CHINA'S APPROACHES TO ATTRACT AND NURTURE YOUNG BIOMEDICAL RESEARCHERS*

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Introduction

In a span of four decades, China has evolved from a peripheral player to become the world's most robust and dynamic economy. Along with its rapid economic progress, and the many improvements in the quality of life for a large Chinese population, as a variety of indicators suggest, China's science and technology (S&T) capabilities also are on a sharply rising trajectory. Since the 1990s, spending on S&T and research and development (R&D) in China has been increasing at a rate faster than the rate of overall economic growth, with expenditure on the life sciences/biotechnology R&D usually accounting for some 20 percent of the total. In 2016, China spent RMB1.55 trillion ($233 billion), or 2.08 percent of its increasing gross domestic product (GDP), on R&D.[1] This represents the highest number among countries with a similar economic development level, being higher than that of EU's average while still much lower than that of the U.S., whose respective figures were $499 billion and 2.78% of GDP in 2015.[2]

In recent decade, there has been a steady rise in the contributions of Chinese scientists to international publications. Measured by the number of papers published in journals indexed by *Science Citation Index* (*SCI*), a bibliometric database compiled by Clarivate Analytics, a company formed after Onex Corp and Baring Private Equity Asia acquired the intellectual property and science assets, including *SCI*, from Thomas Reuters, in 2016, China ranked second in the world, accounting for some 20% of the world's total. In 1997, China only contributed 0.2% of the world's hottest papers, or papers cited among the top one-tenth

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[1] National Bureau of Statistics of China, "Statistical Communiqué of the People's Republic of China on National Economic and Social Development in 2016 (February 28, 2017)" (in Chinese), available online at http://www.stats.gov.cn/tjsj/zxfb/201702/t20170228_1467424.html (accessed on July 20, 2017).

[2] Richard Van Noorden, "China tops Europe in R&D intensity," *Nature*, Vol. 505 (January 9, 2014): 144−145; Mark Boroush, "U.S. R&D Increased by More Than $20 Billion in Both 2013 and 2014, with Similar Increase Estimated for 2015," *InfoBrief*, NSF 16–316 (Arlington, VA: U.S. National Science Foundation, September 2016).

of one percent; but in 2016, that statistics rose to 20%.[3] Chinese inventors also have filed the most patent applications in recent years.[4]

China's exponential rise in the S&T terms is attributed to the reform and open-door policy, especially the reform of the S&T system since the mid-1980s; the leadership's vision on the role of S&T in the country's modernization; and government's commitment in S&T, evidenced in its increasing expenditure in S&T. Also underlying the impressive performance taking place in the Chinese S&T system, and in economy in general, is the emergence of a very large talent pool whose quality has been improving. Indeed, Chinese institutions of learning have been turning out an increasing number of well-prepared graduates. In 2016, China graduated 7.04 million undergraduates and 564,000 postgraduates with 53,778 at the doctoral level, slightly less than 55,006 in the U.S. (**Table 1**),[5] making it unequivocally one of the largest and most important countries in the world in terms of higher education. More broadly, in 2015, China's human resources in science and technology (HRST) reached 79 million, R&D personnel totaled 3.76 million person-years with 1.62 million R&D researchers.[6]

[Table 1]

Against such a background, this paper focuses on how China has approached the nurturing of the next-generation biomedical talents. It will first review China's research funding and evolving talent policy to lay down a foundation for the discussion. It will move onto an analysis of various talent-attracting and nurturing programs and especially their funding and structure. Then, it will describe a couple of cases in which how individuals and

[3] "Yang Wei: Papers Supported by the National Natural Science Foundation of China Accounted for One-Ninth of the Papers Published Globally" (in Chinese), available online at http://www.nsfc.gov.cn/publish/portal0/tab434/info69785.htm (accessed on July 20, 2017).

[4] See, for example, Jing Fang, Hui He, and Nan Li, "China's Rising IQ (Innovation Quotient) and Growth: Firm-Level Evidence," *IMF Working Paper*, WP/16/249 (Washington, DC: International Monetary Fund, December 2016), available online at https://www.imf.org/external/pubs/ft/wp/2016/wp16249.pdf (accessed on July 20, 2017).

[5] Ministry of Education of China, "Statistical Bulletin of National Education Development in 2016" (in Chinese), available online at http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/201707/t20170710_309042.html (accessed on July 20, 2017).

In 2015, the U.S. universities awarded a total of 55,006 research doctoral degrees, the highest number, according to the U.S. National Science Foundation. Three-quarters of those degrees were in science and engineering. National Center for Science and Engineering Statistics, Directorate for Social, Behavioral and Economic Sciences (comp.), *2015 Doctorate Recipients from U.S. Universities*, NSF 17–306 (Arlington, VA: U.S. National Science Foundation, June 2017).

[6] Ministry of Science and Technology of China, "An Analysis of the Development of China's Human Resources in Science and Technology in 2015" (in Chinese), available online at http://www.most.gov.cn/kjtj/201706/P020170628506396562537.pdf (accessed on July 20, 2017).

institutions in biomedicine have benefited from such a favorable policy environment. The paper will end up with identifying some of the problems afflicting the nurturing young biomedical researchers in China.

There is a caveat on the data. The discussion and analysis in the paper rely upon statistics and data concerning China's HRST that I have accumulated over time and collected specifically for this particular study from Chinese government sources. Indeed, there are not many, if any, alternative reliable sources of such data. In addition to the regular concerns that one would have on the Chinese-source data, such as reliability, accuracy, and consistency, the main problem encountered is a huge gap that remains between China and the U.S. on data's level of granularity. It is not because there does not exist such data in China; instead, the Chinese government does not disclose detailed information. For example, data are available on the total number of Ph.D. degrees that Chinese universities and R&D institutes award each year by disciplines such as science, engineering, medicine, agriculture, and others (see **Table 1**); but data are unavailable on the number of Ph.D. graduates in sub-disciplines, or mathematics, physics, chemistry, biology, geology, and others in science; basic medicine, clinical medicine, preventive medicine, medical technology, traditional Chinese medicine, pharmacy, and so on in medicine.[7] This constraint has made it difficult, if not impossible, to have a more nuanced analysis and interpretation.

Research Funding in China

In China as in other countries, government is a major funder for R&D activities.[8] It supports scientific research through block funding to institutions of learning and competitive national S&T programs to individual investigators or teams of investigators. At one time, there were some 100 centrally financed civilian national S&T programs administered through about 30 government agencies, thus "resulting in fragmentation of policy purposes, wasteful duplications, and misaligning of incentives contributing to widespread corruption and misconduct plaguing Chinese science."[9]

Since 2014, China's national S&T programs have been reorganized into five

[7] For an in-depth discussion of the problems associated with Chinese data on HRST, see Denis Fred Simon and Cong Cao, *China's Emerging Technological Edge: Assessing the Role of High-End Talent* (Cambridge and New York: Cambridge University Press, 2009), pp. 347–375.

[8] Yutao Sun and Cong Cao, "Demystifying Central Government R&D Expenditure in China," *Science*, Vol. 345 (August 29, 2014): 1006−1008.

[9] Sun and Cao, "Demystifying Central Government R&D Expenditure in China"; Cong Cao and Richard P. Suttmeier, "Challenges of S&T System Reform in China," *Science*, Vol. 335 (March 10, 2017): 1019−1021.

categories. In addition to basic research supported mainly through the National Natural Science Foundation of China (NSFC), the other four categories are "major national S&T programs," including the mega-engineering programs under the Medium and Long-Term Plan for the Development of Science and Technology (2006–2020) (MLP) that used to be administered by various government agencies; "key national R&D programs," replacing the programs under the Ministry of Science and Technology (MOST) such as the "State High-Technology R&D Program" (the "863 Program") the "State Basic Research and Development Program" (the "973 Program"), and including the mega-science programs under MLP and programs administered by the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MOIIT), and other S&T-mission ministries; "special funds to guide technological innovation," integrating similar programs under NDRC, MOST, MOIIT, and the Ministries of Finance and Commerce; and "special funds for programs for developing human resources and infrastructure," including programs for key national labs, national engineering research centers administered by MOST and programs for national engineering labs, national engineering research centers under NDRC.[10]

In general, faculty members and researchers are paid a modest salary by the state. In recent years, prominent scholars have seen their power in negotiating their compensation packages and other supports with universities and research institutes. The practice in which investigators supplemented their salary partially with grants has been abolished amid the nationwide anticorruption campaign. Therefore, investigators are not allowed to budget a salary component in grant proposals to the national S&T programs, although partial labor cost for post-docs, research assistants, and technicians is permissible. In addition to institutional efforts to build up research infrastructure, the central government also pay for the construction and operational costs of large facilities through national S&T programs and other programs.[11]

China's Evolving Talent Policy

As a concept, talent (*rencai*) has gained increasing popularity and importance in China since the turn of the twenty-first century, when the leadership realized that "empowering the nation with talent" (*rencai qiangguo*) is key to "rejuvenating the nation

[10] Cao and Suttmeier, "Challenges of S&T System Reform in China."

[11] Yutao Sun and Cong Cao, "China: Standardize R&D Costing," *Nature*, Vol. 536 (August 4, 2016): 30.

with science, technology, and education" (*kejiao xingguo*), a strategy introduced in the mid-1990s. China paid attention to talent as it was facing a serious talent challenge, especially at the high end, despite possessing the world's largest S&T talent pool and having a very full pipeline in higher education. Critical concerns proliferated from multiple segments of the society – from the Chinese political leadership to enterprise chief executive officers, including the country heads of most multinational corporations operating in China – about whether China's potential can be realized given the uncertainties surrounding the demand and supply, quantity and quality, and effective utilization of China's current and future S&T workforce.[12]

In fact, a slew of factors had ensued collectively China's talent challenge in the early twenty-first century. The after-effects of the Cultural Revolution still lingered; during the ten years between 1966 and 1976, higher education was disrupted, professionals were prosecuted and deprived of the right to carry out their work, leading to a dearth of well-educated specialists in all areas. The "brain drain" of talents abroad after China opened its door in the late-1970s had constrained the domestic access to the best and brightest minds. The qualitative improvement of the talent pool had been sacrificed amid the quantitative expansion of higher education since the late-1990s. And China was fast approaching an "aging society," which would have significant implications for the supply and utilization of the talents.[13]

Under these circumstances, in an unprecedented move, the Chinese Communist Party's Central Committee (CCPCC) took the talent issue seriously and strategically. It held conferences in both 2003 and 2010 to address the problems that plagued the talent pool; it established a high-level taskforce – the Central Leading Group for Coordinating Talent Work – within the Organization Department of the CCPCC, an important party agency in charge of selecting, appointing, and evaluating high-level party and government officials; and it even put the talent issue into the party's constitution. In 2006, China launched 15-year MLP, signaling its commitment to rely more on "brains" rather than "brawn" to bring China into a strong, leadership position.

The Central Leading Group for Coordinating Talent Work also led the work on a National Medium and Long-Term Plan for the Development of Talent (2010–2020).[14] The

[12] Simon and Cao, *China's Emerging Technological Edge*.

[13] Simon and Cao, *China's Emerging Technological Edge*, pp. 22–56.

[14] Central Committee of the Chinese Communist Party and State Council of China, "National Medium and Long-Term Plan for the Development of Talent (2010–2020)" (in Chinese), available online at

formulation of the plan highlighted the urgency that China needed to achieve transformations especially at five fronts – from harvesting population dividend to talent dividend, from pursuing a "made in China" to "created in China" model, from attracting foreign capital to attracting human capital, from emphasizing "hardware" to "software," and from orienting toward investment to innovation. In addition to guiding policies and strategic goals, the plan sets up national talent development targets, specifies sectors in which talent is in great demand, calls for establishing national programs to support and nurture the development of talents in various fields, and prioritizes areas in which improvements in policy and institution are necessary so as to better utilize talent.[15] In a word, this means a transformation of China's economic development model from one that is labor-, investment-, energy-, and resource-intensive into one that is increasingly dependent upon technology, innovation, and talent.

Major Programs Targeting the Attracting the Return of Outstanding Young Researchers

Having realized its most immediate talent challenge, especially a shortage of the talent at the high end, the Chinese government has adopted various measures, trying in particular to deal with the seriousness of the "brain drain." Major programs in place for this purpose included the Hundred Talents Program at the Chinese Academy of Sciences (CAS); the National Science Fund for Outstanding Young Scholars at the National Natural Science Foundation of China; and the Cheung Kong Scholar Program at the Ministry of Education.[16] Originally introduced in the 1990s, these programs have been upgraded recently to reflect the fact that they had not been aggressive enough to attract the permanent return of many of the best and brightest Chinese students and scholars staying beyond their overseas research and study stint.

The Hundred Talents Program

In 1994, CAS set up the Hundred Talents Program (HTP, *bairen jihua*) to recruit

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http://www.gov.cn/jrzg/2010-06/06/content_1621777.htm (accessed on July 20, 2017). Denis Fred Simon and Cong Cao, "Human Resources: National Talent Safari," *China Economic Quarterly*, June (2011): 15–19.

[15] Huiyao Wang, "China's National Talent Plan: Key Measures and Objectives" (Washington, DC: The Brookings Institution, November 23, 2010), available online at https://www.brookings.edu/wp-content/uploads/2016/06/1123_china_talent_wang.pdf (accessed on July 20, 2017).

[16] Cong Cao, "China's Brain Drain and Brain Gain: Why Government Policies Have Failed to Attract First-Rate Talent to Return?" *Asian Population Studies*, Vol. 4 (2008): 331−345.

scientists mainly from abroad under the age of 45, with an offer of RMB2 million ($240,000) for three years, including money for research, a housing subsidy and a moderate salary. Most of those recruited into the program had foreign study and/or research experience or directly returned from abroad.

The National Science Fund for Distinguished Young Scholars

Also in 1994, NSFC launched the National Science Fund for Distinguished Young Scholars (NSFDYS, *guojia jiechu qinnian kexue jijin*) as a deliberate measure for the development of a cadre of outstanding academic leaders in the frontier of international science and technology. Known as the premier's fund as it was set up under the then Premier Li Peng and has been supported by his successors such as Zhu Rongji and Li Keqiang, the fund provides support to promising scientists aged 45 or under in the natural sciences, engineering, and management sciences (health sciences initially were part of the natural scientific field).[17] Awardees are selected based on a track record of significant accomplishment and allowed to pursue research of their own interests. Awards were initially made for a three-year period, with awardees in experimental and technological sciences getting RMB600,000 ($72,000), and half that amount going to those engaged in theoretical research. The funding has been increased to RMB800,000 ($97,000) in 1997, RMB1 million ($121,000) in 2002, RMB 1.2 million ($145,000) in 2003, RMB1.6 million ($195,000) in 2005, RMB2 million in 2006 ($251,000), to RMB3.5 million ($570,000) in 2014 for experimental and technological science and a smaller amount for theoretical science. The award tenure has been extended to four and now five years. The annual number of awardees also has been increased from 50 initially to 200 with a total of 3,400 having been awarded and the total amount of funds for the program having reached RMB5.9 billion by 2016 (**Table 2**).[18] Again, most of the earlier awardees had foreign study and/or research experience.

[Table 2]

[17] Cong Cao and Richard P. Suttmeier, "China's New Scientific Elite: Professional Orientations among Distinguished Young Scientists," *The China Quarterly*, No. 168 (December 2001): 959−983.

The establishment of the fund also took its cue from the U.S. NSF's Presidential Early Career Award for Scientists and Engineers.

[18] Liu Bin, Qiao Lili, and Zhang Yi, "An Analysis of the Funding Status and Achievement Impact of National Science Fund for Distinguished Young Scholars in the Life Sciences" (in Chinese), *Science Funds in China*, No. 2 (2016): 122−131.

The Cheung Kong Scholar Program

In August 1998, MOE launched the Cheung Kong Scholar Program (CKSP, *changjiang xuezhe jihua*) with an initial donation of HK$70 million ($9.5 million) from Hong Kong business tycoon Li Kai-shing's Cheung Kong Holdings and matching fund from the ministry. It awarded Cheung Kong professorships to outstanding young- and middle-aged scientists under 45 in the natural sciences and engineering, through global searches, at Chinese universities. MOE intended in three to five years to appoint 300 to 500 Cheung Kong professors, who would receive a stipend of RMB100,000 annually for five years. The program also had a chair professorship component offering short-term teaching and research opportunities to those to work at Chinese universities on the part-time basis. In 2004, MOE adjusted the program to include appointments in the humanities and social sciences and shorten the term of appointment to three years. The age of the Cheung Kong professors also has been extended to 55.

An Assessment

These government-sanctioned programs did not fundamentally reverse China's "brain drain" situation. For example, although most of the awardees in the programs mentioned here had foreign experience, until 2008 only one-third to one-half of them received their doctorates from abroad. This means that many, if not most, of the more rigorously trained Chinese with overseas Ph.D.s had not returned. Set up in 2003 amid much fanfare and backed by the Ministry of Science and Technology and the Beijing municipal government, the newly established National Institute of Biological Sciences (NIBS), which will be discussed further in the paper, offered a competitive salary and benefits that were set halfway between typical levels in the U.S. and in China, with principal investigators (PIs) then earning around RMB400,000 after tax, significantly outdoing China's entire research community. PIs also were promised a significant level of autonomy in research and administration. Nevertheless, only half of the early cohort of PIs had foreign doctorates, with the other being Chinese Ph.D.s, followed by several-year overseas post-doctoral research experience, mostly in the U.S. In other words, if such high-profile programs with significant incentives and backed by enormous resources had failed to attract more high-quality talent home, it could hardly be claimed that the effort of turning around the "brain drain" had been successful.[19]

[19] Cao, "China's Brain Drain and Brain Gain."

Indeed, according to statistics from the U.S. National Science Foundation (NSF), in 2003, of the some 62,500 Chinese Ph.D.-level personnel in the American science and engineering workforce, 75% received their degrees from American universities.[20] The number of expatriate Chinese life scientists also seemed to be large. In 2007, one-third of the approximately 300,000 Chinese students overseas were in the life sciences;[21] and approximately 2,500 expatriate Chinese life scientists were on faculty at American universities.[22] The existence of such a large expatriate Chinese scientific community, upon which the Chinese government, universities, and other organizations always have wanted to draw, also gave reasons that the government was ready to introduce the Thousand Talents Program to entice better and more qualified talent from overseas and that NSFC, MOE, and CAS wanted to upgrade their programs targeting young talent with better credentials.

The Thousand Talents Program

In December 2008, in order to further address the "brain drain" problem and also take advantage of the global financial crisis that cost some professionals, including scientists and researchers, their positions, the Central Leading Group for Coordinating Talent Work launched an Attracting Overseas High-End Talents Program (*haiwai gaocengci rencai xiyin jihua*), also known as the Thousand Talents Program (TTP, *qianren jihua*), hoping to attract some 2,000 expatriate Chinese scholars to their homeland within five to ten years. The program initially targeted full professors at well-known foreign institutions of learning, experienced corporate executives, and entrepreneurs with core technologies under 55 years old for leapfrogging China's scientific research, high-tech entrepreneurship, and economic development. In return for their permanent return and services, the central government offers a resettlement subsidy of RMB1 million tax free, and local governments and employers contribute a matching fund including housing, a salary close to their overseas level, and a significant amount of fund for research or entrepreneurial activities. The program has been successful in luring back some prominent academics such as Xiaodong Wang, the first U.S.-

[20] Cao, "China's Brain Drain and Brain Gain." The data on the number of China-born Ph.D. recipients in the U.S. are drawn from National Science Board, *Science and Engineering Indicators 2006*, Vol. 2, NSB 06−01A (Arlington, VA: National Science Foundation, 2006), p. A3−55, Appendix table 3−18 Foreign-born U.S. residents with S&E and S&E-related highest degree, by degree level and place of birth: 2003.

[21] Zhu Chen, Hong-Guang Wang, Zhao-Jun Wen, and Yihuang Wang, "Life Sciences and Biotechnology in China," *Philosophical Transactions of the Royal Society, B: Biological Sciences*, Vol. 362 (2007): 947−957.

[22] Wang Danhong, "Biologist Shi Yigong: The Twenty-first Century Is the Century of the Life Sciences" (in Chinese), *Science Times*, August 7, 2007, available online at http://news.sciencenet.cn/sbhtmlnews/20078623474428186299.html (accessed on July 20, 2017).

bound Chinese student in the reform and open-door era to become a member of the U.S. National Academy of Sciences (NAS) and a Howard Hughes Medical Institute investigator at the University of Texas Southwestern Medical Center; Yigong Shi, a chair professor at Princeton University, and many others from world's leading institutions of learning.[23] However, quite a number of the TTP awardees prefer to maintain their full-time overseas positions and moonlight in China rather than returning to take up a full-time position. As such, the program only had partially addressed China's "brain drain" problem.[24]

Under these circumstances, and in light of the national talent development plan, mentioned above, in December 2010, the Central Leading Group for Coordinating Talent Work approved the introduction of a component for emerging young scholars within TTP, the Young Thousand Talents Program (YTTP, *qingnian qianren jihua*), vigorously attracting some 400 promising young talent from overseas annually between 2011 and 2015 and making them innovative leaders in academia or high-tech entrepreneurship with moral character, outstanding professional ability, and comprehensive quality. The program is available for scientists under 40 working in a natural science or engineering field who have a Ph.D. degree, ideally from a foreign institution, three or more years of post-doctoral experience, and a formal teaching or research position at a well-known foreign institution of learning or enterprise. Overachievers during overseas doctoral studies or on the job may be considered regardless of experience. Awardees are required to work full-time in a Chinese organization for three years. In return, the central government provides a one-time resettlement subsidy of RMB500,000, and an RMB1–3 million fund for research and other activities to awardees who are treated equally as TTP awardees in the provision of working and living conditions. Between 2011 and 2016, more than 3,000 had been selected through a very competitive process, including peer review, oral defense, panel review, and voting (**Table 3**). The life sciences have been the largest discipline in terms of the number of awardees. The 2015 awardees averaged 34 years old, with 6% 30 or younger.[25] Two-thirds

[23] Sharon LaFraniere, "Fighting Trend, China Is Luring Scientists Home," *The New York Times*, January 7, 2010, p. A1.

[24] David Zweig and Huiyao Wang, "Can China Bring Back the Best? The Communist Party Organizes China's Search for Talent," *The China Quarterly*, No. 215 **(**September 2013): 590−615; Simon and Cao, "Human Resources: National Talent Safari."

[25] "An Analysis of the 2015 Youth Thousand Talents Program" (in Chinese), available online at http://www.1000plan.org/qrjh/article/60547 (accessed on July 20, 2017).

(66.37%) of the talents recruited in 2016 between 32 and 36 years old, and another 11.15% were between 27 and 31.[26] In 2017, some 3,500 applicants competed for 400 positions.[27]

[Table 3]

The Ten Thousand Talents Program

The Thousand Talents Program targets overseas high-end talent with prestige, resources, and honor, putting domestic talents, including those early returnees, in a disadvantageous position. In September 2012, the Central Leading Group for Coordinating Talent Work, the same group that launched TTP, officially introduced the Ten Thousand Talents Program (TTTP, *wanren jihua*) to stimulate the enthusiasm of domestic talents.

The program intends to identify 10,000 talents at three levels in ten years. The first level includes some 100 who have great promise to win a Nobel Prize for China or to become world-class scientists. The number of talents at the second level will be 8,000, who are in urgent need for China's S&T and economic development, including leading S&T and innovation talents, technological entrepreneurs, leading academics in the philosophy and social sciences, excellent teachers, and project leaders. The third level targets some 2,000 under 35 years old in the natural sciences and engineering (37 years old for females for childbearing) and 38 years old in philosophy and the social sciences (40 for females) who have the potential to outperform their peers in the future. This component for nurturing the third-level talents also is called the Young Top-Notch Talents Program (YTNTP, *qingnian bajian rencai jihua*). Again, the appointees receive generous financial support from the government. For example, RMB1 million is available for the first-level talents – six announced in July 2013 – for their independent research, personnel training and team building, to be matched by funds from local governments and employers. Supporting policy will be worked out to help research administration, professional platform, human resources, the use of fund, assessment and evaluation, incentives and so on.[28]

Programs for Emerging Young Scholars

[26] "It's Difficult to Get in but the Benefits Are Tremendous" (in Chinese), *Intellectuals WeiChat Public Account*, June 23, 2016, available online at http://oicwx.com/detail/1034909 (accessed on July 20, 2017).

[27] "Yang Wei: Papers Supported by National Natural Science Foundation of China."

[28] Sheng Ruowei, "The First Cohort of the Ten Thousand Talents Program" (in Chinese), *People's Daily*, October 30, 2013, available online at http://politics.people.com.cn/n/2013/1030/c1001-23369112.html (accessed on July 20, 2017).

Meanwhile, NSFC, MOE, and CAS have introduced schemes for emerging young scholars within their respective programs of attracting and nurturing talents. These programs lower the age limits of the recruits and provide them with various incentives. For example, the Science Fund for Emerging Distinguished Young Scholars (SFEDYS, *youxiu qingjnian kexue jijin*), which NSFC rolled out in 2012, is for young researchers under 38 years old (40 for females). It requires that awardees have a Ph.D. degree or the equivalent level of education, are experienced in research, and make at least a 9-month full-time employment commitment. NSFC provides each awardee with a fund of RMB1.3 million for three years for research, while the awardee's employer usually matches with a salary support and other incentives (**Table 4**). MOE introduced a young component for its Cheung Kong Scholar Program, Young Cheung Kong Scholar Program (YCKSP, *qingnian changjiang xuezhe jihua*), setting the age at 38 for those in the natural sciences and engineering and 45 for those in the humanities and social sciences. The program also requires a Ph.D. degree and associate professor for a domestic applicant. Young Cheung Kong professors are appointed for a three-year term, with MOE providing an annual stipend of RMB100,000 on top of their regular salary (stipend for Cheung Kong professors is increased to RMB200,000) (**Table 5**). Finally, under its new reform-oriented Pioneering Initiative, CAS modified its Hundred Talents Program, providing new recruits with a special fund of RMB800,000 in the first two years while the employing institute matches with a fund of no less than RMB500,000. An evaluation will be conducted toward the end of the second year to determine whether the scientist merits continuous support from the program and if so, CAS will provide a special fund of RMB2 million and an infrastructure fund of RMB600,000.[29]

[Tables 4 and 5]

The NSFC Programs

Along with various programs targeting talents, NSFC has had a history of supporting and nurturing early career researchers. Established in 1986 and following the model of the U.S. NSF, NSFC is China's major agency funding peer-reviewed basic research and mission-oriented basic research (*yingyong jichu yanjiu*) in the natural sciences and engineering (mathematical and physical sciences; chemical sciences; life sciences; earth sciences; engineering and materials sciences; and information sciences), management sciences, and

[29] The Chinese Academy of Sciences, "Global Recruitment of Pioneer 'Hundred Talents Program' of CAS," available online at http://english.cas.cn/join_us/jobs/201512/t20151204_157107.shtml (accessed on July 20, 2017).

health sciences. It now provides funds to projects initiated by individual scientists and teams of scientists within three broadly defined programs: exploration (funds for general, key, and major projects; funds for major research projects); talent (funds for young researchers; funds for researchers from underdeveloped regions; NSFDYS; SFEDYS; funds for innovative research teams; funds for outstanding scholars from overseas and Hong Kong, Taiwan, and Macau; funds for young foreign researchers working in China); and infrastructure (joint funds with provincial governments; funds for major instrument R&D program; funds for basic data and resources share platforms; funds for emergency management projects). In 2016, NSFC had a budget of RMB26.8 billion ($4.03 billion), representing a very significant increase from RMB80 million ($23.2 million) in 1986. According to Yang Wei, NSFC's president, in 2016, 70% of the Chinese-scientist-authored papers acknowledged NSFC's support; as these papers accounted for nearly 20% of the global total, this translates into a fact that one of every nine papers published globally got NSFC funding.[30] Competition for NSFC grants, many of which are small scaled, tends to be fierce with the success rate usually around 20%.

NSFC pledges to be a FRIEND of scientists by being Fair in reviews; Rewarding in fostering research; International in global participation; Efficient in management; Numerous in grants; and Diversified in disciplinary coverage.[31] One of its missions is to nurture young scientists along with expanding the territory of exploration, enriching the source of innovation, and strengthening interdisciplinary interaction.[32] NSFC has a more sustainable and structured channel for achieving this mission.

Indeed, one of the most striking features of NSFC is its recognition of the importance of supporting scientists at the start of their career. In 1987, the second year of its existence, NSFC established a Fund for Young Scientists (*qingnian jijin*) as part of the talent-nurturing programs to help early-career researchers become independent professionally and develop innovative thinking and research capabilities. To be a PI for the fund, a scientist needs to be 35 years old or younger (40 for females), to have a Ph.D. degree or equivalent level of educational credentials, and to be able to lead a young research team to carry out innovative work (**Table 6**). The fund often is the first national-level grant for some of those choosing an academic career – 20,000 to 30,000 of about 50,000 Ph.D.s that China now produces each

[30] "Yang Wei: Papers Supported by the National Natural Science Foundation of China."

[31] Wei Yang, "Boost Basic Research in China," *Nature*, Vol. 534 (June 23, 2016): 467−469.

[32] Mu-ming Poo and Ling Wang, "A New Face at Natural Science Foundation of China: An Interview with NSFC President Wei Yang," *National Science Review*, Vol. 1 (2014): 157–160.

year (see **Table 1**) in number – over an administrative and industrial career to launch their research career.[33]

[Table 6]

Young scientists, with or without a grant from the Fund for Young Scientists, also are eligible for applying for funding from the general project program (*mianshang xiangmu*). In 2016, the number of projects supported by the Fund for Young Scientists was almost the same as that supported by the general projects (16,112 vs. 16,934), although the total amount of funding for the former was only one third of the latter (RMB3.12 billion vs. RMB10.17 billion).[34] And the success rates for both also were identical (22.89% vs. 22.87%).[35]

With the introduction of NSFDYS and SFEDYS in 1994 and 2011 respectively, NSFC has a chain of programs in place to systematically support and nurture the next generation of talented researchers. A young scientist grant may lead to a general-project grant, and a couple of general grants may put a young PI in a good position to put a bid in the competition of SFEDYS and eventually NSFDYS. Altogether, the three programs supporting young scientists have accounted about 20% of NSFC's total funding. If the amount of grants in other programs awarded to young scientists, usually under 45, is included, the percentage of the NSFC fund for young scientists can be significantly higher. Young scientists also may be part of other projects, small or large, while master's and doctoral students have the opportunities to get involved in projects of their advisors. Indeed, NSFC grantees are getting younger. For example, in 2016, about two-thirds (64.2%) of its general projects have a PI 45 years old or young, indicating the coming of age of young scientists in China.[36]

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[33] Poo and Wang, "A New Face at Natural Science Foundation of China."

[34] NSFC (comp.), *Annual Report of the National Natural Science Foundation of China (2016)*, available online at http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/02.html (accessed on July 20, 2017).

[35] National Natural Science Foundation of China (comp.), *Annual Report of the National Natural Science Foundation of China (2016)* (in Chinese), available online at http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/03_01.html and http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/03_06.html (accessed on July 20, 2017).

Funding for general programs is the largest at the NSFC, reaching RMB12.1 billion or 45.2% of the total in 2016. NSFC (comp.), *Annual Report of the National Natural Science Foundation of China (2016)*, available online at http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/02.html (accessed on July 20, 2017).

[36] National Natural Science Foundation of China (comp.), *Annual Report of the National Natural Science Foundation of China (2016)* (in Chinese), available online at http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/03_01.html (accessed on July 20, 2017).

Funding for general project programs is the largest at NSFC, reaching RMB12.1 billion or 45.2% of the total in 2016. NSFC (comp.), *Annual Report of the National Natural Science Foundation of China (2016)*, available online at http://www.nsfc.gov.cn/nsfc/cen/ndbg/2016ndbg/05/02.html (accessed on July 20, 2017).

Until the Department of Health Sciences was established in 2010, funding for biomedical projects was administered as part of the Department of Life Sciences at NSFC. The total number of the NSFDYS awardees in the life sciences over the years is 597, accounting for 17.6% of the total. The life sciences, according to NSFC, include the following disciplines: microbiology; botany; ecology; zoology; biophysics, biochemistry and molecular biology; genetics and bioinformatics; cell biology; immunology; neuroscience; biomechanics and tissue engineering; biology and integrated biology; developmental and reproductive biology; fundamentals of agronomy and crop science; plant protection; horticulture and plant nutrition; forestry; animal husbandry and grassland science; veterinary science; aquatic science; food science; and psychology. The top five disciplines in which NFSDYS has been given are biophysics, biochemistry and molecular biology; botany; cell biology; microbiology; and neuroscience.[37] Apparently, some of the disciplines are biomedicine related. Given the interdisciplinary and multidisciplinary nature of the life sciences, there also is possibility that awardees engaged in such research have received grants from other departments.

Similar to the U.S. National Institutes of Health (NIH), in the health sciences, NSFC mainly funds projects on the morphology, structure, function and dysplasia of cells, tissues, organs and systems of the body and the occurrence, development, outcome, diagnosis, treatment and prevention of diseases. At the height of the SARS crisis and its immediate afterwards in 2002 and 2003, there were discussions whether China should follow the American model to set up an NIH-type institution. The proposal was not materialized but the establishment of the Department of Health Sciences within the NSFC in 2009 signals the attention paid to biomedical research in China, although the actual impacts of the work supported by the department remains to be seen.[38]

Now, the Department of Health Sciences is the largest within NSFC in terms of the number of projects supported by the Fund for Young Scientists and the general-project funds. But the success rate in the department – around 20% – has been consistent and similar to that in other departments. A total of 176 young scientists have been awarded NSFDYS in the health sciences in the last seven years and 264 young scientists have been successfully in getting an SFEDYS, accounting for 12.68% and 13.21% respectively (see **Table 2** and **Table 7**).

[37] Liu, Qiao, and Zhang, "An Analysis of the Funding Status and Achievement Impact of National Science Fund for Distinguished Young Scholars in the Life Sciences."

[38] Jiao Li, "After Long March, Scientists Created 'Chinese NIH'," *Science*, Vol. 327 (January 8, 2010): 132.

[Table 7]

Peer Review

Although the scientific community has recognized the problems associated with peer review, such as slow and expensive, inconsistent, and bias, that compromise the integrity of the process, with scarcity in funding and journal space only putting the review process under further pressure,[39] there is no viable alternative to it in evaluating grant proposals, publications, scientists, and institutions. By depending upon experts to make decisions scientifically and democratically, peer review still is the cornstone to ensure the quality of research and distribute resources and honor in a fair, open, and transparant way. As a latecomer to the activities of modern scientific research, China has learned from other countries in research governance, including the evaluation and assessment of grant proposals.

Soon after its establishment, NSFC started to translate the reports on the evaluation and peer review at foreign research funding agencies. They included the 1987 report that the then U.S. General Accounting Office submitted to Congress comparing the role of peer review at NSF and NIH;[40] the 1990 report that assessed the peer review practice at U.K research councils, also known as the *Boden Report*;[41] the 2001 NSF report on merit review process, among others. These reports not only have become a "window" through which NSFC learned how peer review is practiced in foreign countries but also have helped NSFC to develop and improve its peer review process.

Following U.S. NSF, NSFC has set up a series of regulations specifying various aspects related to the foundation's administration from call for proposals to distribution of grants. For example, the term of experts on a review panel now is limited to two years. Key to maintaining a fair and transparent peer review process is to avoid conflicts of interest. Therefore, grant applicants can name up to three persons to be avoided in the review; reviewers should recuse themselves if they have close relationship with applicants including relatives, advisors, students, colleagues from the same organization, collaborators, students of

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[39] See, for example, Richard Smith, "Peer Review: A Flawed Process at the Heart of Science and Journals," *Journal of the Royal Society of Medicine*, Vol. 99, No. 4 (April 2006): 178–182.

[40] United States General Accounting Office (GAO), *University Funding: Information on the Role of Peer Review at NSF and NIH* (Washington, DC: GAO, 1987).

[41] Advisory Board for the Research Councils (ABRC), *Peer Review: A Report to the Advisory Board for the Research Councils from the Working Group on Peer Review* (London: ABRC, November 1990).

the same advisors, and others.[42] NSFC allows applicants failing to peer review to request a re-evaluation on a procedural basis. And it makes a specially appointed team available at panel meetings to monitor the process. While the composition of panels takes into consideration of the presence of young scientists, the review does not give early-career applicants favorable treatment.

Despite differences in running the peer review process, NSFC's scientific departments all try to preserve its core value, which is to rely on experts, to preserve the democratic principle, to support research and researchers based on merit, and to be fair and reasonable. Here, the practice at the Department of Health Sciences is used to illustrate how NSFC carries out the peer review.

NSFC has a fixed deadline, usually in March annually, for grant proposal submission to most of its programs. Once NSFC collects all the proposals, program officers at each department run a preliminary check to ensure that the proposals meet the formality requirement. Program officers then randomly select three to five experts from a database for each proposal depending upon the level of support. For example, the proposals for Fund for Young Scientists are reviewed by three experts while those for SFDYS and NSFEDYS five. Reviewers then judge and comment on the proposals independently based on scientific merit, innovativeness, social impacts, and feasibility of the proposed research, as well as credentials of the PIs, the team, and rationality of the budget. When the reviews are back, program officers rank all the proposals, eliminating low-scored, clearly incompetent proposals, and determining those to be further discussed at panel meetings, whose members spend most of the time deliberating marginal cases.

NSFC does not set quotas for any of its programs, which literally means that any scientist working in China – Chinese or foreign – can submit a proposal as long as she meets the eligibility.[43] Consequently, NSFC has been overloaded proposals that have been increasing year over year, not only lowering the success rate but also tremendously increasing the burden of the foundation as well as reviewers. For example, the Department of Health Sciences received more than 20,000 proposals in 2016, representing a 30% increase over 2015. Despite maintaining a fairly large expert database, every year, the department has to assign each reviewer dozens of proposals for review. Comments on each proposal turn out

[42] NSFC, "Code of Conduct of Review Experts" (in Chinese), available online at http://www.nsfc.gov.cn/publish/portal0/tab229/info48790.htm (accessed on July 20, 2017).

[43] At one time, proposals for NSFDYS had to go through an institutional evaluation before being submitted to the NSFC for assessment. Such a practice was abolished later.

to be brief, which raises the concerns over the quality of the review. To improve the process, the department has tested a practice of holding a group expert meeting to determine preliminarily whether a proposal warrants a full review. In 2016, 177 experts participated in such meeting, during which each proposal was read by at least three participants, who ended up eliminating 3,964, or 19.19% of the submissions. Yet, each reviewer still was assigned 15 proposals in the next round.[44]

The peer review process for NSFDYS is similar but adds an oral defense component where those scoring higher in peer review present themselves in front of an expert panel on their significant accomplishments and future research plan and then answer questions from the panel. A list of potential NSFDYS awardees, or those passing peer review, oral defense, and panel review, is posted online for a period of time to solicit comments but NSFC only consider non-anonymous feedback. Given the large number of proposals/applicants, success rates for three young-scientist-oriented health sciences programs have remained low in the last five years (see **Table 7**), as those at other departments.

The Young Thousand Talent Program has adopted a similar procedure, that is, no limits are placed institutionally. But the situation is different for the Cheung Kong Scholar Program. MOE specifies that each university can only recommend one candidate for each discipline/position, unless it has overseas applicants who enter peer review directly. If there are more candidates, a university has to conduct an institutional review to put forward one applicant with the most prospects. Internal review usually does not measure candidates against specific quantified indicators but those involved in the selection usually want to maximize the chance so that the university could get more Cheung Kong professors. Applicants then submit materials to MOE, who organizes peer review, oral defense, and panel meetings to assess them.

Some Significant Outcomes

In this section, I'd like to use two cases to illustrate how young Chinese researchers in health sciences/biomedicine have benefited from a very favorable environment toward them.

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[44] Hu Mingde, Peng Yuhua, Han Liwei and Dong Erdan, "An Overview of the Evaluation of Proposals at the Department of Health Sciences in 2016" (in Chinese), *Science Funds in China*, No.1 (2017), 41−45.

One of the recommendations that the international panel made after reviewing NSFC's 25 years of operation was to take drastic steps to reduce the number of proposals submitted. NSFC introduced a measure so that those whose proposals failed twice in a row have to have a one-year gap before submitting another proposal. But it has not solved the problem. See Richard N. Zare and Ernst-Ludwig Winnacker, "China's Science Funding," *Science*, Vol. 334 (October 28, 2011): 433.

They are the National Institute of Biological Sciences (NIBS), a newly established institution, and Nieng Yan, a very promising structural biologist.

NIBS was founded in December 2005 with endorsement from eight Chinese government agencies – MOST, NDRC, MOE, the then Ministry of Health (MOH), CAS, NSFC, and the Beijing municipal government. The institute is governed by a board of trustees consisting of representatives from the eight agencies that is responsible for formulating institute's policy, as well as selecting well-known scientists to serve on the institute's scientific advisory board. The board members in turn select and appoint institute's director and are consulted on the appointment of principal investigators and academic affairs. Continuous funding has come from MOST and the Beijing municipal government, which also oversee the operation of NIBS.[45]

As a very young R&D institute as well as a government's strategic initiative, NIBS has experimented an alternative way of conducting original research aiming at understanding the fundamental mechanism of life and of running a scientific institution and nurturing the next generation of life scientists in China. The appointment of two Chinese-American scientists – Xiaodong Wang, a U.S. NAS member then at the Southwestern Medical Center of the University of Texas, and Xingwang Deng, a plant biologist holding Daniel C. Eaton Professorship of Plant Biology at Yale – co-founding directors was unthinkable at the Chinese context, showing government's eagerness for talents. Having been appointed director for the second term in 2010, Xiaodong Wang returned to Beijing on a full-time basis.

There were only three senior academics when the institute was established. Wang, Deng, and Yi Rao, then a chair professor of neuroscience at Northwestern University and the institute's deputy director of academic affairs, were all under 45 years old. NIBS has recruited its PIs through highly competitive global searches, although thus far it only has appointed ethnic Chinese who typically have Chinese or foreign Ph.D.s with a number of years of post-doctoral research at a foreign institution. But both the young PIs and the young institute have been on a steep learning curve. Altogether, the institute has attracted and nurtured more than 500 scientists working on a variety of life sciences-related research topics. Initially, it only relied on government funding for its operation; now PIs also compete

[45] The introduction of NIBS draws intensively from NIBS, "Introduction," available online at http://www.nibs.ac.cn/en/about.php?cid=2&sid=3 (accessed on July 20, 2017) and Cong Cao, "The Emerging Research Institutions of Life Science in China," in Jon Sigurdson (ed.), *China's New Knowledge Systems and Their Global Interaction* (Stockholm, Sweden: Swedish Agency for Innovation Systems [VINNOVA], Stockholm School of Economics, and Lund University, 2004), pp. 43−49.

for funding through programs such as NSFDYS, presumably the institute's funding situation is not as stable as in its early days.

NIBS has been performing extremely well in achieving breakthrough in fundamental research of the life sciences. Its scientists have published major findings in leading international journals of the life sciences such as *Cell*, *Nature*, *Science*, *PNAS*, among others. They also have gained their international reputations. In 2012 when the prestigious Howard Hughes Medical Institute (HHMI) introduced for the first time a program for international early-career investigators, of the 28 awardees, seven were Chinese including four at NIBS (**Table 8**).[46] Shao Feng, one of the seven, joined NIBS after receiving his Ph.D. in biological chemistry at the University of Michigan Medical School and conducting post-doctoral research at the University of California, San Diego, and Harvard Medical School. He has published 10 papers in *Cell*, *Nature*, and *Science*. In 2015, Shao was elected an elite member (*yuanshi*) of the CAS, the youngest at that time.

[Table 8]

In recent years, the institute has seen migration of some of its staff to other Chinese institutions of learning to dissipate concerns whether newly established R&D institutions such as NIBS are merely a few "isolated spots" in China's vast research scene. The alumni continue to perform impressively. In April 2017, for example, structural biologist Chai Jijie, one of the early NIBS PIs and now a professor at Tsinghua University, was honored with Germany's Alexander von Humboldt Professorship. Carrying a total fund of €5 million for a period of five years, the prestigious professorship enables him to carry out long-term and groundbreaking research at the University of Cologne and the nearby Max Planck Institute for Plant Breeding Research.[47]

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[46] Howard Hughes Medical Institute (HHMI), "HHMI's International Early Career Scientists" (Chevy Chase, MD: HHMI, January 24, 2012), available online at http://www.hhmi.org/news/hhmis-international-early-career-scientists (accessed on July 20, 2017). See also Michael Wines, "Global Research Awards Showcase China's Gains and Efforts to Retain Scientists," *The New York Times*, January 25, 2012, p. A4.

HHMI teamed with the Bill & Melinda Gates Foundation, the Wellcome Trust in the U.K., and the Calouste Gulbenkian Foundation in Portugal to launch the second competition for its international early career scholar program. See HHMI, "Philanthropies Select 41 Scientists as International Research Scholars" (Chevy Chase, MD: HHMI, May 9, 2017), available online at https://www.hhmi.org/news/philanthropies-select-41-scientists-international-research-scholars (accessed on July 20, 2017).

Of the 41 awardees announced in May 2017, seven are Chinese, none of whom are affiliated with NIBS. Does this suggest that young life scientists at the institute are lagging behind or the overall level of life sciences research in China is making much progress in the last five years or both?

[47] Alexander von Humboldt Foundation, "Award Winner 2017 – Jijie Zhai" (Bonn, Germany: Alexander von Humboldt Foundation), available online at http://www.humboldt-professur.de/en/preistraeger/preistraeger-2017/chai-jijie (accessed on July 20, 2017).

Nieng Yan is one of the seven China-based first HHMI international early-career investigators. Under the supervision of Yigong Shi, a renowned structural biologist at Princeton University, she received her Ph.D. in 2004 and stayed on for three years as a post-doctoral fellow, also under Shi. In 2007, Yan followed Shi to return to Tsinghua University, their alma mater, starting her independent academic career. At Tsinghua's medical school, she has done extremely well and published extensively, including some 20 papers in *Cell*, *Nature*, and *Science* as a correspondence author.

Yan received her first NSFC grant in 2010 and was awarded an NSFDYS in 2011 after two tries and several other grants from NSFC totaling over RMB8 million. Yan was appointed a Cheung Kong professor in 2014. In addition to the HHMI award, she also received the Protein Science Young Investigator Award, which recognizes a scientist in the first eight years of an independent career who has made an important contribution to the study of proteins, and the Raymond and Beverly Sackler International Prize in Biophysics, a prize set up by Tel Aviv University in Israel to promote originality and excellence of research in the field of biophysics, both in 2015.

In May 2017, the Princeton University Board of Trustees announced the appointment of Nieng Yan to the Shirley M. Tilghman Professor of Molecular Biology.[48] Having received the offer in 2015, Yan explained the reasons behind her decision to move to Princeton now that she worries about the possibility of complacency being in the same environment for too long and that a new environment would give her new pressure, stimulation, and inspiration so as to help her to make new breakthrough.

While the appointment acknowledges Yan's significant scientific accomplishment as well as the research environment at Tsinghua and probably in China that has become conducive to the development of young scientists, her departure also was said to do with her unpleasant experience with application for NSFC funding, although Yan denied it categorically.[49] In a 2014 blog, Yan documented her failure to get a key-project proposal funded at NSFC as her findings on crystal structure of the human glucose transporter GLUT1, or "my signature work" in her own words, had not been published when the grant proposal was submitted. While pointing out that the reviews were fair, Yan also indicated

48 Susan Promislo, "Board of Trustees approves 14 faculty appointments, May 9, 2017," available online at https://www.princeton.edu/news/2017/05/09/board-trustees-approves-14-faculty-appointments (accessed on July 20, 2017).

49 Han Xiaotong, "Tsinghua Open Yan Ning to Accept Princeton's Chair Professorship" (in Chinese), *The Paper*, May 9, 2017, available online at http://www.thepaper.cn/newsDetail_forward_1681339 (accessed on July 20, 2017).

that HHMI took the risk in giving her the award for international early career scientists (Yan's key project was funded two years later anyway). Ultimately, Yan challenged NSFC for considering what kind of research to support and how to encourage innovation through funding.[50]

Conclusion and Discussions

By leveraging its significant investments that heretofore have been made to modernize and upgrade its higher education system and R&D infrastructure, China has captured and harnessed its most strategic resource – talents, or those Chinese with higher-caliber abilities and skills of strategic significance to its modernization and national wealth creation. Of them, a new generation of scientists, including biomedical researchers, has been injecting new impetus into China's scientific research enterprises and embarking on a quest to close appreciably the nation's prevailing technological gap with the West in science and high technology. A select number of them have been active at the international frontier of biomedical research, represented by the winners of the HHMI international early-career investigator program (see **Table 8**) and other similar programs and the appointments of some of them to the prestigious positions.

In the last decade, China has witnessed updates of its various programs targeting early-career researchers. The five programs that stand out include the National Science Fund for Distinguished Young Scholars, and the Young Cheung Scholars Program, the Young Thousand Talents Program, the Young Ten Thousand Talents Program, and the Science Fund for Emerging Distinguished Young Scholars, run by different government agencies, from the Central Leading Group for Coordinating Talent Work to NSFC and MOE. YTTP, YTTTP, and YCKSP carry monetary incentives, which are matched by generous funding for research from employers and local governments. And NSFDYS and SFEDYS grantees normally receive a stipend and other benefits from their employers as rewards. Returnees who are recruited to such programs also get a generous resettlement package from governments and employers. With the exception of YTTTP, other programs are open to non-Chinese nationals as long as they meet other requirements such as age, academic credential, and research experience. NSFC even has a special fund gearing toward young foreign scientists working in China and the applicants can submit their grant proposals in English. Although the success

[50] Yan Nieng, "A Failed Grant Proposal, a blogpost on September 2, 2014" (in Chinese), available online at http://blog.sciencenet.cn/blog-65865-824367.html (accessed on July 20, 2017).

rates at all NSFC programs have remained low, NSFC's research-funding mechanism is acknowledged meritocratic, where the best ideas and brightest scientists – young and old, Chinese and foreign – have found success.[51] NSFC also plays the role of America's NIH in China, with some 20% of its funds allocated to research in the health sciences, including those toward young researchers. Not only intact amid the most recent reform that reorganizes and streamlines China's national S&T programs, NSFC also is expected to see its funding increase in the coming years, especially amid government's emphasis on fundamental research.

Indeed, the age limit – 45 years old – is the same for both the NSFDYS awardees at NSFC and the Research Project (R01) grantees at NIH. However, an R01 award supports "a discrete, specified, circumscribed project" that is performed by an investigator in "an area representing the investigator's specific interest and competencies,"[52] and NSFDYS is a career award given to established investigators who are selected based on their previous performance and will have the freedom to pursue their interests of research. On the other hand, SFEDYS, another NSFC program, targets early-career researchers with three to five years of post-doctoral experience; in this sense, it seems to be similar to the Early Career Faculty Development Program at NSF. SFEDYS awardees are most likely at the ranks of associate or even full professor, compared to its American counterparts who usually are assistant professors, although both awardees have some three years of post-doctoral experience.

In addition to the programs discussed in the paper, Chinese central and provincial governments, local governments, and organizations also have introduced programs for the similar purpose of attracting and nurturing young talents. For example, MOE, through its China Scholarship Council, supports Chinese to pursue post-doctoral research overseas for a duration of six months to two years. Fund is available for returnees with foreign Ph.D. degrees or post-doctoral research experience. A competitive post-doctoral fellowship also is available for researchers with domestic or foreign Ph.D. degrees. Almost each provincial government has its own Thousand Talents Program, offering similar generous packages to returnees. All this is a very positive development that may generate results in the long run.

However, philanthropy almost does not exist in China to support higher education and scientific research; and it is very difficult, if not impossible, for early-career researchers to

[51] Zare and Winnacker, "China's Science Funding."

[52] National Institutes of Health, "Definition of an R01," available online at https://grants.nih.gov/grants/funding/r01.htm (accessed September 10, 2017).

get funding from non-NSFC-sourced national S&T programs. Therefore, resources available for early-career researchers still are limited. Young faculty members initially appointed as post-docs at some colleges and universities are more likely to put up their first grant proposals as their appointments as regular faculty members is contingent upon their getting a grant from NSFC's Fund for Young Scientists along with *SCI* publications. Some institutions even stipulate that newly appointed faculty receive a grant from NSFC's general-project program within a couple of years of their initial appointments, or they have to leave. These, plus an increasing and high production of Ph.D. graduates at domestic institutions of learning (see **Table 1**) as well as an increasing return of those from overseas who have turned to limited opportunities offered by various programs, inevitably have led to a downward trend of success rates for funding.

That early-career researchers or junior faculty successfully secure their grants does not necessarily guarantee their independent career as inbreeding binds quite a significant number of them with their advisors, thus stifling the development of their ability. In addition, the programs mentioned in the paper tend to select the same group of young researchers, showing a significant "Matthew Effect" (see **Table 8**). For example, SFEDYS grantees are most likely to be appointed the Young Cheung Kong professors at universities, and also become NSFDYS later. Therefore, recruits to TTP and YTTP are prohibited from applying for CKSP and YCKSP respectively.

A favorable policy environment toward those with foreign Ph.D. degrees and overseas research experience gives foreign degree and experience a premium in obtaining research funding and even academic positions in China. For example, those with domestic Ph.D.s need to have five years of foreign research experience to become eligible for YTTP. Such a situation has generated not only resentment among those without such experience but also tensions between the two groups. In fact, such policy has been driving young Chinese researchers abroad to make up the academic credential and research experience gap. Moreover, China does not have enough post-doctoral and academic positions to accommodate an annual large number of Ph.D.s produced. For example, despite domestic post-doctoral positions have been on the rise continuously over years, only 16,794 secured such a position in 2015,[53] much lower than the number of domestic Ph.D. graduates in that

[53] Office of the National Postdoctoral Management Committee of China, "Number of New Postdoctoral Researchers in Each Year (1985–2015)" (in Chinese), available online at http://www.chinapostdoctor.org.cn/WebSite/program/Info_Show.aspx?InfoID=8076603f-551d-42c5-97b7-14735a0e6e8d (accessed on July 20, 2017).

year, which was 53,778, and lower than the actual number of Ph.D.s pursuing an academic career, which was about 20,000 to 30,000, as alluded (see **Table 1**). Salaries for domestic post-docs tend to be low but pressure for performance and future jobs is high.[54] Consequently, some, especially the best and brightest of domestic Ph.D.s, likely go abroad, quite a number of whom end up residing overseas rather than returning. This is the exact reason that the Central Leading Group for Coordinating Talent Work to introduce TTTP to cater the interests of domestic talents, including the early careers. China needs to balance between attracting talents from overseas and developing a capable indigenous talent pool.

Nonetheless, it also is worth mentioning that programs aiming at attracting the permanent return of overseas talents only have accomplished limited success. For example, of the 470,000 foreign higher education credentials certified by the Chinese Service Center for Scholarly Exchange between 2008 and 2014 during which most of the policy and programs were initiated, less than 10% had an overseas Ph.D. degree with only 13.87%, or 6,500, of such degrees earned at American universities.[55] The figure is less than a quarter of the total number of Ph.D. degrees in science and engineering, 28,010, that American universities had awarded to Chinese nationals during the same period.[56] While a significant number of those recruited into the YTTP are returnees from the U.S., at best they are at the level of tenure-track assistant professor at American universities.[57] As such, it still is an uphill battle for China to attract and nurture early career scientists.

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[54] Muhammad Z. Ahmed, David Plotkin, Bao-Li Qiu and Akito Y. Kawahara, "Postdocs in Science: A Comparison between China and the United States," *BioScience*, Vol. 65, No. 11 (November 2015): 1088–1095, on 1091.

[55] Zhang Yichi, "Report on Foreign Degree Certification Released for the First Time" (in Chinese), *The Elite Reference*, November 9, 2016, p. 18.

[56] National Center for Science and Engineering Statistics, Directorate for Social, Behavioral and Economic Sciences (comp.), *2015 Doctorate Recipients from U.S. Universities*, NSF 17–306 (Arlington, VA: U.S. National Science Foundation, June 2017). Table 26. Doctorates awarded for 10 largest countries of origin of temporary visa holders earning doctorates at U.S. colleges and universities, by country or economy of citizenship and field: 2005–15.

[57] See, for example, Sun Yutao and Zhang Shuai, "An Empirical Study on the Effects of the Academic Young Brain Gain Policy: The Example of the Young Thousand Talents Program" (in Chinese), *Studies in Science of Science*, Vol. 35, No. 4 (2017): 511–519.

CHINA'S APPROACHES TO ATTRACT AND NURTURE YOUNG BIOMEDICAL RESEARCHERS

TABLES

Table 1 Ph.D. Graduates at Chinese Institutions of Learning

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Philosophy	201	233	281	348	392	436	524	547	576	698	703	756	735	708	680	610	8428
Economics	701	675	837	1204	1309	1617	2038	2149	2274	2461	2371	2383	2314	2328	2262	2184	29107
Law	322	500	663	770	1022	1191	1700	1871	1940	2208	2414	2510	2789	2828	2803	2631	28162
Education	151	189	229	307	410	455	629	821	890	919	857	921	1008	938	971	978	10673
Literature	355	504	643	837	1033	1216	1660	1892	2011	2102	2129	2241	1955	1952	1887	1811	24228
History	236	292	315	454	473	547	603	725	778	824	827	836	792	822	799	679	10002
Science	2408	2638	2808	3705	4518	5458	7241	8051	8953	9570	9638	9881	9762	10396	10922	10978	116927
Engineering	4611	5009	5252	6573	8054	9427	12130	14479	15276	17386	17428	17703	17890	18331	18537	18729	206815
Agriculture	499	510	626	756	977	1093	1544	1903	1936	2006	1973	2241	2365	2435	2382	2549	25795
Medicine	1520	1774	2166	2825	3700	4291	5481	5907	5782	5586	5762	6991	7813	8228	8457	8707	84990
Military Science		3	5	6	13	22	35	22	23	21	23	34	33	16	23	30	309
Administration		540	813	1021	1545	1924	2662	3097	3320	3770	3738	3792	3817	3698	3466	3411	40614
Art													440	459	464	481	1844
Total	11004	12867	14638	18806	23446	27677	36247	41464	43759	48658	48987	50289	51713	53139	53653	53778	1072335

Sources: Bureau of Development and Planning, Ministry of Education of China, Educational Statistics (in Chinese), various years, available online at http://www.moe.gov.cn/s78/A03/moe_560/jytjsj_2015/ (accessed on July 20, 2017).

Table 2 Awardees of the National Science Fund for Distinguished Young Scholars (NSFDYS)

Year / Department	2010	2011	2012	2013	2014	2015	2016	Total
Mathematical and Physical Sciences	28	26	27	26	25	24	24	180
Chemical Sciences	29	31	31	31	31	30	30	213
Life Sciences	30	27	27	26	25	24	26	185
Earth Sciences	20	20	20	21	21	21	21	144
Engineering and Materials Sciences	35	37	37	37	38	38	37	259
Information Sciences	25	25	26	25	27	28	28	184
Management Sciences	6	7	7	7	6	7	7	47
Health Sciences	25	25	25	25	25	26	25	176
Total	198	198	200	198	198	198	198	1388

Sources: NSFC (comp.), *Annual Report of the National Natural Science Foundation of China* (various years), available online at http://www.nsfc.gov.cn/publish/portal0/tab224/ (accessed on July 20, 2017).

Table 3 Appointees to the Young Thousand Talents Program (YTTP)

Discipline \ Year	First Cohort	Second Cohort	Third Cohort	Fourth Cohort	Fifth Cohort	Sixth Cohort	Total
	November 2011	January 2012	June 2012	December 2012	February 2014	February 2015	
Mathematics and Physics	22	38	34	28	59	92	263
Chemistry	23	28	22	21	52	106	252
Environment and Earth Sciences	13	25	11	10	33	44	136
Information Sciences	24	23	25	17	45	79	213
Engineering and Materials Sciences	42	55	40	50	97	160	444
Life Sciences	28	52	46	59	112	183	480
Health Sciences						3	3
Total	152	221	178	185	398	667	1801

Sources: http://www.1000plan.org/ (accessed on July 20, 2017).

Table 4 Awardees of the Science Fund for Emerging Distinguished Young Scholars (SFEDYS)

Department \ Year	2012	2013	2014	2015	2016	Total
Mathematical and Physical Sciences	52	50	48	47	47	244
Chemical Sciences	57	58	58	57	57	287
Life Sciences	56	56	57	59	59	287
Earth Sciences	40	39	38	39	38	194
Engineering and Materials Sciences	73	74	73	74	73	367
Information Sciences	53	55	57	59	60	284
Management Sciences	15	14	15	14	14	72
Health Sciences	54	53	54	51	52	264
Total	400	399	400	400	400	1999

Sources: NSFC (comp.), *Annual Report of the National Natural Science Foundation of China* (various years), available online at http://www.nsfc.gov.cn/publish/portal0/tab224/ (accessed on July 20, 2017).

Table 5 Appointees of the Young Cheung Kong Scholar Program (YCKSP)

Discipline \ Year	2015	2016	Total
Mathematics and Physics	19	24	43
Chemistry	17	16	33
Life Sciences	26	23	49
Environment and Earth Sciences	13	10	23
Engineering and Materials Sciences	34	48	82
Information Science	22	17	39
Health Sciences	17	22	39
Management Science	8	9	17
Humanities and Social Sciences	55	60	115
Total	211	229	440

Sources: Ministry of Education of China, "Announcement of the Appointments to the 2015 Cheung Kong Scholars Program" (in Chinese), available online at http://www.moe.edu.cn/srcsite/A04/s8132/201604/t20160422_239712.html (accessed on July 20, 2017); "Announcement of the Appointments to the 2016 Cheung Kong Scholars Program" (in Chinese), available online at http://www.moe.gov.cn/srcsite/A04/s7051/201704/t20170401_301718.html (accessed on July 20, 2017).

Table 6 Grantees of the NSFC Fund for Young Scientists

Department \ Year	2010	2011	2012	2013	2014	2015	2016	Total
Mathematical and Physical Sciences	929	1386	1501	1638	1728	1733	1630	10545
Chemical Sciences	808	1170	1271	1390	1534	1428	1450	9051
Life Sciences	1139	1939	2036	2233	2353	2214	2208	14122
Earth Sciences	868	1300	1407	1541	1623	1582	1622	9943
Engineering and Materials Sciences	1530	2309	2505	2744	3036	2900	2867	17891
Information Sciences	1033	1584	1688	1855	1940	1943	1918	11961
Management Sciences	340	557	607	650	705	675	697	4231
Health Sciences	1703	2901	3007	3316	3502	3680	3720	21829
Total	8350	13146	14022	15367	16421	16155	16112	99573

Sources: NSFC (comp.), *Annual Report of the National Natural Science Foundation of China* (various years), available online at http://www.nsfc.gov.cn/publish/portal0/tab224/ (accessed on July 20, 2017).

Table 7 Grantees of Various Funds for Young Scientists at NSFC's Department of Health Sciences

Year	Fund for Young Scientists			General Project Program			Science Fund for Emerging Outstanding Young Scientists			National Science Fund for Outstanding Young Scientists		
	Proposals	Awards	Success rate (%)	Proposals	Awards	Success rate (%)	Proposals	Awards	Success rate (%)	Proposals	Awards	Success rate (%)
2010	8487	1703	20.07	18977	3163	16.67	N/A	N/A	N/A	235	25	10.64
2011	13942	2901	20.81	21670	3663	16.90	N/A	N/A	N/A	262	25	9.54
2012	16007	3007	18.79	24870	4200	16.89	507	54	10.65	233	25	10.73
2013	15865	3316	20.90	19412	4072	20.98	388	54	13.92	256	25	9.77
2014	17959	3502	19.50	16197	3800	23.46	440	54	12.27	275	25	9.09
2015	18388	3680	20.01	19587	4102	20.94	405	51	12.59	300	26	8.67
2016	20657	3720	18.01	20316	4102	20.19	562	52	9.25	320	25	7.81

Sources: NSFC (comp.), *Annual Report of the National Natural Science Foundation of China* (various years), available online at http://www.nsfc.gov.cn/publish/portal0/tab224/ (accessed on July 20, 2017).

Table 8 Awardees to the HHMI Early Career Scientist Programs

Name	Undergraduate Institution (Year)	Ph.D. Institution (Year)	Post-doctoral Experience (Years)	Institution at the Time of the Award	Major Funding Programs Received (Year)
Junjie Hu	Fudan university (2000)	New York University (2005)	Harvard Medical School/HHMI (2005–2008)	Nankai University	NSFDYS (2012); YTTTP (2013); CKSP (2015); HTP (2015)
Feng Shao	Peking University (1996)	University of Michigan Medical School (2003)	UCSD (2003–2004); Harvard Medical School (2004–2005)	NIBS	NSFDYS (2012); TTTP (2016)
Chun Tang	Zhejiang University (1998)	University of Maryland Baltimore County (2003)	NIH (2003–2007)	CAS Wuhan Institute of Physics and Mathematics	HTP (2009)
Xiaocheng Wang (F)	Shandong University (1992)	Peking University (1999)	University of Colorado (1999–2006)	NIBS	NSFDYS (2013); HTP (2016); TTTP (2015)
Nieng Yan (F)	Tsinghua University (2000)	Princeton University (2005)	Princeton University (2005–2007)	Tsinghua University	NSFDYS (2011); CKSP (2014)
Hong Zhang	Anhui University (1991)	Albert Einstein College of Medicine (2001)	Massachusetts General Hospital Cancer Center, Harvard Medical School (2001–2004)	NIBS	NSFDYS (2012); HTP (2012); TTTP (2013)
Bin Zhu	Zhejiang University (1992)	CAS Shanghai Institute of Plant Physiology (1999)	Friedrich Miescher Institute, Switzerland (1999–2002); HHMI/University of Medicine and Dentistry of New Jersey/Robert Wood Johnson Medical School (2002–2006)	NIBS	NSFDYS (2014); TTTP (2014); HTP (2015)
Lingling Chen (F)	Lanzhou University (2000)	University of Connecticut Health Center (2009)	University of Connecticut Stem Cell Institute (200–-2011)	CAS Shanghai institute of Biochemistry and Cell Biology	SFEDYS (2013), YTTTP (2013)
Qiaomei Fu (F)	Northwestern University (2007)	Max Planck Institute for Evolutionary Anthropology (2013)	Max Planck Institute for Evolutionary Anthropology (2013–2014); Harvard Medical School (2015–2016)	CAS Institute of Vertebrate Paleontology and Paleoanthropology	YTTP (2017)
Wei Ji	Peking University (2003)	UCLA (2008)	Ludwig Cancer Center at UCSD (2009–2013)	Tsinghua University	YTTP (2013); SFEDYS (2014)
Guohong Li	Wuhan University (1995)	University of Heidelberg (2003)	Howard Hughes Medical Institute (2003–2009)	CAS Institute of Biophysics	HTP (2009); NFSDYS (2015); TTTP
Ying Liu (F)	Nanjing University (2006)	Southwestern Medical Center (2011)	Massachusetts General Hospital, Harvard Medical School (2011–2014)	Peking University	YTTP (2004)
Hai Qi	Peking University Medical School (1996)	University of Texas Medical Branch, Galveston (2003)	NIAID/NIH (2003–2009)	Tsinghua University	NSFDYS (2014); CKPS (2015); TTTP (2016)
Yanli Wang (F)	Wuhan University (1996)	University of Science and Technology of China (2004)	Memorial Sloan Kettering Cancer Center (2006–2011)	CAS Institute of Biophysics	HTP (2010); SFEDYS (2012)

Sources: Author’s research.
Notes: HHMI – Howard Hughes Medical Institute; CAS – Chinese Academy of Sciences; NIBS – National Institute of Biological Sciences.
HTP – Hundred Talents Program; NSFDYS – National Science Fund for Distinguished Young Scholars; SFEDYS – Science Fund for Emerging Distinguished Young Scholars; CKSP – Cheung Kong Scholar Program; YCKSP – Young Cheung Kong Scholar Program; TTP – Thousand Talents Program; YTTP – Young Thousand Talents Program; YTNTP – Young Top-Notch Talents Program, a component of the Ten Thousand Talents Program.