mao era, science writers and informed "netizens" shared the same concern over the historicity of cells. Both then and now, Chinese scientists and critics have cared much more about the concept of maintaining biological continuity with the past than with the exact mechanisms of how this was achieved.

In China as elsewhere, the study of cell lineage is often intertwined with the bigger questions of the "origins of cells" and the "origins of life." But the intertwining of lineage and origins has played out in distinctive ways in the respective contexts of the U.S. and China.

In the U.S., the notion of the "origins of life" is sometimes mixed up with Darwinian doctrine of "the origin of species," but they are actually different concepts. Darwin's theory of evolution and the laws of natural selection address how various species (animals and humans alike) evolved from the same common ancestor, but he left open the question of how the first forms of life came into being. This is why he titled his book *The Origin of Species*, not *The Origin of Life,* or *The Origin of Cells*. While it is clear that Darwin convincingly disproves the notion of "God creates man," it is less clear whether Darwin also invalidates the idea of "God creates life." This is because there is compelling evidence to explain the process of human evolution but definitive evidence is still lacking when it comes to the genesis of the first fully functional cell.[427] The uncertainty has led some creationists to come up with creative interpretations of Darwin's texts that are consistent with their beliefs.[428]

Unlike in the West (and perhaps especially in the U.S.), discourses on the "origins of cells" and the "origins of life" in China did not emerge as contentious issues that blemished Darwinian theory or challenged any indigenous belief system. The question of "cell origins" was not framed in a binary opposition between evolutionism and creationism, nor did any Chinese scientist or informed reader ever raise the question as to

[427] Existence of rudimentary organs like the appendix in human fossil and parallel structures in different species are some of the evidence in support of his evolutionary thesis.

[428] For example, see Cornelius Hunter, *Darwin's Proof: The Triumph of Religion Over Science* (Brazos Press, 2003). The author is an American biophysicist in search of a theological foundation in Darwin's writings.

"who created life?"[429] From the republican to post-Mao periods, insofar as I know, the possibility of cells or other basic forms of life originating from some supreme deity has never come up in print or digital media. It appears that Chinese people put the weight on the *continuity* of cells rather than the *creation* of forms of life throughout the history of twentieth-century China.

What implications can we draw from the Chinese discourses on cell continuity? First, the Chinese attachment to cell continuity shows that concepts such as the "origins of cells" and "origins of life" cannot be reduced to a dichotomy between creationism versus evolutionism just because this is the context in which debates in the West have tended to play out. The clash between religion and science is not the only way in which knowledge of biology is discussed and interpreted by educated citizens. The social understanding and acceptance of biological theories is inevitably embedded in a country's political and historical contexts.

That Chinese value connections with the remote past is a cliché that requires no explication as Chinese cultural practices to honor ancestors manifest in many diverse forms; but "ancestors" conjure up images of human or ape-like creatures at the very least. The Chinese cultural meanings ascribed to the boundaries between men and apes, yetis and "humans gone wild" were the topic of Sigrid Schmalzer's *The People's Peking Man*. In her fascinating story about the changing images of human identity and concepts of humanity in twentieth-century China, she recognized the overriding significance Chinese people assigned to ancestral figures:

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[429] Recasting the role of God in creating the "first cell" is the goal of many American creationists such as Jonathan Sarfati. See Thomas Heinze, "Did God Create Life? Ask a Protein," available at <http://creation.com/>.

> Nothing from the rich reservoir of popular culture has influenced paleoanthropology more than the passionate concern for ancestors. The notion of national ancestors has permeated Chinese materials on human evolution produced by scientists and circulated through official channels. Yet an interest in ancestors is hardly limited to paleoanthropologists and state officials. Rather, it is broadly shared throughout the general population, especially although not exclusively in China.[430]

Schmalzer is right in suggesting that the Chinese passion for ancestors trickled down from elites to the mass. What I will add is that the popular concern with the biological past is not restricted to species but can be found at the level of cells. I argue that Chinese are concerned about ancestral cell lineage in addition to ancestral creatures.

Preservation of the genetic connection with the past is where Bei and Lepeshinskaya parted company in the pre-Mao eras; in the post-Mao era, the continuity of cells continued to be a core issue in online forums. Cell continuity has been repeatedly woven into the fabric of contemporary Chinese society, hence the bitter current debate on Fang's website.

Concluding Remarks

The story of biophysics in twentieth-century China is informative and interesting because it shows that a field that is so amorphously defined and loosely institutionalized in the U.S. can gain momentum in China. In the U.S., biophysics did not coalesce into an independent program despite the organizational efforts of Francis Schmidt. The

[430] Sigrid Schmalzer, *The People's Peking Man: Popular Science and Human Identity in Twentieth-Century China* (Chicago: University of Chicago Press, 2008), p. 291.

institutional structure of biophysics does not necessarily have any relationship with the effectiveness of its research enterprise. Just because biophysicists are scattered at different schools under different names does not mean biophysical research cannot be done. But as historians of biology have revealed, the impulse to put together an intellectually influential and well-funded biophysical program was present among some leading biophysicists. Not all practicing biophysicists care about what biophysics is or how to make the discipline more coherent, but that biophysics in the U.S. is an ill-defined and fragmented field has been recognized in the science literature for some time.

Throughout the twentieth century, Chinese biophysicists gradually established a scientific discipline. In the period 1949 to 1958, they went from sharing an institutional space with experimental biology to making a separate institute for biophysics; between 1958 and 1964, biophysicists created a department of biophysics and transformed the biophysics study program; between 1966 and 1971, they went from launching the biological sounding rockets to being a part of the military-industrial complex; between 1972 and 1974, they went from leading the U.S.–China scientific exchange to launching a specialized journal. What the history of biophysics in twentieth-century China demonstrates is the concrete steps Chinese biophysicists took to realize their dream of building a scientific discipline.

Large-scale institutionalization of science and technology in modern China became apparent after 1949. The policy imperative and nationalist sentiment to pursue wealth and power via the avenue of science and technology offered a favorable environment for new scientific fields to develop. It was in this unique national, social, and historical context that biophysics was instituted in China. During the Cold War, biophysicists accommodated their discipline to the needs and expectations of the state. This is clearly illustrated in the priority given to Mission 581 and cosmobiology—an area unfamiliar to Bei or any existing biophysicists at the time. But they were willing to create new research facilities and training programs as needed in order to fulfill the mission's requirements. Participation in "Two Bombs, One Star" provided biophysicists with the aura of military connections and the prestige of laying the groundwork for subsequent human spaceflight.

Accompanying biophysicists' commitment to the space-and-rocket mission is their ambition to create an independent biophysics educational program at the newly established USTC. The disciplinary styles and departmental considerations of biophysics between 1958 and 1962 were shaped by the institutional relationship with program chairs in biochemistry, biomechanics, and bio-intelligences. The course modules, teaching plans, and concentration of the biophysics program at USTC reflected not just biophysicists' roles in the space mission but also their unique orientation to biological science. A biological style, focusing on the imparting of basic knowledge in biological subject matter, was found in the bio-intelligence study plan. Between 1963 and 1966, those who majored in cosmobiology at USTC were recruited into the sounding rocket project and worked alongside rocket engineers, nuclear scientists, and military servicemen.

The Mao-era episodes of biophysicists working with and negotiating with the Ministry of National Defense illustrated how scientists lived with military officers and learned to adapt military imperatives to their disciplinary interests, especially during the Cultural Revolution. Mission did not just "drive" disciplines by giving them the opportunity to thrive at USTC; it also protected mission-oriented disciplines from political critiques when such needs arose. The completion of “Two Bombs, One Star” in the post-Mao period precipitated a movement toward professionalization among biophysicists. A new disciplinary model was beginning to emerge by the 1970s as the last cosmobiologists were transferred to the defense establishments and left the label “biophysicists” behind at the Academy. Professional interests replaced national interests after the completion of the space-and-rocket mission and as the partnership between state-delegated mission and scientific disciplines faded, the slogan “mission drives discipline, disciplines facilitate mission” fell out of fashion. As keen disciplinary builders, Bei Shizhang and other leading biophysicists sought new impetus to drive their discipline, and ultimately they were able to seize the incentives offered by the changing political circumstances in the late 1970s to enhance the professional status of biophysics.

Under Deng, the scientific community was allowed to pursue the internal developments of their disciplines, and while self-governance and/or self-determination were not promised, Deng-era scientists did enjoy an increased access to professional knowledge that was previously seen as “elitist” and “bourgeois.” Readers of *PIBB* were exposed to accounts of professional development of biophysics around the world and this in turn prompted the domestic professionalization of biophysics, which had begun in the late-Mao period with the launch of *PIBB*.

At the beginning of this dissertation, I promised readers that the history of biophysics in China could bring new perspectives to modern Chinese historiography, and I hope to summarize in this epilogue what was intended by that promise. What is the take-home message for historians and scholars of China studies, and what interpretive light does my study cast on the general landscape of modern Chinese history and history of science?

For any historian of science in East Asia, it is almost inevitable to address the relevance or irrelevance of Needham's question (i.e. "why didn't the Scientific Revolution take place in China?"). Most historians have moved away from Needham's paradigm because they have recognized the futility and presumptuousness that accompanied this kind of negatively charged question. It is about as futile as asking about what did not happen in history, as that line of inquiry is linked to the ethnocentric assumption that what did happen somewhere else (i.e. the Scientific Revolution in sixteenth-century Europe) was demonstrative of a superior culture, thus suggesting the influence of cultural biases more than a truly objective analysis.

But Needham's specter is still haunting not just the historiography of pre-modern Chinese science but that of modern Chinese history in general. People may choose not to take his particular views but many studies of modern Chinese history are still affected by a certain view of China's "deficiency" or "failure to catch-up." Sigrid Schmalzer gave an excellent critique of this mode of scholarship in modern Chinese history:

> Many historians from diverse political perspectives have written modern Chinese history in the tragic mode as a story of missed opportunities—for liberalism, for capitalism, for socialism, for feminism, or for other priorities. Such approaches may be unfair or even dangerous when they

> imagine China as the opposite of the West or when they chastise China for not living up to the authors' expectations.[431]

The impulse to judge any non-Western societies by *our* Western standards is all too familiar to anyone who has living experiences across cultures. Questions such as "why didn't they create a more fair, transparent and efficient government system like ours?" erupted when one was exposed to reports of rampant corruption going on among Chinese government officials. But Needham's kind of "why not" question can be posed in both directions. Instead of picking on what are regarded as flaws in non-Western societies and measuring them against Western norms, one can turn to inadequate aspects in the West and judge them with non-Western expectations. Again, Sigrid Schmalzer has set the stage: "What if we asked why acupuncture did not emerge in Europe, or why Western countries took so long (compared with China) to develop meritocratic bureaucracies?"[432] The purpose of this thought experiment is to imagine alternative scenarios by turning the "haves" and "have-nots" question on its head. Westerners are not always on the "haves" side, even when it comes to science and technology—an area which many Westerners hold particularly dear. Acupuncture and the talents selection program of the medieval Chinese bureaucracy highlight aspects in the history of science where pre-modern China enjoyed a significantly superior system to that of Europe.

My study suggests that the history of the institutionalization of biophysics in modern China is also an example in which the West (mostly the U.S.) does not quite measure up against the Chinese standard. By no means does the trajectory Chinese

[431] Sigrid Schmalzer, *The People's Peking Man: Popular Science and Human Identity in Twentieth-Century China*, p. 298.
[432] *Ibid*.

biophysics underwent endow the research enterprise of biophysics or science in China with an absolute advantage. But a study of the Chinese experience in organizing a scientific discipline does help to cast doubt on the assumption that the institution of science and technology in the West is always better organized than that in the rest of the world. It could also serve as a starting point to critique Western histories of science in China and the West, and analyze the ethnocentricities that are apparent or subtle in many accounts. R. Bin Wong has pointed to the potential fruitfulness of this approach.[433] I share Wong's enthusiasm for less Western-centered historical analyses. The fact is that the Chinese ambition in making organized inquiry into nature, whether it is through ancestry, history, or biophysics, is as strong and as shared of a sentiment as any that motivates inquiry into nature in the West.[434]

[433] R. Bin Wong, *China Transformed: Historical Change and the Limits of European Experience* (Ithaca: Cornell University Press, 1997)
[434] The intellectual spirit and desire of ancient Chinese in organizing learned disciplines (science and medicine included) is the subject of G.E.R. Lloyd in his *Disciplines in the Making: Cross-cultural Perspectives on Elites, Learning, and Innovation* (Oxford: Oxford University Press, 2009).

ABBREVIATION

ABBS (*Acta Biochemica et Biophysica Sinica*), 生物化学与生物物理学报

BFMIB (The Beiping Fan Memorial Institute of Biology), 北平静生生物调查所

CAS (The Chinese Academy of Sciences), 中国科学院

CAST (China Academy of Space Technology), 中国空间技术研究院

CFPEC (The China Foundation for the Promotion of Education and Culture), 中華教育文化基金董事會

HAME (The Harbin Academy of Military Engineering), 哈尔滨军事工程学院

IBP (The Institute of Biophysics), 生物物理研究所

IEB (The Institute of Experimental Biology), 实验生物研究所

IRUH (*Information and Research of University History*), 校史资料与研究

INS-CAS (The Institute of Nuclear Sciences), 核能研究所

MOE (Ministry of Education), 教育部

NDSTC (National Defense Science and Technology Commission), 国防科学技术委员会

OUA (Office of University Archive), 大学档案馆

PIBB (*Progress in Biochemistry and Biophysics*), 生物化学与生物物理进展

Second MMB (The Second Ministry of Machine Building), 第二机械工业部

Seventh MMB (The Seventh Ministry of Machine Building), 第七机械工业部

SIMED (Shanghai Institute of Machine and Electricity Design), 上海机电设计院

T-7A (S1) rocket, 探空 7 号甲生物 I 型火箭

T-7A (S2) rocket, 探空 7 号甲生物 II 型火箭

T-7M rocket, 探空 7 号模型火箭

Third MMB (The Third Ministry of Machine Building), 第三机械工业部

USTC (University of Science and Technology),中国科学技术大学

Zheda (The University of Zhejiang), 浙江大学

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Occasionally, I consulted the following sources regarding the U.S. Biophysical Society that are stored at the Center for Biological Sciences Archive at the Special Collections at the University of Maryland at Baltimore County:

Box 4, 5 (Executive Board Meetings)
Box 8, Folder 22 Program Committee, 1957-9
Box 8, Folder 23, First Biophysics Conference, 1957
Box 13, Folders 1-6, International Biophysics Congress

Box 15, Folders 13,14,15,16,17
Box 16, Folders 18, 20, 28, 29
Box 17, Folders 12, 14