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The knowing world: A new global history of science

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Abstract

This article proposes a new global approach to the history of science centered on questions of geopolitics, historical consciousness, and cultural identity. Arguing that the field is now at a crossroads between its longstanding focus on the history of the natural sciences in the Western world, and the prospect of some form of worldwide history of science, the article describes a new undergraduate lecture course, designed by the author and taught at Rutgers and Harvard since 2015, which neither begins in Western Europe nor culminates with the United States. It aims to articulate an original vision for the field on this basis. Histories of science can and should offer deep histories of the global present, it is argued, by rethinking how historical narratives involve geographical decisions about where to focus analytical attention (and where not) and tackling narrative and geography together as linked issues. The approach proposed here is neither *science in context* nor *knowledge in transit* but engages the notion of a *knowing world*: one made up of multiple scientific cultures and long historical memory, and requiring dialectical movement back and forth across both space and time on a worldwide scale to grasp the scientific past's importance for the present, as well as the present's impact on how we perceive the past. Explicitly addressing polemics of identity, culture, race, and nationhood can help us to construct a more civic-minded and geopolitically informed history of science of use in the changing circumstances of the twenty-first century.

Keywords

Global history, geopolitics, nationalism, teaching, historiography, methodology, narrative, history of science, modernity, imperialism

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The past is present: Science, geopolitics, and memory

The Five-Hundred-Meter Aperture Spherical Telescope, known as FAST, has attracted considerable international attention. Constructed by the Chinese in Guizhou Province, in Southwest China, it is the largest radio telescope ever built. FAST is striking: a vast metallic crater resembling a gigantic steel drum, it sits nestled in a lushly picturesque if arduous mountain landscape. A *New York Times* story about the installation published in 2016 led with the possibility that the Chinese may now become the first people to establish contact with extraterrestrial life through their prodigious new capacity for deep-space communications (the Chinese also recently became the first nation to land on the far side of the moon). The *Times* article also mentioned how the construction of the telescope necessitated the displacement of local inhabitants by the Chinese government. Most memorably, the authors of the article, Chris Buckley and Adam Wu, quoted several Chinese astrophysicists about the significance of FAST both for science and for China. Their remarks were particularly interesting because they linked the pursuit of "pure science" to the conscious pursuit of national prestige. "Astronomy is an ultimate expression of 'pure' science … [and] a luxury that only the most advanced economies enjoy," Luis Ho commented. "Now we're racing to catch up and want to recreate the glories of our ancestors," observed another, Zeng Chengmin. This is "the first time that China will have an unsurpassed opportunity to be at the international forefront of deep space exploration." The *Times* article ended with the suggestion that American researchers may in future be afforded some access to the information FAST collects, but leaves the reader in little doubt as to the nationalist spirit that animates current Chinese science.[1]

Buckley and Wu concluded that "China's history of subjugation to the West in previous centuries reinforced the belief that scientific prowess is essential for any modern power." But they did not explain or detail the history behind this statement. Early modern history and past polemic are indeed present in the story of FAST and continue to resonate. Guizhou Province has long been subject to the ambitions of the Chinese state: in the seventeenth and eighteenth centuries, it was incorporated into the expansionist Qing empire, entailing the administration of the Miao people as ethnographic subjects and their military subjugation. Most striking for our purposes is the way in which the rhetoric of China's new primacy in the "luxury of pure science" responds to narratives of Chinese isolation and scientific retardation. The most influential such interpretation, by the twentieth-century British sinologist Joseph Needham, championed the extraordinary technical inventiveness of East Asian civilization but sought to account for its lack of a scientific revolution and failure to invent modern science through theoretical innovation. Today, however, China seeks to reverse such narratives – including its troubled twentieth-century history of foreign invasion and the debacle of Maoism – by laying claim to a prized cultural status symbol: the pursuit of knowledge for its own sake, with no immediate

1. Chris Buckley and Adam Wu, "China Hunts for Scientific Glory, and Aliens, with New Telescope," *New York Times*, September 26, 2016; see also Ross Andersen, "What Happens if China Makes First Contact?," *The Atlantic*, December 2017, <www.theatlantic.com/magazine/archive/2017/12/what-happens-if-china-makes-first-contact/544131/> (accessed December 2018).

practical application. In a momentous shift, its scientists now speak openly of seizing the geopolitical moment in science as well as economics. The recent documentary on de-extinction entitled *Genesis 2.0* (2018) features Huanming Yang, chairman and co-founder of Shenzhen-based BGI Genomic Services – the world's largest genomic sequencing center – declaring his ambition to collect the DNA of every living organism on earth. An event Yang did with J. Craig Venter in Singapore in 2012, whose Q&A may be viewed online, palpably suggests a changing of the guard. Indeed, the authors of *The Times*' article on FAST, published as Donald Trump was winning the 2016 presidential election, convey the sense of being uneasy witnesses to a historic transfer of scientific ambition away from American shores. Such ventures demonstrate how the deep scientific past and polemics about culture, modernity, and identity are very much in play in the present, even as they resonate in new ways, with presumptions of Western primacy *knowingly* challenged by other powers.[2]

In South Asia, Prime Minister Narendra Modi has promised to make India one of the world's top three scientific powers in the coming generation, joining the United States and China. It is perhaps unsurprising, therefore, that polemics about the heritage of Indian science have accompanied the intensification of *Hindutva* – a hegemonic form of Hindu nationalism promoted by Modi's ruling Bharatiya Janata Party (BJP). In 2015, a speaker at the annual Indian Science Congress stated – to the chagrin, it should be noted, of those Indian scientists present – that evidence for the existence of airplanes in ancient India could be traced to the Vedas, the scriptural basis of Hinduism. Modi has himself suggested that the elephantine Hindu deity Ganesha may be evidence that ancient Indians mastered genetics and plastic surgery. Meanwhile, a petition with over 18,000 signatories was organized to call on Harvard University Press's Murty Classical Library of India, which publishes English translations of ancient Indian texts, to remove the series' American editor Sheldon Pollock. The petition cited Pollock's criticism of India's increasingly authoritarian government and his alleged disrespect for "the greatness of Indian civilization," and recommended that such projects should be directed only by Indian nationals. At the same time, India was being courted on the world stage as a vital partner in the campaign to reduce carbon emissions worldwide through the 2015 Paris climate accords. The international press heralded Modi's friendship with U.S. President Barack Obama. This new respect was "sweet," *The Guardian* commented, because "India has long felt slighted by the global powers."[3]

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2. Buckley and Wu, "China Hunts" (note 1); Laura Hostetler, *Qing Colonial Enterprise: Ethnography and Cartography in Early Modern China* (Chicago: University of Chicago Press, 2001); Joseph Needham, *Science and Civilisation in China*, 7 vols. (Cambridge: Cambridge University Press, 1954–); Robert Bickers, *The Scramble for China: Foreign Devils in the Qing Empire, 1832-1914* (London: Penguin, 2011); *Genesis 2.0* (dir. Christian Frei, 2018), <www.genesis-two-point-zero.com> (accessed January 2019); Yang and Venter Singapore Q&A (2012), <www.youtube.com/watch?v=rjMhEs5rCcc> (accessed January 2019); Dennis Normile, "China's Sequencing Powerhouse Comes of Age," *Science* 335 (2012): 516–19.
3. Rama Lakshmi, "Indians Invented Planes 7,000 Years Ago," *Washington Post*, January 4, 2015; "Removal of Sheldon Pollock as Mentor and Chief Editor of Murty Classical Library (2015)," <www.change.org/p/mr-n-r-narayana-murthy-and-mr-rohan-narayan-murty-removal-of

But like *The Times*' article on FAST, *The Guardian* failed to provide its readers with any historical context to situate its account of the present geopolitical moment. As with FAST, only more so, the scientific past irrepressibly animates the polemics of what the Indian philosopher of science Meera Nanda has provocatively called "Hindutva's science envy" and the question of India's status as a world power today. The claim that modern scientific and technical achievements have Vedic antecedents – there have also been arguments over Vedic origins for quantum mechanics – might be fanciful, but they are not entirely without precedent. As historian Gyan Prakash demonstrated in *Another Reason* (1997), the nineteenth century witnessed concerted attempts to reconcile India's ancient intellectual heritage with the prestige of modern Western science, introduced by the British in the context of imperial rule and the claims of Orientalism: the study of Indian civilization by European scholars, which contrasted alleged Indian decadence and poverty with Western industrial progress and material prosperity. The legacy of Orientalism is essential to understanding the furor over *Hindutva* in all its complexity. There are those aligned with the BJP, who seek to exploit anticolonial nationalism to suppress political dissent, and there are those like Nanda, who defend freedom of speech and reject nationalist scientific claims by insisting that Indian science is simply inferior to its modern Western counterpart. The history of Indian manufacturing bears heavily on the present too. Mohandas K. Gandhi invoked native traditions to imagine a future of *Swaraj* (self-rule) based on technoscientific autonomy, symbolized by his *Dhoti* and *Charkha* (a Hindu garment and spinning wheel). With British imperial restrictions lifted by decolonization, India could finally return to its high pre-modern levels of manufacturing and become a world industrial power. Obama's embrace of Modi in 2015 thus arguably represented the culmination of India's *return* to the world stage, with an American president conceding that Indian industrial policy would now shape the earth's common ecological future.[4]

Both FAST and *Hindutva* feature in an introductory undergraduate lecture course on the history of science I have taught at Rutgers and Harvard since 2015, centered on questions of geopolitics, memory, and cultural and racial identity. The history of science currently finds itself at a crossroads between longstanding narratives of the rise of modern Western science; critical studies of Western sciences (including histories of science and empire); and the as yet largely unrealized prospect of some form of global story about the sciences. There have been numerous brilliant intercultural histories of scientific knowledge in recent years on many different parts of the world, executed on a range of historical and regional

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-prof-sheldon-pollock-as-mentor-and-chief-editor-of-murty-classical-library> (accessed August 2018); Sanjay Krishnan and Teena Purohit, "Swadeshi Indology and the Destruction of Sanskrit," *The Wire*, March 10, 2016; "Prime Minister Modi Says India Intends to Join Paris Climate Agreement This Year," *The Guardian*, June 7, 2016. For similar nationalist tendencies in historiography in China, see Jeremiah Jenne, "Chinese Academy of Social Sciences Throwing Shade at the New Qing History (April 23, 2015)," <www.jeremiahjenne.com/the-archives/2018/4/8/chinese-academy-of-social-sciences-throwing-shade-at-the-new-qing-history> (accessed August 2018).

4. Meera Nanda, "Hindutva's Science Envy," *Frontline*, September 16, 2016; "Meera Nanda's Freudian Slip Reveals her Hinduphobia," *Hindu Post*, September 6, 2016; Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton: Princeton University Press, 1999), esp. pp.190–226; "Prime Minister Modi," *The Guardian* (note 3).

scales, but some form of coherent approach that productively links such work together and addresses questions of narrative has remained elusive. My course, and this article, are an attempt to sketch such an approach, one that draws such histories into relation rather than keeping them separate, to help move the field in revealing new directions and encourage others to do likewise. This is in no way to demote or usurp the authority of regional specialists on whose linguistic expertise and deep historical knowledge my aim to sketch a larger picture of course relies. Rather, it is precisely to promote the importance of their work for our field as a whole, and not just among fellow specialists but also among students and ultimately the general public. Some working knowledge of and basic conversancy with the deep world history of science should be required of us all. One obvious context for this recasting of the field is, of course, the ascendancy of the Asian and Middle Eastern economies and techno-sciences – *Nature* has reported that Chinese scientific papers outnumbered U.S. papers for the first time in 2016 – not to mention the increasing fragility of the European Union and the Trump Administration's militant opposition to climate science in the United States, suggesting that Western scientific primacy may be coming to a historic end. But the deeper claim on our attention is arguably the sheer intellectual excitement in grasping how so-called Western and non-Western histories have been intertwined and mutually defining, and therefore concern us all, whether our research focuses on the Global North or the Global South.[5]

In what follows, I present an exercise not in research-led teaching but an example of teaching-led research and synthesis: neither a manifesto nor the projection of a formal program but a specimen of that rare yet hopefully useful genre – a dispatch from the classroom. I describe my course and on this basis aim to articulate an original vision for our field. The approach is neither *science in context* nor *knowledge in transit* but explores instead what I call *the knowing world*: a planet made up of multiple scientific cultures and long memories of past judgments about who possesses the requisite faculties and resources to count as scientific and therefore modern, and who does not. I argue that this deep historical memory is entirely consequential for our understanding of the geopolitics of science, both past and present, especially because of the resurgence of nationalist politics and identity-mongering as our most recent era of globalization appears to give way to a new xenophobic territoriality. As I have already aimed to show in my introductory account of the deep histories at work in FAST and *Hindutva*, grasping the full significance of the scientific past's relation to the geopolitical present requires *dialectical movement back and forth across space and time*. That is to say, we need to consider how

5. Jeff Tollefson, "China Declared World's Largest Producer of Scientific Articles," *Nature* 553 (2018): 390, <www.nature.com/articles/d41586-018-00927-4> (accessed August 2018); Bruno Latour, *Où atterrir: Comment s'orienter en politique* (Paris: La Découverte, 2017). It would be impossible to do justice to the richness of recent scholarship on science that may be defined as global, and my notes in this essay will largely (through not exclusively) refer to materials used in the course. For additional references to the literature on early modern science in a worldwide context, see the bibliography in James Delbourgo, *Collecting the World: The Life and Curiosity of Hans Sloane* (London: Penguin, 2017). For slightly differing versions of the syllabus as used during 2016–17, see <https://cla.umn.edu/premodern/news-events/news/globalizing-history-science> (accessed August 2018). Readers interested in more information about student assignments used to date are invited to contact the author at jdelbourgo@history.rutgers.edu

the deep past has shaped the present; how present circumstances re-shape our view of the past; how the idea of *modern science* has shaped perceptions of both Western and non-Western societies; and to grasp how perceptions of science's narrative and its geography work in tandem. The sooner we explicitly address how polemics of cultural identity color perceptions of science, the sooner we might begin to construct a new civic-minded, pluralistic, and geopolitically informed history of science of use in the twenty-first century.[6]

Trajectories: From London and Philadelphia to Jamaica and beyond

Before describing the course, it seems useful to situate my approach to it through a brief autobiographical note. I trained at Cambridge and Columbia as an early modern European and colonial historian of science, receiving my doctorate in 2003. I have published monographs on electricity in eighteenth-century North America and on the formation of the natural history collections of Hans Sloane (1660–1753), which resulted in the foundation of the British Museum; and I have co-edited collections of essays on science and empire in the Atlantic world, and the history of go-betweens in the production of scientific knowledge around the turn of the nineteenth century. While conducting research on experiments with electric eels in eighteenth-century Dutch Guiana, the focus of my initial research shifted from the laboratory to the field (to use slightly anachronistic terms) and showed me how natural philosophy and natural history were related rather than entirely discrete endeavors. This shift raised pressing questions about the interactions between Amerindians, Africans, and Europeans in the making of scientific knowledge – a theme I later pursued in the first part of my book on Sloane, which examines Sloane's voyage to Jamaica (1687–9) and extensive interactions with the island's enslaved Africans over a period of fifteen months, as he collected hundreds of plants, animals, and curiosities.[7]

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6. Jim Secord, "Knowledge in Transit," *Isis* 95 (2005): 654–72. The class I have taught at Rutgers is listed under the inherited title "Science and Society"; at Harvard, I taught it as the introductory course in the Department of History of Science entitled "Knowing the World." I mean no disparagement to manifestos and have benefited in particular from the following special issues: Lissa Roberts (ed.), "Science and Global History, 1750–1850: Local Encounters and Global Circulation," *Itinerario* 33 (2009): 7–95; and Sujit Sivasundaram (ed.), "Global Histories of Science," *Isis* 101 (2010): 95–158; see also Fa-ti Fan, "The Global Turn in the History of Science," *East Asian Science, Technology and Society: An International Journal* 6 (2012): 249–58; Arun Bala, *The Dialogue of Civilizations in the Birth of Modern Science* (Houndmills: Palgrave Macmillan, 2006), pp. 7–20; Gabriela Soto Laveaga and Pablo Gómez, "Introduction," *History and Technology* 34 (2018): 5–10; Jo Guldi and David Armitage, *The History Manifesto* (Cambridge: Cambridge University Press, 2014).
7. James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in Early America* (Cambridge, MA: Harvard University Press, 2006); James Delbourgo and Nicholas Dew (eds.), *Science and Empire in the Atlantic World* (London: Routledge, 2007); Simon Schaffer et al. (eds.), *The Brokered World: Go-betweens and Global Intelligence, 1770-1820* (Sagamore Beach, MA: Science History Publications, 2009); Delbourgo, *Collecting the World* (note 5).

A pivotal chapter in the second part of the book examines Sloane's worldwide correspondence network, which supplied the majority of his rarities, and which I wrote in part by drawing insights from the go-betweens project in which I participated (published in 2009 as *The Brokered World*). Researching Sloane's networks obliged me to read into several different regional histories in order to understand his ability to procure objects from travelers who interacted with many different populations in various parts of China, Japan, India, the greater Caribbean, North America, and beyond. I became acutely aware that all roads in Sloane's story would necessarily lead back to London, but I felt it should be possible to re-visit the kinds of exchanges that built Sloane's collections and re-envisage them from other vantages. Up to this point, I had taught several undergraduate courses at McGill and Rutgers on Enlightenment science in a transatlantic context, the history of early modern science and empire, and a classic survey of Western science from the Greeks to contemporary U.S. biotechnology. Trained as I was in synchronic and micro-historical approaches, this last course proved particularly disheartening due to its scale, Western focus, and inability to situate the sciences in deeper cultural contexts. Frustrated by the seeming inevitability that any longue durée science narrative would be Western-centered and progress-driven, researching Sloane's networks revived my curiosity to experiment with new narrative orientations. So much meaning is encoded in narrative structure itself, I concluded, that this structure simply had to change. I therefore decided not to teach another science and empire class but to design an introductory course that neither began with Europe nor culminated in the United States, using a core of early modern materials with which I was most familiar, while moving both backward and forward in time from that core.[8]

This trajectory was guided by a series of historiographical reflections. The prospect of constructing some form of general approach not structured by the development of the natural sciences in the Western world was daunting, with almost no textbook guidance. Jim McClellan and Harold Dorn's *Science and Technology in World History* (multiple editions since 1999) must be acknowledged as a heroically pioneering attempt in this regard, one I used in part and often found very instructive. But because that textbook's narrative arc still has pre-modern non-Western sciences feed into the development of modern Western science, it could not serve as a structural model for a new approach. I was well aware that many historians of science, including those who work on imperial, broad regional, and global contexts, mistrust grand narrative as either fatally compromised by teleology or simply uninteresting by contrast with synchronic histories' ability to situate science within a range of intersecting cultural domains, such as the political and the religious. I had earlier come to similar conclusions, but I now questioned whether the only effective narrative was a distorting one in the tradition of Whig histories of progress. There were some striking new models to consider. Lorraine Daston and Peter Galison's *Objectivity* (2007) recounted three centuries of historical epistemology in Europe and North America, for example, but said nothing about the rest of the world. My impression from recent scholarship and conversations with colleagues was one of enormous potential openness to "the global history science," whatever that might mean, but

8. For my classic survey, I used Andre Ede and Lesley Cormack, *A History of Science in Society: From Philosophy to Utility* (Toronto: University of Toronto Press, 2007), now in a third edition (2016).

how exactly to practice it? *Can* a global history of science ever become a coherent study, given the language barriers and expertise required to master very different traditions of knowledge-making around the world? What kind of narrative approach might emerge that would not reproduce old teleologies or do violence to local knowledges by subordinating them to a monolithically Western concept of "science," or for that matter "the global"? Some scholars have, indeed, recently criticized global history as chimerical in its universalism and unduly influenced by corporate globalization's admittedly nebulous rhetoric of "global perspectives." Now the G-word is a lightning rod of political discontent, motivating a nationalist revanche in the wake of economic globalization's inability to effectively distribute its benefits, both material and identitarian. Is "the global" still even desirable?[9]

Notwithstanding these very real counter-currents, and in some ways because of them, I came to believe that a non-specialist could contribute to crafting a productive approach to the global historical study of science through a first attempt at a larger framework. I write, therefore, in the spirit of the generalist in the belief that explicitly reframing the bigger picture – rather than leaving it tacitly intact or tacitly subverted – is sometimes important, and that we have arrived at such a moment in the history of science. In reality, grand narratives have already returned, if they ever went away. In addition to *Objectivity* and the textbooks already cited, Patricia Fara published *Science: A Four Thousand Year History* in 2009, while 2015 saw the publication of David Wootton's *The Invention of Science: A New History of the Scientific Revolution* and physicist Steven Weinberg's *To Explain the World: The Discovery of Modern Science*. The last two books present resolutely familiar narratives of progress, but here I should clarify the approach I myself took to this fundamental question in my course. Belief in narratives of scientific change and progress are inevitable, especially when it comes to students and the general public. Furthermore, they are *not* illegitimate; it is perfectly reasonable to want to know how scientific knowledge and disciplines have evolved over time. We might call this the history of scientific disciplinary progress. However, without what we might call the deep cultural history of natural knowledge, narrow histories of disciplinary progress produce significant distortions. They would tell you, for example, that Isaac Newton synthesized the new heliocentric astronomy and framed mathematically computable laws of motion, but not that he devoted much of his intellectual energy to alchemical work and biblical chronology. Of course, the deeper issue is that histories of disciplinary progress often undergird faith in Progress with a capital P, and an automatic equation of science with liberal and progressive politics despite the existence of many historical examples to the

9. James McClellan and Harold Dorn, *Science and Technology in World History* (Baltimore: The Johns Hopkins University Press, 1999), now in a third edition (2015); Juan Pimentel and J. Pardo Tomás, "And Yet, We Were Modern: The Paradoxes of Iberian Science after the Grand Narratives," *History of Science* 55 (2017): 133–45; Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007); John Tresch, "Cosmologies Materialized: History of Science and History of Ideas," in Darrin McMahon and Samuel Moyn (eds.), *Rethinking Modern European Intellectual History* (New York: Oxford University Press, 2014), pp.153–72; Richard Drayton, David Motadel, David Bell and Jeremy Adelman, "Discussion: The Futures of Global History," *Journal of Global History* 13 (2018): 1–21.

contrary – hence the horror at Trump's emergence and the subsequent desire to reclaim both scientific and political progress evident on the Marches for Science that took place in 2017. We shall return to this question below. The simple point I wish to make for now is that when even Christian Dior is disseminating its own global narratives of the history of plant science in advertisements placed in *Scientific American* to promote their make-up products, it is in the public interest for trained scholars to be writing science's global history instead, and not just for each other but for the public.[10]

Finally, because all knowledge, and all instruction, is shaped by local circumstances, it seems important to note that I designed this course at Rutgers University, a large public institution with a diverse student body in New Brunswick, New Jersey. Teaching in a large history department allowed me to shape an approach in many ways free from excessive curricular constraint. I could not presume any prior knowledge of the subject among my students, since they take the class as an elective and not as part of a tightly structured major or course sequence. Roughly half the class consisted of humanities students; roughly half were science students. I teach, in other words, at an institution where an expansive approach is welcome and even necessary to appeal to students of different educational, economic, and personal backgrounds. As my discussion of FAST and *Hindutva* signal, I drew repeatedly on contemporary science journalism in developing my approach. When I taught the class at Harvard, I was fortunate to have three professional journalists who were fellows in the MIT Knight Science Journalism Program audit the class: conversations with them deepened my belief in the importance of bringing history and journalism closer together, and that historians and journalists are natural allies who should collaborate much more. Most striking of all from a pedagogical and civic perspective was the fit between the course content and the many different ethnic backgrounds of the students, especially at Rutgers, where I taught science students of Latin American, East Asian, South Asian, Middle Eastern, and other parentage. A fascinating consonance between subject and student thus became evident, and the challenge of providing some of today's aspiring scientists with an understanding of their place in world history proved a great source of inspiration.[11]

Science's world history: The course

I shall now briefly outline the contours of the course before moving on to a more substantial account of its central questions and methods. The one-semester course is fifteen

10. Patricia Fara, *Science: A Four Thousand Year History* (Oxford: Oxford University Press, 2009); David Wootton, *The Invention of Science: A New History of the Scientific Revolution* (London: Penguin, 2015); Steven Weinberg, *To Explain the World: The Discovery of Modern Science* (London: Penguin, 2015); "In Medicine and Skincare, Plants are Staging a Comeback," Dior Science, *Scientific American*, May 4, 2018, <www.scientificamerican.com/custom-media/plants-are-staging-a-comeback/> (accessed January 2019).
11. Noemi Oreskes is probably the most prominent exemplar of combining scholarship and journalism in U.S. history of science today. My thanks to journalists Maura O'Connor, Meera Subramaniam, and Bianca Vasquez-Toness, MIT Knight Science Fellows in 2016–17, and Anthony Dibattista of the Rutgers Center for Historical Analysis, who facilitated a one-day seminar for New Jersey high school teachers on globalizing the history of science, which I ran in 2017.

weeks long and meets in lecture format for eighty minutes twice a week, with time allocated for discussion within that structure. We begin with a brief sketch of the classic narrative of the history of science as the rise of modern Western science since the sixteenth century. Key topics include the Scientific Revolution and its claim to defining modernity; the notion of Western science as an exceptional achievement in world history and the history of human civilization; Darwinian evolution (and social Darwinism and scientific racism in the context of nineteenth-century imperialism); and, finally, the shift from Big Science in the United States during the nuclear and space age to privatized sciences of computing and genetics down to the present. We then historicize the core of this narrative by explaining how and by whom it became academically codified, drawing from work by Marwa Elshakry and others on leading figures like the founder of *Isis*, George Sarton, and Joseph Needham, who shaped the academic history of science in the Anglophone world by the mid-twentieth century. The fundamental issue we explore is that no historical narrative is immemorial or immutable, but consolidated by specific individuals with institutional resources in specific contexts marked by contemporaneous demands – specifically, how the struggle between fascism, communism, and liberalism between the 1930s and the early Cold War influenced historical debates about science, progress, and intellectual agency. We grant that narratives of scientific progress are extremely powerful in our own time but, if we can understand them as historically contingent, we can rethink them. Here it is crucial to discuss how such narratives not only organize time but space. If we can see how narratives of progress mark our perceptions of the geography of science, we can see the world differently, as well as the past.[12]

The remainder of the course is organized more by geography than narrative per se, although it is conducted with as much chronological sensitivity as possible, including explicit critical reflection on the narrative choices we make as we move between different world regions. The class breaks down into a total of six different units of equal size, each consisting of approximately three lectures followed by a session devoted to discussion of primary source materials. After our introductory lectures, part two of the course examines the production of scientific knowledge in Islamic societies during the medieval and early modern eras in the Middle East and at the eastern edge of the Mediterranean. We consider experimental knowledge as practiced in the Islamic Caliphates and the Caliphates' culture of translation and commentary on manuscripts from ancient Greece and Rome, before moving on to the Ottoman Empire and looking at questions of imperialism, exploration, and geography in the sixteenth century. Part three turns from the Mediterranean to the Atlantic to examine ways of knowing among the Maya and Aztec prior to Spanish contact, before considering how the Columbian Exchange moved knowledge between American and Iberian societies, specifically botanical knowledge, and how Creole Spanish America emerged as a distinctive scientific culture. Part four shifts our attention to East Asia and looks at the exchange of knowledge through Catholic missionary contacts in China and Dutch commercial relations with Japan from the sixteenth to the eighteenth centuries, examining how East Asians understood and adopted

12. Michael Aaron Dennis, "Historiography of Science: An American Perspective," in John Krige and Dominique Pestre (eds.), *Science in the Twentieth Century* (London: Routledge, 1997), pp. 1–26; Marwa Elshakry, "When Science Became Western: Historiographical Reflections," *Isis* 101 (2010): 98–109.

astronomical knowledge and experimental machinery from Europe. Part five traces Europeans' pursuit of science through the extension of commercial and imperial networks during the same period, which gave rise to vastly expanded natural history collections (networks that included Africans via the Atlantic slave trade) and new models of physical science through the figures of Newton and Benjamin Franklin. Finally, part six focuses on South Asia. Beginning with the Mughal Empire, we examine Orientalism in British India and its rejection by statesmen such as Gandhi and Nehru in the twentieth century, concluding with present-day polemics over the relationship between Hindu nationalism, science, and industry.

This structure merits some initial clarification. Any dream of total coverage proves elusive; choices as to what to include are shaped by constraints of availability and accessibility. That said, there is no defense for leaving out the Pacific, the continent of Africa, or Russia. All of these regions could and should be included in future versions or a longer course, and other scholars would naturally make different decisions about where to focus their attention (I am currently in the process of teaching material relating to these regions at the graduate level). I want to stress, however, that what matters here is less the specific version of the course I have taught to date than the approach that has emerged, which I shall draw out more clearly below. Suffice it to say that I made the decision to cover less territory but cover it better than stretching even further geographically would have allowed, by spending roughly four classes on a given region. This I did with several distinct goals in mind: to foster a basic awareness of and literacy in a region's scientific culture, rather than treating it as a mere source community contributing to imperial, European, or Western science (it is important to elucidate these contributions but also to guard against what I call "contributionism" – valuing the knowledge of non-Western peoples exclusively in subordinate terms); to set up meaningfully contextualized readings of primary source materials (in English translation) to shed light on the movement of knowledge from the perspective of non-Western peoples; and to unpack how the very question of *science* gets framed and discussed in a given region, both in scholarly terms and through present-day polemics, typically in relation to assumptions about the primacy of modern Western science.[13]

The course prizes intellectual open-endedness more than any search for strict definitions; does not assume a specific or narrow conception of what to count as *science*; and includes a substantial amount of material that clearly pertains to medicine and technology as well, and which could and should be connected to a series of domains we now class under distinct terms like ecology, religious belief, and so on. This does not, however, mean that the course tacitly imposes a Western notion of science (or, for that matter, *nature*) on the societies we examine, but encourages students precisely to see that we are

13. On the Pacific, see for example David Turnbull, *Masons, Tricksters and Cartographers: Comparative Studies in the Sociology of Scientific and Indigenous Knowledge* (London: Routedge, 2000); for Africa, Clapperton Mavhunga (ed.), *What Do Science, Technology, and Innovation Mean from Africa?* (Cambridge, MA: The MIT Press, 2017); for Russia, Loren Graham, *Lonely Ideas: Can Russia Compete?* (Cambridge, MA: The MIT Press, 2013); and Asif Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957* (New York: Cambridge University Press, 2010). Readers interested in the new expanded graduate version of the course (2019), which also includes Africa, Oceania, Brazil and Russia, are invited to email the author for the syllabus.

always engaged in acts of *translation* when we speak today in English about the *sciences* of other times and places. What the philosopher Justin E. H. Smith has written of philosophy applies *mutatis mutandis* to science: "academic philosophers … take themselves to be the sole embodiment of something universal, whereas … they are only one particular instance of something that takes on many different forms. They take themselves to represent philosophy as a civilization, whereas there are really only many different cultures of philosophy." On the one hand, there are multiple ingenious systems of knowing and intervening in the natural world that deserve our attention, and which we should strive to grasp on their own indigenous terms as plural and fluid rather than timeless or essential. But, on the other, it would be a mistake to ignore the deeply ingrained *idea* that Western science uniquely brought about modernity. The idea of Western science *as* modernity has proven far too consequential in world and imperial history – and continues to capture the undergraduate and public imagination through popular culture and histories like Wootton's and Weinberg's – to be un-invented, no matter how desirable such a feat of extrication might now seem. It has set the historic terms by which non-Western scientific cultures have been deemed worthy of attention (or not) and by which they have been forced to compete for comparative respect against judgments that they are culturally, cognitively, or racially inferior. We therefore strive to understand past ways of knowing on their own terms yet also to acknowledge that our own inherited assumptions about something we call modern Western science condition that understanding. We explicitly discuss how contemporary geopolitics and (increasingly nationalist) nation-states aim to co-opt our political identities through retrospective invocations of "traditions." Ultimately, we are not engaged simply in deconstructing the narrative of the rise of modern science but in the construction of a new history of science centered on questions of identity and historical consciousness. This history is neither programmatically anti-Western nor comprehensively "decolonized," but one where Western and non-Western narratives are seen to have existed in mutually defining relation. We take up the historian of colonial Latin America Serge Gruzinski's genial question *what time is it there?* to ask how and *when* different societies have come to see themselves in world history by knowingly affirming, contesting, or appropriating the idea of modern Western science. *The Knowing World* thus proposes a geopolitically pluralistic vision of the history of science that is both rigorously historicist yet sensitively presentist, in which many pasts resonate in our global present.[14]

14. Justin E. H. Smith, *The Philosopher: A History in Six Types* (Princeton: Princeton University Press, 2016), ch.2, quotation p.105; Clapperton Mavhunga, *Transient Workspaces: Technologies of Everyday Innovation in Zimbabwe* (Cambridge, MA: The MIT Press, 2014); Projit Mukharji, *Doctoring Traditions: Ayurveda, Small Technologies, and Braided Sciences* (Chicago: The University of Chicago Press, 2016), esp. introduction; Projit Mukharji, "Cultures of Fear, Technonationalism and the Postcolonial Responsibilities of STS," *East Asian Science, Technology and Society: An International Journal* 6 (2012): 267–74; Lorraine Daston, "The History of Science and the History of Knowledge," *KNOW: A Journal on the Formation of Knowledge* 1 (2017): 131–54; Bruno Latour, *We Have Never Been Modern*, trans. Catherine Porter (Cambridge, MA: Harvard University Press, 1993); on decolonizing science, see Rohan Deb Roy, "Decolonise Science: Time to End Another Imperial Era," *The Conversation*, April 5, 2018, <http://theconversation.com/decolonise-science-time-to-end

Let's now look more closely at the central themes of the course, section by section. Beginning with the Islamic Caliphates offers the advantage of allowing us to refer back to the knowledge of the ancient Greeks and Romans by exploring the translation culture of medieval Arabic and Syriac. But this act of retrospection is not our primary emphasis, quite the opposite: we seek to question the classic notion that Caliphate sciences are only relevant as a waystation from ancient to modern Western science. While the students are provided with a basic grounding in the translation, experimental, and mathematical aspects of Caliphate sciences, it cannot be expected that general students from varied backgrounds will easily master and absorb detailed specialist literature on such topics: non-specialists require a larger framework in which historical facts will meaningfully resonate. We therefore discuss what is at stake when we in the twenty-first century even begin to talk about science in the medieval Islamic Caliphates. To do so, we situate ourselves with respect to the major narratives and polemics that frame these themes in our society today: polemics about Orientalism; essentialist claims about Islamic culture and Arab societies; and *golden age* narratives that stress the decline of post-medieval Arab civilization and the rise of the West, feeding contrasts between Western modernity and Islamic fundamentalism. We look at popular polemics like Bernard Lewis's *What Went Wrong?* (2001) and scholarly debates such as the exchange between George Saliba and Toby Huff over Huff's *Rise of Early Modern Science* (1993), which undertakes to explain how Arabic science "lost the lead" and why it "did not give rise to modern science." We then scale down to a single individual, Jābir ibn Hayyān, the eighth-century Baghdad polymath, and discuss how to approach him as a historical figure. We consider his career as an alchemist; read him in both recent and early modern English translations, where he was known as Geber; and examine how different writers situate Jābir in the history of science today.[15]

-another-imperial-era-89189> (accessed August 2018); Stuart Theobald, "How We Can Decolonize Science," *News24*, October 23, 2016, <www.news24.com/Opinions/Voices/how-we-can-decolonise-science-20161021> (accessed August 2018); and by contrast Dan Roodt, "Blacks and Liberals Want to Abolish Science," *American Renaissance*, October 26, 2016, <www.amren.com/news/2016/10/blacks-and-liberals-want-to-abolish-science/> (accessed August 2018); Serge Gruzinski, *What Time is it There?: America and Islam at the Dawn of Modern Times*, trans. Jean Birrell (London: Polity, 2010); Nishimoto Ikuko, "The 'Civilization' of Time: Japan and the Adoption of the Western Time System," *Time and Society* 6 (1997): 237–59; On Barak, *On Time: Technology and Temporality in Modern Egypt* (Berkeley: University of California Press, 2013); Vanessa Ogle, *The Global Transformation of Time: 1870-1950* (Cambridge, MA: Harvard University Press, 2015); Marwa Elshakry, *Reading Darwin in Arabic, 1860-1950* (Chicago: University of Chicago Press, 2013); Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation* (Chicago: University of Chicago Press, 2008), esp. p.xiii.

15. McClellan and Dorn, *Science and Technology*, 103–15 (note 9); Elshakry, "When Science Became Western" (note 12); Bernard Lewis, *What Went Wrong?: Western Impact and Middle Eastern Response* (New York: Oxford University Press, 2002); Toby Huff, *The Rise of Early Modern Science: Islam, China and the West* (Cambridge: Cambridge University Press, 1993), p. 52, review by George Saliba (1999), <http://baheyeldin.com/history/george-saliba-1.html> and reply by Huff: <http://baheyeldin.com/history/toby-huff-1.html> (accessed August 2018);

Having explored Orientalist polemics through Lewis, Huff, and Saliba gives students some understanding of the stakes in reading and interpreting Jābir's arcane alchemical writings today. We open up the fundamental question of translation by discussing how our understanding of figures from distant cultures is already shaped by a translator's choices, which can make such figures seem either familiar and canonical, or alien and exotic. The argument that the origins of modern experimental science lie in alchemical work is by now well established in the scholarly literature. Is Jābir then to be included in a global narrative of the development of empirical and experimental practices? Here, reading from British-Iraqi physicist and popular historian Jim Al-Khalili's *House of Wisdom: How Arabic Science Saved Ancient Wisdom and Gave Us the Renaissance* (2010) proves revealing. Al-Khalili aims to redeem Jābir as a great scientist whose techniques, in his view, foreshadowed modern experimental techniques; but Al-Khalili finds his alchemical ideas to be embarrassing gibberish (a word that may in fact derive from *Geber*) that should simply be ignored. This is history of science at its most selective, as Al-Khalili's subtitle signals: it does not ask what Jābir thought important in his time and place but imposes anachronistic judgments about modern science – albeit to laudably broaden the history of science beyond the prejudices of a racist Orientalism for general readers. (I set the students the exercise of critiquing Al-Khalili's account of Jābir: is it good history or bad? Shibboleths about keeping historiography out of the undergraduate classroom notwithstanding, the students seem rather to enjoy this assignment. They are also asked to write about how Jābir's identity shifted in translation as Geber and what this reveals about the cultural politics of translation.) Al-Khalili's patriotic approach might well be dismissed as ahistorical, but the deeper issue is to understand how both historical identities and present polemics drive and clash in such an account. Of course, we must still ask: is the best response to claims of Islamic scientific irrelevance a defense of Islamic scientific achievement as a contribution to modern science, and at what point might Jābir's alchemy compel attention on its own cultural terms? This contributionist dilemma recurs in the recent story of a student in Florida named Derek Black. A white supremacist, Klan-member, and relative of David Duke, Black publicly recanted his views in 2016 after learning about medieval Europe's "technological backwardness" in contrast to "the great Islamic societies that had developed algebra." Narratives of scientific progress are not necessarily racially exclusive, but can be put to anti-racist ends too. Our ultimate aim is less to reach a definitive judgment on such questions than to give students the liberating capacity to sort through the contemporary politics that shape our very approach to such ostensibly historical notions as "Islamic science" – not to liquidate the possibility of its knowability, but to open a more knowing and therefore clearer path toward it.[16]

Jābir ibn Hayyān, "The Book of the Monk," in Franz Rosenthal (ed.), *The Classical Heritage in Islam* (London: Routledge, 1992), pp.248–51; Richard Russell, "From the Translator to the Reader," in *The Works of Geber* (London, 1686); William Salmon, *Medicina practica, or the Practical Physician* (London, 1707), preface paragraphs 26–36 and plates preceding 335.

16. William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern European Culture* (Princeton: Princeton University Press, 1996); Jim Al-Khalili, *The House of Wisdom: How Arabic Science Saved Ancient Wisdom and Gave Us the Renaissance* (London: Penguin, 2010), xxv–xxix, 35–48, 52–66; Eli Saslow, "The White Flight of Derek Black," *Washington Post*, October 15, 2016.

As we move forward in time to Ottoman Turkey to conclude our section on the early Muslim empires, we find similar dynamics at work in the question of how to think about Ottoman science. We focus on geography, navigation, and cartography as the Ottomans fought the Portuguese for commercial supremacy in the sixteenth-century Indian Ocean. Reading from Giancarlo Casale's *Ottoman Age of Exploration* (2010), we again confront a narrative of golden age and decline, this time through Casale's counter-claim that the Ottomans became a formidable exploratory maritime power. His book has had its critics, one critique being to question the apparent casting of the Ottomans in a European mold as explorers on a par with the civilization that produced Columbus. Casale's work is nonetheless of great value in its examination of evidence like the Atlantic map Admiral Piri Reis presented to Sultan Selim I in 1517, which Casale uses to challenge the marginalization of the Ottomans in world history as a parochial power lacking the allegedly more cosmopolitan global outlook of the Europeans (Turkey's relationship to Europe today of course remains a hotly contentious cultural and political question). The issue is a crucial one, although our perception of Ottoman science may well alter if we shift focus from cartography and navigation to Sufi alchemy, for example: the latter suggests a rather different image of the kinds of knowledge that preoccupied Ottoman minds (it should be noted, however, that alchemy remained a prized learned pursuit in this period in Western Europe too). Again, our aim is to open up possibilities for interpretation rather than tie them down, and to ask what is gained by both global and regional framings of Ottoman knowledge. The intellectual spirit driving Casale's highly readable work certainly makes for a bracing contrast to William Burns' *Scientific Revolution in Global Perspective* (2015), where the relevant chapter applies a classic Litmus test to non-Western scientific cultures by seeking to establish when heliocentrism was taken up by the Ottomans, predictably to find them lagging well behind. Burns is thus instructive too in his own way, by showing how much work remains to be done to make sense of scientific cultures like the Ottomans' both on their own terms *and* in a larger historical framework, without resorting to one-dimensional comparative judgments about progress or retardation. Mario Biagioli's droll conceit that the Scientific Revolution is an "undead" category of historical analysis that stalks the earth despite its scholarly lifelessness thus continues to seem relevant. The question of who is modern and scientific, and who is not, has not quite been interred, let alone replaced, and still gets perpetuated.[17]

Part three moves to the Atlantic theater, Central and South America, and early modern Iberian scientific culture. This is, of course, a familiar world-history turn that follows the conjunction of American colonization and the establishment of a Sinocentric world economy, the lynchpin of which was China's uptake of Spanish silver as currency. We take

17. Giancarlo Casale, *The Ottoman Age of Exploration* (Oxford: Oxford University Press, 2010), esp. pp.180–203; William Burns, *The Scientific Revolution in Global Perspective* (Oxford: Oxford University Press, 2015), pp.153–9; Mario Biagioli, "The Scientific Revolution is Undead," *Configurations* 6 (1998): 141–8. See also Harun Kuçuk, "Early Modern Ottoman Science: A New Materialist Framework," *Journal of Early Modern History* 21 (2017): 407–19, one of several valuable correctives to approaches like Burns', published in J. B. Shank's edited special issue, "After the Scientific Revolution," *Journal of Early Modern History* 21 (2017); for an updated bibliography of the subject, see Steven Shapin, *The Scientific Revolution*, 2nd ed. (Chicago: The University of Chicago Press, 2018).

time to examine indigenous American cultures of knowledge before the Columbian Exchange. We use McClellan and Dorn's survey for essential background on Maya, Aztec, and Inca knowledge, including the Mayan calendar, astronomical installations like Chichen Itza, and the irrigation system at Tenochtitlán with its famed *chinampas*. As in the Caliphates, astronomy was central to organizing religious worship, calendrical time, and astrological prediction in these societies. But we consciously break with McClellan and Dorn's traditional focus on physical science and switch our attention to plants, animals, and healing. It bears repeating that the historical image of the sciences alters dramatically depending on just which sciences we consider, and that this switch alone expands our cast of characters to many more kinds of men *and women* than those featured in classic science narratives. Combining historian Marcy Norton's history of chocolate in early modern American societies with English-translation extracts from physician Francisco Hernández's researches in Mexico City, as well as visual evidence from Conquest-era codices, we take a specific plant (cacao) and follow it from Amerindian society through the Columbian Exchange to Spanish interpretations of the drink the Aztecs called *chocolatl*. After seeing how these Americans used spiced *chocolatl* in elite ceremonies, and how the Spanish both craved and feared what they considered a diabolical pleasure, students are invited to eat some spiced chocolate and imagine how it tasted to these different groups. One key lesson again concerns translation. At Harvard, we examined cacao specimens from the Gray Herbarium to see first-hand how *little* information about indigenous sourcing Western botanists have typically included with their samples. But we question the notion that translation involves the *erasure* of indigenous knowledge as it becomes incorporated into Western systems. Norton's history here makes a fine counterpoint: she shows how Hernández's recommendation of chocolate as a febrifuge, theorized in European terms as the cooling of hot humors, was based on his observations of indigenous practices. Instead of merely confirming erasure, important though it is to recognize, such histories of translation allow us to repopulate the history of science with more of its actual cultural variety and re-envision it as one not merely of Western extraction but interaction and fusion.[18]

We also step back from our immersion in specific stories and sources to analyze the framing of Iberian science more generally, a question much discussed in recent years, through its ambiguous relationship to Western modernity. Here, the scholarship of Jorge Cañizares-Esguerra has proven foundational. Iberian sciences have long been excluded from narratives of the Scientific Revolution and modern science, in favor of Northern European physical science, heliocentric priority, and the Newtonian synthesis of the New Astronomy. This omission effectively situated Iberian science in the Global South, with

18. Marcy Norton, *Sacred Gifts, Profane Pleasures: A History of Tobacco and Chocolate in the Atlantic World* (Ithaca: Cornell University Press, 2008), pp.121–40; Simon Varey (ed.), *The Mexican Treasury: The Writings of Dr. Francisco Hernández* (Palo Alto: Stanford University Press, 2000); Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987), esp. ch. 7. For bioprospecting in modern Mexico, see Cori Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2003). Casale and Norton show how work by scholars not formally trained in the history of science is helping to drive the field forward and outward in important ways.

the Spanish Empire cast as a story of decline, burdened by a "Black Legend" (*la leyenda negra*) of allegedly exceptional colonial atrocities, and positioned as a foil to white Anglo-Saxon Protestant histories of the North Atlantic. As we have already seen with Al-Khalili and Casale, the question is whether it then becomes desirable to write Iberian sciences back into modernizing narratives like the Scientific Revolution, and even argue for Iberian priority in regimes of empirical fact-making as Cañizares-Esguerra and Antonio Barrera-Osorio have done; or would this simply perpetuate teleologies of European primacy, only in an Iberian key? In class, we explore the complex resonance of "Spanish America" today, when "Hispanic" routinely denotes the ethnic identity of Central and South American immigrants often subject to racist discrimination in the United States (against which Cañizares-Esguerra writes explicitly), even though its blurred connotations also refer back to Spanish imperialism. Cañizares-Esguerra's masterful evocation of the Creolized character of Spanish-American knowledge in the New World – neither European nor indigenous but an irreducible fusion of the two – has had undeniable impact in drawing renewed attention to the geopolitics of knowledge-making throughout the Atlantic world. Arguing for the primacy of Iberian sciences among European empires is unquestionably an important corrective – and here Portuguese imperialism and Lusophone sciences can and should feature far more prominently too. But why not seek a less Europe-centered orientation and integrate the ways of knowing of Native Americans and enslaved Africans as well? Recent studies of African healers by James Sweet on colonial Brazil and Pablo Gómez on the Spanish Caribbean point emphatically in this direction. One need not share the objective of reinstating the Scientific Revolution in Iberianized form, however, to appreciate that those who have been denied a certain modernity should insist on reclaiming it, and why such an approach resonates with the hemispheric politics of contemporary U.S.–Mexico relations, especially since Trump's cynical promotion of a southern border wall. Our aim in class is once more to show that we write better history the more conscious we become of how the present impinges on our view of the past.[19]

19. Jorge Cañizares-Esguerra, *How to Write the History of the New World: Epistemologies, Histories and Identities in the Eighteenth-Century Atlantic World* (Palo Alto: Stanford University Press, 2001); Jorge Cañizares-Esguerra, "Spanish America: From Baroque to Modern Colonial Science," in Roy Porter (ed.), *The Cambridge History of Science, Vol. 4* (Cambridge: Cambridge University Press, 2003), pp.718–38; "The Core and Peripheries of our National Narratives: A Response from IH-35," *American Historical Review* 112 (2007): 1423–31; Antonio Barrera-Osorio, *Experiencing Nature: The Spanish American Empire and the Early Scientific Revolution* (Austin, TX: University of Texas Press, 2010); see also Daniela Bleichmar, *Visible Empire: Botanical Expeditions and Visual Culture in the Hispanic Enlightenment* (Chicago: The University of Chicago Press, 2012); for colonial sciences in the Lusophone world, Neil Safier, *Measuring the New World: Enlightenment Science in South America* (Chicago: University of Chicago Press, 2008) and Hugh Cagle, *Assembling the Tropics: Science and Medicine in Portugal's Empire, 1450-1700* (Cambridge: Cambridge University Press, 2018); Pimentel and Tomás, "And Yet, We Were Modern" (note 9); James Sweet, *Domingos Álvares: African Healing and the Intellectual History of the Atlantic World* (Chapel Hill: University of North Carolina Press, 2011); Pablo Gómez, *The Experiential Caribbean: Creating Knowledge and Healing in the Early Modern Atlantic* (Chapel Hill: University of North Carolina Press, 2017).

When we turn to East Asia in part four, we see how potentially similar questions concerning the exchange of knowledge across continents get framed and narrated very differently. China here makes for a vivid contrast with Latin America. Colonialism and neocolonialism often frame the history of Latin America, through the region's subjection first to Spain and Portugal, and latterly its economic relationship with the United States. China, on the other hand, appears as an external rival to Western history. To some extent this difference is, of course, the product of history itself; but it also results from the conditioning of narrative expectations. Studies such as Kenneth Pomeranz's *The Great Divergence* (2000) approach Chinese history primarily as an index of economic rivalry with the West, assembling a competitive comparative history that seeks to explain why Europe outstripped China in the Industrial Revolution. Some historians of science such as Toby Huff do, of course, still aim to explain which civilizations are scientifically "in the lead," a question which often preoccupies journalistic coverage of the sciences today, as we noted in the way American reporters have covered the FAST story. But this rather aerial style of retrospective historical assessment often tends to ignore vital cultural questions about what the pursuit of science and technology actually meant to people in their own time and place. In our course, we explore how foreign observers of the Celestial Empire have often criticized its isolation while enviously eyeing its markets. The British, for example, lamented Chinese indifference to the scientific and industrial offerings of the 1793 Macartney Embassy, claiming they lacked the kind of open curiosity about other cultures they proudly took themselves to exemplify – cosmopolitanism featuring here as an agonistic polemic of modern identity and cultural comparison. Yet the Middle Kingdom nourished its own official mythology of splendid indifference, regarding itself as the center of the civilized world, without need of barbarian wares or ideas.[20]

In reality, this was far from true, and the oscillating relationship between isolation and interaction is one of the key themes we explore in examining Chinese science and technology, not least through the impact of Jesuit missionaries after the late sixteenth century. We read McClellan and Dorn's chapter on China for background while once more reflecting on the kind of history such surveys provide. McClellan and Dorn provide an exemplary critique of Needham's teleological question about China's failure to invent modern science – only to then try to answer it! When discussing Jesuit interventions in Chinese science, we take care to seek Chinese views of Western religion, science, and technology rather than prioritize European perspectives in the manner of much Jesuit historiography. We read extracts from Qiong Zhang's detailed account of how the seventeenth-century Shanghai physician Wang Honghan combined Christian, Aristotelian, and Confucian metaphysics after he converted to Christianity in surprising and creative ways that confounded the missionaries he dealt with. Zhang's exegesis is brilliantly forensic. But teaching such complex material can be extremely demanding with undergraduates in an introductory lecture class, rather than a more specialized seminar focused on Chinese culture or religion, and points to a crucial general issue, which readers may already have noticed: the question of readability, accessibility, and intelligibility, which is rooted in

20. Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000); Simon Schaffer, "Instruments as Cargo in the China Trade," *History of Science* 44 (2006): 217–46.

the tension between specialist and generalist agendas. Much of the most important recent research by specialists in cross-cultural histories of scientific knowledge presents a challenge of accessibility to non-specialists, potentially limiting its readership as a result. Teaching such material effectively can be extremely challenging; my own ad hoc solution has been to spend considerably more time *talking* it through in class. Students won't always digest dense prose that deals with unfamiliar concepts, but the instructor can and should hope to break such material down verbally and translate it into terms that resonate for general audiences approaching it in a larger framework.[21]

We take pains to see how Sino-Jesuit collaborations in areas such as astronomy and cartography served the goals of Ming and Qing administrators, and don't just illuminate a picture of the formation of global scientific networks centered in the Western world, as Bruno Latour's influential model of "centers of calculation" might be taken to imply. We've seen already how the FAST radio telescope embodies a number of questions concerning the place of Chinese science in world history. All I would add here is to attest to the intellectual and pedagogical vibrancy of using different kinds of contemporary material to explore the convergence of past and present, such as promotional videos on FAST, which students can interpret in light of what they now know about the history of Chinese science and how it has been framed in relationship to notions of Western primacy. Promotional material may of course easily be dismissed as a species of propaganda. China takes "a big step forward" toward "mind-blowing" revolutions in astronomy, one declares, with dramatic background music providing the soundtrack to FAST's heroic construction, one that could seemingly only happen in China, whose mountainous Guizhou Province provides the "ideal" natural–technical landscape for the realization of such a project. But these videos invaluably communicate something of the *affect* of current Chinese scientific ambitions, embodied in individual scientists. "We haven't had this chance before," comments the project's chief scientist and engineer Nan Rendong with an air of solemn anticipation. The self-consciousness, the historical *knowingness* of such statements is fascinating, as is their careful presentation to an international audience. The *China Icons* video on FAST features both English- and Chinese-speakers and English subtitles, and has apparently been viewed on YouTube over 950,000 times. FAST is itself an English acronym. Its combination of movement between past and present meanings, and national and global orientations, encapsulates a particularly resonant

21. Joanna Waley-Cohen, *The Sextants of Beijing: Global Currents in Chinese History* (New York: W.W. Norton, 1999); McClellan and Dorn, *Science and Technology*, pp.117–40 (note 9); Qiong Zhang, "Hybridizing Scholastic Psychology with Chinese Medicine: A Seventeenth-Century Chinese Catholic's Conceptions of *xin* (Mind and Heart)," *Early Science and Medicine* 13 (2008): 313–60; Nathan Sivin, "Why the Scientific Revolution Did Not Take Place in China – or Did it?" *Environmentalist* 5 (1985): 39–50; Benjamin Elman, *On Their Own Terms: Science in China, 1500-1900* (Cambridge, MA: Harvard University Press, 2005); Catherine Jami, "Do All Paths Lead to Modernity?: The Kangxi Emperor (1662-1722) and the Sciences," in Olga Lomová (ed.), *Paths to Modernity: Conference to Mark the Centenary of Jaroslav Průšek* (Prague: Karolinum Press, 2008), pp.151–70; Carla Nappi, *The Monkey and the Inkpot: Natural History and its Transformations in Early Modern China* (Cambridge, MA: Harvard University Press, 2009).

example of *the knowing world* as an approach to the history of science: one that reveals both the force of the past in the present and the contestation of that history through nationalist self-assertion on the world stage.[22]

Our exploration of Japan offers two more rich cases of these dialectics of past and present, nation and world. Like China, historical narratives about Japan have often centered on themes of isolation and the absence of curiosity about other cultures. The Edo period or era of *sakoku* or national seclusion (1603–1868) was a reaction to the disrupting presence of Catholic missionaries, which led to the Japanese limiting their interactions with outsiders largely to trading with the Dutch East India Company on Deshima Island in Nagasaki Harbor. This policy of retrenchment was to have momentous delayed consequences when Japan later rushed to compensate by modernizing, industrializing, and militarizing in the late nineteenth century, resulting in imperial aggressions in Korea and China and its calamitous role in the Second World War. But early modern Japan was hardly so uncurious as we might at first suppose. We look at natural history collections to explore the remarkable relationship between the German physician Engelbert Kaempfer and his Japanese translator Imamura Gen'emon (later known as Eisei), who helped Kaempfer to smuggle Japanese curiosities out of Nagasaki in the 1690s, before they were purchased decades later by Hans Sloane in London. Students are fascinated by the reversal of their narrative expectations of European imperialism, when they realize the numerically insignificant and essentially unarmed Dutch traders were anything but the dominant force on Deshima. Although we only have Kaempfer's self-serving account of his dealings with the Japanese as a guide, we read against the grain to ask why his translator Eisei was willing to risk his life by collaborating with this barbarian outsider, exploring how Eisei's own curiosity about European languages and medicine played the decisive role in enabling Kaempfer to assemble what was then a landmark collection of Japanese curiosities. That Kaempfer's haul remains in the British Museum down to the present allows us to discuss how the Western geography of today's encyclopedic museum collections became established through large-scale historical forces that were nonetheless filtered by strikingly contingent personal relationships.[23]

We also examine the self-conscious cultural specificities of Japan's technical and scientific place in the world. In his illuminating study *The Lens Within the Heart* (2002), Timon Screech analyzed at length how people in eighteenth-century Japan reacted to the importation of new Dutch experimental apparatus and optical devices with a mixture both of playful openness and serious concern. They worried that learning to look at the natural world through glass (*rangaku*, or mechanical Western-style knowledge) would divorce them from that world emotionally and spiritually, where native traditions like

22. Latour, *Science in Action*, ch.7 (note 18); Hostetler, *Qing Colonial Enterprise* (note 2); "FAST: The World's Largest Telescope – A China Icons video" (2016), <www.youtube.com /watch?v=7SRV3rnULO0> (accessed December 2018).
23. Yu-Ying Brown, "Japanese Books and Manuscripts," in Arthur MacGregor (ed.), *Sir Hans Sloane: Collector, Scientist, Antiquary, Founding Father of the British Museum* (London: British Museum Press, 1994), pp.278–90; Engelbert Kaempfer, *Japan Today* (London, 1727), in Beatrice Bodart-Bailey (ed.), *Kaempfer's Japan: Tokugawa Culture Observed* (Honolulu: University of Hawai'i Press, 1999), pp.187–90, 234–5, 360–68.

Shintoism had long nurtured a deeply felt sense of relation with nature as not entirely separate from their own selves (*shingaku*, or "heart learning"). We pose the following question: *are the electronic devices we use today culturally specific or cultureless and universal?* Most students tend to assume the latter, but the history of Japanese robotics suggests otherwise. We explore Japan's long history of puppetry, dolls, and automata, which is distinctive from Western traditions of humanoid machinery through its attribution of sympathetic affect to such machines. The long thread through this history, which has been traced by the Tokyo-based technology journalist Tim Hornyak, is fascinating. Where modern European etymology links "robots" to slaves (*robot* derives from *rab* or *rob*, the Slavic word for *slave*), Japanese traditions identifying humanoid robotics with warmly animate companionship can be dated back to associations with dolls and puppets over several centuries, as well as forward to pop culture figures such as *Astroboy*, also known as *Mighty Atom*: a post-Hiroshima comic strip android hero (1952–68) destined to bring about the salvation of the Japanese people amidst the ruins of the nuclear age. To this day, the affective embodiment and design of humanoid robots in Japan appears especially uncanny to Western eyes, conflicting with expectations that such machines would inevitably embody a menacingly alienated alterity and portend a devastating future of postindustrial obsolescence, if not annihilating war. This Japanese tradition suggests how popular narratives of artificial intelligence enslaving and destroying humanity are in fact a culturally specific Western concern that masquerades as a universal one.[24]

In part five of the course, we turn to Europe. What now to make of its association with the Scientific Revolution and the invention of modern science, and how to retell its own important story? We explore why the Scientific Revolution narrative has proven so influential, discussing our own predilection for identifying progress in history, simply because the narrative is so well-constructed as a focused history of physical science driven by dramatically significant changes, as well as extraordinary figures and singular characters such as Galileo and Newton. By this point in the course, we have already encountered Europeans – mainly Iberians – in our sections on Mexico and Asia. But the structural advantage of our sequence is that studying the Caliphates, Ottomans, Mexico, and East Asia before considering Europe in its own right of itself changes how we perceive even canonical European science. Newton's *Principia* (1687) provides a vivid example. We see how the Dutch, French, and British sought to emulate Iberian long-distance sciences, establishing colonies and commercial networks, and accumulating unprecedented quantities of specimens and natural history reportage. When we examine how Newton culled mathematical observations from travelers from the Guinea Coast to the Pacific, the worldly sources of the *Principia* in trade and empire (including the Atlantic slave trade)

24. Timon Screech, *The Lens within the Heart: The Western Scientific Gaze and Popular Imagery in Later Edo Japan* (Honolulu: University of Hawai'i Press, 2002), pp.166–211; Timothy Hornyak, *Loving the Machine: The Art and Science of Japanese Robots* (Tokyo: Kodansha International, 2006); "Robot-Staffed Hotel Opens in Japan," *CBS This Morning* (2015), <www.youtube.com/watch?v=HVVk0b9DX8Q> (accessed December 2018); see also Yulia Frumer, "Cognition and Emotion in Japanese Humanoid Robotics," *History and Technology* 34 (2018): 157–83, and Robert Liss, "Frontier Tales: Tokugawa Japan in Translation," in Schaffer, *Brokered World*, pp.1–47 (note 7).

become powerfully evident, showing Newtonian natural philosophy to have had much in common with the global trafficking of commercial natural history, with which it has often been sharply contrasted. We draw both canonical and obscure actors into relation, rather than parsing them into distinct narratives, to assemble a more accurate picture of European sciences' global ambitions. We now see Newton as part of the world that made him, repopulating it with the many kinds of people who animated its networks, including women naturalists like Maria Sibylla Merian and enslaved African "herbologists" such as Domingos Álvares and Graman Quacy of Surinam. From a selective account of noble quests for truth in physics, European sciences re-emerge as part of a worldwide story of providentialist religion, colonialism, bioprospecting, militarism, and emergent concepts of racial difference.[25]

We extend this approach to recast a second exemplar in the history of physics and connect it to the present-day United States: Benjamin Franklin's experiments with electricity in 1750s Philadelphia. Similar to the case of Newton, we see how commercial networks created the preconditions for Franklin's experimental work, circulating concepts, apparatus, and techniques from Britain to its colonies. Just as important, we explore how this episode became an origins story for U.S. science, twice over, both in the eighteenth and twentieth centuries. Teaching this material at Harvard was particularly resonant since Cambridge is a key site in the memorialization of Franklinist electricity. The university's Science Center now houses the Pope Orrery (1776–87), a mechanical planetarium assembled in the decade after the founding of the United States and depicting the Newtonian universe adorned by figurines including Newton and Franklin, joined together to celebrate a transatlantic tradition in Enlightenment natural philosophy. We explore how historian of science I. Bernard Cohen renewed this notion of Franklin as the transatlantic lynchpin in a universal history of science passing from Europe to America. With the British Empire in eclipse and American hegemony ascendant during the Second World War and early Cold War, Cohen assigned Franklin a primary place in the history of science comparable to Newton's for his theorization of the conservation of electric charge (a point he put to Albert Einstein in Einstein's last interview in 1955), insisting that this theoretical achievement was far more significant than Franklin's invention of the lightning rod. Franklin's theories were the true origin of American science, Cohen suggested, not their practical application. That argument still resonates today – *not* because it has been won in the culture at large, however, but because it is so contested. Franklin was indeed a cosmopolitan Enlightenment theorist of natural phenomena, but he became enduringly reimagined as a homespun backwoods tinkerer when populist hostility to science as elitist took hold in the early nineteenth century. Cohen's view of Franklin was conditioned by his own historical circumstances: he championed Franklin

25. Latour, *Science in Action* (note 18); Latour, *We Have Never Been Modern* (note 14); Simon Schaffer, "Newton on the Beach: The Information Order of *Principia Mathematica*," *History of Science* 47 (2009): 243–76; Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, MA: Harvard University Press, 2004); Harold Cook, *Matters of Exchange: Commerce, Medicine and Science in the Dutch Golden Age* (New Haven, CT: Yale University Press, 2007); Sweet, *Domingos Álvares* (note 19); Susan Scott Parrish, *American Curiosity: Cultures of Natural History in the Colonial British Atlantic World* (Chapel Hill: University of North Carolina Press, 2006), pp.1–7.

as an exemplar of "the practical use to which *pure science* is put" at the precise moment he was advocating for federal funding for "pure science" to fight the Cold War. We discuss how Trump's attacks on the authority of climate research today may seem an unprecedented reversal of liberal scientific American norms, but aim to show that such anti-science stances in fact possess a genealogy as long as the nation itself.[26]

The current U.S. administration makes for a striking contrast with the scientific ambitions of both China and India. The sixth and final part of the course considers South Asia. India presents an extraordinarily complex dialectic between past and present, nation and globe, not least because anticolonial histories have become nationalist political currency through *Hindutva* under Modi's ruling BJP. We trace the Mughal Empire's conquest of the Hindu peoples of the subcontinent during the sixteenth century; the Mughals' decline; European competition for regional ascendancy; the establishment of British rule; and the movement for *Swaraj*, up to and including present-day Hindu nationalism. Time constraints preclude a substantial philosophical engagement with ancient Indian scripture and theology, but we aim to make two essential points: to recognize the foundational importance of the Vedas, in anticipation of their subsequent role in Orientalist and nationalist debates over Indian identity and heritage; and to explore, albeit briefly, regional knowledges and practices that enjoyed substantial autonomy from those of Europeans, such as *Unani* medicine – a combination of Galenic-Arabic and Ayurvedic medical traditions. We examine Indo-European maps and pictures as co-productions of cartographic and botanical knowledge, before focusing on questions of temporality as Orientalists (such as James Mill) came to insist on positioning India as racially degenerate and mired in superstition by contrast with the technoscientific achievements and industrial advances of European society.[27]

We return to the cultural meanings of translation through the story of the Sialkot mathematician Tafazzul Hussain Khan, who became only the third person to translate Newton's *Principia*, and see how the question *what time is it there?* took on unprecedented force in exchanges between the East India Company and their Asian hosts and subjects. As with Eisei in Nagasaki, we strive to pose symmetrical questions concerning historical actors even when the archive is asymmetrical, and set students assignments based on primary sources where they are asked to envision the exchange of knowledge from the perspective of an Eisei or a Tafazzul rather than the East India Company. British

26. Delbourgo, *Most Amazing Scene of Wonders* (note 7); James Delbourgo, "Atomic Franklin," *Raritan Quarterly* 33 (2014): 27–39, Cohen quotation (italics mine), p.32; Latour, *Où atterrir* (note 5).

27. McClellan and Dorn, *Science and Technology*, pp.141–9 (note 9); Seema Alavi, *Islam and Healing: Loss and Recovery of an Indo-Muslim Medical Tradition, 1600–1900* (Houndmills: Palgrave Macmillan, 2008), pp.18–53; Kapil Raj, "Surgeons, Fakirs, Merchants, and Craftspeople: Making L'Empereur's *Jardin* in Early Modern South Asia," in Londa Schiebinger and Claudia Swan (eds.), *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2004), pp.252–69; Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900* (Houndmills: Palgrave Macmillan, 2010); Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca: Cornell University Press, 1992), 95–108, 166–77.

Orientalists imaginatively insisted that their sciences in fact embodied the *return* of an ancient wisdom to the Indian subcontinent, rather than the imposition of any foreign innovation. But later Indian nationalists were no less creatively historically minded. Gandhi and Nehru both argued, each in his way, that India's destiny as a modern techno-scientific nation would have to be guided away from Western racism and materialism by the virtues of ancient Indian (Hindu) identity, with reference to its Vedic heritage. Many scholars have come to consider such programs of cultural and political renewal as "alternative modernities," as Warwick Anderson has discussed, but these modernities crucially invoked, constructed, and mobilized indigenous *antiquities* to articulate their visions of the future. Time's arrow seems, once more, to circle around on itself: one had to go back in order to move forward, and *come* back to take one's place in the world. As we noted in the introduction, India's prominence in contemporary environmental debates about global warming marks the *return* of its manufacturing prowess, not the beginning.[28]

We also aim to grasp the complexity of the geopolitics of history of science in ways that may confound our own liberal assumptions. We have already observed that the legacy of Orientalism has recently played a prominent rhetorical role in the suppression of political criticism and intellectual inquiry, for example in the petition to remove Pollock from the Murty Library editorship and the withdrawal in India of University of Chicago scholar Wendy Doniger's book *The Hindus: An Alternative History* (2009). The aim of our class discussions is not to justify such illiberal intellectual nationalism as merited by the history of Orientalism, but to understand the grounds of current controversies and the histories that shape today's volatile polemics. Polemics surrounding what the U.S.-based Indian philosopher of science Meera Nanda has termed "Hindutva's science envy" – its varying claims to parity with, connection to, or superiority over Western science – are arguably even more complicated. This is because, as a liberal, Nanda rejects nationalist Indian pronouncements, but she does so by reaffirming the unique superiority of Western science, in terms that James Mill could well have embraced. Some replies to Nanda in the popular Indian press have countered that the spiritual values of Indian civilization *do* make its sciences superior to a materialistic Western science that has subjected its own populations and imperils environmental sustainability, in terms reminiscent both of Gandhian and left-wing Western critiques. The blurred patterns of such polemical twists pose an excellent challenge for our class, which argues for the value of learning about Indian science and technology on their own terms and in relation to the wider world, but without subordinating them to a narrative of Western modernity or primacy. The lesson does not provide a definitive answer, however, because in a crucial sense there isn't one:

28. Simon Schaffer, "The Asiatic Enlightenments of British Astronomy," in Schaffer, *Brokered World*, pp.49–104 (note 7); see also Simon Schaffer, "Oriental Metrology and the Politics of Antiquity in Nineteenth-Century Survey Sciences," *Science in Context* 30 (2017): 173–212; Prakash, *Another Reason* (note 4); Dhruv Raina, *Images and Contexts: The Historiography of Science and Modernity in India* (Oxford: Oxford University Press, 2003); Ross Bassett, *The Technological Indian* (Cambridge, MA: Harvard University Press, 2016); Warwick Anderson (ed.), special issue on "Postcolonial Technoscience," *Social Studies of Science* 32 (2002); Suman Seth, "Colonial History and Postcolonial Science Studies," *Radical History Review* 127 (2017): 63–85; Elshakry, *Reading Darwin in Arabic* (note 14).

the geopolitics of how we understand the history of science *varies* according to where we are in the world and when we imagine ourselves to exist in time. Nanda's example shows that as we move around the world, we become disoriented, and usefully so. When we see that what we take to be the logical relationship between science, history, and politics doesn't work elsewhere as we might expect, we come to understand our own views as local and historically conditioned, rather than universal or self-evident. This is ultimately the most important lesson the course aims to teach.[29]

Conclusion: New orbits, new stories

The notion that creativity flourishes on margins more than at centers has a venerable allure. I want to end not with recent developments in the history of science in Berlin or Paris, Cambridge or Cambridge, Chicago or Palo Alto, but at Virginia Commonwealth University of the Arts in Qatar, on the northeast coast of the Arabian Peninsula. In his new book *Space Science and the Arab World* (2018), Jörg Mathias Determann, a German-born assistant professor at VCU, tells the story of modern Arab space exploration. Beginning in the nineteenth century with the Syrian Protestant College (renamed American University of Beirut in 1920), Determann recounts the experiences of Arab scientists in relation to nationalist politics in the Middle East as well as the international scientific community, coming all the way up to the present to examine ambitious current projects such the Qatar Exoplanet Survey, which has yielded new information about distant planets, and the United Arab Emirates' plan to establish a city on Mars by the year 2117. Such developments remind us once more that in a changing geopolitical order, where new wealth and scientific ambition are ascendant in regions like the Persian Gulf as well as East and South Asia, the classic narrative of scientific progress from Europe to America no longer makes sense, because non-Western sciences aren't just the past – they're the present and the future.[30]

Determann's history demonstrates how the concept of a *knowing world* can inform research as much as teaching. Crucial to his analysis is the realization that Islamic or Arab-world sciences have been overwhelmingly identified with their medieval *golden age*, as Marwa Elshakry has well demonstrated, and that it is necessary to study contemporary practices in the region, albeit with a deep sense of history that accounts of contemporary or recent science often lack. The relation between geography, temporality, and identity thus becomes part of the warp and weft of Determann's argument rather than mere context or prelude. He shows how golden age and decline narratives continue to shape popular memory (streets and buildings are still named for Avicenna, for example, while recent science fiction fantasizes about grand returns to medieval glory), and how Arab states have self-consciously come to see space exploration as a test of national prestige through the notion of an "Arab Renaissance" (*al-nahda*). Determann also tells individual stories that resonate poignantly, and even comically, with the geopolitics of science and its conflicting cultural assumptions. When Sultan bin Salman of Saudi

29. See notes 3–4.
30. Jörg Mathias Determann, *Space Science and the Arab World: Astronauts, Observatories and Nationalism in the Modern Middle East* (London: I.B. Tauris, 2018).

Arabia left Earth on the shuttle *Discovery* in 1985, the prince became the first Arab and first Muslim astronaut in space. In preparing for this flight, NASA officials were unsure how this cross-cultural collaboration would work, so they invited personnel from the oil company Aramco to provide bin Salman's American colleagues a one-day seminar in Saudi culture. "When people heard about Saudi Arabia," Determann comments, "they would have perhaps been reminded of *Lawrence of Arabia*, of camels and sand, of harems and sultans and princes and sheikhs. A lot of Americans didn't quite know what to make of a Saudi astronaut. What kind of person would that be, and how do you integrate him as a crew member on a space shuttle?" In reality, this knowing Saudi prince had an MA in communications from the University of Denver, understood American culture, and spoke English rather better than the French astronauts associated with his mission (even as he brought an astrolabe onto the shuttle with him as a symbol of his own scientific heritage). "But somehow," Determann observes, "NASA administrators had less worries about cultural misunderstandings with the French."[31]

In this essay, I have attempted to set out one possible way to frame a coherent global history of science through the notion of a *knowing world* centered on questions of geopolitics, cultural identity, and historical memory, in which Western and non-Western histories inform each other, and in which the deep past continues to animate the present while the present animates the past. My hope is that this account can stimulate and encourage colleagues and students to attempt their own new approaches to reconceiving our field. As readers can see, my own is rooted in my background in the early modern era but not confined to it, in the belief that some of the approaches described here could be adapted elsewhere, and provide a useful stepping-stone to other visions of what the history of science could become in the future. Without doubt, many serious challenges remain: the increasing volatility of identitarian and racial polemics and the need to talk them through with skill and sensitivity; the issue of language barriers and the politics of translation; engaging with debates from beyond Anglophone scholarly communities; and training and hiring the next generation of scholars with the skills to open up our field even more. Building on my knowledge in a range of historical subfields as I have, my hope is nevertheless that an integrated approach that relates different regions by challenging assumptions about who is past and who is present in science's global history offers a model of rigorous historicity, a response to the civic urgency of the present, and a path to new histories.

My own view is that the resurgence of nationalism dramatically increases rather than diminishes the importance of understanding its deep historical sources in worldwide perspective, and by *deep* I mean that we cannot limit ourselves to post-1800 histories (or later) as has increasingly become the case, for example, in history and history of science hiring priorities in the United States. There can be no timeless global "view from nowhere" in which locality or historical circumstance is entirely transcended; we are all situated somewhere specific in time and place, even as we continue to contend with the

31. Determann, *Space Science and the Arab World* (note 30), and interview in Marina Koren, "The Middle East's Growing Space Ambitions," *The Atlantic*, June 4, 2018, <www.theatlantic.com/science/archive/2018/06/middle-east-space-ambitions/561776/> (accessed August 2018); Elshakry, *Reading Darwin in Arabic* (note 14).

notion of some form of universal narrative of science. In situating my own scholarly trajectory, and indeed throughout this essay, I have aimed to convey something of the topical vitality and sheer intellectual vibrancy in studying the history of science from a proliferation of vantage points and moments in time, to grasp among other things the inevitable locality and specificity of one's own. This does not mean we cannot strive, knowingly, to understand the wider world in meaningful ways. My students have reacted with enthusiasm, imagination, and curiosity to this endeavor, and have encouraged me to believe that precisely because there is no single or universal vantage on the history of science, we should explore how and why this is so in the changing circumstances of the present.[32]

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32. Steven Shapin, "Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science," *Transactions of the Institute of British Geographers* 23 (1998): 5–12.