Conclusion

Ku-ming (Kevin) Chang and Alan Rocke

University reforms that institutionalized research education in the principal European countries and in the United States have been well studied; the remainder of this paragraph offers a quick summary of the received wisdom. The so-called Humboldtian reforms made Prussian universities, and Berlin in particular, leaders in higher education from the early nineteenth century onward. The Prussian university reformers, including Wilhelm von Humboldt, established original research and the training of students in research into important objectives for the university, and this research ethos quickly spread across German states in the next few decades. The reception of the research ethos was late and slow in France. The Napoleonic reforms at the beginning of the nineteenth century radically reorganized the *Université de France* and hollowed out its function in advanced studies. By the 1850s and 1860s, French scholars began to advocate the German model of academic training after seeing its strength, and used their country's defeat in the Franco-Prussian War of 1870–71 as their battle cry for a systematic reform of French higher education. Reform measures were rolled out gradually over two decades from the mid-1870s. Britain accepted the research ethos even more slowly. Colleges had usurped most functions of the university at Oxford and Cambridge in the early modern period, and many of them resisted attempts to implement curricula and degrees for advanced research until the late nineteenth century. Oxford and Cambridge thus often accepted changes later than other British universities—those in London, the other industrial cities, and Scotland. As part of the national rebuilding after the Civil War, leading American colleges upgraded to universities by adding graduate and professional schools, while new universities such as Johns Hopkins, Clark, and Chicago deliberately fashioned themselves as research universities. All of them bypassed the tradition-bound college and placed research education in graduate schools. Once begun, university reforms

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after the German model of research education were pursued with enthusiasm in the United States.

This volume focuses on the education that prepares students (or junior scholars) for advanced research. Research education is of great importance for the history of higher education and the history of science, for over the course of the century that this volume examines, the ability to do advanced scientific research came to be seen as the entry qualification for the academic profession. The training for this ability became the definitive education for academics. The history of research education is in this sense a story of the modern academic profession.

The chapters in this special issue/volume substantiate and fruitfully complicate the common understanding of the history of higher education in the dimensions that are discussed in the preface. These chapters examine representative disciplines that rely on different instruments and methods of research. Some chapters study cases of disciplinary education in individual countries, while others compare disciplinary practices across several countries. Reaching beyond the Eurocentrism that is embedded in the received wisdom summarized in the first paragraph of this conclusion, this volume expands its attention to major countries in South Asia, East Asia, and Latin America. This coverage includes not only sovereign countries that were more or less free to choose their academic systems, but also colonized societies or regions upon which external systems were imposed. This volume also pays attention to women researchers, whose entrance to academia was late and slow, but monumentally important. Instead of comparisons of national systems that are common in the international studies of higher education, this volume deliberately investigates concrete cases in which institutional culture and disciplinary practice shaped research education.

Together, the authors of this volume approach the history of research education across several axes: the foundation of research education in the university; the instruments of research education and their multiplication; expansion of higher education and proliferation of disciplines; the emergence of women researchers; and the roles of state, nation, imperialism and globalization. Below we summarize prominent findings in individual chapters, and weave together themes that are visible only by comparing or digesting several or all of them.

The Foundation of Research Education in the University

Most of the chapters in this country study the research education at universities, either comparatively or in individual countries. Indeed, one of the most significant changes in higher education in the last two centuries

is the very fact that universities, at least select ones, took over the function of training in advanced research. It was pointed out in the introduction to this volume that the most advanced scientists or scholars, such as members of scientific academies, often received their training outside universities in the eighteenth century.[1] In the twentieth century, none would be elected to the national academy without university education, not to mention graduate training. When new forms of research institutions appeared in the nineteenth century or later—the Robert Koch Institute, the Pasteur Institute, the Kaiser Wilhelm Gesellschaft, the CNRS (*Centre National de la Recherche Scientifique*)—they recruited researchers who had received university and often doctoral education. This trend has only intensified today, when industry, as well, recruits university-educated scientists or PhDs into its research and development departments.

German universities, and those that shared a similar model in the Austro-Hungarian Empire, differed from their counterparts in other Western countries in that they offered research education following graduation from Gymnasium, which meant that in the German-speaking lands the doctoral degree (in theology, law, medicine, and 'philosophy', i.e., the various sciences) was the first degree that a student received after secondary education.[2] In this sense, doctoral education that taught advanced research was technically 'undergraduate'. The challenge, then, was that these universities were still obliged to provide education to those who had no interest in an academic career. Kasper Risbjerg Eskildsen points out in Chapter 2 that German professors were made acutely aware that they could not train all students as researchers, especially in an age of rapid expansion of higher education. They either selected only a very few research-minded students for their seminars,[3] or, like Waitz, opened two seminars, one for students who were research-minded, and the other of more practical nature for those who were not. German universities thus accommodated this difference by diversifying their curricular offerings.

[1] For an analysis of the career of the members of the Royal Academy of Sciences in Paris, see Ku-ming (Kevin) Chang, in Matthew D. Eddy, Seymour H. Mauskopf, and William R. Newman (eds.), 'Communications of Chemical Knowledge: Georg Ernst Stahl and the Chemists at the French Academy in the First Half of the Eighteenth Century', in *Chemical Knowledge in the Early Modern World*, Osiris, 2nd Series (Chicago, 2014), 149.

[2] Among all German universities, Jena preserved the bachelor of theology degree, Leipzig the bachelor of law, and Bonn the Master of Arts. These were the few exceptions that were degrees awarded after secondary education and before the doctorate. Max Baumgart, *Grundsätze und Bedingungen zur Erlangung der Doctorwürde bei allen Facultäten der Universitäten des deutschen Reichs* (Berlin, 1884), 45, 93, 161–2, 165–6.

[3] This was Leopold von Ranke's solution. He reserved the seminar only for gifted students, and thought that lecture courses were enough for ordinary students. Leopold Ranke, 'Vorrede', in *Jahrbücher des deutschen Reiches unter dem sächsischen Hause*, i (Berlin, 1837), viii–ix.

They only granted the doctoral degree to a very small percentage of students.[4]

To further select their teaching staffs, German universities introduced the *Habilitation*, a postdoctoral qualification requiring, among other elements, a second major research project. In the nineteenth century, starting with Berlin, the habilitation was institutionalized as the qualification or license that gave the recipient the *venia legendi*, the privilege to teach at the university, although the preparation for the habilitation involved little formal training.[5] All aspirants to an academic career, even in the professional faculties, needed the habilitation before they were admitted to teach at the university. This in fact distinguished the German academic profession from the traditional learned professions of theology, law, and medicine.[6]

Other countries accommodated students' different career goals by relegating research training to postgraduate levels. Throughout the first two thirds of the nineteenth century, students in France and Britain received higher education in arts or sciences that had limited specialization. Most training in specialized research was available only after university education, hence 'post-graduate'. Often this postgraduate training was quite informal. In English universities, postgraduate research fellowships, certificates, and degrees (such as the Bachelor of Science, Doctor of Letters, and Doctor of Science) appeared in the late nineteenth century for university graduates to pursue. Some required limited coursework; others required the submission of published works as proof of scholarly achievements (Chapter 1). In France, the *doctorat d'état* was a degree available to those who had completed university study and thus had been granted the *licence* degree. A university graduate usually taught at a secondary school. To become a professor, they needed to work on a major

[4] At Berlin, the rate of students who receive their doctorate was constantly below 2 percent in the 1900s and barely 3.6 percent in 1923/24. Siegfried Wollgast, *Zur Geschichte des Promotionswesens in Deutschland* (Bergisch Gladbach, 2001), 206. Through the nineteenth century, the faculties of traditional professions—theology, law and medicine—continued to train students for practical roles, generally shunning over-specialized focus. The faculty of philosophy meanwhile educated students who sought a teaching career in the Gymnasium. Many students skipped the doctoral degree and took state examinations instead. If they passed, they entered these professions.

[5] The habilitation was essentially an apprenticeship in the university that stipulated little formal training. It required a doctoral degree, certain years of residence, a research paper that could not be the candidate's dissertation, and a public lecture in front of the faculty to which the candidate belonged. No habilitation-level coursework was offered. Paul Daude, *Die Rechtsverhältnisse der Privatdozenten: Zusammenstellung der an den Universitäten Deutschlands und Oesterreichs*. . . (Berlin, 1896), 7–8.

[6] Martin Schmeiser, *Akademischer Hasard: das Berufsschicksal des Professors und das Schicksal der deutschen Universität 1870–1920: eine verstehend soziologische Untersuchung* (Stuttgart, 1994), 31.

thesis for the *doctorat d'état*, a postgraduate degree while they were teaching in secondary education. After the French defeat in the Franco-Prussian War, the reforms that ensued expected this thesis to be a very substantive work, often hundreds of pages long, based on original research. While laboratory training was provided for doctoral work in experimental sciences, little residential study and little professorial supervision was required or offered for candidates in the humanities (Chapter 6). In the United States, the Doctor of Philosophy degree, though modelled on the German degree, was postgraduate, for it was awarded to college graduates. Pursued essentially by those who wished to pursue an academic career, the American PhD demanded residential study, a set coursework, and a dissertation that presented the results of advanced research.

When non-Western societies—India, Japan, China, Korea, and Taiwan, those reviewed in this book—introduced universities, they first implemented its function of teaching. At least in this early stage, the university was expected to produce personnel that their traditional institutions could not provide, such as civil servants, lawyers, and judiciaries for modern statecraft; scientists and engineers for the material and economic infrastructure of the society (geologists to explore mineral resources, for example); doctors of Western medicine; and teachers for modern secondary and tertiary education. During this period, original research was not demanded from the teaching staff of the university, nor was it provided for. The training of its students for advanced research was likewise scarcely addressed. When research education was finally offered, it was at first available at the postgraduate level only.

Once postgraduate research training was put in place, it began to infiltrate into undergraduate education. This was especially true in the societies where no formal graduate education was available, such as Britain and Japan. In these countries, even if doctoral degrees were available (and sometimes graduate schools or programs were opened), there was no set curriculum and no formal training (Chapter 5). The only way to give students serious training in research (after it had become desirable) was to offer it in the undergraduate curriculum, at least to select students. As Wei-chi Chen, Wan-yao Chou, and Ku-ming (Kevin) Chang show in Chapter 16, this was also the case for Japan's colonies, such as Taiwan.

A pattern that the cases in this special issue seem to suggest is that leading universities in all countries eventually became, or at least aspired to be, research universities. Although in Germany every university was meant to be a research university, the leading city of the German Empire, Berlin, had to maintain its status as the site of the best of all research universities by keeping a constellation of the greatest scholars in almost all disciplines (though in the field of language studies Leipzig was paramount).

Elsewhere in Europe and North America, only selected universities were equipped to support advanced research. Again, it was the leading national universities—such as Paris, Oxford, Cambridge, Harvard, Yale, Johns Hopkins, and Chicago—that received this equipment. This trend also applied to latecomers in higher education in the non-Western world. The universities that stood out—Calcutta, Tokyo, São Paulo, and Peking—eventually took upon themselves the task of original research and the teaching of research, despite material and cultural constraints.

What might explain this almost universal phenomenon? Local factors may have varied from one place or society to another, but a common factor is that by the late nineteenth century, or at least by the early twentieth, it had become the norm that the goal of scholarly work was to seek the advance or progress of knowledge. In Max Weber's words, for academics 'to be superseded scientifically is not simply our fate but our goal'.[7] This mentality was already deeply rooted in Western societies by the time Weber gave his famous lecture 'Science as a Vocation' in 1917. In non-Western countries or societies, this research ethos was first brought home by the students or scholars who studied in Western countries. The result was the same perception: A respectable university could only win and sustain its status by conducting and supporting original research that received the approval of its peers. This pressure was greatest for the leading universities of the country, for they produced the majority of the academic elite of their home society, and often received the most resources.

The establishment of research education coincided with the secularization of the university. In the Middle Ages, theological teaching dominated the university curriculum; the university saw its core mission to train clergy. This began to change already in the early modern period, and was radically altered in the nineteenth century. The faculty of philosophy (or the faculties of letters and sciences in France) became the core of the university, supporting an ever increasing number of disciplines. Local contexts varied from one country or society to another. In Germany, it was Kantian, idealist, and neohumanist currents of thought that elevated the faculty of philosophy, a base for disinterested learning, over the professional faculties. It France, it was the French Revolution and the following Napoleonic reforms in higher education that removed the domination of religion over the faculties of letters and sciences (which were split from the faculty of philosophy of the pre-Revolutionary university). In both countries, reforms in the early nineteenth century secured employment in secondary schools for the students of philosophy (or letters and sciences),

[7] Max Weber, 'Science as a Vocation', in David Owen and Tracy B. Strong (eds.), *The Vocation Lectures*, trans. Rodney Livingstone (Indianapolis, 2004), 11.

thus strengthening these faculties' practical attraction to students. In Britain, a career in the Anglican Church had traditionally been the favorite choice for the graduates of Oxford and Cambridge, but through much of the nineteenth century students spent most of their college years in these two leading universities learning and preparing for the examination subjects in mathematics (at Cambridge) and classics (at Oxford). Meanwhile, more 'modern' universities, such as the University of London, were created. After the American Civil World, leading American colleges deliberately worked to upgrade themselves to universities by introducing graduate schools. In all these countries, the studies in natural sciences and the humanities served as the model for all learning in the university, thanks to their original contributions to human knowledge.

The secularization of university education also reflected the general trend of European society. Barberis provides a telling example in Chapter 6. Just as Christianity was losing its function of unifying the society in France, the Minister of Public Instruction of the Third Republic created a position in 'Science Sociale et Pédagogie', with the goal of providing a secular morality based on science to replace what the Catholic Church had offered.

In non-Western societies, university teaching and research arrived as an alien institution. The university had no relation to the indigenous religion; in fact, it may even have competed with institutions that imparted the learning of traditional religion. In general, the appeal of Western higher education was rather its promise of material developments for the country, although colleges of Western missionaries intended otherwise. University education thus largely served to instill science or Western modernity to these societies, promoting secularization.

Instruments of Research and their Multiplication

Before the nineteenth century, the lecture and the disputation were two chief forms of teaching in European universities, although the latter was losing its dominance in the early modern period.[8] Philologist Friedrich August Wolf was the first to develop the seminar as an instrument to train junior scholars in methods for philological research. His academic heir

[8] William Clark points out that philology had its roots in rotational disputation that had been used since at least the early modern period: 'On the Dialectical Origins of the Research Seminar', *History of Science*, 27 (1989), 111–54. See also Friedrich August Wolf's integration of disputation into his seminar: Carlos Spoerhase and Mark-Georg Dehrmann, 'Die Idee der Universität: Friedrich August Wolf und die Praxis des Seminars', *Zeitschrift für Ideengeschichte*, 5 (2011), 111.

August Boeckh carried on the philological seminar at Berlin into the 1860s. It is well known that the philological seminar served as the model for seminars in history and in the faculties of theology and law.[9]

Eskildsen's chapter, examining Georg Waitz's seminar at Göttingen in the 1860s, shows the multiplication of the seminar as an instrument of historical research. Waitz had modelled his seminar on his professor Leopold von Ranke's 'seminar of all history seminars' that was started at Berlin in the 1830s. It in turn became the model for many more. Instead of methodical training, Waitz emphasizes the character-transforming power of the seminar. As Eskildsen points out, the seminar was thought to shape the junior historian's relationship to his object, his discipline, and his community. As students became professors, they duplicated the historian's identity that formed in the seminar, and multiplied the seminar to educate the next generation of historians.

Historical research multiplied not just on the personal and local levels, as in Waitz's seminar, but also on a large, and even transnational, scale. In the second half of the nineteenth century, a considerable number of historians—including Paul Fredericq, a Belgian, Kristian Erslev, a Dane, and G. Stanley Hall, an American—investigated methods and instruments of historical teaching in Germany and sometimes other countries (Chapter 2). They published reports in their languages (sometimes also translated into other languages), disseminating the methods of distinctive historical training impersonally in their countries and even abroad.

John Joseph and Daniela Barberis describe the ways in which French humanists and social scientists dealt with the lack of formal programs for research training in their country. A product of the German university, Ferdinand de Saussure was hired to teach comparative Indo-European philology at the *École Pratique des Hautes Études*, a new institution that was created in 1868 as an experiment to provide research training with lectures and especially seminars. His job was, in a strong sense, to replicate at *École Pratique* what he had learned in Germany. Indeed, Saussure trained some of the best French language scholars, and 'set the agenda for French doctoral training in linguistics and adjacent areas at least through the

[9] On the importance and working of the seminar, see the classical and recent studies of Friedrich Paulsen, *The German Universities and University Study* (New York, 1906), 212–15; R. Steven Turner, 'Historicism, Kritik, and the Prussian Professoriate, 1790–1840', in Mayotte Bollack and Heinz Wismann (eds.), *Philologie und Hermeneutik im 19. Jahrhundert* (Göttingen, 1983); William Clark, *Academic Charisma and the Origins of the Research University* (Chicago, 2006), 141–82; Spoerhase and Dehrmann, 'Die Idee der Universität: Friedrich August Wolf und die Praxis des Seminars'; Carlos Spoerhase, 'Das "Laboratorium" der Philologie? Das philologische Seminar als Raum der Vermittlung von Praxiswissen', in Andrea Albrecht et al. (eds.), *Theorien, Methoden und Praktiken des Interpretierens* (Berlin, 2015), 53–80.

1960s' (Chapter 8). Barberis's chapter shows how French sociologists, led by Émile Durkheim, offered his supervision to junior scholars who usually taught in secondary schools or provincial universities far away. Using his journal *Année sociologique* as a base, Durkheim trained junior scholars by instructing them to write book reviews and working closely with them on their original writings. They did this through extensive and frequent correspondence, when regular meetings were impossible.

Also short of formal programs of research education, British universities likewise turned to instruments that were less formal, and that were often not exclusive to research or post-graduate education. Seminar teaching, as Janet Howarth shows in Chapter 5, was rare and in fact unpopular at Oxford and Cambridge even at the turn of the twentieth century. British academics preferred conversations in the college dining hall, or Socratic dialogues in the classroom. Examinations for the Bachelor of Arts degree and honors gradually accommodated certain degrees of specialization and accepted non-standard answers to the essay questions. Some tutorials switched the focus to essay-writing, and university prizes and college fellowships were increasingly won by 'dissertations', which were research papers in the English sense. Howarth summarizes the British culture as one 'that valued quality over quantity of scholarship, collegiality and individual insights over hierarchy and the research school, literary merit and readability over mere originality'.

Training in the experimental sciences was very different from its counterpart in the humanities. At least on the rhetorical level, the neohumanist and idealist reformers who placed Berlin at the forefront of research universities favored pure, disinterested *Wissenschaft* or scholarly pursuits such as philology, history, philosophy, and mathematics, and some of them denigrated the experimental sciences as involving material interests and manual work. The experimental sciences were given significant impetus after Justus Liebig and colleagues influenced by him publicized their value. In Chapter 3, Alan Rocke analyzes the factors that contributed to the phenomenal success of Liebig's chemical laboratory in Giessen. These included personal, material, institutional, and disciplinary factors. This constellation of factors made the success of the Giessen model difficult to reproduce at first. Liebig's success, however, motivated German principalities, competing with one another, to support chemical laboratories. For similar reasons foreign universities, governments, and even individual scientists also tried to reproduce the Giessen model, or at least the research laboratory, from the 1840s on, with varying degrees of success.

Research education gradually became a core mission for theoretical scientists such as mathematicians in the middle third of the nineteenth

century, again first in Germany. Like philologists, mathematicians also took advantage of the seminar as their instrument of research training. As seen in Karen Parshall's chapter, starting with Carl Jacobi at Königsberg, the seminar was the space in which students mastered and presented the most recent mathematical literature, learned to show calculations or analyses on paper, and worked out the solution or the proof of a mathematical problem under the supervision of a professor or his assistant.[10] In the second half of the century, mathematicians responded to the rapid growth of new fields by providing a growing number of specialized lecture courses and thematic seminars. They organized mathematics clubs on campus as support groups for interested students, and established specialized journals and professional organizations to serve specific fields or the discipline at large.

As for the humanities, France played a catch-up game for both theoretical and experimental sciences. In the early nineteenth century, France was the obvious European leader in both theoretical and experimental sciences (mathematics, chemistry and physics). Beginning in the 1830s, the ambitious and capable chemist Jean-Baptiste Dumas expressed fears that Germany was moving ahead of his country. By mid-century, the lead of Germany was becoming obvious to many observers. Unable to find state support for their chemical laboratories, French chemists set up private ones where junior chemists found suitable training in experimentation. All but one of them soon failed, and the one that survived did not prosper until the higher education reforms of the Third Republic finally provided support. For theoretical sciences like mathematics, the reforms increased the size and funding of the faculty of sciences and the number of lectures and seminars. They accommodated doctoral studies, and made it possible for good young scholars to teach specialized courses full-time as *maîtres de conférences* (newly created positions that were lower than professors in rank) in the faculties of sciences. Paid in these positions, junior scientists would not be distracted by teaching in secondary school.

Britain presented a different case for experimental and theoretical sciences. The young University of London forged ahead of Oxford and Cambridge in constructing a purpose-built academic laboratory (the Birkbeck Laboratory) in 1845. For the rest of the century, chemical laboratories, chairs, or professorships slowly appeared in England (in Manchester, for example) or Scotland (e.g. Edinburgh), almost all filled by chemists who received experimental training in Germany (Chapter 3). For

[10] Gert Schubring, 'Das mathematische Seminar der Universität Münster, 1831/1875 bis 1951', *Sudhoffs Archiv*, 69/2 (1985), 165, 171, 172, 177.

mathematics, as shown in Parshall's chapter, Cambridge had an advantage over other British institutions in its Mathematics Tripos, an honours examination. This advantage waned as the Tripos tested students on increasingly antiquated questions and memorization. Systematic teaching in mathematical research was still largely absent in British universities through the nineteenth century.

Over the course of that century, medicine became a vast terrain of teaching, practice, and research that was based on clinical work. The medical faculty at the Prussian University of Halle at the turn of the eighteenth century consisted of only two chairs—one in theoretical medicine and the other in practical medicine. In contrast, around 1900 the medical faculty at Berlin, which replaced Halle as the leading Prussian university, consisted of no less than 36 professors (and many more unpaid lecturers or *Privatdozenten*), five research institutes, a university hospital (the *Charité*), and at least ten clinical departments.[11] By the mid-nineteenth century, teaching at the sickbed had become a staple of the medical curriculum in major Western countries, while laboratory training in the basic sciences competed for time. In fact, as In-sok Yeo points out, following the example in Europe and the US, Japanese and Korean universities in the 1920s and 1930s favored basic science over clinical work as the choice of doctoral research in medicine. Most doctoral projects, however, were experimental research on phenomena found in clinical observations. As Theodore Porter explicates in Chapter 7, statistical studies of clinical phenomena also grew.

Fieldwork as an instrument of research training began to be accepted toward the end of the nineteenth century. Up to that point, humanistic studies were largely based on texts, for which personal presence at the site of investigation was not required. For example, Sanskrit philology, a respectable field by the 1870s, was still very much a so-called armchair study that required no visit to India.[12] Fieldwork was valued in, for example, archaeology, ethnology/anthropology (Chapter 1), language studies (Chapters 8 and 9), geology, and paleontology (Chapter 15). Though all valued experience in the field, these disciplines relied on different technologies to tackle different materials. Archeologists looked for artifacts by excavation, while anthropologists studied 'primitive' culture or society by living amongst aboriginal peoples. Fieldwork had become a requirement for advanced degrees in these two disciplines by the

[11] *Verzeichnis der Vorlesungen, welche auf der Friedrich-Wilhelms-Universität zu Berlin im Sommer-Semester 1900 gehalten werden* (Berlin, 1900), 33.

[12] Pascale Rabault-Feuerhahn, *Archives of Origins: Sanskrit, Philology, Anthropology in 19th-Century Germany* (Wiesbaden, 2013), 233–7.

turn of the twentieth century. Language studies followed later. In the 1880s, Saussure had to urge his students in Paris, chief among them Antoine Meillet, to study the language where it was spoken (Chapter 8). Without training in advance, Meillet was on his own in the field. In the 1920s, Edward Sapir took his student Fang-Kuei Li to a Native American tribe, demonstrating to the junior scholar the process of selecting and interviewing informants (Chapter 9).

Another important mode of training may be characterized as apprenticeship. The German *Habilitation* can serve as an example. Most training available to the candidate at this stage was the observation of professors and *Privadozenten* at work. In German universities there were also positions like *Assistent*, who helped a professor with his teaching or laboratory. The junior scholar essentially accumulated training as an apprentice when he worked on the *Habilitation* or as an assistant. As Chen, Chou, and Chang show in Chapter 16, in Japan and its colonies a promising university graduate either studied in graduate school, which provided no formal education except a scholarship, or worked as assistant, teaching assistant, or lecturer. He apprenticed as a junior member of the teaching staff, observing his master teach and perform research.

Chen, Chou, and Chang's chapter also presents the mode of self-training that was available in Japan and its colonies (and elsewhere). When an academically-minded university graduate taught high school in a region where no university was nearby, they studied local history, archaeology, or geology by investigating monuments or primary materials in the city, or took their students to do small-scale field surveys or excavations. They thus trained themselves by applying to their new material the research training that they had received from undergraduate education. If their publications won recognition, they returned to academia and even ascended to its top.

The case of Japan and those of India and China show that research training could take place outside universities. Before a research university was in place in Bombay, museums and scientific societies supported scientific research, though such research might have been more curatorial in nature than original (Chapter 12). In China, it was the Chinese Geological Survey that funded the first academic journal for the discipline and fostered the first generation of geologists, paleontologists, and even archeologists in the country (Chapter 14). Also, as Porter indicates in Chapter 7, many figures who were seen as professional statisticians learned on their jobs and improved statistical tools and theories by meeting the needs of their practical work.

Based on the comparative analyses in this volume, five modes of research education can be identified: formal education (which may be graduate or

undergraduate) that could include training in the seminar, the laboratory, or fieldwork; informal immersion in school life (such as conversations in the college dining hall); apprenticeship in junior academic positions; self-training without the resources of a nearby university (or universities); and advanced study abroad (see below). Depending on the junior scholar's institution or country, he may experience just one mode of training, or multiple at the same time or different points in time.

Disciplinary Identity and Proliferation amid the Expansion of Higher Education

As noted above, Germany experienced an expansion of higher education in the 1860s and 1870s. Although the modern research university was taking root across German states during the *Vormärz* period (the decades preceding the March revolution of 1848 in Germany), the size of universities remained relatively small until the 1860s. A result of industrialization and its consequent prosperity, this expansion also occurred in other European countries.[13]

Some academics experienced this expansion with complaints. An example discussed above was the Göttingen historian Waitz, for whom this expansion meant a decrease in the quality of students. He complained about the qualification of the majority of students. In addition to the seminar that he led for academically-minded students, he coped with this reality by opening a second seminar for students who were not interested in original historical research.

Complaints apart, positive consequences also derived from the expansion of higher education. Mathematicians were happy to see enrollment in their courses grow to 250 at times in a single German university (Chapter 4). Material investment also grew. Before the 1860s, support for chemical laboratories could be seen as individual experiments among competing German universities (and their states). The completion in 1868 of a lavish laboratory at Berlin, which a generation prior Liebig had characterized as reactionary toward experimental sciences, marked the beginning of a new norm that was replicated rapidly and widely across Germany. Indeed, the decades after 1870 saw more investments in new institutes and professorships in the unified German Empire, including the newly annexed University of Strasbourg. The increases of the student

[13] Konrad H. Jarausch, 'Higher Education and Social Change: Some Comparative Perspectives', in Konrad H. Jarausch (ed.), *The Transformation of Higher Learning, 1860–1930: Expansion, Diversification, Social Opening, and Professionalization in England, Germany, Russia, and the United States*, (Chicago, 1983), 9–36.

body, the teaching staff, and material investments were also evident in France, Britain, and the United States.

Concurrent with the expansion of higher education was the proliferation of disciplines. The increase of scholars, students, and resources encouraged and supported specialization, then as well as now. James Turner has shown the many disciplines that developed out of philology in the second half of the nineteenth and the twentieth centuries.[14] His chapter in this volume also illustrates the diversification of classical studies into comparative literature, classics, anthropology, and archaeology, among other fields. Language studies were also drifting from text-oriented philology to becoming linguistics and phonetics (Chapters 8 and 9). In France, Durkheim, as Barberis shows (Chapter 6), worked to assert the independence of sociology from philosophy (in which he had been trained) or education (which was the subject of his first professorship). Earth sciences also diversified into geology, paleontology, and archaeology (Chapter 14).

The chapters by Turner and Porter remind us that as late as the turn of the twentieth century, there were still areas of studies that could not be easily defined as a discipline. Turner's chapter investigates 'common erudition'. The first example is John Linton Myres, who taught and published in classical literature and history, did archaeology by actual excavations, founded the Royal Anthropological Institute's journal *Man*, and became the institute's president. The other examples are Charles Eliot Norton of Harvard, who taught art history, Dante and organized the Archeological Institute of America, Andrew Lang, classical scholar, historian of Scotland, and anthropologist, and the Canadian-American Simon Newcomb, astronomer, mathematician, and economist. Their work covered a wide range of today's disciplines. Instead of specialists, they are better seen as generalists.

Common erudition was supported at particular places and in a particular age. Myres, Lang, and Norton were educated at Oxford or at Harvard, where colleges preferred general, classics-based learning to specialized knowledge. Their appointments at their alma maters were essentially to provide the same education to students, even though they were free to publish in areas rooted in classical studies that were splitting into different disciplines. Without previous formal education, Newcomb taught himself mathematics until he enrolled at the Lawrence Scientific School of Harvard. His broad expertise in astronomy, mathematics, and economy were the result of his practical works in nautical sciences

[14] James Turner, *Philology: The Forgotten Origins of the Modern Humanities* (Princeton, 2014).

(including planetary observation) and later at Harvard's observatory, which eventually won him the appointment as the Professor of Mathematics at Johns Hopkins. Economics may be seen as an extension of his previous work in mathematics. None of these four scholars had a PhD, which required specialized research for the dissertation. Without a doctorate their appointments would have been very difficult, if not impossible, in Germany or France at the time or thirty years later in the US.

New disciplines may grow out of a common root, while a discipline may also claim different roots. In Britain, from classics grew philology, archaeology, and to some extent anthropology (Turner). In Japan and colonial Taiwan, archaeology, aboriginal ethnology, and anthropology of contemporary society were joined in the Institute of Ethnology (Chapters 16). In Europe, philology gave birth to language sciences, while linguistics and phonetics competed, in France and England at least, to be *the* science of language. The American tradition, however, saw linguistics as part of anthropology (Chapter 9). As seen above, archaeology may have its roots in classical studies and ethnology. But those were not the only influences. As Yen shows in her chapter, geologists also expanded their reach to archaeology (and paleontology) in the early twentieth century. Thus classics, ethnology, and geology may all claim to be the origin of archaeology.

Porter points out in his chapter that an academic subject like statistics was more than just the discipline of mathematical statistics that gradually received chairs or departments in Western institutions. Statistics was 'highly heterogeneous, resisting any neat classification'. It served as a method in many disciplines and industries, such as agriculture, medicine, psychology, and ecology, as well as economics, insurance, industrial quality control, and regressions. Statistics was therefore both a field and a method with many applications. Its practitioners continued to be trained on their jobs or in disciplines outside of mathematical statistics, even after the advanced degree in statistics appeared in the early twentieth century.

Turner investigates the possible causal relationship between disciplinary training and the formation of a discipline. The instruments or methods of research training, such as the seminar and the laboratory, indeed instill a disciplinary identity in students (Chapters 2, 3, 4, etc.); that is, they shape the discipline. This does not necessarily mean that a particular instrument of research generates a discipline, for an instrument of training is often shared by several disciplines. Though the seminar was first adopted to train students in philology, for example, it was then used in history, mathematics, and other disciplines. Likewise, fieldwork first served as the method of research and training for anthropology, and was consequently used by Sapir, first trained as an anthropologist, to prepare his students in

linguistics. The instrument of research training, like the seminar, thus is not discipline-specific. It may serve several disciplines at a time, or it may sustain a discipline while also generating a new one.

On the other hand, several instruments of training may have been available to a discipline. Language scholars had fieldwork, auditory training, and the phonetic laboratory at their disposal, though they did not employ them equally. Scholars at Chicago and Yale preferred fieldwork, the phoneticians at University College London preferred ear training, and the scholars of African languages at Hamburg placed greatest emphasis on instrumental analyses in the laboratory (Chapter 9). Or a junior scholar may have received his training in a combination of several research instruments. An anthropologist may have been trained in the seminar and also in the field. A physician might have been trained at the bedside as well as in the laboratory. A chemist might have started in the laboratory and then served as an assistant to a professor, like an apprentice. Hence, disciplines may not have been training-specific.

The Role of Women in Research

To pursue a career of academic research, women faced two major hurdles. They first had to be admitted to the university, and they subsequently needed a formal position in the university or a research institution. The former was hard to come by until the nineteenth century, and even later in some societies. The latter came much later.

The openness to women's higher education is not correlated to a country's research standing. Germany, the leader in research education, formally admitted women to universities only after 1900, the last major Western country to do so. France admitted women gradually, beginning in the 1870s and 1880s. The first colleges for women were established at Oxford and Cambridge also in the 1860s and 1870s, although full degrees were not available for women until the 1920s and 1940s, respectively. The University of London granted its first degrees to women in 1878.[15] The United States, hardly a leader in higher education otherwise, forged ahead of European countries in opening colleges to women in the 1830s, though at first the number was small. By the 1870s there were a considerable number of private co-educational or women's colleges. Boston University was the first to confer the PhD to a woman, Helen Magill White, in 1877, and Bryn Mawr College, for example, set up a

[15] Richard J. Evans, *The Feminists: Women's Emancipation Movements in Europe, America and Australasia 1840–1920* (London, 2012), 66, 111, 128.

doctoral program in mathematics for women in the 1890s.[16] In Japan, women's colleges opened in the 1900s, though women were not admitted to national universities until decades later.[17] Women were admitted to Chinese state universities and women's colleges in 1919, following the small missionary colleges established in the previous decade.[18] Though China fell behind Japan in many aspects of higher education, it appointed the first women to Peking University, its flagship state university, in 1920, much earlier than Japan did.[19]

Several chapters in this volume pay attention to women who received research education in the first half of the twentieth century. Their careers can be generalized into three types. First, they did not obtain academic appointments even after receipt of the doctorate. The reason may have been partly personal or familial; for instance, Maria von Tilling, who received her PhD in language studies at Hamburg in 1924, gave up her teaching position there to relocate with her husband for his appointment at Leipzig (Chapter 9). Or in many cases jobs were not available: Barbara Freire-Marreco, with a certificate of a largely postgraduate program in anthropology at Oxford and a college scholarship at Somerville College, Oxford, never acquired a full-time appointment, although she continued to write, edit and publish in anthropology (Chapter 1).

The second type consists of women who taught and did research in low-rank positions in an academic laboratory or department. These included Karl Pearson's women students in his Laboratory of Eugenics (Chapter 7) and the female staff of Daniel Jones' Department of Phonetics (Chapter 9), both at University College London. Mary Haas was supported by postdoctoral fellowships at Yale in the 1930s and 1940s (Chapter 9).

A third category was those women who received professorships at women's colleges or co-educational universities. Jeanne M. Vidon-Varney, for example, received a university doctorate (lower than the state doctorate) in phonetics at the Sorbonne, and then found a teaching position at Barnard College, a women's college affiliated with Columbia University;

[16] Margaret W Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore, 1982), Chapters 1 & 2; 'Helen Magill White', in *Encyclopedia Britannica*, 2018, https://www.britannica.com/biography/Helen-Magill-White; Karen Hunger Parshall, 'Training Women in Mathematical Research: The First Fifty Years of Bryn Mawr College (1885–1935)', *The Mathematical Intelligencer*, 37/ 2 (2015), 71–83.

[17] Barbara Sato, *The New Japanese Woman: Modernity, Media, and Women in Interwar Japan* (2003), 26.

[18] Ruth Hayhoe, *China's Universities, 1895–1995: A Century of Cultural Conflict* (New York, 1996), 38, 46.

[19] For the Chinese case, see Denise Gimpel, *Chen Hengzhe: A Life between Orthodoxies* (2015), 1–2, 22–3. For Japan's conservatism in providing higher education and opening university positions to women, see Anne M. Harrington, 'Women and Higher Education in the Japanese Empire (1895–1945)', *Journal of Asian History* 21 (1987), 178–86.

she finally became a professor of French at Columbia in 1958. Another Sorbonne graduate in phonetics became a lecturer at Wellesley College in 1935 and later at the College of William and Mary (Chapter 9). Indeed, women's colleges were usually women's best hope for a teaching and research career, although some co-educational institutions began to hire women.

The fact that French women scholars found jobs in the United States suggests that it was harder for women to pursue an academic career in France (and likewise Germany) than in the US. The interwar decades constituted a period of transition for women's academic employment. Though the earliest appointment of women in academics took place before World War I, a small but signficant number of women received research education or doctorates between the wars. The number of them who found teaching or research positions also ticked up. Jones' lecturer Ida Ward received a professorship at SOAS in 1944, Haas a faculty position at Berkeley in 1948, and Vidon-Varney a full professorship at Columbia in 1958 (Chapter 9). These dates indicate that it was only after World War II that academic appointments of women opened substantially; even then, gender discrimination was a reality of life for female scholars.

Nations, States, Colonies, and Scientific Globalization

An important reason for the success of Berlin (and Prussian universities in general) as a leader of European higher education was the state's support and investments towards research, which were extraordinary in comparison to the other European countries. Already in the lead, German universities celebrated a further boom after the unification of Germany, as the country was enriched by industrialization. France and Britain, though wealthy and powerful, did not sufficiently recognize the value of research, much to the chagrin of their intellectuals who saw German academia charge ahead in Europe. France started seriously spending on academic research only after the Third Republic was established in the 1870s. As Howarth shows, in England it was the college culture of Oxbridge that resisted change. Thus Parliament, representing state power, had to impose reforms on these two ancient universities with national legislation. In the US, the land grants of the federal government after the Civil War helped jump-start some fine state universities. This factor should not eclipse the US-specific phenomenon that private universities relied on philanthropy that was generous to an extent envied by their European peers.

Some of the most important initiatives in the history of higher education were motivated by nationalism. The foundation of the University of Berlin was partly a result of a nationalistic reaction to Prussia's defeat by

Napoleon. The reason why the other German states were relatively quick to accept the Prussian higher education reform was a result of nationalism, both particularist and pan-German. During the Vormärz period, German intellectuals called loudly for a unified country. Powerful German princes had to work hard to show their mandate as the unifier, while small ones endeavored not to be overshadowed by their larger peers. Each looked to strengthen his cultural capital by elevating the standing of his state's university, through staffing it with famous scholars and building appropriate infrastructure when necessary. Systematic higher education reform gained momentum in France only after the country suffered a humiliating loss to Prussia in 1870–71. Britain sensed little urgency for reform in part because the nation experienced no survival crisis. Leading American institutions began or accelerated their reorganizations after the Civil War, in part in the image of Germany. In the eyes of Americans, Germany, like their own country, was working for unification after a series of wars, and experiencing similar industrial and social developments. Americans were the most enthusiastic followers of German academia until the First World War.[20]

A foreign institution for non-Western societies, the university was often accepted at moments of national crisis. Some of these societies had had institutions of learning that educated their traditional elite. In imperial China and Korea, it was the centuries-old Civil Service Examinations and the associated web of private schools and state programs that prepared their intellectual, political, and cultural elite. In Muslim societies, it was the madrassa. Few of these societies voluntarily gave up their institutions for the Western educational system that was topped by the university. Japan and China accepted the university as the Western powers' aggregation made it clear that their survival was in serious danger. In India, Korea and Taiwan, it was the colonial rulers who made the decision. For all these societies, the university was at the heart of Westernization, serving as the institution that trained the country's new elite to staff the modern state machine. For the countries that managed to keep their sovereignty, the university also promised to strengthen them with science, technology, and economic growth against aggressive powers. In many societies—Japan, China, and India, for example—within a few decades the newly introduced university (or college) became the exclusive institution where the new elite received their education.[21]

[20] Jurgen Herbst, *The German Historical School in American Scholarship: A Study in the Transfer of Culture* (Ithaca, NY, 1965), 9–10.

[21] In contrast, Egypt, chief among Arabic countries in terms of Muslim institutions of learning, has kept the great Madrassa Al-Azhar open along with universities.

Political stability and economic prosperity were often the preconditions for the development of higher education in non-Western and Western societies alike. This was clear for Latin American countries. As Ana Alfonso-Goldfarb, Márcia Ferraz, and Silvia Waisse show in their chapter, independence did not bring peace and prosperity to Latin American countries. Most of them were mired in frequent border conflicts, civil wars, coups, dictatorships, and economic troubles thereafter. Peru was able to introduce a university reform in the 1850s and 1860s thanks to its economic boom from the guano trade. It introduced doctoral programs that addressed research in the 1870s. Argentina likewise began its higher education renewal at the turn of the twentieth century and set up sustained doctoral training thanks to its prosperous agricultural export. Doctoral programs that supported research also began in Mexico when the country recovered from political turmoil in the 1920s. Likewise, the university in Rio de Janeiro, the capital of Brazil, was reorganized as the industrialization after World War I generated an economic boost to the relatively peaceful republic. When the central government became repressive, Brazilian intellectuals found shelter at the University of São Paulo under the auspice of the autonomous state government. As Danian Hu and Hsiao-pei Yen note in their chapters, it was difficult for universities that were opened (or reopened) after the founding of the Chinese Republic to support research, for they were plagued by financial shortage, a result of endless civil wars. By comparison, the United States and Japan enjoyed a relatively unbroken growth of higher education until the Great Depression (which affected almost all countries worldwide), thanks to continuous political and economic stability.

A common theme in the early phase of university education in non-Western societies was the presence of foreign instructors. This of course was not exclusive to these societies. Saussure, who was Swiss, taught in Paris, for instance. The French case, however, was not comparable with their non-Western counterparts in scale. The staffing of foreign instructors was common, or even inevitable, for societies that started university education on their own, especially at a time when all university disciplines were new to them. This had been the case in Japan and China before they were able to recruit enough properly trained domestic scholars for their universities (Chapters 11, 13 and 14). In Latin America, university teaching and research likewise often depended on foreign professors who received training in Europe (Chapter 10). In India, Taiwan, and Korea, colonial rulers imposed a new system of education upon local societies, filled the teaching staff, first exclusively and then dominantly, with instructors from the metropole (Chapters 12, 15, and 16). This transition often took decades to complete.

Overseas study was another common theme for Western and non-Western countries alike. European students constantly studied at universities of foreign countries from the earliest time of universities in the Middle Ages through the early modern period. Russian and Muslim students joined the study tours beginning in the eighteenth century. The transatlantic flow of students started in the sixteenth century with the ambitious Latin American elite, who sought a degree or study experience at Salamanca, Coimbra, or other prestigious universities in the Iberian Peninsula. Starting in the nineteenth century, the number of international students increased dramatically while the countries of their origins diversified. The Latin American transatlantic flow was outnumbered by North American students. More than ten thousand Americans travelled to German universities for the PhD, pre-doctoral or post-doctoral study before World War I. Japan sent dozens of students to Europe and the United States for advanced education every year in the late nineteenth century, and the number grew to hundreds in the first half of the twentieth century. Chinese students followed Japan's lead to travel westward for advanced education. Their favorite destination country was in fact Japan, which was much closer and more inexpensive than Western countries, and had a written language containing many Chinese characters. Japanese and Chinese, never formally colonized, were free to study at a country of their own choice (or that of their funding agency). For the Japanese, Germany was a regular destination for law, medicine, and the humanities, although for chemistry or natural sciences in general, Britain and the United States were major destinations thanks to the ties of the first generation of foreign instructors (Chapter 11). While wealthy students made international study tours at their own expense, the others went on scholarships from national, local, and even colonial governments. Indeed, government scholarships for study abroad were a phenomenon common to almost all countries.

Latecomer countries in research education often tried to replicate back home the hardware and software that they were familiar with abroad, though with local adaptations. Sometimes the incentive to do research was imposed or adopted by foreign instructors, and sometimes it was proposed by returnees from Western universities. The seminar, the laboratory, statistics, fieldwork, and so forth, were accepted as instruments for training junior scholars, though adapted to meet local realities. As Yoshiyuki Kikuchi and Chen, Chou and Chang point out, in Japan and Taiwan (then ruled by Japan), the seminar was not just a class in which a professor and his own students met. It was instead an organization that interested scholars and students in all universities and colleges (and sometimes academically-minded high school teachers) in the region to gather and study the latest literature published in foreign languages, and to present

their works in progress. Kikuchi also shows that professors of chemistry at Tokyo reorganized their laboratories to adapt to different groups' power structures and preferred teaching styles.

The opening of universities cannot be equated, then or now, with support for research or doctoral programs. There were at least three obstacles to the founding of the research university. First, universities were very elite when first introduced, accepting only a tiny number of students. The state and its clientele had little interest in a still higher degree as long as the university fulfilled its primary function to train qualified personnel for modern bureaucracy, professions, and businesses. The second obstacle was associated with the first. The role of researcher was non-existent in Japan at first,[22] and in fact in many other societies. It generally took societies a long time to appreciate the value of research and then to support it. The early success of chemistry in gaining a doctoral program in Argentina, for instance, was not due to the country's recognition of scientific research for its own sake, but to the wide applications of chemistry to industry, agriculture, and public health (Chapter 10). Third, the previous development in the nineteenth century in Europe had upped the ante for funding scientific research. The lavish chemical laboratories in Germany that were constructed in the 1860s and later each cost hundreds of thousands of marks (Chapter 3). The collection and the international postage of specialized journals in each discipline, proliferating in major Western countries, also demanded extra funds. The expenditure for raw material and accessories was another issue. Fortunate to have teaching laboratories early on in Tokyo, professors of chemistry had no funding for research. As a result they diverted funding from teaching to pay for research. Funding for university research, or the establishment of research institutions, became available only at the turn of the twentieth century and especially after World War I (Chapter 11). In China, state universities lacked funding for research. It was a missionary institution, Yenching University, that first offered steady support for research in physics, thanks to the generous endowment of the United States-based Harvard-Yenching Institute (Chapter 13).

Colonized peoples often had to wrangle with their alien rulers for educational resources, or provide their own. Colonial rule often first introduced the conflict between traditional learning and Western knowledge. A few decades into colonial rule, employment opportunities (as physicians, lawyers, teachers, or state employees) made the local population aware of the value of modern education. They thus asked for access to education

[22] James R. Bartholomew, *The Formation of Science in Japan: Building a Research Tradition* (New Haven, 1989), 68–87.

for their children. First motivated by exploitation of human and material resources, colonial rulers dispensed very limited educational resources for their subjects. Their instinct was always to train servants instead of independent thinkers in colonies. In India and Korea, missionaries and the local elites established colleges in addition to the limited number of state-funded colleges or universities. The most ambitious of the traditional landed elite or newly rich sent their children to the metropole of the empire for higher education. Successful merchants, such as Kamsetji Tata (1839–1904), endowed the Indian Institute of Science, an institution for advanced research in natural sciences. In Korea and Taiwan, the local elite proposed to open a university with their own resources (Chapters 15 and 16). Only then did the colonial governments respond by opening the sixth and seventh imperial universities of Japan in Seoul and Taipei. Ironically, even thereafter racial discrimination made it harder for local students to enter colonial universities than universities in the metropole. Thus, well-to-do Korean and Taiwanese students continued to pursue higher education and even doctoral training in Japan. A small number even traveled to the West for this purpose.

Racial discrimination came together with the resistance of colonial subjects. As Mathew and Sohoni show, the few museums or other facilities in India with research functions were always staffed by the British at first. Over time, the Indian elite developed interest in sciences, and some successful entrepreneurs and philanthropists, such as Tata, endowed research institutions that were mean to promote Indian science and scientists. Indeed, local students of science with outstanding qualification, like Homi Bhabha, increasingly won research positions. In the interwar decades some of them worked with Indian nationalists for the project of an independent country.[23] The resistance in Korea was also strong. As Yeo shows in his chapter, the Korean resistance found shelter in the Severance Union Medical College, which, supported by Western missionaries, provided an alternative of new education, scientific research, or even modernity in general to the state-controlled imperial university.

Empires themselves invested resources in particular areas of research that sometimes created a double irony. Over the nineteenth and the first half of the twentieth centuries, states increasingly invested in research that benefited governance. The rulers in India, Korea, and Taiwan established institutes, in or independent of universities, to study the natural resources, languages, history, and society of the colonies (and even the empire's targets of expansion). Often the locals were trained and employed to help

[23] Pratik Chakrabarti, *Western Science in Modern India: Metropolitan Methods, Colonial Practices* (Delhi, 2004), 272–97.

with the taming or control of their own people, the first irony. After emancipation, these local employees often formed the nucleus of higher education research forces that trained new generations of researchers, the second irony.

Oppressive imperialism and rising nationalism in the colonies, which were prone to clash with each other, did not stop the flow of students to the metropoles. The flow of international students has been noted above. Colonial subjects often had little choice but to travel to the metropole of the empire for advanced study. Thus Indians headed for Britain, while Korean and Taiwanese students headed for Japan. Those who studied abroad often had the ambition to modernize their home society with their knowledge of science and institutions in advanced countries. They also aspired on a personal level to the elevation in social, economic, and even political status that returnees often enjoyed. These reasons made higher education remarkably global in the age of first globalization.

This age also witnessed a scale of international cooperation and foreign aids never seen before. Once imperialist powers had forced non-Western countries to open for trade and Christianity, missionaries established colleges and universities there, usually with funds from their home societies. Sometimes Western governments endowed scholarships for non-Western students, such as the study-abroad scholarship that was created with China's indemnity payments to the United States government for the Boxer Rebellion, which educated a generation of leading Chinese intellectuals in American universities. Western philanthropies were also active in non-Western countries. Yenching University enabled the education of the first generation of physicists, male and female, in Beijing (Chapter 13). The Rockefeller Foundation supported various programs in China (Chapter 13), Argentina (Chapter 10), and many other countries. Although these philanthropies had their own agendas, and were thus not simply altruistic, they supported local developments and to some degree international collaboration in education and research. Even world wars did not stop international collaboration. The International Federation of University Women was created right after the Great War to promote women's solidarity, mutual understanding, and intellectual exchange across national borders.[24]

The internationalization of academia and scientific research was to a great extent the result of the so-called first wave of globalization. Between 1880 and 1914, the world saw a historically unprecedented surge in integration due to a huge drop in transportation costs, a fall of tariffs, a

[24] Christine von Oertzen, *Science, Gender, and Internationalism: Women's Academic Networks, 1917–1955* (New York, 2014).

vast flow of capital, and massive migration of people to unpopulated regions across national borders.[25] The same factors supported the movements of foreign teachers and students, the multiplication of international scholarly organizations, increasingly frequent international congresses, the rising scale of international philanthropy, and the replication of advanced academic culture and institutions at home.

The internationalization of research education, however, differed from economic globalization in several regards. First of all, while the British Empire was the greatest promoter of the first globalization, Germany was the leader of scientific research during this period (Chapters 2, 3, 4, 8), the model to which Britain and France looked for higher education that pursued scientific research. Germany also invested much more heavily in universities than its peers, even though Britain and France industrialized earlier and accumulated greater wealth. Most American students or junior scholars travelled to Germany instead of Britain or France for research education. In addition, scientific globalization did not take place on a homogeneous ground. 'Empire effects' were significant in conditioning the flow of students and scholars and the organization of higher education.[26] Scientific internationalism continued even when trade barriers went up to stop the first globalization in the wake of the First World War. Universities that supported research and training in research did not arrive in some countries, Brazil for example, in the first age of globalization, although São Paolo was an important center of industrialization at the time.[27] Research education globalized, though not at the same pace with economic globalization.

A New Beginning

The period from 1845 to 1950 set the foundation for research education in many parts of the world. The case studies in this volume provide a general

[25] *Globalization, Growth, and Poverty* (New York, 2002), 23–6; Thomas Piketty, *Capital in the Twenty First Century*, trans. Arthur Goldhammer (Cambridge, MA, 2014), 395; Christopher M. Meissner, 'New Perspectives on the First Wave of Globalization', *NBER Reporter*, 1 (2015), 13–16; Luigi Pascali, 'The Wind of Change: Maritime Technology, Trade, and Economic Development', *American Economic Review*, 107/9 (September 2017), 2821–54.

[26] We are using Niall Ferguson and Moritz Schularick's term of 'Empire Effect' to mean a different effect, but comparable to what they describe. For the authors it was lower interest rates, accessible to colonies within the British empire, that facilitated the flow of capital to colonies. Niall Ferguson and Moritz Schularick, 'The Empire Effect: The Determinants of Country Risk in the First Age of Globalization, 1880–1913', *The Journal of Economic History*, 66/2 (2006), 283–312.

[27] Danilo Antón, 'Latin America: Five Centuries of Globalization', *Macalester International* 6 (1998), 30–1. Note that the author sees the globalization in the late nineteenth and early twentieth centuries as the second wave of globalization for Latin America.

picture over this time frame. Before 1848, philological and historical seminars, as well as a small number of research groups in the physical and biological sciences, had consolidated their places in German universities. Between 1848 and 1870 the chemical laboratory (e.g., Liebig at Giessen) and the mathematical seminar (e.g., Jacobi at Königsberg) transformed from what had been an exceptional presence to a regular one in German academia. From 1870 to World War I, France, Britain, the United States and the other Western countries worked to catch up in the humanities and experimental and theoretical sciences by reproducing the German model at home, though always with local adaptations. This was the first period of rapid expansion and specialization for higher education in Europe and the US. During the interwar period, the German hegemony in science waned due to the crippling postwar economy, while French, British, and especially American science flourished. British universities finally introduced the PhD at the end of the Great War, even though their humanists were slow to embrace the degree.

The non-Western countries were (and still are) too diverse to fit into a single picture. The Latin American countries, sometimes known as 'the other West',[28] had domesticated European higher education in their colonial period. Amid the protracted post-independence political and economic troubles, individual countries like Peru, Argentina, Mexico, and Brazil in turn introduced doctoral programs that required research, usually in moments of relative political stability and economic prosperity. In the mid-nineteenth-century British colony of India, colleges were established that emphasized literary education on the English model, while Japan mixed elements of diverse models into its own system that started as part of its program of Westernization in the 1870s. In these two countries, support for research and research education became regularly available in the first half of the twentieth century. This was reproduced in Japan's colonies in Korea and Taiwan in the 1920s. University education replaced the Civil Service Examination in China at the turn of the twentieth century and research education, though limited, was provided later in the century.

Thus, by 1950 all the countries surveyed in this volume had accepted the value of research for their best universities. Seeing original research as what distinguished themselves, these institutions provided research education, even if sometimes very limited, to the most promising students preparing for the academic profession. In some countries, China for example, doctoral programs were not available. There, academics admired

[28] Marcello Carmagnani, *The Other West: Latin America from Invasion to Globalization* (Berkeley, 2011).

Western higher education as it provided solid doctoral training, thus preferring Western doctorates for their new recruits. Most of the countries that had no universities before World War II opened their own soon after 1945. For these countries, the opening of a national university (or more) served as a declaration of their political and cultural autonomy. Their universities then followed the paths that their non-Western peers had heralded to support research education. As seen above, in these countries research education was often offered at the graduate level. Graduate education, especially doctoral, has become the highest education across the globe. Thus, World War II marked a new beginning, even though conditions that had started before the war continued partially thereafter for a short while, as in Taiwan and Brazil. Before 1945 doctoral or graduate education had almost universally remained a thoroughly elitist entity, and only a very small number of doctoral degrees were awarded annually. From about 1950 on, doctoral education experienced remarkable global expansion.

Today, research universities sometimes have more graduate students than undergraduates. Altogether the countries of the world award tens of thousands of doctorates a year, led by the United States and China. In the nineteenth century, a researcher in a museum, a scientific academy, or a factory may have completed their training and career all in one institution. Now, museums and the R&D departments of big corporations expect their positions for advanced research to be filled largely by those who have PhDs. The relationship between universities and industry are much closer than a century ago. It is also easier for women to lead an academic career. Scientific globalization has reached a new height. The global foundation for all these developments was laid in the period that is surveyed and analyzed in this volume.

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