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PART I

Contexts

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1 Introduction

The rising volume of scientific research coming out of Asia has been making headlines since the start of the twenty-first century.[1] Much of this attention has focused on the rapid ascent of China, with plentiful news stories and reports about the amount of funding the Chinese government has invested in upgrading its scientific research system.[2] In 2007, China overtook the United States (USA) to become the largest producer of natural science and engineering doctorates in the world. In 2015, China produced 32,000 doctorates in these fields, while the USA produced 30,000.[3] China's overall research and development (R&D) expenditure now exceeds that of the European Union (EU) as a whole.[4]

Several other Asian countries have also been expanding their investments in scientific research and education in the last two decades and they have paid particular attention to the life sciences. In 2003, Singapore opened its multibillion dollar Biopolis campus to serve as the base for several of the country's public research institutes that focus on the biomedical sciences. The Asian R&D offices of several multinational pharmaceutical businesses were also set up on the Biopolis campus.[5] In 2008, the South Korean government launched its 577 Program to boost the proportion of the country's Gross Domestic Product (GDP) spent on R&D to 5 percent, and promised to funnel

[1] Woetzel and Seong 2020; Veugelers 2012; *Nature* 2007. There is even an *Asian Scientist* magazine (www.asianscientist.com) that publishes articles highlighting research and researchers from Asia. It was launched in 2011. The journal *Asia Pacific Biotech News*, started in 1997 by World Scientific Publishing, focuses exclusively on life science research in the Asia Pacific region (www.asiabiotech.com/about-us.html).

[2] Xie, Zhang and Lai 2014; Veugelers 2017; Zhou 2015; Zhang, Sun and Bao 2017.

[3] Khan, Beethika, Carol Robbins and Abigail Okrent, "The State of U.S. Science and Engineering 2020," National Science Board, January 15, 2020, figure 11, accessed on January 12, 2021, https://ncses.nsf.gov/pubs/nsb20201/global-r-d.

[4] Khan et al., "The State of U.S. Science and Engineering 2020," figure 11.

[5] Chan 2006; Cyranoski 2001; Smaglik 2003.

these funds equally to basic and applied research in seven key technology areas, including the life sciences.[6] In 2018, Taiwan opened its National Biotechnology Research Park (NBRP) adjacent to Academia Sinica, the country's premier base for scientific research.[7] Together with the Hsinchu Biomedical Science Park, which is about an hour's drive south of Taipei, the NBRP is expected to raise Taiwan's competitiveness in biotechnology. In 2010, India began setting up a series of new universities along the lines of its renowned Indian Institutes of Technology (IIT), but now with a focus on science education and research.[8] Called the Indian Institutes of Science Education and Research (IISERs), these seven universities offer students a joint bachelor's and master's degree in various scientific fields – including the life sciences. These are just some of the many centrally led initiatives launched by different Asian governments over the last two decades – all aiming to propel a rise in their respective country's global scientific standing. As a result of these efforts, Asia's overall share of the world's R&D investment is now larger than that of the Americas and Europe, and it continues to grow.[9] More and more patents are being filed in Asia and the number of scientific journal articles published by scientists based in Asian countries has also increased considerably.[10]

But behind this science story, there is a *migration* story. The elite scientists who are leading these new research institutes and carrying out this cutting-edge research in Asia are rarely "homegrown" talent.[11] Instead, the vast majority of the scientific personnel fueling the current boom in Asia's scientific research output were born in Asia but trained in the West, primarily in the USA but also in the United Kingdom (UK), continental Europe and Canada. Only after the completion of their training, and sometimes after several more years of working as academic scientists in the West, did they return to work at the top research universities and institutes in various Asian countries. Vanya, an Indian

[6] Stone 2008.
[7] *Taiwan Today* 2018.
[8] Stone 2012; *Nature* 2016.
[9] Heney 2020; Grueber and Studt 2013.
[10] Grueber and Studt 2013; King 2004; Leydesdorff and Zhou 2005; Veugelers 2017.
[11] Paul and Long 2017; Cerna and Chou 2014; Ortiga et al. 2018; Yeoh and Lai 2008. Israel has adopted a similar return policy, encouraging highly skilled emigrants or its "knowledge diaspora"(Welch and Hao 2016) who are believed to be able to contribute to the national economy to return (Cohen 2009).

scientist, is one such Western-trained returnee. She now works at a top research institute in India where all of her colleagues have a similar migration history. As she put it, "My entire research institute is full of people who have all moved back [to India]. So, you know, I am very much par for the course. Every single one of them has been abroad and then come back."

Like me, Vanya had a parental history of international migration and return that had influenced her own migration decisions.[12] When they were young, Vanya's parents left India to train in the West. Their decision to return to India in the 1970s was considered unusual by their peers and relatives. Vanya shared the difference in people's reactions to her parents' return decision in the 1970s versus her own return in the 2000s:

> When they came back [to India] in the 1970s, hardly that many people were coming back. Now, that's not the case. Now, I'm not unusual at all.
>
> I remember my parents being asked, "Why are you coming back? How foolish are you? You know, if you're medical doctors, if you live in the USA, you will make a ton of money and live a very smooth and simple life."
>
> But now, nobody asks us that much. I mean, people do ask it, but it's a lot less given that there are so many people who make that move [back to India]. It's not unusual now.

In the present day, most returning Asian scientists go back to work in their country of birth, but other returnees are choosing to work in another Asian country. Singapore, in particular, has been a beneficiary of what I call "halfway-return" migration that brings elite Asian-born, Western-trained scientists back to Asia, but to an Asian country other than their birth country.[13]

Why did these Asian scientists choose to train in the West? Has the logic around training locations changed in recent years? What made

[12] I wrote about my own multigenerational history of international migration in the Preface.

[13] Even though "halfway-return" is not quite grammatically correct, I use this term as this is what one of my interviewees used to describe his journey from China to the USA for doctoral and postdoctoral training, and then from the USA to Singapore to start work in a public research institute. "Halfway-return" speaks to a third option that is situated somewhere in-between staying in the West versus a "true" return to one's birth country.

some of these scientists choose to return to Asia after their training, while others remained in the West? Is the calculus around this return decision changing? How does their gender and nationality affect Asian scientists' experiences in the West and their return logics? What happens after return, when Western-trained Asian scientists set up labs in Asia? What do these scientists bring back with them when they return? These are the questions motivating this book. To answer them, I draw on in-depth interviews I conducted with 119 elite Asian bioscientists who trained at top universities in the West, 86 of whom had returned to Asia – though not always to their country of birth. These 119 bioscientists are drawn from a range of Asian countries but the vast majority come from my four main Asian fieldsites – China, India, Singapore and Taiwan.

From my interviews, I identified four interlinked developments in the Asian "corner" of the contemporary global scientific field. The first development relates to recent upgrades of the scientific research systems in select Asian countries. These improvements in research systems are driven in a top-down manner by the governments of these countries investing significant public funds into scientific R&D. As a result of these improvements, the volume of return migration to Asia is increasing as ambitious Asian scientists no longer see Western countries as the only viable base from which to launch a successful research career.

But returning scientists require graduate students and postdoctoral fellows – the foot soldiers of science – to staff their labs, and so they (and their governments) are now seeking to expand the availability and improve the robustness of local scientific training options, rather than outsource the task of training to Western countries. This leads to the second finding of this book which is the increasing diversification of training pathways emerging within the Asian scientist migration system. The consequence of macro- and micro-level efforts to improve the scientific training infrastructure in select Asian countries is that more aspiring Asian scientists are delaying when they leave home for training in the West, with increasing numbers leaving only at the postdoctoral moment, rather than earlier at the doctoral training moment. Intra-Asian mobility is also increasing for training, networking and career progression purposes. And so, while more aspiring Asian scientists may choose to stay and train in their own country of birth, others are instead moving to another Asian country that offers attractive packages for trainees and is closer to home than the West. Western countries still play an important role in these trainees' professional lives, but not in the same way that they used to twenty years ago. This book traces all of these dynamic changes in the Asian scientist migration system.

The third change I uncover is how returned Asian scientists are attempting to affect the scientific research systems and scientific cultures in the top Asian research organizations where they return to work. By tracing elite Asian scientists' journeys to the West, and exploring their experiences there as well as back in Asia (for those who chose to return), this book identifies the "scientific remittances" these returning scientists bring back with them. Having reached a critical mass, returning Asian scientists are now driving change from the ground up in their Asian research universities and institutes. I investigate the changes these elite scientists are seeking in how labs are run, teams managed, science is taught and applied, and how the next generation of Asian scientists is being mentored. I show that while Asian governments may have been focused on making structural changes to their domestic scientific research systems – from improving the quality of available research technology, to increasing the funding for scientific research – they instigated a more fundamental change in scientific cultures, resulting from the new values and perspectives that returning Asian scientists are bringing back with them.

My fourth finding is the extent of variation that exists *across* the scientific research systems and scientific cultures in Asia, and the differing challenges that my four Asian case countries face as they seek to enhance their relative standing in the global scientific field. These challenges operate at the level of scientific research systems, but also in terms of the specific scientific cultures that exist in individual research organizations. These are described firsthand by the scientists I interviewed in my four Asian case countries. As a result, I am able to differentiate between the scientific terrains in each of my case countries, rather than treat Asia as a monolith. Similarly, this book does not treat the West, or the practice of science in Western countries, as a uniform whole. Given that my interviewees trained in a range of Western countries, their interviews highlight the differences between various Western countries' scientific research systems and scientific cultures, debunking the idea of a single "Western science," in addition to the idea of a single "Asian science."

My hope is that, through all this, *Asian Scientists on the Move* will give readers an insight into the rapidly changing global scientific field – and particularly the Asian corner of this field – without allowing readers to fall prey to simplistic East–West narratives. From a theoretical point of view, this book is distinct from migration scholarship that sometimes sidelines developmental and other large-scale societal processes that shape and are shaped by migration.[14] In contrast, this book embeds its analysis of the migrations of individual academic bioscientists from different parts of Asia within the larger story of their particular country's scientific development, showing the mutually influencing relationship that exists between development and migration even among the highly skilled.

This book also contributes to science and technology studies (STS) with its detailed descriptions of the scientific training environments in my four Asian case countries and how these environments have changed since the 1980s and 1990s. This is possible thanks to the composition of my interviewee sample which includes successive generations of elite Asian scientists who left their home country to go to a Western country for training in three different time periods (the 1980s and earlier, the 1990s, and the 2000s), and successive cohorts of returnees as well. But before I can introduce my interviewees, I need to first situate the object of my study: the global scientific field, and Asia's place within it.

A Social Field Analysis of the Global Scientific Field

This book explores the global scientific field: how it has changed in recent years, how scientists from Asia physically and figuratively navigate this field, and how four Asian countries – China, India, Singapore and Taiwan – are working to change their relative position within this field. In order to do all this, I start by explaining what a social field is, the social actors and norms that comprise the global scientific field, what holds symbolic value within this field, and how the field interacts with other social fields (in particular, the "field of power")[15] to shape scientists' career course and life course.

14 De Haas 2010.
15 For this section, I draw primarily on Pierre Bourdieu's work on field analysis. It was Bourdieu who insisted that a key part of field analysis is understanding how

Concepts for Analyzing the Global Scientific Field

French sociologist Pierre Bourdieu defined social fields as segments of the broader social space that possess their own particular social structure, their own internal logic determining how status is achieved within the field, and some degree of autonomy from the broader society.[16] Social fields are comprised of social actors (or agents) who could be individuals or formal/informal groups, organizations, or even larger entities such as states. These agents hold different positions within the field depending upon their possession of, or access to, the particular resources that have been deemed worthy within the field. These resources, or "capitals" as Bourdieu termed them, can take different forms and the list of possible capitals has only increased and gained more specificity since the time Bourdieu first outlined three key capitals – economic, social and cultural.[17] Bourdieu also emphasized that capitals have symbolic value only in relation to particular fields. In the context of the scientific field, "scientific capital" has been identified as a science-specific version of these three and other capitals. Scientific capital includes:

(1) Research funds (economic capital) to buy scientific equipment and materials, and hire research staff,
(2) Advanced training (human capital) in scientific research methods, tools and know-how,
(3) An ease and familiarity with the history, norms and values of one's subfield, and institutional affiliation with key organizations in the subfield (cultural capital), and finally,
(4) Network contacts with and recognition by the field's gatekeepers and other researchers in one's subdiscipline (social capital).[18]

The possession of one or more of the above types of scientific capital imbues an individual with status within the global scientific field. But scientific capital can also be used to acquire and accumulate *additional* status within the field, primarily through publishing in high impact-factor journals. This is a version of the Matthew Effect, first

any given social field relates to the broader "field of power" (Bourdieu 2005:33; Bourdieu and Wacquant 1992:97).
16 Bourdieu 1993; Archer et al. 2015.
17 Bourdieu 1986.
18 Bourdieu 1988; Archer et al. 2015.

coined by sociologist Robert Merton (1968), which posits that in science, as in life, those with more get ever more, while those with little get less.[19] In the biological sciences, the top-ranking journals to which ambitious academic scientists submit their articles include *Nature* (and its sister journals, including *Nature Cell Biology* and *Nature Genetics*), *Science*, *The Lancet*, *Cell*, the *Annual Review of Plant Biology*, *Genome Biology*, and *Trends in Ecology and Evolution* – to name a few. Other ways to garner respect and recognition in the field are successfully securing large research grants, and winning prizes and filing patents stemming from one's discoveries. Additional capital-linked criteria used to determine status within the scientific field include one's rank, the reputation of the research organization where one works, the overall size of one's research support team and research laboratory, the number of one's citations, and involvement in high-profile research collaborations.

Even as scientists regularly collaborate on joint research projects, Bourdieu wrote that every social field is a "field of struggle," where agents are constantly jockeying for greater relative positions within the field through the accumulation, exchange and monopolization of field resources.[20] However, even as they are in competition with each other, all agents in the field are united by a sense of the importance of their struggle (or the "game" as Bourdieu termed it). All the actors also have an unspoken agreement over how this game should be played and what should count as status markers within the game.[21] This collective acceptance of the rules of the game is critical because it is what effectively makes the field a field and demarcates its boundaries. At the same time, however, each field is dynamically changing with either new actors attempting to enter the field, or existing actors working to

19 Merton 1968.

20 Bourdieu 1993. Another form of "struggle" that can occur within a scientific field is a clash of paradigms to explain particular scientific phenomena. Thomas Kuhn's (1962) *Structure of Scientific Revolutions* is perhaps the most well-known account of such a struggle within the scientific field when a long-standing paradigm comes under increasing threat as more and more scientists within the field begin to accept a new way of looking at particular phenomena/evidence. The discipline may enter a period of crisis as this clash of paradigms continues, until the new paradigm replaces the old one in what Kuhn called a "scientific revolution." I do not deal with paradigmatic conflicts in *Asian Scientists on the Move*; instead, I study the much more traditional struggle for power and status within the scientific field.

21 Lenoir 2006.

raise their relative position within the field by accumulating new capital or changing the rules of the game to block new entrants.

Within the global scientific field, the actors involved are myriad and operate at different levels. They include states and their relevant government ministries,[22] public and private universities and research institutes, corporations that house a scientific research arm to develop new technologies and products or fund academic research collaborations, and also individual scientists and students training to become scientists. Within the contemporary scientific field, particular countries (almost all in the West) are viewed as occupying the center or "core" of the field, meaning that most of the key institutions and individuals within the field are based in these countries.[23] After World War II, the USA in particular grew in prominence within the global scientific field as the single largest producer of science and engineering doctorates, and the largest individual funder of scientific R&D in the world. Asian countries were largely situated on the periphery or semi-periphery of the global scientific field for most of the twentieth century, resulting in a gravitational force that encouraged the westward migration of aspiring Asian scientists. But, as I show in this book, the topography of the global scientific field is shifting as select Asian countries are investing significant economic resources – acquired through their strong performance in other fields or by diverting funds from other sectors – into improving their standing as producers of scientific research.

Within the global scientific field, I focus on the life sciences which cover the various branches of science concerned with the study of life and living organisms. The life sciences encompass a broad range of subdisciplines from ecology to genetics and everything in-between. The life sciences can be considered a field in and of itself. Likewise, the scientific actors, institutions and research systems in each country can also be considered to constitute their own geographically contained field, situated within the overarching global scientific field.

22 Typically, this would include a ministry/department of education, and a ministry/department of science and technology, though this unit is sometimes subsumed under a ministry of trade and economy.
23 Dear 2001; Jacob 1997; Jasanoff 2005; Xie and Killewald 2012.