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AHR
HISTORY LAB
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An experimental space to reimagine contemporary historical practice.

IN THIS LAB

Reading Nature's Archives

WITH

Authoritarianism 101: A Global History

History Unclassified

Inside the History Lab

The September 2026 History Lab focuses on the imaginative ways in which historians are using archives and other primary sources in their research and teaching to transform our understandings of the past.

It opens with "Reading Nature's Archives," a forum that foregrounds new approaches to the research and writing of environmental history. Organized by David Biggs, the forum brings together a team of distinguished environmental historians who each offer short essays centered on a reading of a particular object or visual form of documentation. Their "archives" range from ivory figurines, whale bones, roof tiles, porcelain earthenware, and botanical prints to a colonial era cattle census, photographs of the sun, aerial imaging of former warscapes, and a twenty-sided golden cosmic box. Together, the contributors provide a set of novel critical methods for reading these sources attuned to how situated forms of knowledge about nature are often shaped by longer histories of borrowing, theft, erasure, and resilience. As Biggs argues in his introduction to the forum, the essays model what Achilles Mbembe calls "a planetary library or archive" that can remake historical apprehensions of the intertwined worlds of human history, nature, and technology.

Two History Unclassified essays explore the complexities and rewards for historians in drawing upon primary sources from and about their own families. In "From Here to There: Thinking with a Chinese Family Archive," Tobie Meyer-Fong examines a small collection of documents, photographs, and artifacts preserved by her mother-in-law. Meyer-Fong considers how these intimate histories allowed her to write a different kind of transnational

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microhistory of war, revolution, and the migratory processes of isolation, engagement, and return for a Chinese American family during the second half of the twentieth century. "In our present moment," she argues, "the family archive affords the opportunity to think expansively through that which is local, small, personal, and intimate and to amplify our understanding of an interconnected world."

Family history is also at the center of Stephanie Palazzo's "Forever in Fiction: The Politics of Closure," a reflection on her fieldwork on the closing of the Three Mile Island Nuclear Power Plant in the wake of the most publicized civilian nuclear accident in the United States. Palazzo grew up in a Pennsylvania town near the site of the Three Mile Island. As a young girl, some years after the accident, Palazzo lost her sister. Years later, early in her field work, she encountered a book at the local public library that purported to detail her sister's illness and death. The tidy narrative the book told of grief and closure, at odds with the more ambiguous lived realities of her sister's death and its aftermath, ultimately prompted Palazzo to reframe how she approached the everyday meanings of nuclear decommissioning and more broadly resist what she sees as the urge to silence messy realities in prevailing narratives of historical closure.

The September Lab concludes with the publication of new modules from the *AHR*'s Authoritarianism 101: A Global History project designed to offer teachers and students a broad historical perspective on the history of authoritarianism in all regions of the world. Each module in the project features on a single textual or visual primary source to focus on big questions about the global histories of authoritarianism and provides a brief contextual essay and teaching plan.

The Authoritarian 101 modules featured in this edition of the History Lab engage with authoritarian histories in China, the United States, Egypt, Cuba, India, Argentina, and South Korea through a variety of primary sources including short texts, photographs, and film. These modules allow students to explore issues such as why elections matter in authoritarian states, the processes through which publics can be socialized into supporting authoritarian regimes, how and why authoritarian states seek to control the movement of people, the nature of popular challenges to authoritarian rule, and why authoritarian states seek to control cultural institutions.

All thirty of the modules that make up Authoritarianism 101: A Global History are free to access. They are available on the project website along with supplementary teaching materials. We encourage readers to use one or more of these modules in your own classrooms. We also imagine the modules can form the basis for student-led discussions about the history of authoritarianism by high school history students, undergraduate history majors and history graduate students, or be used by reading groups at local public libraries.

Mark Philip Bradley

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Reading Nature's Archives

For eighteen years, I have taught my university's five-hundred-student general education course "The Long Twentieth Century" from an environmental and green perspective, reflecting my particular interests and specialties as an environmental historian who wades into science and technology studies and dabbles in historical geography. However, in recent years, since the COVID-19 pandemic and the eruption of AI in universities, notions about how we study, how we teach, and especially how we frame research in relation to terms like *world*, *global*, and *planet* are undergoing seismic shifts. Earth's average annual temperature in 2024 surpassed the 1.5°C threshold above its preindustrial average for the first time, and we are accelerating toward the 2°C mark. AI agents have not only transformed the term-paper game and student cheating, but universities are now inking deals to bring AI tools into course software, labs, and libraries.

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Many may be rightly concerned that the present moment is a crisis of colliding phenomena with long histories entangled in colonialism, revolutions, wars, and social movements; but the present moment is also a profound opportunity. Historians, students, and teachers alike are taking deep dives into questions like "What's special about the human experience?" and "With all the recent scientific discoveries showing how our genes, our biology, and our futures are connected with industrial, geologic, and biological processes, how do we understand the human experience as it's embedded in so many natural and industrial processes ranging from subatomic planes to the cosmos?" This spring, I took a different tack with my gen-ed class. I renamed it "Planetary Consciousness," and after raising big questions about planetary entanglement and showing clips of debates like Joe Rogan's interview with Jensen Huang on AI and consciousness, I introduced into our coursework five-minute meditations, journaling, a collective read-in, and other experiential encounters that challenge students to roam the boundaries between what's human—experience, feeling, consciousness—and what's AI, digital, or even "planetary."[1] We tackled snippets of philosophy, and after the midterm, students wrote their own "planetary family histories" with a little help from novelist Imbolo Mbue, whose novel about multiple generations coping with tragedy in an oil-polluted African river delta is a planetary tragedy of operatic proportions.[2]

This planetary turn is also the inspiration for this History Lab forum, which began as a series of conversations with colleagues working in different areas and periods and with different framings who study science, technology, art, archaeology, theology, and other topics in various places around the world. The primary question that all authors in this Lab forum ask is, how do we read, decipher, interpret, or incorporate various natural, material, visual, and nontextual "archives" in our research, teaching, and community engagement? Cameroonian philosopher Achille Mbembe's essay "Planetary Entanglement" features in a kickoff piece for my class, and it is relevant to this dialogue about archives and methods. Mbembe argues that the world has entered a new epoch where traditional boundaries between human history, nature, and technology have dissolved. Among the many ideas he proposes, one that the authors in this Lab forum engage with concerns what Mbembe calls a "planetary library" that historians and others can use to make sense of this intertwined world. He writes,

> The planetary library will only come into being as these distinct archives are summoned to enter into active relation with one another. The planetary library project rests on the assumption of the inseparability of the different archives of the world. . . Instead of holding them apart, it will recognize them as assets shared with all humans, nonhuman actors, and self-sustaining systems.[3]

Mbembe goes on to state that this act of constituting a planetary library or archives is in effect the argument. In the same vein, this

Frontis: Skeleton of a blue whale, "Hope" in the Central Hall of the Natural History Museum in London, England. Diego Delso/Wikimedia Commons/CC BY-SA 4.0.

History Lab forum, "Reading Nature's Archives," presents nine different pieces where the method is the argument, and the authors draw from a rich panoply of objects and framings to consider different segments of an emergent library or archives.

The contributors in this Lab forum reflect recent generations of scholars engaged with environmental history, which grew as a fringe subfield out of environmental movements since the 1960s. It is now one of history's fastest-growing areas, with dedicated courses, journals, book series, and conferences. Environmental history went mainstream beginning in the early 2000s with books like Michael Pollan's *The Botany of Desire: A Plant's-Eye View of the World* becoming bestsellers and films like Davis Guggenheim and Al Gore's *An Inconvenient Truth* becoming box office hits.[4] Since then, environmental history has grown rapidly both inside and out of universities. It has moved far beyond modern or Western history, too, as historians reconsider works like Pliny the Elder's *Natural History* (77–79 CE) and the Chinese *Classic of Mountains and Seas* (ca. fourth century BCE). Curators, high school teachers, and community organizations now regularly examine new and old topics through green lenses.

In recognition of environmental history's origins and the present planetary moment, this Lab forum's title is crafted with three words intentionally selected to point to two core questions that environmental historians have always grappled with: What does it mean to *read nature*? And what constitutes an environmental *archive*? Raymond Williams once wrote that "nature is perhaps the most complex word in the [English] language," considering how the term can evoke simultaneously an essence, a force, and the material world with or without humans.[5] Working from this etymological and semantic quagmire to the question of translation, especially in non-Western languages, one is then confronted with the problem of reading or understanding what is meant by "nature" in languages like Chinese, Persian, and Vietnamese. Various texts in the Sinosphere use the term *qi* (氣) to describe a "vital essence" or life force when describing mountains, rivers, and other natural features; but are they understanding this essence in the same way that a Greek, English, or American writer might in describing forces of nature? For anyone who's discussed these questions with Williams's essays in a seminar, the eventual answer most people reach is that there is no definitive answer and there never will be. How one defines or translates words like *nature*, *qi*, *environment*, *ecology*, *Gaia*, *green*, *landscape*, *cosmos*, and *oikos* in their study becomes a core part of the argument.

The act of reading must also be considered more deeply. Besides reading texts or images, how does one read environmental information such as tree rings, the stars, whalebones, genetic code, and plant fibers? And how does one present their readings? Cartographic historian Mark Monmonier's classic *How to Lie with Maps* shows how mapmakers consciously or unconsciously "lie" by presenting the nature they are describing using certain symbols, noting (or erasing)

various features, and choosing which place-names to list.[6] Much of what can be read is data produced by scientists, and it depends on specific technologies that record selected features but not others. Much of this data may have political or economic significance, too, so there may be limits on who can access or read it, even in archives. How one reads and interprets sources has always been core to historical research and writing, but what sets natural or environmental sources apart are the additional scientific and technological languages one must acquire to access them.

Finally, archives and the act of archiving are always a core part, sometimes the largest part, of the environmental historian's argument. As the essays in this collection show in various ways, the historiographic frontier in environmental history is ever expanding as historians draw attention to data, specimens, materials, recordings of energy fluctuations, and colors that when compared against other sorts of archives reveal new perspectives and raise new questions. This act of selecting new sources or archiving for environmental historians has been deeply influenced by ecofeminist historians like Donna Haraway who argue that developing environmentally contextualized knowledge is eco-feminist in the sense that it is "about limited location and situated knowledge, not about transcendence and splitting of subject and object."[7] Along similar lines, environmental historians working with different kinds of knowledge about nature, especially Indigenous knowledge, must reckon with histories of borrowing, theft, erasure, and resilience that are woven into various archives, especially museum collections.

As the pieces in this History Lab forum show, the act of reading nature's archives involves deep philosophical, conceptual, and ethical positioning, or situating, and it requires historians to reflect on the ways one reads. Here follows a brief tour:

- Arash Khazeni examines a golden icosahedron not just as a physical object, looted by the British from Tipu Sultan in southern India, but as a scientific instrument that reflects a specific understanding of the relationship between Earth and the cosmos, what he terms an "archive of astral sciences."
- Archaeologist Ellen Hsieh's essay on porcelain-inlaid earthenware found in the 1600 *San Diego* shipwreck in Manila Bay treats material and sensory experiences as vital historical data. Moving beyond functional interpretations, Hsieh situates the objects within Iberian practices of consuming and valuing clay, arguing that their significance lay in the sensory experiences they produced.
- Samuël Coghe's essay on cattle censuses in colonial Madagascar demonstrates how a specific natural resource (livestock) became

part of a planetary library when its biological data was synthesized with administrative and financial archives. Cattle censuses act as a "window onto colonial knowledge production," where the biological state of the herd was interpreted as a reflection of "colonial progress."

- Jonathan Schlesinger, J. Ryan Kennedy, Kristine Korzow, Vicky M. Oelze, and Peter E. Sauer treat physical objects—specifically ivory figurines from a museum collection—as biological repositories that via mass spectrometry and other methods record the history of an entire species, especially elephant populations from before the twentieth century, where systematic biological studies do not exist. This "ivory archive" reveals the massive, planetary-scale event of centuries of human hunting, trading, and collecting, which fundamentally altered the Earth's biological landscape.
- Thomas Fleischman and Ryan Tucker Jones take a similar approach in their study of whale parts, showing how substances from oil still oozing out of whale skeletons hanging in museums to earplugs and baleen record a lifetime of environmental data, including stress levels, diet, and ocean chemistry, effectively archiving the health of the oceans. Fleischman and Jones advance an "additive empiricism," which accepts biological and behavioral data as valid historical evidence.
- My piece explores how historians read conflict landscapes in Vietnam. It considers intervisual approaches to historic aerial images and how the recent explosion of digital imagery might be employed with historic aerial imagery and "ground-truthed" knowledge to better expose multilayered, entangled histories of conflicts like the Vietnam War, showing how they are tied to deeper pasts and postconflict recovery.
- Ruth A. Morgan's essay on solar photography focuses on how people read scientifically sourced data about natural processes. She extends the planetary library to include the sun, treating thousands of glass plate negatives and "sun portraits" held at places like the Royal Observatory, Greenwich, as a distinct archive. By measuring and "reducing" these images into printable results, British astronomers converted raw natural signals into historical evidence.
- Shen Hou's essay on the red roofs of Qingdao treats the city's architectural skyline not just as a cultural or aesthetic choice but as a material record of environmental, geological, and colonial history. Hou shows that "red roofs, green trees, emerald sea, and blue skies" formed a singular, integrated system where the "intermingling" of natural forces (sea and sky) with human technology (clay tiles) formed a distinctive material archive.

- Yiyun Peng's essay asks how historians can combine modern botanical knowledge with collections of historic botanical drawings and paintings for a single plant to show how these visual archives may reveal vital information about the changing morphology of the plant as well as highlight different cultural perspectives on a plant and its economic uses.

David Biggs

On behalf of the authors, I wish to thank *AHR* editor Mark Bradley and managing editor Sarah Muncy as well as the anonymous reviewers and the contributors, especially those who presented drafts of their work at the recent AHA annual meeting in Chicago. Let me conclude by conveying a hope expressed by contributors that these essays and methods might not just appeal to academic researchers but also find their way into high school classrooms or museum programs; this is key if we are to train future generations to read in our planetary library.

1 Joe Rogan, host, *The Joe Rogan Experience*, podcast, episode 2422, "Jensen Huang," Spotify, December 3, 2025, https://open.spotify.com/episode/0yT4ec9M6GobLC5ByN8pX3?si=8NrMbta7RWmhY3aHVrxW4A. Jensen's reflection on "what consciousness is" follows Rogan's joking about Nvidia creating the Terminator and Rogan's articulating common fears about synthetic biology at the twenty-eight-minute mark.
2 Imbolo Mbue, *How Beautiful We Were* (Random House, 2021).
3 Achille Mbembe, "Planetary Entanglement," in *Out of the Dark Night: Essays on Decolonization* (Columbia University Press, 2021), 39.
4 Michael Pollan, *The Botany of Desire: A Plant's-Eye View of the World* (Random House, 2001).
5 Raymond Williams, *Keywords: A Vocabulary of Culture and Society* (Fontana, 1976), 184.
6 Mark Monmonier, *How to Lie with Maps*, 3rd ed. (University of Chicago Press, 2018).
7 Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," *Feminist Studies* 14, no. 3 (1988): 575–99, here 583.

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Arash Khazeni

Archive of the Seven Spheres

Earth and Cosmos in the Eighteenth-Century Deccan

Among the objects looted by the East India Company from the treasury of Tipu Sultan, nawab of Mysore, following the conquest of Srirangapatnam in 1799 was a golden icosahedron with each of its twenty sides inscribed with an Arabic numeral (Figure 1). The mysterious gold box measures 2 1/4 by 2 3/8 inches and is adorned with the numbers 11, 20, 21, 31, 41, 51, 61, 71, 81, 91, 101, 201, 202, 301, 401, 501, 601, 701, 801, and 901. The golden icosahedron was exhibited at the Metropolitan Museum of Art in 2014 and the Victoria and Albert in 2015 before being sold at auction in 2019. The mystery of the box and the story of its theft and eventual sale at auction elevated its fame as a prized objet d'art and gained notoriety in the press, leading to calls for its repatriation and critiques of its place in a contested postcolonial politics of possession. But the purpose and meaning of the polyhedron and the intellectual and scientific context in which it was produced in the court of Tipu Sultan remain unknown, and all references to this extraordinary object, while putting forth some generic theories, conclude that its purpose remains inscrutable. It has been hypothesized that the twenty numbers represent complex mathematical calculations and numerical relations that approximate the values of pi, the golden ratio, and their squares, or that the object was a supernatural talisman possibly correlating to the numerical codes and mysteries of the Qur'an, whereas in fact the numbers correspond to *abjad*, the Arabic-Persian alphanumeric system of mathematical theorems and constructs related to the letters of the alphabet. Viewed and labeled as a "box," the spherical object—embellished with minute stars—has received insufficient attention for its resemblance to a planetary body. It seems to have lost its meaning

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Figure 1. The gold icosahedron of Tipu Sultan. Inscribed on twenty sides with Arabic *abjad* numerals corresponding to letters in the Arabic alphabet. Mysore, South India, circa 1780–90. Courtesy of Metropolitan Museum of Art, *Treasures from India: Jewels from the Al-Thani Collection*.

when detached from the archive of astral sciences in the court of late eighteenth-century Mysore that it was once part of. Crafted within an Indo-Persian cultural world where the environment was seen as a mirror of the sky, the gold, sunlike polyhedron was an instrument to bridge the distance between the stars and the Earth.

Amid the chaos of the last decades of the eighteenth century in India, the Kingdom of Mysore in the Deccan turned to reading the planets and stars to divine and affect the future during troubled times. The colonial encounter with the British East India Company and the Anglo-Mysore Wars of 1767–99 had taken their toll on the kingdom and its lands. Francis Buchanan's survey of Mysore, published in 1807 as *A Journey from Madras Through the Countries of Mysore, Canara, and Malabar*, records the ruinous ecological effects of the Third Anglo-Mysore War (1790–92) and the campaigns of the East India Company, which depopulated villages, destroyed settlements, and brought famine to the region.[1] In the densely forested Western Ghats mountains of Karnataka, the Indigenous Coorg tribes rebelled against the kingdom, the clashes further ravaging and bringing ruin to the land. Between 1789 and 1795, the environmental devastation of warfare was compounded by the failure of the southwest monsoon of the Indian Ocean in consecutive summers, resulting in drought and the "Skull Famine" of 1791 in the Deccan.[2] Like a sign of dark times, a series of solar and lunar eclipses, including the dreaded conjunction of Saturn and the north lunar node in the zodiac sign of Pisces, appeared in the Deccan sky during the 1790s.[3]

Seeking to bring the order of the stars to the Earth, Tipu Sultan and his court astrologers, scientists, and scribes collected and produced

an archive of Persian and Arabic manuscripts on the laws of the movement of planets and stars and their effects on fortune and misfortune on Earth. Numerous volumes from among the more than two thousand manuscripts, seized after the fall of Srirangapatnam in 1799 and now kept in the collections of the India Office in London and the Asiatic Society of Bengal in Calcutta, were on the related sciences of astronomy (*ʿilm al-nujum*) and astrology (*ʿilm ahkam al-nujum*), including original texts compiled under court patronage to reconcile Persianate and Sanskritic knowledge of the celestial spheres, as well as grimoires and books on talismans and divination based on knowledge of the astral sciences. In "The Climate of History: Four Theses," Dipesh Chakrabarty has called for bringing together global and planetary histories in the age of the Anthropocene, when humanity has become a geophysical force impacting the Earth's systems and climate.[4] This essay approaches the concept of planetary history but takes it into a different cultural orbit and archive, that of Islamicate occult and metaphysical sciences, to explore how in the late eighteenth-century Deccan the Earth and its environment were understood as part of a planetary system and cosmos.[5] In keeping with the experimental approach of this History Lab forum and the theme of "reading nature," it details aspects of the visual and talismanic culture of the archive of planetary sciences collected in the court of Tipu Sultan in Mysore.

During the late eighteenth century, with the devolution of the power of the Mughal dynasty (1526–1858), various independent princely states emerged as sovereign in the Indian subcontinent. Among these was the Kingdom of Mysore in the Deccan. Between 1761 and 1799, Haydar ʿAli (r. 1761–82) and his son Tipu Sultan Fath ʿAli Khan (r. 1782–99) became the de facto nawabs, or regents, of Mysore and established an Indo-Persian sultanate with its capital city at Srirangapatnam, an island fortress in the Kaveri River. Through a series of wars fought against the East India Company, they resisted British colonial expansion into southern India, while seeking alliances with the Ottoman Empire, Qajar Persia, Durrani Afghanistan, the Sultanate of Oman, the Maratha Confederacy, the Konbaung Empire of Burma, and Republican France. But by the 1790s, Mysore's star began to wane. Upon the conclusion of the Third Anglo-Mysore War in 1792, Tipu Sultan was forced to cede half his kingdom to the British Governor-General Lord Cornwallis and to send two of his sons as hostages to the British in Bengal. Ravaged by war and famine, in 1799, the kingdom was dramatically conquered by the Company, with Tipu Sultan killed at the gates of the capital.[6]

The pursuit of the astral sciences in eighteenth-century Mysore was only natural as it was an enduring element in the repertoire of Persianate kingship and court culture in South Asia. The astral sciences were pervasive previously in the Mughal Empire and the Deccan Sultanates, including close exchanges with Vedic astrology. It was during the last uncertain and chaotic years of his reign, in times of colonialism, war,

and famine, however, that Tipu Sultan and members of his court most intensely sought knowledge of the movements and influence of planets and stars to affect the fortune of their empire. East India Company observers took note of Tipu Sultan's interest in the science of astrology, deriding it as "fatalism." In *Historical Sketches of the South of India*, Mark Wilks, a Company soldier who took part in the siege of Seringapatam and later became British resident at Mysore, disparaged the nawab's dependence on such occult practices and superstitions as astrology, writing, "Tippoo, as if despairing of human aid, was seeking those delusive means of penetrating into futurity, so familiar in the history of every country, and of even engaging supernatural aid, through the incantations of the bramins." Wilks speculated how Tipu Sultan's perceptions of astrology had changed over time, since "in his early youth" Tipu had "treated with derision the science of astrology" but in the last decade of his reign he had become "a convert to its reality."[7]

The planetary preoccupations of Tipu Sultan and his court stemmed in part from the nawab's interest in the measure of time. In 1784, Tipu Sultan instituted a new calendar he named the "Mawludi," a lunisolar calendar beginning with the birth of the Prophet Muhammad in 571, rather than the conventional Islamic lunar calendar beginning with the Prophet's flight from Mecca to Medina in 622.[8] A synthesis of the Islamic lunar and Indian solar calendars, the Mawludi introduced a cycle of sixty solar years consisting of twelve lunar months based on the Vedic Panchanga calendar prevalent in Mysore, corresponding to the five revolutions of the planet Jupiter around the Sun. Using the *abjad* system of Islamic numerology, new names of months were created, with the initial letter of each month representing its place of order in the calendar.

The pursuit of the astral sciences to uncover the cosmic order is most vividly traced through the archive of astrological texts collected in Tipu Sultan's library, or *kitabkhana*. These works were first fully cataloged by the Orientalist Charles Stewart in his *Descriptive Catalogue of the Oriental Library of the Late Tippoo Sultan of Mysore* (1809), and many of these texts are now kept in the collections of the British Library in London and the Asiatic Society of Bengal in Calcutta.[9] The collection naturally contained copies of some of the classic titles in the canon of Islamic astronomy and astrology, including various editions of Nasir al-Din Tusi's *Kitab-i Zij-i Ilkhani*, compiled at Maragha in 1272 during the reign of the Mongol Ilkhanid dynasty (1256–1335), and Ghiyath al-Din Jamshid ibn Masʿud al-Kashani's *Kitab-i Zij-i Khaqani*, dedicated to the Timurid sultan, astronomer, and mathematician Ulugh Beg (r. 1447–49). The collection extended far beyond these canonical sources, however, to contain more original works, including several focused on the recovery and translation of Indian and Sanskritic astral sciences. Among these texts in Tipu Sultan's library was possibly the celebrated manuscript *Nujum al-ʿUlum* (*Stars of the Sciences*), an illustrated encyclopedia of astrology and astral magic composed in Bijapur in 1570 during the reign of Sultan ʿAli ʿAdil Shah (r. 1557–79) of the

ʿAdil Shahi dynasty and now kept in the Chester Beatty Library in Dublin.[10] *Nujum al-ʿUlum* would have found a ready audience in the court of Tipu Sultan, under whose order in 1791 Zayn al-Abidin Shushtari (1754–99), the head Persian scribe (*mir munshi*), produced a compendium of Indo-Persian astral sciences titled *Topaz* (*Zabarjad*).[11] Still other works were on sciences closely related to astrology, such as treatises on geomancy, known as "the science of the sand" (*ʿilm al-raml*), books of stones, and grimoires on the talismanic arts. Taken together, this cosmographic archive presents a view of the Earth as bound to the movements of the celestial sphere, the knowledge of which could shape the fate of the sovereign.

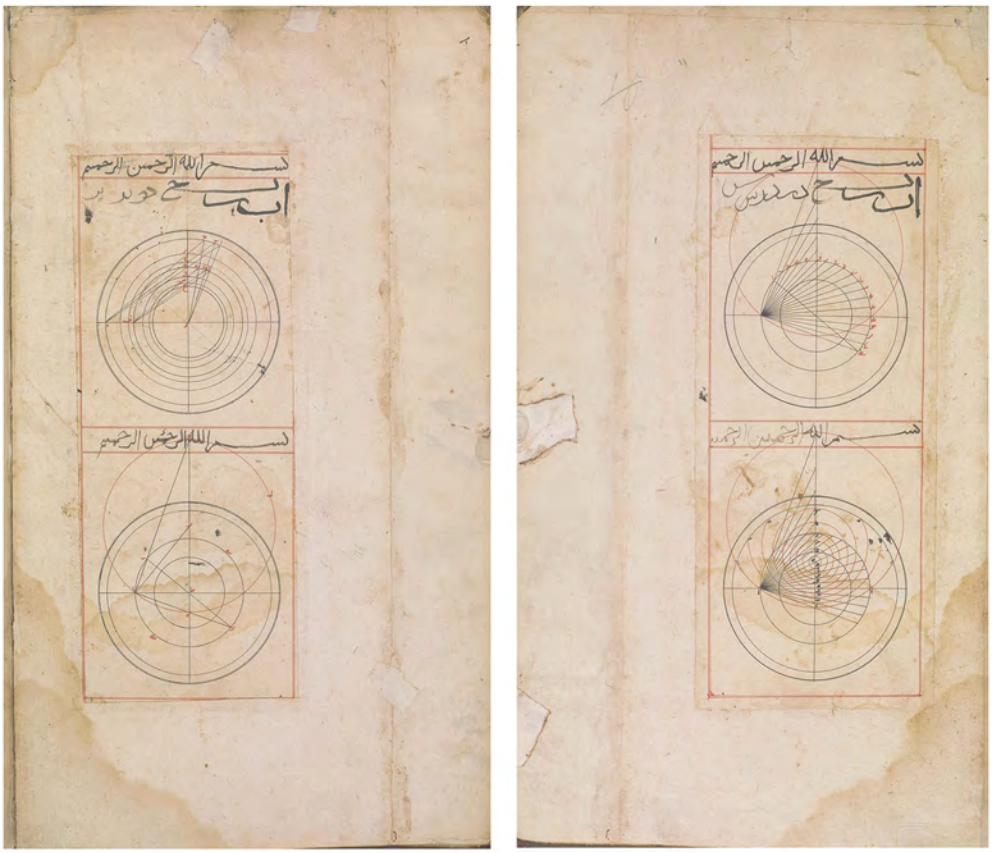

Figure 2. Concentric circles of the celestial sphere and the latitudes of the Earth to be engraved on the interchanging tympans (*lawhat*) of an astrolabe along with the phrase *bismallah al-rahman al-rahim* ("in the name of God, the merciful, the compassionate"). *Sunnat-i Astrolabe*, British Library, IO Islamic 1514, fols. 11r–11v. Courtesy of Qatar Digital Library.

Some works on the astral sciences once kept in Tipu Sultan's library provide visual representations and abstractions of the Earth's place within the cosmos (*ʿalam*). A Persian manuscript on the preparation and working of the astrolabe maps the Earth and its climes within the spheres of the universe. Titled *Risala-yi Astarlab* (*Treatise on the Astrolabe*), it includes drawings that sketch the concentric circles of the celestial sphere to be engraved on the interchanging tympans or

plates (*lawhat*) of the instrument (Figure 2).[12] The sky or celestial sphere (*samavat*) is the realm of the seven heavenly bodies and other stars that appears to rotate around the Earth, which lies at its center. In this model of the universe, derived from Ptolemy, the Earth was the stationary center of the cosmos, with the Sun, Moon, and planets orbiting around it in a series of nested spheres. The face of the astrolabe's plate maps the celestial sphere on a two-dimensional flat surface. The concentric rings to be etched on the astrolabe trace the motions of the seven heavenly bodies, while a stereographic projection corresponds to the horizon lines representing the altitude of the Sun, Moon, and planets. The lines of the circles and the projections are marked by letters of the Arabic alphabet. Some of the letters signifying points on the spherical lines—*aleph* (ا), *ba* (ب), *ha* (ح)—correspond to the string of letters written in the heading beneath the phrase *bismallah al-rahman al-rahim* ("in the name of God, the merciful, the compassionate"). The presence of this devotional invocation suggests the protective and divinatory properties of the astrolabe as a scientific instrument of planetary cartography, in addition to its use in determining the time, geographical latitudes, and location of prayer. The adjacent folio page features a chart that identifies the seven heavenly bodies, or "seven stars" (*al-kawakib al-sabʿah*), Sun (*Shams*), Moon (*Qamar*), Saturn (*Zuhal*), Jupiter (*Mushtari*), Mars (*Mirrikh*), Venus (*Zuhra*), and Mercury (*ʿUttarid*), along with information on their orbits (*aflak*), sequence of movements (*harakat*), and changing positions in relation to the cosmic center (*markaz-i alam*) of the universe.[13]

The representation of the universe engraved on the astrolabe placed the Earth within a spherical planetary system. Concentric circles, referred to throughout the manuscript of *Risala-yi Astarlab* as *dayira*, represent the repeating pattern of the universe. The concentric lines and coordinates of the celestial sphere were mirrored onto the terrestrial in this cosmographic perspective of the universe. The concentric rings of the celestial bodies aligned with the circles dividing the seven climes (*haft iqlim*), the latitudinal zones of the Earth. These spherical lines included the tropics, the equator, and the *almucantar*, the circle on the celestial sphere parallel to the horizon. The different interchanging plates of the astrolabe were engraved with celestial lines and coordinates specific to a particular latitude on Earth. A corresponding star chart in the manuscript lists the names of major cities (*al-bilad*) in the temperate climes of the Islamicate world and their corresponding positions on the astrolabe, including the latitude (*al-ʿarudh*), time (*al-saʿat*), and the numerical coordinates (*al-ʿadad*) to find the constellation of stars at a certain time of night from the vantage of a particular location.[14] The treatise thus depicts the astrolabe as a cosmographical instrument for taking measure of the cosmos in relation to the Earth's climes. The astrolabe conveyed essential knowledge about the motion and altitude of the celestial bodies used for telling time, astronomy, and navigation. But because the astrolabe was associated with seeking knowledge of the

future through astrology and divination, often inscribed with prayers and signs and thought to capture celestial forces, it was also a talismanic object for predicting fortune on Earth.[15]

With the means to map the connection between Earth and cosmos, one could begin to interpret and redirect planetary influences. Other manuscripts from the library of Tipu Sultan detail the esoteric arts of engraving talismanic figures and formulas on material objects. These include *Kitab Dhakhirat al-Iskandar* (*The Book of the Treasure of Alexander*), kept in the British Library as Manuscript India Office Islamic 673, an Arabic treatise in ten chapters on the hidden sciences of talismans and celestial magic attributed to Aristotle (Arastutalis) and dedicated to Alexander (Iskandar).[16] In the preface, it is written that it is a lost work of the great god Hermes (Hirmis al-Kabir) dictated to the philosopher Apollonius (Balinas) and passed on to Aristotle, who in turn presented it to Alexander. According to its framing narrative, the original work was written in Greek on 360 leaves of gold and deposited in a golden chest, lying buried until it was rediscovered during the ninth century and translated from "the Greek and Roman languages" into Arabic at the request of Abbasid Caliph al-Muʿtasim (r. 833–42).[17] In revealing knowledge of the hidden, unseen world, *Kitab Dhakhirat al-Iskandar* details the arts of the preparation of an array of talismans, including chapters on different talismanic arts and instructions for the creation of talismans to harness and direct the power of the cosmos for desired outcomes. The instructions carefully outline the auspicious astrological timing (such as when a particular planet is in the ascendant) to imbue the talisman with desired celestial energies; depict the images, symbols, and inscriptions to be engraved to bond the talisman; and specify the materials out of which the talisman is to be made.

The sixth chapter of the manuscript is on the talismans and seals of the seven planets (*khatam al-kawakib al-sabʿah*) "in the way described by Hermes, who impressed many kings by wearing them."[18] Foremost among these planetary talismans for receiving the celestial influences that dwell in the ether was the seal of the Sun (*khatam al-Shams*), a marvelous talisman representing royal power intended for kings. In *Kitab Dhakhirat al-Iskandar* and other Arabic and Persian treatises on the astral sciences, the Sun (Arabic: *al-Shams*) is given preeminence among the seven celestial bodies and praised as *Nir al-ʿAzm*, or the "Great Light," with the different climates on Earth—the seven climes—attributed to its solar rays.[19] The Sun influenced the Earth's climate and terrain, caused plants to grow, and determined the different races of people on the planet. The Sun talisman, it was believed, allowed kings to harness the star's radiant powers.[20] Likewise, in the previously mentioned sixteenth-century Persian manuscript *Nujum al-ʿUlum*, the astrological charts or *chakra* are given for different phases in the appearance of the Sun (Persian: *Aftab;* Sanskrit: *Suri*) across the horizon and the talismanic grounding of solar rays in different terrestrial zones (*zamin*) on Earth (Figure 3).[21] The view of the cosmic terrestrial

Figure 3. The Sun's Path, *Ayn Suri Chakra*. The path of the Sun across the northern and southern hemisphere, shown with the talismanic diagram to indicate how solar energy from the Sun's orbit could be summoned to attain victory during war. The diagram, identified in Persian as *chakr* to denote the Sanskrit word *chakra* (cycle), is inscribed with the cardinal points as well as the Persian transliteration of the Sanskrit names for the Sun's northern and southern journeys, Uttarayana and Dakshinayana. *Nujum al-ʿUlum* (*Stars of the Sciences*), Chester Beatty Library, MS In 02, fol. 301r. Courtesy of Chester Beatty Library.

power of the Sun in these texts of astral talismans correlates with the prominence of solar iconography and symbolism, such as on banners, in the court of Tipu Sultan.[22] The Sun was the brightest illumination in a universe of diverse planetary and astral radiance that were classified in astrological texts from the library of Tipu Sultan. This archive represents a view of the Earth as a mirror of the celestial sphere before there was a separation between these two realms with the advent of nineteenth-century colonial science.

Within three years of the fall Srirangapatna, the Great Trigonometrical Survey of India was initiated in 1802 under the auspices of the East India Company by mapping the Carnatic region across the newly acquired territory of Mysore.[23] The geodetic survey drew "from a great number of the observations of different fixed stars" to define exact latitude and longitude and determine the curvature and shape of the Earth.[24] But although the science of geodesy mathematically linked the Earth to the stars to make terrestrial measurements, it treated the two as separate in a universe of pure physics bound by mathematical laws. This sky was not the celestial sphere. Stripped away of their celestial influences and meanings, the stars were fixed in space to measure the disenchanted Earth.

The golden icosahedron inscribed with Arabic numerals and stars noted at the beginning of this piece belonged to this archive of the astral sciences collected in the court of Tipu Sultan during the troubled last decade of his reign and wars against the British East India Company in the Deccan. Astrological treatises and books of divination and geomancy, as well as the vibrant material culture of talismans, it was believed, could be used to summon the influence of the cosmos and mediate the natural world. Seen in this light, the gold polyhedron, with the appearance of a radiant stellar or planetary body, might be understood as a twenty-sided die used in the science of divination, its inscribed numerals correlating to *abjad* letters that could be read for their astral significance when rolled.[25] Crafted at an astrologically auspicious time and made with specific materials and inscriptions, the golden die would have been cast to seek counsel or answers about the unknown, its coded numerals likely relating to a small *abjad* code chart or cipher kept folded inside and used to find hidden cosmic influences. It is a lost object from the archive of planetary sciences kept by the Kingdom of Mysore to mediate Earth and cosmos during the chaos of war and colonialism in late eighteenth-century India.

Arash Khazeni is professor of history at Pomona College. He is the author of *Tribes and Empire on the Margins of Nineteenth-Century Iran* (2010), *Sky Blue Stone: The Turquoise Trade in World History* (2014), and *The City and the Wilderness: Indo-Persian Encounters in Southeast Asia* (2020).

1 Francis Buchanan, *A Journey from Madras Through the Countries of Mysore, Canara, and Malabar*, 3 vols. (London: W. Bulmer, 1807).

2 Richard Grove, "The Great El-Niño of 1789–93 and Its Global Consequences: Reconstructing an Extreme Climate Event in World Environmental History," *Medieval History Journal* 10, nos. 1–2 (2006): 75–98.

3 Charles Philip Brown, *Carnatic Chronology: The Hindu and Mahomedan Methods of Reckoning Time Explained* (London: Bernard Quaritch, 1863), 76.

4 Dipesh Chakrabarty, "The Climate of History: Four Theses," *Critical Inquiry* 35, no. 2 (2009): 197–222. Also see Dipesh Chakrabarty, *The Climate of History in a Planetary Age* (University of Chicago Press, 2021).

5 In recent years, a wave of new studies on Islamicate occult and metaphysical sciences by Matthew Melvin-Koushki, Azfar Moin, Travis Zadeh, and Francesca Leoni, among others, have examined notions of the cosmos in Islam. See A. Azfar Moin, *The Millennial Sovereign: Sacred Kingship and Sainthood in Islam* (Columbia University Press, 2012); Francesca Leoni, *Power and Protection: Islamic Art and the Supernatural* (Ashmolean Museum, 2016); Matthew Melvin-Koushki and Noah Gardiner, eds., "Islamicate Occultism: New Perspectives," special issue, *Arabica* 64, fasc. 3/4 (2017); Emma J. Flatt, *The Courts of the Deccan Sultanates: Living Well in the Persian Cosmopolis* (Cambridge University Press, 2019); Liana Saif, Francesca Leoni, Matthew Melvin-Koushki, and Farouk Yahya, eds., *Islamicate Occult Sciences in Theory and Practice* (Brill, 2020); and Travis Zadeh, *Wonders and Rarities: The Marvelous Book That Traveled the World and Mapped the Cosmos* (Harvard University Press, 2023). This innovative wave of work has been focused on the medieval and early modern periods, however, and there exist no studies centered on the practice and reception of Islamicate occult and astral sciences in specific colonial contexts.

6 The standard modern political biography of Tipu Sultan, based on diverse primary sources in Persian, English, French, and Urdu, remains Mohibbul Hasan, *History of Tipu Sultan* (World Press, 1971). Newer historiography on Tipu Sultan and his reign in Mysore has nuanced older perspectives that emerged from the Anglo-Mysore Wars, and that cast him alternately as a Muslim imposter in a Hindu land overthrown by the East India Company and as a martyr who opposed British conquest, by exploring such themes as anticolonial resistance, modernization and development, and the culture of collecting. Despite these advances, more recent works still tend to ultimately approach this history through political narratives and frameworks and remain heavily grounded in English-language colonial source materials. See Irfan Habib, ed., *Confronting Colonialism: Resistance and Modernization Under Haidar Ali and Tipu Sultan* (Anthem, 2002); Maya Jasanoff, *Edge of Empire: Lives, Culture, and Conquest in the East, 1750–1850* (Knopf, 2005); and Kaveh Yazdani, *India, Modernity and the Great Divergence: Mysore and Gujarat (17th to 19th c.)* (Brill, 2017). This is also true of William Dalrymple's recent popular history *The Anarchy: The East India Company, Corporate Violence, and the Pillage of an Empire* (Bloomsbury, 2019). For a notable exception, see Kate Brittlebank, *Tipu Sultan's Search for Legitimacy: Islam and Kingship in a Hindu Domain* (Oxford University Press, 1997), as well as her articles that examine the more esoteric elements of Tipu Sultan's sovereignty, including "Sakti and Barakat: The Power of Tipu's Tiger; An Examination of the Tiger Emblem of Tipu Sultan of Mysore," *Modern Asian Studies* 29, no. 2 (1995): 257–69, and "Accessing the Unseen Realm: The Historical and Textual Contexts of Tipu Sultan's Dream Register," *Journal of the Royal Asiatic Society* 21, no. 2 (2011): 159–75. In these studies, Brittlebank focuses on themes of kingship and religion instead of external relations and war with Britain. Still, Tipu Sultan's archive of Persian-language manuscripts on astral and earth sciences remains completely unexplored. For two recent works approaching the reign of Tipu Sultan from the global contexts of the oceanic South and the Indian Ocean hajj, see Sujit Sivasundaram, *Waves Across the South: A New History of Revolution and Empire* (University of Chicago Press, 2020), and Rishad Choudhury, *Hajj Across Empires: Pilgrimage and Political Culture After the Mughals, 1739–1857* (Cambridge University Press, 2023).

7 Mark Wilks, *Historical Sketches of the South of India, in an Attempt to Trace the History of Mysoor*, vol. 3 (London: Longman, Hurst, Rees, Orme, and Brown, 1817), 437. Such a polemical and disparaging opinion of astrology was not shared by all Company observers, some of whom did engage with Indo-Persian astral sciences. See C. A. Bayly, *Empire and Information: Intelligence Gathering and Social Communication in India, 1780–1870* (Cambridge University Press, 1996), 247–64.

8 The Hijri calendar is a lunar calendar that consists of twelve months based on the motion of the moon, and because a lunar month is 29.53 days, the Islamic calendar is consistently shorter than a solar year by about 11 days.

9 On texts of astronomy and astrology, see Charles Stewart, *A Descriptive Catalogue of the Oriental Library of the*

Late Tippoo Sultan of Mysore (Cambridge: Cambridge University Press, 1809), 101–5. An earlier catalog of Tipu Sultan's library is extant in a manuscript at the British Library; see *Correspondence Relating to Tipu Sultan's Manuscripts*, BL, MSS Eur.E.196, fols. 178v–180r. For more recent analyses of Tipu Sultan's archive, see Ursula Sims-Williams, "Collections Within Collections: An Analysis of Tipu Sultan's Library," *Iran: Journal of the British Institute of Persian Studies* 59, no. 2 (2021): 287–307.

10 *Nujum al-ʿUlum*, Chester Beatty Library, MS In 02. Stewart notes the existence in Tipu Sultan's collection of a "Thick Quarto, Nastâlik Character; gilt, and ornamented with strange Pictures, said to resemble the Genii and other Beings of the invisible World." Identifying its title as "*Jâmî âl Ulûm*," Stewart classifies it as "a treatise on Universal Science, in Fifty-three Chapters; viz. Astronomy, Geography, Physic, Music, Theology, War, Agriculture and Horticulture, Omens, Talismans, Chymistry, the Magnet, &c. &c.—a strange Mixture of Truth and Fiction. It also contains a Description of the Twelve Sects of Jogies or Fakīrs, between whom and the Sūfies there appears to be little Difference." See Stewart, *A Descriptive Catalogue of the Oriental Library of the Late Tippoo Sultan of Mysore*, 95. This is corroborated by David Price, who described finding in Tipu Sultan's palace library a "very curious Persian manuscript … a treatise on magic" illustrated with "diagrams and pictorial illustrations" that was separated from the collection and not in the catalog. See David Price, *Memoirs of the Early Life and Service of a Field Officer, on the Retired List of the Indian Army* (London: William H. Allen, 1839), 446. Citing Price, Ursula Sims-Williams suggests that it "is no doubt a copy of the *Nujum al-ʿulum*, possibly even to be identified with the famous manuscript Dublin, Chester Beatty, MS In 02." See Sims-Williams, "Collections Within Collections," 288. Indeed, there are other Persian texts on aspects of Vedic astrology that are known to have entered Tipu Sultan's collection that once belonged to the courts of the Deccan sultanates—for instance, "Tarjuma-i Barahi" (the Persian translation of Varahamihira's "Brihatsamhita"), formerly belonging to Muhammad Qutb Shah, sultan of Golconda; see BL, IO Islamic 1262. For analysis of *Nujum al-ʿUlum* in the context of the Adil Shahi court in which it was produced, see Flatt, *The Courts of the Deccan Sultanates*, 210–67.

11 This work is extant in a single late eighteenth-century Persian manuscript. Zayn al-Abidin Shushtari, *Zabarjad*, Asiatic Society of Bengal, Calcutta, MSS 1506. For some examples of the literature on Indo-Persian astral sciences, see works by David Pingree, including "Astronomy and Astrology in India and Iran," *Isis* 54, no. 2 (1963): 229–46; *The Thousands of Abu Maʿshar* (Warburg Institute, 1962); and *From Astral Omens to Astrology: From Babylon to Bikaner* (Istituto Italiano per l'Africa e l'Oriente, 1997). Also see Eva Orthmann, "Circular Motions: Private Pleasure and Public Prognostication in the Nativities of the Mughal Emperor Akbar," *Horoscopes and Public Spheres: Essays on the History of Astrology*, ed. Günther Oestmann, H. Darrel Rutkin, and Kocku von Stuckrad (De Gruyter, 2005); Eva Orthmann, "Lettrism and Magic in an Early Mughal Text: Muhammad Ghawth's *Kitab al-Jawahir al-Khams*," *The Occult Sciences in Pre-Modern Islamic Cultures*, ed. Nader El-Bizri and Eva Orthmann (Ergon Verlag, 2018); Eva Orthmann, "The Occult Sciences at the Mughal Court During the Sixteenth Century," *The Empires of the Near East and India: Source Studies of the Safavid, Ottoman, and Mughal Literate Communities*, ed. Hani Khafipour (Columbia University Press, 2019); Moin, *The Millennial Sovereign*; Flatt, *The Courts of the Deccan Sultanates*; and Jean Arzoumanov, "Persian Garlands of Stars: Islamicate and Indic Astral Sciences in Seventeenth-Century North India," *Journal of South Asian Intellectual History* 5, no. 2 (2022): 183–216.

12 *Sunnat-i Astrolabe*, BL, IO Islamic 1514, fols. 11 r–11v. The manuscript came into Tipu Sultan's library from the collection of ʿAbd Allah ibn Hasan ʿAli al-Isfahani, an astronomer protégé of Nawab Samsam al-Dawla Hizabr Jang Miyan Ghulamshah Khan, for whom he compiled astrological and calendrical tables in 1768. See also Hermann Ethé, *Catalogue of Persian Manuscripts in the Library of the India Office*, vol. 1 (Oxford: H. Hart, 1903), 1231. Five manuscripts on astrology and chronology with Isfahani's seal were in Tipu Sultan's library. See Sims-Williams, "Collections Within Collections," 302.

13 *Sunnat-i Astrolabe*, BL, IO Islamic 1514, fol. 12r.

14 *Sunnat-i Astrolabe*, BL, IO Islamic 1514, fol. 4v.

15 On the association of astrolabes with divination and predicting fortune, see Emilie Savage-Smith, ed., *Magic and Divination in Early Islam* (Routledge, 2017), and Francis Maddison and Emilie Savage-Smith, *Science, Tools & Magic* (Oxford University Press, 1997).

16 More specifically, the title is *Kitab Dhakhirat al-Iskandar al-Malik ibn Filiqs Dhu al-Qarnayn*, which means "Alexander the King, Son of Philip, the Two-Horned One" and refers to Alexander, who is sometimes associated with the Qur'anic figure Dhū al-Qarnayn ("the Two-Horned One") in Islamic tradition. See *Kitab Dhakhirat al-Iskandar al-Malik ibn Filiqs Dhu al-Qarnayn*, BL, IO Islamic 673. See also Otto Loth, *A Catalogue of the Arabic Manuscripts in the Library of the India Office* (London: Secretary

of State for India in Council, 1877), 130–31.

17 *Kitab Dhakhirat al-Iskandar*, BL, IO Islamic 673, fol. 4v. Other manuscripts of the *Kitab Dhakhirat al-Iskandar* are extant, including at the Staatsbibliothek in Berlin, the Asiatic Society in Calcutta, and Columbia University in New York. The text has also been the subject of translations and studies. See Julius Ruska, *Tabula Smaragdina: Ein Beitrag zur Geschichte der Hermetischen Literatur* (Carl Winter, 1926); Manfred Ullmann, *Die Natur- und Geheimwissenschaften im Islam* (Brill, 1972); Christopher Warnock, ed., *The Book of the Treasure of Alexander: Ancient Hermetic Alchemy and Astrology*, trans. Nicholaj de Mattos Frisvold (Renaissance Astrology, 2010); Lucia Raggetti, "Apollonius of Tyana's *Great Book of Talismans*," *Nuncius* 34, no. 1 (2019): 155–82; Lucia Raggetti, "*The Treasure of Alexander*—Stories of Discovery and Authorship," *Education Materialised: Reconstructing Teaching and Learning Contexts Through Manuscripts*, ed. Stefanie Brinkmann, Giovanni Ciotti, Stefano Valente, and Eva Maria Wilden (De Gruyter, 2021); and Liana Saif, "A Preliminary Study of the Pseudo-Aristotelian Hermetica: Texts, Context, Doctrines," *al-ʿUsūr al-Wustā* 29 (2021): 20–80.

18 Raggetti, "*The Treasure of Alexander*—Stories of Discovery and Authorship," 313.

19 *Kitab Dhakhirat al-Iskandar*, BL, IO Islamic 673, fol. 7r.

20 *Kitab Dhakhirat al-Iskandar*, BL, IO Islamic 673, fol. 36r–36v.

21 *Nujum al-ʿUlum (Stars of the Sciences)*, Chester Beatty Library, MS In 02, fol. 300r-301v.

22 Brittlebank, *Tipu Sultan's Search for Legitimacy*, 146-50.

23 On the Great Trigonometrical Survey of India, see Matthew Edney, *Mapping an Empire: The Geographical Construction of British India, 1765-1843* (University of Chicago Press, 1997).

24 William Lambton, "An Account of the Trigonometrical Operations in crossing the Peninsula of India, and connecting Fort St. George with Mangalore," *Asiatic Researches; or, Transactions of the Society Instituted in Bengal, for Inquiring into the History and Antiquities; the Arts, Sciences, and Literature of Asia* (London: Vernor, Wood, and Sharpe, 1811), 290.

25 On dice and divination, see Brandon Dotson, "Three Dice, Four Faces, and Sixty-Four Combinations: Early Tibetan Dice Divination by the Numbers," *Glimpses of Tibetan Divination: Past and Present*, ed. Petra Maurer, Donatella Rossi, and Rolf Scheuermann (Brill, 2019).

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Ellen Hsieh

Archiving Asia

The Porcelain-Inlaid Earthenware in the *San Diego* Shipwreck

In the archaeology of the early modern Pacific world, ceramic assemblages encompass several distinct categories: Chinese and Japanese porcelain, renowned for its technological sophistication, economic importance, and aesthetic significance; Chinese and Southeast Asian stoneware, essential for transporting goods across vast oceanic distances; Indigenous earthenware, which supported daily colonial life while embodying the enduring presence of Native communities; European ceramics, reflecting the cultural persistence of colonists; and colonial-style products, which represent profound cultural transformations within the colonies.

Figure 1. Porcelain-inlaid jugs discovered from the *San Diego* shipwreck. Museo Naval. Photo by Ellen Hsieh.

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Colonial-style ceramics in the early modern Iberian world include tin-glazed majolica and earthenware, with the latter receiving less academic attention. Manufactured in the colonies, these pieces feature European-influenced designs that distinguish them from Indigenous products. Among various colonial productions, the porcelain-inlaid vessels discovered in the *San Diego* shipwreck are particularly noteworthy for their craftsmanship and potential cultural significance (Fig. 1). The *San Diego* was a Manila galleon that sank in Manila Bay in 1600. Fully laden and ready to depart for Acapulco, the vessel was hastily transformed into a warship to counter a Dutch attack, ultimately sinking without firing a single shot. Discovered in 1992, the wreck yielded only a very small quantity of this porcelain-inlaid ware among its extensive cargo.[1] Other than the shipwreck, this ware has been found only at a few early colonial sites in Luzon.[2]

Amalia de la Torre's pioneering study compared discoveries from the wreck with Native earthenware traditions, concluding that this ware reveals the cultural influence of the colonizers on Indigenous craftsmen.[3] Nevertheless, subsequent scholars, such as Donna Arriola, Kazuhiko Tanaka, and Eladio Terreros, have explored the origins and evolution of inlay technological traditions, highlighting influences from Europe and the Americas.[4] Since the inlay tradition today survives only in Nisa, Portugal, and Ceclavín, Spain, the border region between these countries has traditionally been considered the ware's origin. However, Ricardo Costeira da Silva currently challenges this assumption, suggesting scholars consider Coimbra as an alternative source.[5] Regardless of debates about origin, Iberian Peninsula examples use quartz as inlay material with predominantly phytomorphic motifs. On the other hand, in the Spanish Americas, feldspar and other minerals are employed instead. Archaeological specimens have been discovered at early Spanish colonial sites throughout Mexico, the Caribbean, and Florida.[6] Together with other decorative techniques, such as attaching, sealing, and incising, some inlaid examples feature large feldspar pieces placed together, while others display clusters of tiny fragments. Beyond discussions of origin and evolution, my recent study identified several pieces from archaeological sites in Intramuros (the Spanish city) and Parian (the Chinese quarter), interpreting this ware as tangible evidence of early hybridity in colonial Manila. It substituted for the role majolica played in the Americas while simultaneously reflecting European colonial identity.[7]

Nevertheless, several critical questions remain unresolved: Why was this specific type of ware manufactured in the Philippines? Why was it selected for the *San Diego*'s cargo? Why was its production limited to the early colonial period? Does the production and consumption of this ware indicate fundamental cultural change in Spanish Manila, or does it reflect the established colonial cultural patterns? What was the contemporary meaning and perceived value of this ware? Addressing these questions requires detailed examination of both production processes and contemporary consumption culture.

Based on collections from the *San Diego* housed at the National Museum of the Philippines in Manila and Museo Naval in Madrid, at least five distinct types of porcelain-inlaid vessels were loaded aboard. These vessels typically exhibit a characteristic squash-like body profile and include a lamp, jugs, and cups. The single lamp features a cross handle, spout, vertical ear, and ring foot, with porcelain chips inlaid on the handle, mouth rim, and body (Fig. 2a). The jug represents the most common form, featuring a short neck, two vertical ears, two horizontal lugs, and a short ring foot (Fig. 2b). Porcelain chips decorate the body and lugs alongside geometric incised patterns. A rare Chinese kraak porcelain example from Chapultepec, Mexico, demonstrates that this form was adapted for Chinese blue-and-white export porcelain production (Fig. 3). Together with the albarello-shaped porcelain discovered in the *San Diego* wreck, these examples represent early Western attempts to commission custom porcelain from China.[8] The cups, while uniformly featuring two vertical ears, can be classified into distinct morphological types: those featuring a short neck and high foot, others with an open mouth and short foot, and specimens with a closed mouth and short foot (Figs. 2c–2e). Porcelain chips embellish the body alongside geometric incisions, attachments, or dot-imprint decorations. Compared with inlaid collections from Europe and the Americas, the types and decorations found in the *San Diego* assemblage are generally relatively simple.

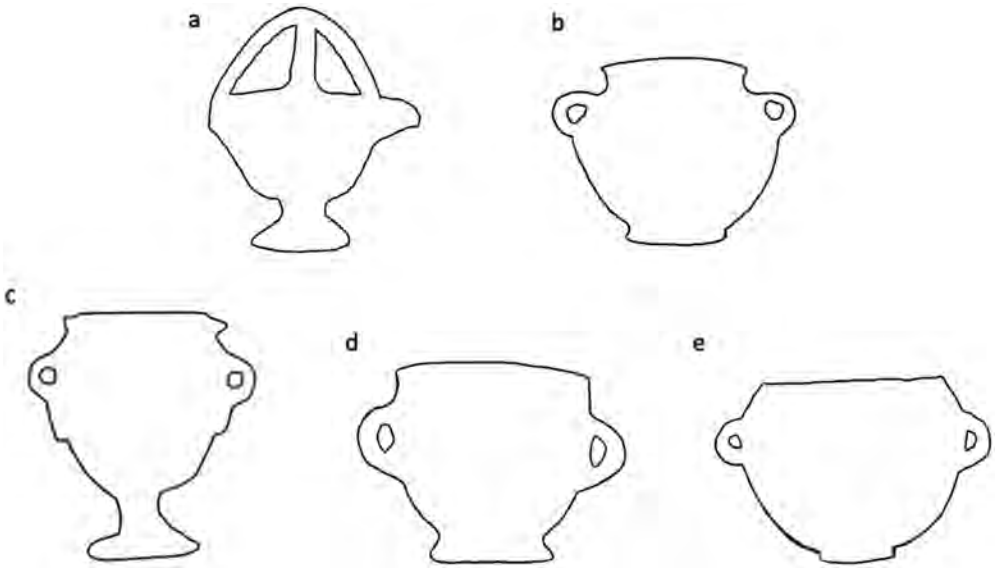

Figure 2. Profiles of porcelain inlaid earthenware discovered from the *San Diego* shipwreck. Illustration made by Pei-pei Jiang and Ying Cheng

Although the use of blue-and-white porcelain as surface decoration was not unprecedented in Asia, the vessels discussed here reflect an early modern Iberian approach to ornamentation. In most cases, the porcelain fragments were embedded so that their broken edges, rather than

their painted surfaces, remained visible. In a few exceptional examples, however, sections of the blue-and-white decoration were intentionally exposed, seemingly to draw attention to the use of valuable imported porcelain. From a distance, these inlaid wares could might be mistaken for earthenwares decorated with white slip or white-painted motifs. Their manufacture, however, required considerably greater labor and technical investment. The traditional process involves preparing clay, crushing stones, screening fragments by size (Fig. 4), and inlaying chips into the clay by hand. Based on preliminary observation, the paste of the discussed ware is finer than that of Indigenous ware, indicating a new kiln was likely developed after the Spanish arrival. Regarding the preparation of porcelain chips, in the specific context of Manila, potters would not have needed to smash intact ware for this purpose, as abundant broken sherds would have accumulated during voyages and the loading process. Screening was probably employed, given the uniform

Figure 3: Chinese kraak porcelain jug, Museo Nacional de Historia, Chapultepec, Mexico. Photo by Ellen Hsieh.

Figure 4: Crushing stones prior to sieving the fragments through a screen (visible in the lower right corner) for use in inlaid earthenware production. Workshop at Nisa, Portugal. Photo by Ellen Hsieh.

sizes of the chips used within individual decorative schemes. Notably, among the various options available to potters at the time, only Jingdezhen products—renowned for their superior quality and distinctive white body—were selected for this specialized application. With fine blue surfaces still visible along the edges of these products, Spanish consumers would certainly have recognized the prestigious use of Chinese porcelain incorporated into them. These choices reflect not only technological preference but also the selective use of locally available and globally circulated resources, linking the ware to broader patterns of environmental extraction and material transformation.

Early modern Iberians possessed a far greater appreciation for fine earthenware than we do today. A type of functional luxury earthenware renowned for its scent, *búcaros* (or *púcaros*) were produced from the sixteenth century and reached their peak in the second half of the seventeenth century. Búcaros encompass a wide range of shapes, including both plain and decorative ware, among them inlaid earthenware.[9] They appear in contemporary still-life paintings: In *Still Life with Boxes, Glass and a Clay Pot* and *June* by Josefa de Óbidos (1630–84), inlaid vessels form part of the feast, representing allegories of Christianity and local monastic life; in *Still Life with Ebony Chest* by Antonio de Pereda (1611–78), inlaid ware appears alongside other exotic objects from the Americas and Asia, showcasing the wealth of Spanish elites.

Historical documents systematically ranked búcaros made in Iberia and the Americas: For scent, prestigious Estremoz ware (also called *barros Estremoz*) occupied the top of the hierarchy, followed by products from Guadalajara (more specifically, from the nearby town of Tolaná), Natá, and Chile; for surface fineness, wares inheriting Indigenous burnishing traditions were considered superior.[10] Their perceived aromatic and absorptive qualities further reflect early modern understandings of the material properties of earth, in which natural substances were believed to embody the qualities of specific places. Estremoz, located near the Spain-Portugal border, a cradle of Iberian martial nobility, served as the production center of búcaros. Because of its fame, similar earthenware made in other regions was sold under its name. Beyond Iberians and their colonies, the ware was distributed widely in Europe and became particularly fashionable among female elites. These vessels primarily served to store and cool water, filter impurities, and detect poisons. In addition, they were used for cosmetic purposes and the treatment of various medical conditions, whereby one might by attach the pottery to their skin or even consume small pieces of it.[11] Some examples of búcaros were specifically called "terra sigillata," directly referencing their deliberate resemblance to ancient Roman redware traditions.[12]

The porcelain-inlaid earthenware from Manila might have joined these hierarchical evaluations had the *San Diego* survived the conflict and completed its journey. Although the exact quantity of this type of

ware aboard the ship remains unclear because of recovery and documentation challenges, these items were evidently not mass-produced. Their precious decorative materials and potential aromatic qualities would have represented both Ming China and the Philippines.

The fashion for búcaros waned by the end of the seventeenth century, although production continued in both the motherland and colonies, becoming integrated into postconquest material culture. Today in Iberia, potters struggle to maintain these traditional practices. Compared with the historical products, the size of the quartz on modern work is smaller for finer decorations. In Mexico, the inlaid technique persisted in Cuernavaca until the early twentieth century. A remarkable collection housed in the Museo Nacional de Antropología in Madrid demonstrates later evolutionary developments of inlaid earthenware in the Philippines. Together with so-called Manila ware and pieces from the Guthe collection produced during the nineteenth century (Fig. 5), these examples indicate the continued evolution of fine earthenware throughout Spanish colonial Philippines. Further research is needed to properly evaluate the specific connections and technological continuities between the early colonial products and their later developments, as well as the changing meanings of these objects over time.

Figure 5: Earthenware in late Spanish colonial Philippines. *Left*: A coffee maker with inlaid decoration from the Cagayan region. Museo Nacional de Antropología, Madrid. Photo by Ellen Hsieh. *Right*: A teapot fragment discovered in the Visayan region. Guthe Collection, University of Michigan. Courtesy of the University of Michigan Museum of Anthropological Archaeology.

This research examines porcelain-inlaid earthenware recovered from the *San Diego* shipwreck within its broader cultural contexts. Through an investigation of production processes and consumption patterns, I argue that this type of ware was initially manufactured

for European consumers rather than representing cultural change within the colony. The distinctive inlaid decorative technique clearly follows European traditions, which might suggest these vessels were designed to evoke nostalgia among Spanish colonists. However, for those already familiar with such vessels from European contexts, these objects may have represented Asia more than Europe.

This paradox emerges from two key observations. First, beyond the inlaid technique itself, the ware's designs express distinctive characteristics, particularly through the use of luxurious inlaid materials. Second, contemporary beliefs about the aromatic qualities inherent in earth from different geographical locations meant that these vessels—crafted from Philippine clay and Chinese porcelain fragments—would have been perceived as a means of archiving Asia, much as people today collect mineral water from different regions. In this sense, porcelain-inlaid earthenware can be understood as an environmental artifact, in which the material properties of clay and mineral-like fragments mediated how Iberians perceived and engaged with Asia.

Only a very small number of porcelain-inlaid earthenware, albarello-shaped porcelain, and jug-shaped porcelain pieces discussed in this work have been discovered to date. Given their rarity, these objects can be regarded as experimental products from the early period of Spanish exploration in Asia. Despite their limited quantity, porcelain-inlaid ware provides insight into the coloniality of Spanish Philippines from multiple perspectives. As an invented tradition drawing from the European classical period, it reveals a kind of Renaissance mentality that influenced the cultural identity of Iberians and their colonial projects. Furthermore, these objects demonstrate that Iberians employed diverse sensory approaches beyond purely visual or textual means to imagine, understand, and culturally navigate Asia—practices that embodied the comprehensive nature of colonial engagement with the region. This interpretation, however, applies primarily to its early production phase, as later examples may have acquired different meanings and functions in colonial society.

Ellen Hsieh is an associate professor of anthropology at National Tsing Hua University, Taiwan, where she also serves as deputy director of the Research Center for Underwater Archaeology and Heritage. A maritime archaeologist, she has conducted fieldwork across Asia, the Americas, and Europe and is the author of *The Archaeology of Early Colonial Manila* (2025).

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Samuël Coghe

Cattle Censuses

Analyzing Cattle Policies in Colonial Madagascar

In recent decades, historians have engaged with colonial censuses from various perspectives. Historical demographers and economic historians have used the human population numbers in the censuses to reconstruct the long-term demographical evolution of particular colonies or even entire continents. Other, more cultural- and postcolonial-history-inspired scholars have analyzed how censuses were instrumental in state-making and ethnic and religious categorization as well as a subject of contestation among those who were to be counted.[1] Yet colonial states not only enumerated and categorized humans. They also eagerly quantified natural resources such as livestock.

Even in colonial Africa, where states had scarce human resources and limited control over the vast territories they wanted to govern, livestock censuses were widespread in the twentieth century. Testimony to this are the many tables and sometimes colorful maps detailing the number and evolution of cattle, sheep, goats, pigs, and additional livestock populations that I and other members of the CATTLEFRONTIERS team encountered during archival research for colonies as diverse as Portuguese Angola, Belgian Congo, French Equatorial Africa, and French Madagascar.[2] The ubiquity of such data reflects the importance that colonial states attached to inventorying, monitoring, and ultimately commoditizing animal—and more broadly natural—resources.[3] Yet colonial and environmental historians have hitherto largely refrained from analyzing these censuses.

This essay teases out their potential for historical analysis by focusing on cattle censuses in Madagascar under French colonial rule (1896–1960). Because of the significance cattle held on the island, the French authorities went to great lengths to count them, more so than any other livestock species, and with methods and goals that are partly similar to how they counted human populations.[4] Nevertheless, because of

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context- and species-specific limitations, these censuses are not a source that historians can easily use to reconstruct the cattle demography of the island. Rather, we can use them more fruitfully as an entry point into analysis of cattle policies and knowledge regimes under colonial rule —analyzing not only how and why census data were produced but also how they were interpreted and used as key elements for policymaking. Arguably, cattle censuses were a lens through which colonial officials at the time read nature, and evaluated, legitimized, criticized, adapted, and reconceived their cattle policies as well as the future of the island's cattle industry.

To understand the logics and materiality of the colonial archive, and hence the paper trail on which this essay builds, it is important to acknowledge that numbers, tables, and maps were produced at different echelons of the colonial administration. The actual registration and counting of cattle on the ground, in so-called *carnets de recensement* (census registers), was done by Malagasy *chefs de canton* or *gouverneurs madinika* and French district administrators, the former for Malagasy-owned cattle (98–99 percent), the latter for European-owned cattle (1–2 percent).[5] District administrators, province governors, and, further up the chain, central veterinary and administrative services in the capital, Antananarivo, aggregated the numbers they received from their subordinates into tables, graphs, and maps for their annual reports. Many of these can be found in the Gouvernement Général de Madagascar archives that were taken from Antananarivo to France around decolonization in 1960 and are now held in the Archives Nationales d'Outre-Mer in Aix-en-Provence. Much of the primary census material (the registers), by contrast, seems to be lost, as both colonial and postcolonial archival policies neglected the preservation of district and provincial archives, where such documents would have been kept.[6] Some scattered remnants can be found in the fragmentary provincial archives that were also taken to France around 1960 (Figure 1).

Cattle censuses were a colonial imposition in Madagascar. Certainly, in the nineteenth century, the self-modernizing Merina kingdom, which was expanding its rule from the central highlands of Madagascar, regularly received cattle as tribute from some of the communities it governed, but the systematic counting and taxing of cattle was introduced by the French colonial state.[7] In August 1897, not even two years after conquest, Governor-General Joseph Gallieni ordered the newly installed district administrators to count all cattle, and also distinguish between humped and humpless cattle.[8] Humped, or zebu, cattle (*Bos indicus*) were introduced from India through East Africa from the ninth century onward and constituted the main cattle species on the island.[9] Humpless, or taurine, cattle (*Bos taurus*), deemed superior in size and production, were imported from Europe from the mid-nineteenth century. Some colonial administrators, especially in the south and southwest of the island, argued that it was still impossible to conduct a

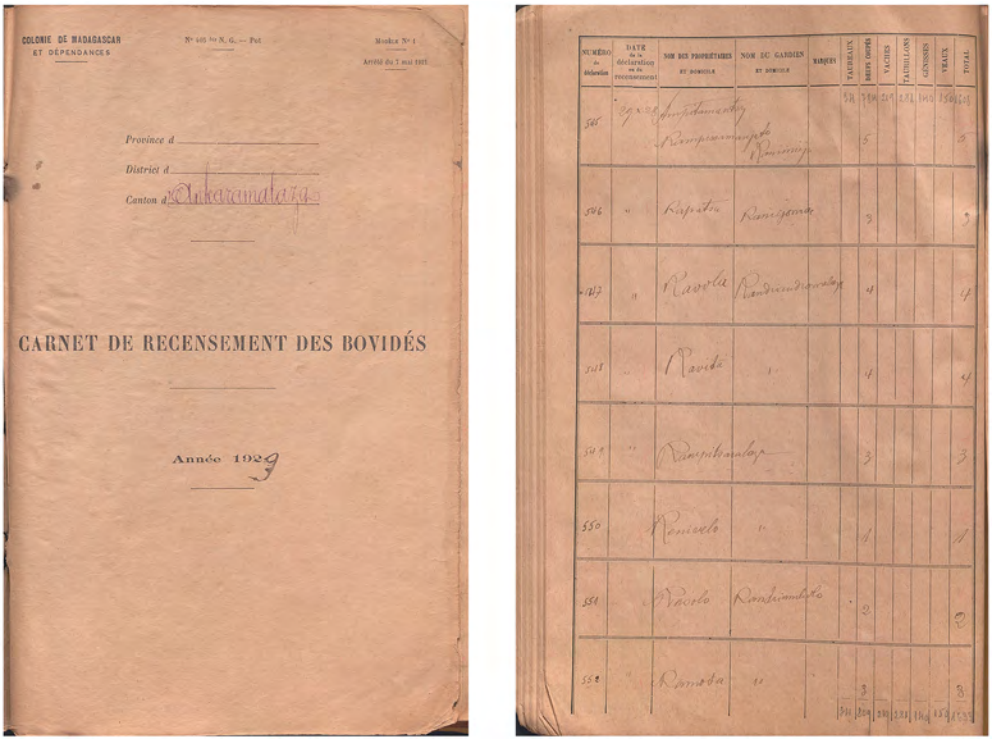

Figure 1. Cover page (*left*) and random page (*right*) of the cattle census register of the canton of Ankaramalaza (province of Fianarantsoa) for 1929. The register documents 5,003 bovines of different age, sex, and reproductive group distributed over 1,573 cattle owners. Archives Nationales d'Outre-Mer, Aix-en-Provence, France, 14PF4.

cattle census, given the lack of effective occupation and security. Many others, however, sent back detailed numbers, which distinguished not only between humped and humpless cattle but also between females, males, and calves.[10] Although these numbers were probably far from accurate, this was an astonishing feat that was enabled only by the preexistence and quick incorporation of knowledgeable Merina officials, such as *madinika* governors, village or neighborhood chiefs (*mpiadidy*), and clerks, into the French administration.[11]

Despite the challenges, counting cattle became an annual practice and a core feature of French colonial rule in Madagascar. It responded to various rationales. Firstly, colonial officials and entrepreneurs considered cattle to be among, if not at the top of the list of, the island's most important resources. Some even dreamed of turning Madagascar into a new Argentina, the most critical exporter of beef in the nineteenth century. Enumerating cattle served to monitor the evolution of the bovine population, and to provide a scientific basis for its rational exploitation, by indicating how many cattle could be slaughtered—or exported in the form of live cattle, hides, and, from the 1910s, meat (canned or frozen)—without depleting the herds.[12] Secondly, putting the natural world into statistics was considered a modern tool of government, which states, including colonial ones, also needed to legitimize their rule on the international stage.[13]

Finally, perhaps the most important application of annual cattle censuses in Madagascar was taxation. Coinciding with the first census in 1898, the colonial government introduced in certain regions (and later generalized) a head tax for cattle that cattle owners had to pay every year and that necessitated prior counting and registration. Gallieni and his successors rationalized cattle taxation as a means to draw Malagasy pastoralists and their huge herds into the market economy and modernize the cattle industry on the island. Like the anthropologists working on East Africa who would later characterize the practice as being part of a "cattle complex," they assumed that many Indigenous cattle owners accumulated cattle for prestige rather than for economic valorization.[14] The head tax was seen as a means to reduce such "irrational" behavior, forcing the owners to regularly sell part of their herds. Such a head tax was also introduced in some other colonies in Africa, but its financial importance in Madagascar grew particularly strong: Between 1914 and 1936, the cattle tax averaged 12,5 percent of the colony's ordinary tax revenue each year.[15]

From the onset, hazardous or divergent interpretations of the census results laid bare the epistemological problems of colonial census-taking. The conclusions that Gallieni drew from the first census illustrate this. While he acknowledged that the 500,692 head of cattle counted in 1897–98 was far below the real number, since many animals had escaped registration and many regions were not included, Gallieni extrapolated that there could not be more than two million bovines on the island, much less than the six to eight million that some European precolonial sources had indicated. He attributed the huge difference between these figures to precolonial exaggerations, but also to the "insurrection" against French occupation, which had allegedly decimated the herds in certain regions.[16] Accordingly, when by 1904 the official census numbers had risen to more than 2.7 million, Gallieni interpreted this evolution as a real increase: a quick "recovery" due to the extraordinary fertility of the zebu cows, the "pacification" of the island, and his own targeted measures, such as an export and slaughter ban on female animals.[17]

Over the next two decades, many followed Gallieni in taking the growing numbers at face value: Cattle censuses recorded a steady increase of two hundred to three hundred thousand animals yearly, peaking at almost eight million in 1921 (Figure 2). This was not without contradictions. While subsequent directors of the veterinary services attributed increases to political stability and veterinary interventions rather than the growing reach of the censuses, they also complained about the persistence of "primitive" Indigenous methods of cattle production, which hampered growth.[18] From what we know today, an average annual growth rate of 7.35 percent (needed to get from 2.4 million in 1904 to 7.8 million animals in 1921) is very unlikely to have reflected only real increase. Not only is it very far above the usual natural growth rates of zebu herds in extensive modes of production,

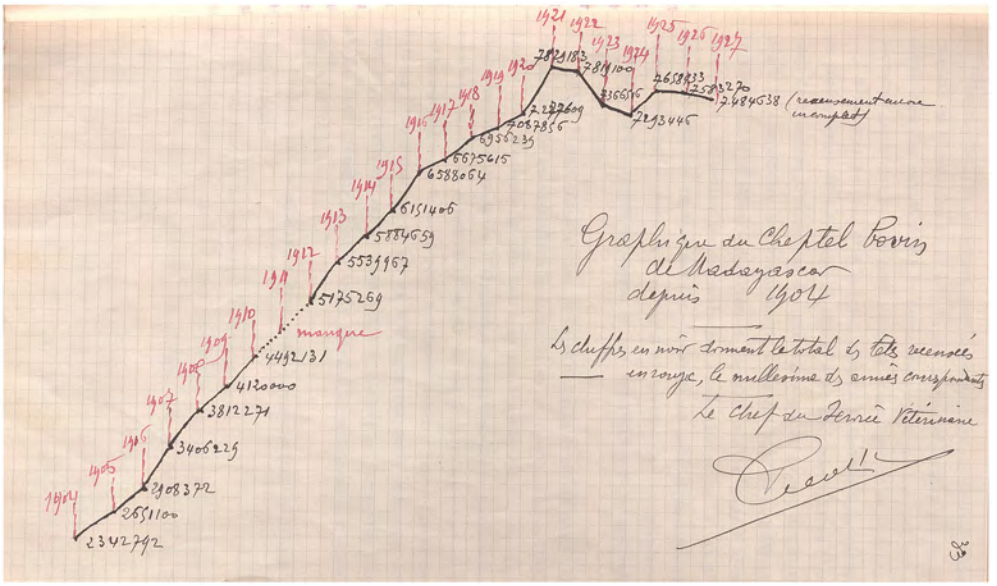

Figure 2. Graph of the cattle population of Madagascar since 1904, from the annual report of the Veterinary Service of Madagascar for 1927, authored by Pierre Geoffroy. Archives Nationales d'Outre-Mer, Aix-en-Provence, France, GGM, 5D(14)/11, p. 33.

which dominated the island, but the 1910s also saw the emergence and quick expansion of a meat export industry that slaughtered more than a hundred thousand animals annually between 1915 and 1919.[19] Colonial vets may not yet have understood limited reproduction in pastoral systems, but they had been privileged witnesses of, and even key actors in, the meat export boom. Yet instead of questioning the statistics, veterinarians proudly announced in 1922 that Madagascar now had the highest cattle-to-human ratio in the world, and in 1923, a map published in the *Economic Bulletin* showcased the ubiquity of cattle on the island, with only the tropical-humid east coast being less densely populated (Figure 3).[20]

However, when the official numbers first stagnated in the 1920s and then began to decline more rapidly in the 1930s, to less than five million in 1937, confidence in both Madagascar's cattle future and the accuracy of the numbers waned. On the one hand, a controversial debate emerged about the main causes of the decline and potential solutions. Many colonial officials blamed Malagasy actors, arguing that pastoralists, villagers, and professional butchers were slaughtering more animals than the natural increase (and increasingly younger females key for reproduction) in order to sell their hides when international market prices were high or to satisfy the rising internal demand for meat. While both causes arguably resulted from growing market integration and social change due to colonial rule, other officials were more directly critical of the role of colonial actors. They accused the meat factories on the island of killing too many animals; the expanding agricultural enterprises for pushing pastoralists into areas less suitable for rearing cattle;

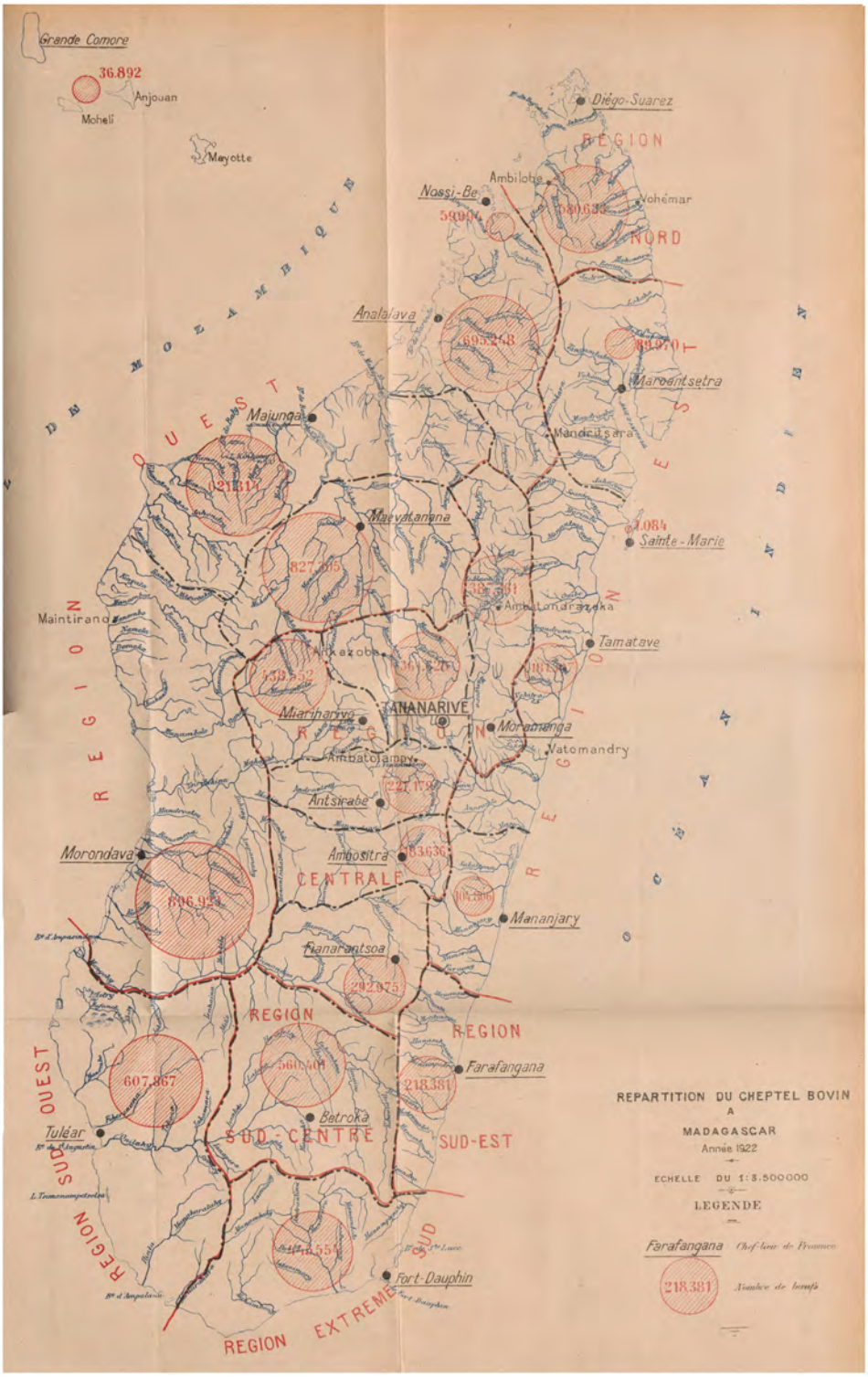

Figure 3. ***Cattle Distribution in Madagascar*****, 1922. Map drawn by the Geographical Service of Madagascar based on the census data of the Veterinary Service.** ***Bulletin Économique de Madagascar*** **20, no. 2 (1923): 92b, digitized by Archives Nationales d'Outre Mer, Aix-en-Provence.**

and the colonial state for having raised the cattle head tax to unbearable levels, thus forcing pastoralists to sell or slaughter substantial parts of their herds or abandon pastoralism altogether.[21]

On the other hand, some district administrators, (province) governors, and administrative inspectors in the 1930s questioned whether the decline was real, arguing that rising cattle taxes had destroyed the trustworthiness of the census as an instrument of measure. They assumed that Malagasy cattle owners had always managed to hide a substantial part of their herds from colonial registration but that increasing taxes had further encouraged this. Commenting on the declining numbers in southern Madagascar between 1932 and 1937, Governor-General Léon Cayla even admitted that colonial administrators had turned a blind eye to such practices while market prices for cattle were low.[22] French officials knew that the linchpins in the system were the Malagasy chefs de canton and that they, unsatisfied with their remuneration during the crisis of the 1930s, were often unmotivated to control cattle owners' declarations.[23]

In the 1940s and 1950s, cattle censuses continued to dampen hopes for a rapid expansion of Madagascar's cattle industry. As official numbers oscillated between five and six and a half million, pessimist discourses of declining, stagnating, or insufficiently growing cattle herds permeated colonial writings, accompanied by a myriad of explanations and potential solutions, in which "endemic" cattle theft and its repression now played a greater role. But rather than detailing this story, let us return to the initial question of this essay. How can we as historians use the ubiquitous census numbers in colonial archives?

Given the unknown accuracy of the censuses, which likely varied over time and space, it seems nearly impossible to use them for reconstructing cattle demography. The—to my knowledge—most ingenious attempt in this direction illustrates the difficulties. It was undertaken in 1962 by four veterinary scientists commissioned by the French Ministry of Cooperation to assess and—without irony—eventually improve the development of Madagascar's cattle industry after independence. Having discarded the figures prior to 1920 as untrustworthy, for the period 1920–60, they took the existing figures and added a barely varying fraud coefficient (mostly 27 percent) and a 19 percent coefficient for the uncounted (since untaxed) newborn calves. These coefficients were carefully estimated for 1960–61, but projecting them back onto the previous four decades failed to factor in historical contingencies such as varying fraud levels in response to varying tax burdens and the impact of droughts, cyclones, and other ecological disasters on cattle birth rates. Moreover, their new numbers inevitably confirmed the colonial censuses: Because of the added percentages, they were substantially higher, but still presented the same curves and turning points as the original censuses, for which the authors also presented similar causes.[24] More sophisticated back-projections, as economic historians have attempted for human demography, are unlikely to be undertaken, given the sheer complexity of determining time- and space-sensitive growth rates.[25]

More fruitfully, historians can use the cattle censuses as a window onto colonial knowledge production and livestock policies. In French-ruled Madagascar, colonial officials went to considerable lengths to produce, compile, and comment on the numbers, as they were considered key for economic planning and exploitation and an indispensable financial instrument for taxation. Although they knew that the accuracy of the censuses was low, because of insufficient territorial control, tax-evading cattle owners and recalcitrant administrative intermediaries, administrators, governors, and veterinary officials mostly preferred to ignore or move beyond such epistemological obstacles. Interpreting the numbers as a true reflection of nature, they celebrated colonial progress when the numbers were rising or denounced the irresponsible behavior of Malagasy cattle owners, merchants, and consumers and the multiple shortcomings of French cattle development policies when the numbers were falling, stagnating, or not growing quickly enough. But for all observers, even those who believed in periodic or continuous undercounting, it was obvious that the evolution of the numbers was not disconnected from falling or at best stagnating exports of hides and beef since the 1920s, and hence reflected that, at the moment of decolonization, Madagascar had not become the new Argentina but remained a rather modest cattle frontier.[26]

Samuël Coghe is associate professor of African and global history at Ghent University. His work deals with the history of European colonialism in Africa, with particular attention to the history of medicine, demography and agriculture, and transimperial and global perspectives. He is PI of the ERC-funded collaborative project CATTLEFRONTIERS (2023–28).

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Jonathan Schlesinger, J. Ryan Kennedy, Kristine Korzow, Vicky M. Oelze, and Peter E. Sauer

Ivory as Archive

Environmental History in Museum Collections

Six ivory figurines from Ming (1368–1644) and Qing (1636–1912) China sit in storage at the Eskenazi Museum of Art, on the Bloomington campus of Indiana University, about as far from China or wild elephants as one could be. They're not in great shape (Figure 1). Two are missing their hats; three their wooden pedestals. Four show only nubs or cavities where a flute or tablet once belonged. Perhaps that's why Dorothy Kempf donated them to the Eskenazi Museum in 1971, nine years before her death, or why the museum doesn't display them alongside other pieces from China or with the ivory from ancient Rome, medieval France, or colonial West Africa. The figurines are kept instead off-site in a "study

Figure 1. Six Eskenazi figurines in a row, all showing wear. *Left to right*: EMA66, EMA30, EMA33, EMA32, EMA31, and EMA67. Photo by Julie Ribits.

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collection" for hands-on learning. And why not? Teachers could put them to work in a course on Chinese art, global trade, or the modern museum.

What about a course on environmental history? More than just artifacts or artworks, ivory carvings are a kind of archive; they preserve DNA, collagen, isotopes, and other historical information about elephants and their homes. This information can identify what sex the elephant was, what lineage it belonged to, where it lived, whether it ate leaves or grasses, and by extension key aspects of its habitat. Of course, each artifact speaks to human histories too—those of hunters, tusk merchants, carvers, dealers, and collectors, to name a few. The archives left behind by such people are relatively familiar to us, with all their strengths and limitations. What about the archive preserved within ivory itself? What might reading the human and ivory archives alongside each other teach us?

These questions matter, in part, because objects like these figurines are so ubiquitous. Indiana University, like other universities, holds hundreds of ivory artifacts. Major museums have major collections; small museums have small ones. Most ivory, however, is tucked away in more humble places: in basements, attics, or drawers. Figurines, fans, crucifixes, netsuke, bracelets, piano keys, and billiard balls: Such things, dispersed across homes and museums, are—by far—the most extensive archives of elephant history we have today, and they might well be the richest and most abundant archive of *any* animal after humans on Earth. When our epoch in Earth's history has passed, and time has buried all this ivory around us, beings from the deep future might detect it as a curious signal: a diffuse but global layer of ivory collectibles. It is a helpful reminder, then, that homes and local museums, as much as ice cores and weather stations, archive our planet's history.

This essay uses the Eskenazi figurines to explore the ivory archive while it remains aboveground. How, then, did six ivory figurines from China come to Bloomington, Indiana?

The Eskenazi Museum records the figurines as gifts of Dorothy Clarke Kempf (1886–1980) and Edward J. Kempf (1885–1971) of Long Island. Edward was an Indiana University alum and an early American psychoanalyst. His career deserves its own book: He left a prestigious post at Johns Hopkins for Dorothy; he argued psychoanalysis could treat schizophrenia; he debated Freud on the issue while hiking in the Tyrolean Alps; he coined the now-discredited term "homosexual panic" (also known as "Kempf's disease"); he became enmeshed in a lawsuit that effectively put psychoanalysis on trial. In 1971, when Edward died, Dorothy edited and published his memoirs, and the Beinecke Library at Yale today holds his archives. Why did the Kempfs purchase the figurines? We may never know. The collected papers and archives paint a vivid picture of Edward and his work but—in ways typical of other collectors' records—say nothing of the couple's ivory.[1]

Perhaps these pieces weren't so special to the Kempfs. More intact figurines are not hard to find: The Smithsonian possesses thirty-nine; the Metropolitan Museum of Art, forty-four; the Field Museum in Chicago, sixty-six; and the British Museum, one hundred fifty-nine. Ivory carvings from China in general became fashionable across Europe and North America through the nineteenth and twentieth centuries. A single British magnate, Victor Sassoon (1881–1961), acquired over five hundred carvings alone; his famed collection now sits in the British Museum. Berthold Laufer (1874–1934), the Field Museum's curator for Asian anthropology, purchased hundreds of carvings from Beijing and Shanghai's antique shops in a single year.[2]

Interest in Chinese ivory waxed in the Kempfs' lifetimes. Building off their newfound collections, scholars and connoisseurs began to publish whole books on the topic, starting with Laufer's *Ivory in China* in 1925.[3] Galleries started showcasing Chinese ivory; tourists returned home from China with ivory souvenirs. Today, simply talking to your neighbor might turn up one of these pieces. One citizen-historian in Indiana let the team study their own family's antique figurine; another had inherited ivory hairpins from Hong Kong; a third had a necklace from Taiwan.

The demand for Chinese figurines in particular traces back to the early modern period. Until the twentieth century, when the ivory craze reached its zenith, there was not one framework for discussing ivory in Ming and Qing texts, but many: the material might be an exotic tribute, for example, a luxury to consume in moderation, or a passing mention in a list of mostly other things. Other materials, like jade, focalized attention in ways ivory did not. Precisely because references to ivory are relatively scattered and disparate, art historians have found that some of the richest interpretations of ivory objects arise from a multilingual and multimedia approach: one that integrates textual, oral, and material evidence. Shih Ching-fei, most notably, used such an approach to show that concentric spheres, or "devil's balls"—perhaps the most celebrated type of Chinese ivory carving—took inspiration from the rose-engine lathe: a European technology that craftsmen at the Qing court put to new use after its introduction by Jesuits.[4] One might wonder, then, did foreign interest and exchange tap into an ancient carving industry or help create it?

The history of ivory figurines, like the devil's balls, suggests the latter. As Derek Gillman first argued, the figurine tradition boomed only after the founding of Manila in 1571, when Spanish patrons commissioned Fujianese craftsmen to produce statuettes of the Virgin and Child. Using images from printed breviaries and late medieval books as models, and in dialogue with native Filipino traditions, these carvers produced Christian ivories for export into the early 1600s; their pieces soon circulated across the Pacific to New Spain and Peru, where many remain today. Back in Zhangzhou, Fujian, the carvers turned to the domestic market, creating new styles that spoke more to Ming tastes. Out went the Virgin and Child; in came bodhisattva Guanyin and Child and other

figures popular in Chinese art, such as Shouxing, the God of Longevity (EMA67), and Han Xiangzi (EMA31), one of the Eight Immortals.[5] The form may have deeper roots—the Metropolitan Museum of Art, for example, dates five of its Ming figurines to the fifteenth century, well before the founding of Manila—but the vast majority of Chinese figurines that survive today date to the period after 1571.[6]

The quantity and variety of ivory objects carved in China expanded from that point forward. New markets and regional styles emerged, as ever more Ming and Qing scholars purchased ivory brush pots, wrist rests, table screens, inlaid tables, and seals for their desks. One nineteenth-century writer described a street in Suzhou with "more than ten shops selling things like bone and ivory hairpins and ornaments, knobs, earpickers, bone and ivory staffs, dice and ivory dominoes of every colour."[7]

China, in this way, was not an outlier. Ivory carving in fact flourished from Paris to Benin to Sri Lanka to Japan in the same period.[8] Shipping tusks helped stimulate markets across these regions: The more tusks sold, it seems, the more carvers found inspiration, and the more their creations whetted consumer appetites.[9] We know demand for ivory drives elephant hunting. Yet perhaps the reverse was also true. Did rising demand for ivory in Ming and Qing China, then, lead to intensified elephant hunting and trade, or vice versa?

To answer the question, it would help to know where, exactly, tusks derived from. Did Portuguese expansion into eastern African markets or Dutch activity in Cape Colony underpin the market? Or were Southeast Asian networks more important? Elephant tusks arrived at workshops in Canton, Zhangzhou, Suzhou, and Beijing through multiple channels, including tribute missions, overland connections with southern Yunnan and mainland Southeast Asia, the South China Sea junk-boat trade, the VOC's sprawling network, and Portuguese ships carrying tusks from eastern Africa, where Swahili and Yao traders organized hunting expeditions and overland transport to the coast. In their own way, Chinese consumers and craftsmen helped shape these networks. Depending on the period, for example, some carvers sought out Asian or African ivory; others discriminated between straight tusks and curved ones, pinkish tusks and cream-colored ones, and tusks from a freshly killed elephant over ones found dead.[10] Not all ivory was equal.

Look closely at a figurine and you'll see the slight arch, the conical taper, and the hollow pulp cavity within: the hallmarks of a unique tusk. These objects came from individual animals; their very shape betrays a natural history. The Kempfs left a memoir and a Yale archive; the Ming and Qing courts recorded tribute; the VOC compiled registers of traded goods. The figurines, even when carved, are what the elephants left us. What then do *they* record?

It was with this question in mind that four partners in research—a historian (Jonathan Schlesinger), a zooarchaeologist (J. Ryan Kennedy), an

MA student (Ellie Kurt), and a PhD student (Andrew Pope)—headed to the conservation lab at the Eskenazi Museum to take small samples

Figure 2. Authors Jonathan (*left*) and J. Ryan Kennedy (*right*) at work in the Eskenazi Museum's conservation lab. Photo by Ellie Kurt.

from each of the six figurines. Over the following months, four different labs went to work at Indiana University, Texas A&M, the University of Arizona, and the University of Utah. What did we find?

Six figurines; six different elephants. Four of the six were Asian elephants (*Elephas maximus*); two were African elephants (genus *Loxodonta*) (Figure 3). Ivory preserves elephant collagen, which differs by genus. To assess it, Kennedy rubbed a small sampling stick on the surface of each figurine for thirty seconds. The sticks—matchstick-sized creations that Dan Kirby invented and that biochemist Kristine Korzow now makes in her lab—collect just enough of the protein collagen for analysis, leaving an abrasion visible only under a microscope (Figure 4). Down in College Station, Korzow used ZooMS, or Zooarchaeology by Mass Spectrometry, to assess the samples. The process works like this: Her team cuts the collagen into smaller fragments called peptides, mass spectrometry determines the mass of those peptides with extreme precision, and the resulting pattern of peptides allows her to distinguish collagen from African and Asian elephants as well as many of their extinct relatives like mammoths and mastodons. The power of the technique lies, in part, in how quick and minimally destructive it is. The technique also excels in detecting what is *not* ivory. ZooMS revealed, for example, that EMA32 had a repaired section made from the bone of a Suid, the family containing domestic pigs and wild boar.

Figure 3. This reproduction of Figure 1 adds a label to each figurine giving its genus. From *left to right*: EMA66, EMA30, and EMA33 are labeled Asian elephant; EMA32 and EMA31, African elephant; and EMA67, Asian elephant.

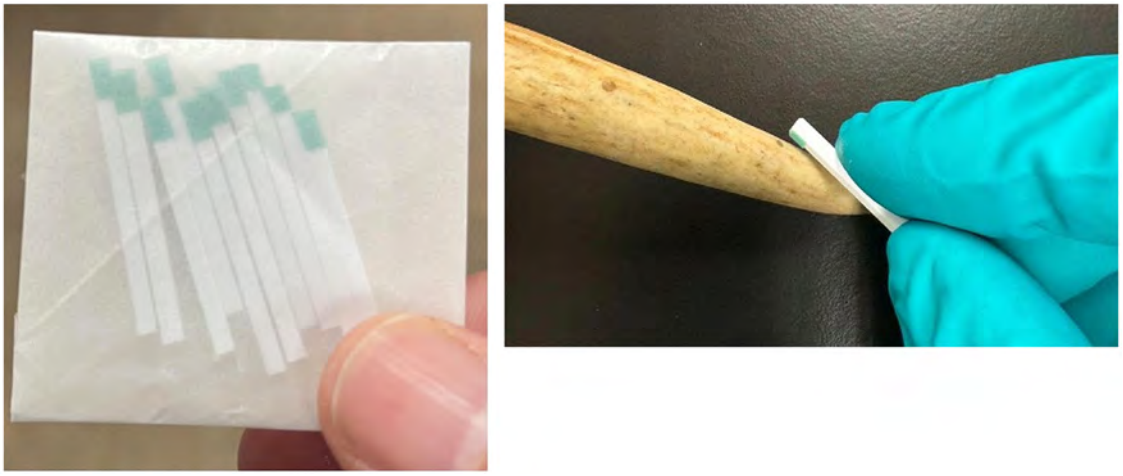

Figure 4. ZooMS sampling sticks, which, when rubbed on ivory, can collect elephant collagen.

That was not all: These six elephants all lived in different places. The elephant EMA31, for example, most likely lived in the larger Congo Basin region. EMA32, in contrast, probably lived in southern Africa: possibly Angola, possibly South Africa, but most plausibly somewhere in modern Zambia or western Tanzania, where Indian Ocean and Portuguese trade networks were most active (Figure 5). Here strontium isotopes offered the critical clue. Rocks and soil have differing geochemical signatures, and one signature—strontium isotopes—presents itself in varying ratios in different regions of the Earth's crust. Elephants absorb these local ratios into their tusks through their diet. In search of these signatures, the team sent tiny samples of ivory—twenty milligrams each—to the Strontium Isotope Facility at the University of Utah, and another partner in research, Vicky Oelze, a biological anthropologist at UC Santa Cruz, helped interpret the results.

Fully decoding those signals will take time. The more scientists map strontium isotope ratios across the Earth, the easier it becomes to identify where elephants once lived, and while such mapping is well underway in Africa, the work has only begun in Asia.[11] We might guess that

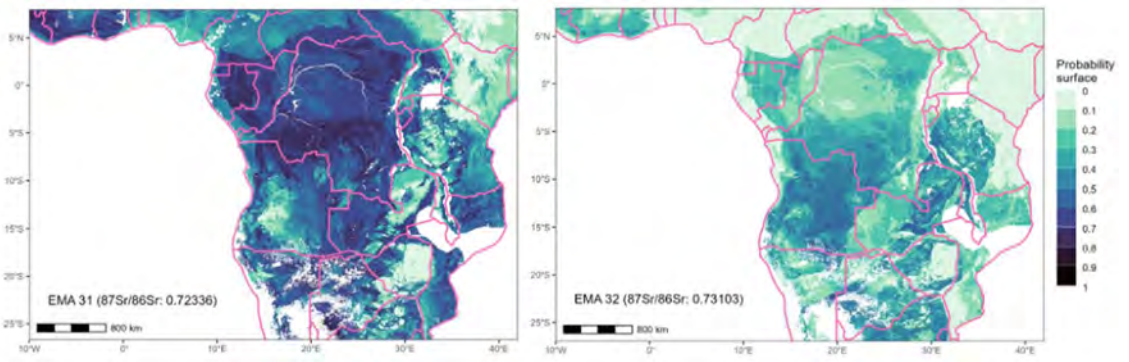

Figure 5. Most likely African regions of origin for EMA31 and EMA32, based on their strontium isotope ratios. The darker the color, the higher the probability that the elephant lived in that region.

EMA33 lived in mainland Southeast Asia or Yunnan's borderlands, but more definitive answers must await future research. We can only feel more confident, at this point, that the four Asian elephants lived in different regions, as their strontium signatures were all distinct.

Their diets showed distinctions as well. EMA32 likely browsed in forests, for example, as did EMA66. Not EMA33, though: He grazed much more on grass. Ivory preserves that information as well. Most tropical grasses, especially in open sunny areas, have an isotopic signature that differs from the one in trees and shrubs—signatures that Peter Sauer at Indiana University's Stable Isotope Research Facility determined using carbon isotopes. Using radiocarbon dating, the University of Arizona's TIME Lab further determined that five of the elephants died between roughly the 1450s and 1630s, while one—EMA66, which stands apart for its unusually light hue—died much later, between 1666 and 1923. If figurine carving flourished only after the founding of Manila in 1571, we

might assume that the five older elephants died at some point from the 1570s to 1630s. Or perhaps not: The conventional narrative might need refining, and the Chinese figurine tradition might predate the founding of Manila, as the Metropolitan Museum pieces suggest.

Yet even without a clearer understanding of these broader patterns, we can still begin to sketch the outlines of elephant biographies. Think of EMA32. This elephant was born in the sixteenth century, perhaps somewhere in Zambia or western Tanzania. We can place EMA32 in a wooded habitat rich with shrubs and leaves. DNA testing in progress will offer more insights, identifying whether EMA32 was female, and so likely living in a tightly knit herd and migrating relatively short distances, or male, and so roaming further afield. We might also learn what happened to this elephant's descendants: whether they survived, if they still live in the region, whether their diet has changed, and if their lifeways or local environment have changed accordingly.

EMA33 lived a very different life. This individual was born in the late sixteenth century too and was almost certainly male, as only Asian elephant males grow tusks. While awaiting further research that can help pinpoint EMA33's range, one reasonable guess is that he lived in mainland Southeast Asia, where his diet was rich with grasses. He might have grazed in one of the region's dry zones or floodplains where wild grasses grow. Or perhaps EMA33 was a captive elephant or a crop raider, feasting on millet: a different life indeed.

Most elephants remembered across history were unusual; they had remarkable tusks, say, or memorable relationships with people. Some belonged to Hannibal or Charlemagne or P.T. Barnum; others were treasured inhabitants of temples or zoos; others became social media phenomena. EMA32 and EMA33 are different: No manuscripts mention them; no books or newspapers sensationalized them; no videos circulate of them online. Their stories are either forgotten or were never known to begin with: all the more reason to understand what we can of their lives.

Imagine three exhibitions, then. One showcases the figurines as icons of Chinese art. Another presents them as emblems of a continent-crossing early modernity. A third centers the elephants and their lived experiences. Each approach has its virtues. The first hews close to the reason most figurines were collected and preserved in the first place: to illuminate Chinese history and celebrate Chinese art. The second investigates the context of the objects' production, connecting threads that bound China to the early modern world. The third speaks to the broader environmental history. The figurines can tell a story about China, if we ask them to, or contribute to our understanding of life on Earth; they are equally at home displayed alongside mammoth tusks and Ming porcelain.

Elephants have histories too. In modern elephants, genetic and isotopic profiles align: Elephants in a given region tend to belong to a

common set of lineages, and their diets tend to overlap, while five hundred miles away, the lineages and diets will differ. Over the past twenty years, biologists like Samuel Wasser and Stefan Ziegler have mapped which elephant subpopulations live where, so that law enforcement can, with proper testing, determine where any trafficked tusk originated.[12] Zooarchaeologists remind us, however, that what holds today has not always been. One team salvaged over a hundred elephant tusks from the *Bom Jesus*, a sixteenth-century Portuguese shipwreck off the coast of Namibia. The DNA they extracted from the tusks corresponded to seventeen lineages of African forest elephants from western Africa. Most of these lineages no longer exist. They had the genetic signature of "forest elephants," moreover, but their diets suggested that these individuals were living in a mixed landscape of forests and savannahs.[13] There is no modern analogue for these elephants. We should not be surprised that elephants and their habitats have changed so much over time; elephant populations were once exponentially larger.

Researching the interconnections between elephant and human histories is beyond the capacity of any one historian. Community members and curators possess the historical carvings and will know best the art history and personal stories behind them. Art conservators likewise know best how to take samples and the science beyind the art; zooarchaeologists, the science behind tusks; biochemists, how to extract and analyze DNA, collagen, and isotopes. Finding common ground across disciplines—each with its own goals, methods, working languages, and academic currencies—can be challenging, and working with ivory in museums and the community takes patience, trust, and a spirit of reciprocity. Yet there is power in expanding the community of partners invested in environmental history and the mutual learning that comes with it. In this case, one partnership brought to light the stories of six elephants and helped connect Indiana to China to Zambia in the process. Every museum collection and every heirloom in the attic offers the same potential. What might the ivory in your own attic reveal?

Jonathan Schlesinger is an associate professor of history and director of the Individualized Major Program at Indiana University.

J. Ryan Kennedy is an assistant professor of anthropology and director of the William R. Adams Zooarchaeology Laboratory at Indiana University.

Kristine Korzow is an assistant professor of anthropology and director of the Paleoproteomics and Archaeogenomics Laboratory at Texas A&M.

Vicky M. Oelze is an associate professor of anthropology at the University of California, Santa Cruz.

Peter E. Sauer is an associate research scientist in the Department of Earth and Atmospheric Sciences and assistant director of the Stable Isotope Research Facility at Indiana University.

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Thomas Fleischman and Ryan Tucker Jones

On the Uses of Whale Bodies for History

When entering the New Bedford Whaling Museum, the first thing you notice is the whale skeletons; the second thing is the smell. The four enormous baleen whales suspended from the ceiling—two right whales, a humpback, and a blue whale—are not gleaming white but rather mottled brown, stained by the oil that continues to ooze from their bones. The blue whale skeleton, known as KOBO, or "King of the Blue Ocean," died from a ship strike twenty-five years ago, but continues to leak about a beaker full every eight years. The smell of his oil, along with that of the other skeletons in the room, is redolent of the factory ships that processed the whales' ancestors, although not derived from the factory ship, since the whales here were collected after the cessation of commercial whaling in 1987. These enormous skeletons draw visitors into the museum, but they also tell their own tales. Embedded within the bones, teeth, and baleen are traces of the whales' lives, encoded in chemicals and compounds. Human records capture the moments and means of the deaths of these whales; their bodies can reveal important facets of their lives. Read together, these historical archives put whales into history in unprecedented ways.

If you know where to look, whale body parts can be found all over the world. There is a street in Hamburg, Schulterblatt Strasse (Shoulder Blade Street), where in the eighteenth century business owners announced their shop's name not by hanging a shingle but by hanging a painted right whale shoulder blade. In 1840s Australia, Aboriginal people constructed dwellings out of the Southern Right whale bones that British whalers discarded onshore, many of which remain to memorialize the death, dispossession, and lucre brought by colonial whaling. In Yorkshire, England, a moldering sperm whale skeleton has lain within a country estate known as Burton Constable for nearly two centuries.

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Figure 1. The sperm whale skeleton in Burton Constable. Lawson Speedway/ Wikimedia Commons/CC BY-SA 2.0.

While the skeleton's notoriety found its way to Melville and into *Moby-Dick*, the remains mostly served as a jungle gym for generations of English children. Whale bodies have been rendered into garden fences, sitting rooms, chandeliers, and barstools.[1] Most whale parts, however, are in museums. Whether in back rooms, suburban warehouses, or subterranean vaults, the natural history museums possess drawers of sperm whale teeth, cabinets of rib cages, and formaldehyde jars filled with whale fetuses, eyeballs, earplugs, and brain stems. And yes, these spaces smell too.

These relics are more than just grisly reminders of past and present perils facing cetaceans. They are also the keys to unlocking chapters of history long thought permanently closed. Foundational thinkers in the field such as Friedrich Nietzsche and R. G. Collingwood dismissed out of hand the possibility that animals might have history, while more recently even historians in the field of environmental history have despaired about the methodological challenges.[2] In 2013, Joseph Taylor characterized marine environmental history in particular as depending fatally on "anecdotal observations and unsystematic records." With the "blending of historical and scientific methods . . . both exciting and perilous," the ocean's history remains a black box, its ecosystems too complex, its data too biased by human cultures of observation.[3] Whale bodies do not completely open this black box, but they allow us to peer into some of its corners, for they retain certain kinds of historical evidence. They connect the life histories of whales with those of humans, and—in some ways—even go beyond the limits of traditional human history.

Whale lives are some of the most evocative in nature's archives. This is not only because whales are crucial components of ocean ecosystems but also because their own histories have been so intertwined with our

own. While humans have hunted whales in various parts of the world for at least twenty thousand years, and may have caused local extinctions as early as the Roman Empire, it is only since the eighteenth century that humans have posed an existential threat to many whale species. Beginning with slow-moving right and bowhead whales in the Arctic and subarctic, then extending to sperm whales and humpbacks in the nineteenth century, and eventually to every large species—including blue whales—with the invention of modern, mechanized whaling in the 1870s, human persecution reduced many whale populations to remnants. The commercial catch peaked in the 1960s, when nearly all the great whale species had been reduced by more than 60 percent of their historical baseline, including the Antarctic blue whales, whose numbers fell from 239,000 in 1904 to just a few hundred individuals. Finally, and very suddenly, humans discontinued the pursuit of whales, as they agreed on a global whaling moratorium in 1982, and enacted it four years later. While many species have since rebounded spectacularly, new anthropogenic threats, like noise pollution, ship strikes, and climate change, endanger their recovery. Despite the end of commercial whaling, human activity will continue to jeopardize the future of cetacean life.

So, to reckon with whale bodies as sources means to first reckon with the animal's death. Unlike traditional primary sources in history—journals, archival documents, letters—whale artifacts are largely a by-product of each whale's murder. Even the science of cetology was founded in the guts and gore of dead whale bodies. In the early twentieth century, the only way "hip-booted" cetologists could get close to these leviathans was to traverse the flensing platform of a shore station or floating factory ship, measuring, tabulating, and weighing every part of the whale.[4] Their goal was explicit: to produce as much information about the "life histories" of these animals so that the industry that supported their research could kill as many as possible. Life histories derived from dead whale bodies, however, began to serve a different purpose by the 1960s as scientists used their research to support a whaling moratorium. By the 1970s, whale science increasingly eschewed the study of dead whale bodies for empirical observations of live ones, through a combination of photographic, video, and audio evidence. Whether undertaken to learn how to kill more whales or how to protect them from being killed, the study of whale life histories has always revolved around the question of whale death.

In a similar fashion, historians of whaling and whales struggle to decenter whale death. As Bathsheba Demuth argued in the *Journal of Social History*, in our attempts to "give agency" to the nonhuman world, we narrow the range of agentive behaviors and actions to only those that alter human action or behavior.[5] In whaling histories, those moments overwhelmingly occur during hunts: when a whale confounds a catcher ship, when she flees deeper into the pack ice upon hearing an approaching ship, or when she resists death until the last liter of blood

pours from her blowhole. In each case, agency becomes emergent through a whale's struggle to survive. But whales and whale history are much more than that. As Demuth wonders, "Is a whale historical when she's doing the more quotidian work of being a whale, birthing and swimming and helping make life flourish in the oceans?"[6] A historian interested in whale bodies can help us move beyond the centrality of humans in our sources and theoretical approaches. We can ask different questions, wholly specific to whales themselves. Questions like, where was this whale born, and where did she travel in her life, and what did she eat? Or, on the social side, who did she know, live with, and learn among? Just what historians ask, however, depends on the nature of the animal source itself.

Take the example of sperm whale teeth, which have both whale-centric and human-centric histories. As Nick Thomas and Nancy Shoemaker tell us, many Indigenous Pacific cultures circulated sperm whale teeth for centuries, most often as objects of exchange, gifts, and markers of social privilege.[7] For them, "whale ivory," or *tabua*, was prized above all other potential riches of a stranded sperm whale, including its blubber and meat. In contrast, American and European whalers never established a profitable market for teeth, instead bartering them for food, drink, or clothing. More famously, whalers practiced their own folk art, scrimshaw, on the teeth. To pass the time on board their multiyear voyages, they etched seascapes, wild animals, family portraits, and even pornography into the enamel, which they then sold to ship captains and harpooners or kept as souvenirs. Today scrimshawed teeth remain the most sought-after relics from the age of whaling.

Figure 2. A spliced sperm whale tooth shows the thin laminations of growth-layer groups. Emőke Dénes/ Wikimedia Commons/ CC BY-SA 4.0.

Cetacean teeth also contain within them a surprisingly detailed history of a whale's life. Pulp stones, mineralization, abrasions, cracks—all surface-level clues of different aspects of a whale's encounter with the marine environment.[8] But for a deeper history, scientists look at what's recorded inside the tooth. Cutting thin cross sections (approximately one to three millimeters) from the tip to the base of the tooth, scientists routinely count the growth-layer groups (GLGs), or alternating lines of light and dark dental growth, inside. Like the rings of a tree, each GLG corresponds to a year in the animal's life. Scientists then count, and recount multiple times, each GLG to get an age estimate.[9]

More recently, advances in biochemistry have allowed scientists to do more than estimate age at death. In a process that's been done on the scales of salmon, the teeth of harbor porpoises, whale baleen, and human teeth, scientists measure the ratio of stable isotopes of carbon and nitrogen in each GLG. Since these elements are acquired solely from prey and ingested water, they offer a surprisingly detailed snapshot of the marine ecosystem in each year of a sperm whale's life.[10] Migration patterns, habitat, dietary changes, sexual maturation, and even social groupings are etched inside growth layers. Carbon, which serves as a background signature of the base of the food web, indicates whether

whales are living within the nutrient-dense waters of the poles or the tropical marine deserts of the equator. Nitrogen, which becomes more concentrated the larger the prey, tells a story of changing diets, not to mention the size of a whale, his relationship to whales with whom he hunts, and where in the ocean he's eating.

Studies of sperm whale teeth have also helped cetologists solve decade-old mysteries about their subjects' social lives. For example, we have known that sperm whales are organized into matrilineal units, with pods of females, juveniles, and dependents sticking to tropical and subtropical waters. Less, however, was known about the internal social structure of those pods. For example, no one knew if behavior, movements, and prey preferences were socially determined or merely the result of genetics, or genetics' dubiously scientific relative, "instinct."[11] A 2017 study of female sperm whales killed along the coast of Peru shed light on this question. An isotopic analysis of their teeth GLGs revealed marked differences in the chemical composition among the animals, an indication of dramatically different feeding strategies and prey preferences among whales who shared the same habitat. While genetically similar individuals, each female likely came of age within a different sperm whale clan, with its own distinct cultural practices and mores related to hunting.[12]

Male sperm whales are even more mysterious. Leaving their natal pods when they reach puberty and migrating polar waters for the rest of their lives, male sperm whales form new social groups with other male sperm whales from all over the world. What happens after that is less clear. Since the rough marine habitat made long-term empirical studies nearly impossible, little was known about the length of their relationships, the ways they communicate, or even where they go—that is, until cetologists started analyzing their teeth. In a 2006 study of eleven male sperm whales stranded on Scottish and Irish islands, scientists revealed a surprising truth. Despite growing up in different natal groups, the male sperm whales shared identical isotopic ratios embedded in their teeth—an indication that not only had these groups of whales been eating the same food source, but they had been traveling and hunting together for over a decade.[13] A mystery was solved: Unrelated male sperm whales did form long-lasting social bonds, a fact recorded in the biological diary of their teeth.

While sperm whale teeth have yielded detailed historical information, not all whales have teeth. Instead, most of the whale species important in human history possess baleen, keratinous filters that hang from their upper jaws to sieve small fish and crustaceans from the ocean water. All mammalian hair—which baleen closely resembles—records changing hormone levels in an animal's life. Whale baleen has been used to establish the number of pregnancies and the intervals between them in highly endangered right whales. Direct historical observation of their calves perfectly matched the spike in pregnancy hormones revealed by the baleen, establishing this method's reliability.[14] However, baleen has

drawbacks as a record of a whale's history. It deteriorates at the edge as it is exposed to seawater and prey, and so it preserves reliable records only of the last ten to twenty-five years of a whale's life.[15] But, as cetologists slowly learned, there are other baleen whale artifacts that contain evidence of life histories, which are also intertwined with those of humans.

From the beginning of the great Antarctic whale rush in the early twentieth century, concerned scientists wanted to age the specimens that were flooding in, largely in order to understand how the population was responding to human predation. Early research, mostly from the United Kingdom's Museum of Natural History, focused on the so-called corpus luteum, a nodule that formed in the ovary at the time of ovulation and then shrank at what was thought to be a fairly consistent rate. The size of the corpus could then roughly establish the age of a female whale.[16] The method had severe limitations, not least because no one knew how many years a whale took to reach sexual maturity (when the first corpora would be produced), and estimates turned out to be wildly inaccurate.

But, in the early 1910s, British scientists noted that baleen whales' ear canals contained long, conical, waxy plugs. In 1955, Museum of Natural History researcher P. E. Purves first described the "arc-like laminations of alternately clear and dark cells" that composed the plugs and marked them—as with sperm whale teeth—almost like tree rings. He also claimed the alternating colors of the plugs could, for the first time, accurately age a baleen whale. Further research in the 1950s, by Purves and several Japanese cetologists, confirmed this, though the fact that the bicolored earplug growth layers were deposited annually was only determined conclusively in 2010.[17]

Earplugs encode different historical information than do teeth. Instead of preserving signatures of whales' diets, and by proxy whales' movements, the lipids and keratins that make up the earplug retain chemicals that come both from within the whale and from its environment.[18] The history of the whale's insides might be the most interesting part, for, among other things, they record the whale's emotions. Earplugs contain measurable and variable amounts of cortisol, produced by whales and humans alike in response to stress. Thus, we can read something approaching an individual whale's emotional history. To take one example, the earplug of a blue whale born in the Antarctic around 1929 shows that it experienced biannual spikes in stress corresponding with the summer hunting season. Trend lines show a stress peak early in the whale's life that continued at a high level until the whale oil market began to collapse in the late 1930s and catches correspondingly (though temporarily) decreased. Interestingly, the whale's stress peaked again during World War II, when no whaling occurred, but during which time ship traffic and armament explosions increased. Earplugs also allow for histories of whales' collective experiences. Samples taken from a variety

of species show that collective whale stress peaked in 1963, precisely the year when global whaling was at its maximum.[19]

This foray into the history of emotions may record the extent to which whales were cognizant of the larger catastrophe unfolding for their respective species. Or it may simply record a physiological response to an immediate threat, as the annual fluctuations suggest. Either way, it provides insights inaccessible to human history—who can write more than an entirely impressionistic history of human stress? It also hints at the way whales experienced this stress. A whale that survived long enough through the global slaughter to provide a useful earplug upon its eventual death was not likely one that was often chased. A chased whale in the twentieth century was usually a dead whale. Instead, these records show the stress of experiencing other whales being killed, their deaths probably heard rather than seen, each one possibly sundering familial, cultural, or communal bonds we are still only guessing at.

More recently, the study of earplugs has intersected with other ways of knowing living whales' life histories. The 2010 study that confirmed the annual deposition of bicolored wax layers was made possible by the fact that researchers had repeatedly observed this particular humpback whale, alive, since 1975, when she was already adult sized. Anointed "whale 68," she had periodically migrated between Hawai'i and Alaska, several times accompanied by calves. Thanks to photo identification of individual whales through their distinctive fluke patterns, global observer networks have been able to piece together living whales' otherwise cryptic life histories. The scientist who examined whale 68's dead body (with an unborn fetus inside) in Glacier Bay, Alaska, in 2010 had first seen the whale eighteen years previously. Her earplugs provided a fascinating contrast with those of whales killed earlier. Whale 68 was forty-five or forty-six years old at death, significantly older than the mean age of humpbacks whose earplugs had been collected during the height of industrial whaling in the 1950s and 1960s (though, even then, there were some in those samples in their nineties).[20] The International Whaling Commission had forbidden the killing of humpbacks in 1964, just before the birth of whale 68, so she was among the first in two generations who would actually make it to adulthood. Throughout her life, she interacted with a humpback society progressively alien from that of her youth, one filled every year with more and more older, experienced whales. Whale 68 also lived in an ocean filling every year with more ship traffic, and it was a collision with a propeller that ultimately killed her, an increasingly frequent form of death for whales since the 1990s.

Further confirmation of the utility of earplugs for aging came in 2024, when scientists examined a number of fin whales killed by Icelandic whalers from 2013 to 2015, part of one of the only remaining commercial hunts in the world. The important breakthrough here was that several fin whales turned out to be quite old, in their eighties. These animals were born around 1920, just as the first intensive burst of whaling in the North Atlantic was ending and pelagic

whaling was emerging in the Antarctic. That shift likely saved these fins, though they still had to evade Norwegian factory whalers for the first thirty-five years of their lives and—at a more modest rate—Icelandic whalers after 1946. By that time, the fins' original population of about thirty thousand had been heavily reduced.[21] The mid-1950s, ironically, was the time where the whales' earplugs began registering the phenomenon that refined their chronological use—increased radiocarbon that coincided with the peak of humans' atmospheric nuclear testing. As with every surface-exposed creature on the globe, these whales absorbed increasing amounts of radiocarbon into the 1980s, after which time those levels began to decrease. In this way, the embodied histories of whales track with those of humans over the twentieth century, their cellular composition and metabolic health depending on the decisions made by a few powerful men in Washington, Moscow, Paris, Beijing, and the like. Of course, the whales were not aware of these distant events, both at the International Whaling Commission and during the Cold War, and they ultimately paid for this ignorance. It was likely their long unfamiliarity with whaling that caught them unaware in 2013, when Iceland, after a forty-year pause, again set their sights on the fins. At the same time, around the world, whale stress as measured by cortisol was increasing, probably because of rapidly expanding container ship traffic, which produces deafening underwater noise. At the least, container ships and military tests have hampered cetacean communication; at worst, they have killed large numbers of whales through violent ship strikes, as happened to both whale 68 and the blue whale hanging in the New Bedford Whaling Museum.

Clearly, there is a vast trove of unexamined whale artifacts the world over, each containing secrets to the lives of whales individually and collectively. Leading scientists of earplugs opine that "a comprehensive database could be derived by combining the analysis of multiple earplugs harvest over multiple generations."[22] However, extracting information from these artifacts through chemical, genetic, or biological testing is only the first step. Rendering that evidence into historical narratives is another challenge entirely. Scientific evidence is like any other type of historical record—partial, impressionistic, and incomplete. Radiocarbon-dating fin whale earplugs or analyzing the isotopes in growth layers of sperm whale teeth offers clues, but not whole biographies.

Fortunately, historians are intimately familiar with partial evidence and the methodological techniques and imaginative leaps necessary to fill in a past both irretrievably lost and immeasurably important. Such a move is harder for animal historians to make, largely because of ideological roadblocks rooted in skepticism about our ability to know animals and their pasts. Whether scientists or humanists, scholars have been less ready, or even able, to extend the same broad interpretative frameworks to nonhuman life. As Bruno Latour writes in the foreword

Figure 3. A group of humpback whales feeding in Alaska. Whale 68, a female, would likely not have been part of such groups, which are primarily male-male associations. Evadb/Wikimedia Commons/ public domain.

to Vinciane Despret's *What Would Animals Say If We Asked the Right Questions?*, animal studies and ethology (the study of animal behavior and culture) rely on a limited analytical approach, one that Latour calls "subtractive empiricism."[23] A subtractive empiricist is in the business of ruling out possibilities, explaining an animal's behavior in terms of what it is not, thus narrowing plausible explanations. In contrast, a so-called "additive empiricist" embraces multiple interpretations, expanding our understanding of what animals can do. Other ethologists, such as Frans de Waal, or—in the field of cetology—Hal Whitehead and Luke Rendell, have increasingly challenged assumptions of our limited insight into animal experience, while showing through rigorous and patient research that animals live deeply emotional, collective, and historical lives. These lives are sometimes radically different from our own, but also sometimes surprisingly familiar and legible.[24] Embracing additive empiricism widens the terrain of plausible animal action in the present and the past. It means expanding our understanding of what an animal can be, as well as what she has been. Historians, reflexively afraid of anthropomorphism, need to catch up.

Were historians to practice subtractive empiricism with the human past, they would abandon all forms of subaltern history and probably all histories before the printing press too. We would hardly understand the first thing about the history of humanity and of our place on the planet. To apply subtractive empiricism to the history of whales and whaling is to pass quietly over the massacre of over three million individuals in the twentieth century alone. It is to probe the means and motives of the murderers without ever inquiring into the experience of the victims. It is to leave the mass of whale bodies lying on the ground, hanging from museum ceilings, silent in their boxes, our own bodies closed off to the stories they tell of a fellow creature's epic brush with extinction.

Thomas Fleischman is an associate professor of history at the University of Rochester, where he specializes in histories of animals, the environment, and modern Europe. He is the author of *Communist Pigs: An Animal History of East Germany's Rise and Fall* (2020) and is currently writing a human-animal social history of industrial whaling and whales in the twentieth century.

Ryan Tucker Jones is Ann Swindells Professor of Environmental History at the University of Oregon. He is the author of *Empire of Extinction: Russians and the North Pacific's Strange Beasts of the Sea, 1741–1867* (2014) and *Red Leviathan: The Secret History of Soviet Whaling* (2022).

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David Biggs

Reading Conflict Landscapes

Aerial Imagery, Ground-Truthing, and Intervisuality in Vietnam

No places on Earth have been as bombed, defoliated, and bulldozed as the former battlefields and bases of Vietnam. In the hills surrounding Hue, where I have studied for over fifteen years, "reading nature" requires attention not just to plants, soils, water, and structures but also to munitions, base operations, concrete ruins, and chemicals. Studying conflict landscapes requires careful attention to subterranean realms in the soil and with local communities. More than fifty years since the end of the Vietnam War, researchers still tread lightly (on the soil and in communities) in research on war legacies. Earth's modern war zones are fraught like this, and they pose practical and ethical challenges for anyone who wants to scrape the surface. Wars also generate a lot of historic materials, especially aerial images and geographically tagged data, and once declassified, these sources offer less invasive means for studying the environmental past. The increasing availability of historic aerial images and the increasing ease of use of geographic information systems (GIS) means that environmental historians and others can assemble new visual means for seeing into the wartime past; however, working with images still requires "ground-truthing," comparing visual information with on-the-ground observation and local sources. Comparing

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images, considering their production and transformations into digital formats, also requires an intervisual method, one that considers images relationally, evolving from one medium to another and from one human viewer to another.

This essay draws on a GIS-based study of two satellite-based images and one digitized preconflict map, plus field research drawn from years of study in central Vietnam, to outline an intervisual method for using aerial imagery in conflict zones with considerations of technical and ethical issues in this work. It begins mid-war in 1969 with a US spy satellite photograph to introduce major features in an area, and then turns to a 2002 commercial satellite multiband image of the same area to produce intervisual comparisons. It then uses the two images in an intervisual analysis combined with ground-truthing to consider how such studies open up new questions in the history of conflict landscapes. The essay ends with a digitized 1909 topographic map as a means to explore deeper, premodern factors that shaped military activities in the area.

Before we enter the lab space, several callouts are in order. First, let me foreground the hyperlinks and QR codes in the published images that link to full-resolution, full-color versions, some enabled with sliders that allow real-time intervisual analysis.[1] Second, a brief note about the history and exponential growth of aerial imagery is due. Once a novel visual perspective tied to the wonders of flight, aerial imagery has become an essential component of everyday life through navigation apps and a major component of geospatial intelligence, or "geoint," in the clandestine, militarized world of surveillance.[2] The advent of cameras in the late 1800s launched this enterprise as hobbyists and militaries alike put cameras on balloons, kites, pigeons, and planes to survey cities, rural landscapes, and battlefields. In World War I, aviators with plane-mounted cameras snapped thousands of images, and the formation of military photo reconnaissance units in turn produced a new sort of imagery archives.[3] The Cold War took cameras into space, and the digital revolution added electronic scanners. Since then, an ever-growing array of vehicles now collect digital data about the Earth's surface using photographic, electronic, radar, microwave, sonic, and laser sensors. The recent explosion of imagery and declassification has attracted historians who have begun to examine histories of aerial imagery and unpack the politics of its use.[4] Some have also built historical GIS applications and explored technical challenges in assessing images that require familiarity with imaging technologies, metadata, and GIS or remote sensing software needed for working with multiband images.[5] Finally, while most historians are relatively new to these areas of research, we must tip our hats to archaeologists who created aerial archaeology as a vibrant subfield that took off in the post–World War I years as it became possible to request aerial photographs.[6]

This excerpt of a CORONA spy satellite photograph (Fig. 1), taken over central Vietnam in the midday on March 20, 1969, offers a good visual starting point to the lab and the conflict zone. A KH-4A "keyhole" camera aboard a Discoverer satellite traveled in an elliptical,

QR code for Figure 1

Figure 1. Excerpt of CORONA frame DS1050-1006DF129 with annotations.

circumpolar orbit between 100 and 150 kilometers above the Earth at 7 kilometers per second. DS1050-1006DF129 was snapped along with thousands of other images during a twenty-two-orbit mission lasting several days. It was called a "keyhole" image because each image was a long and narrow rectangle covering 130 by 30 kilometers of the Earth's surface. CORONA satellites carried two cameras fore and aft to construct stereo images, but on this mission, as with many others, one of the cameras failed or the film was lost on reentry. These early satellites contained film cameras, and the unexposed rolls traveled back to Earth in heat-shielded capsules called "buckets" outfitted with small thrusters and parachutes. US Navy planes with trolling devices grabbed them in midair, and the film then traveled to developing facilities in California before images were sent to Washington. Each CORONA mission cost several million dollars to assemble and launch; they (like their Soviet counterparts) were history's most expensive disposable cameras. Finally, even if the rockets and cameras worked perfectly, meteorologists could not predict the weather; so getting a cloud-free shot like DS1050-1006DF129 was nearly impossible.[7]

Visually, this excerpt of a keyhole image shows an iconic stretch of the central Vietnamese coast at Hue, the former imperial capital. Of the white boxes I've added to indicate major features, the one in the upper left details the imperial city, surrounded by citadel walls and a moat. Two others describe sprawling American military encampments, the Phu Bai Combat Base and airfield, home to US Army and Marines units, and Camp Eagle, the site of the 101st Airborne Division's major encampment and headquarters after the Tet Offensive. The Perfume River runs from south to north on the left side of the image, and a snaking whitish line runs west from the American bases across the river to two FSBs, or fire support bases, on the far left in another square. This

road continued on another thirty kilometers into the Central Highlands, where some of the war's most ferocious battles and heaviest bombing took place. Images like this are especially valuable for researchers today as they show locations and features of former military areas that have long since been built over or forgotten.

A zoomed-in excerpt (Fig. 2) shows the high resolution of the CORONA photographs where ground features were visible at about 1.5-meter resolution, a mark *commercial* space images did not exceed until the 1990s. It shows buildings and walls, the royal palace as a darkish square (left center), and some white rectangles (lower right) near the river. These rectangles were the highly reflective tin roofs of temporary shelters near the point where US Marines fought their way across the river in February 1968 during the Battle of Hue.

That's a general interpretive introduction to an image, but art historians and others are quick to note that how one reads an image rests on not only their understanding of what is in it but also how they learned to read it. How do we know what we know? History teachers often begin with this question, and it's also where intervisuality and ground-truthing come in. How do images, especially aerial photographs, get embedded into ways of knowing and intervisual discourse? Without annotations or guidance, what and how does one see in the CORONA image? A general recognition of rivers, cities, and other features might be conditioned by years of exposure to maps and similar images in textbooks or news media or on apps. Military photo interpreters receive specialized training to recognize things like missile silos or bunkers, but they still test these interpretations by ground-truthing—comparing what the image shows with what eyewitnesses or other ground-based observers report. Ground-truthing can even explain things invisible or blank on an image. For example, in Vietnam, American observers were often confused by People's Army and Viet Cong units that fought hard to hold seemingly "worthless" barren hilltops. There were no visible elements to suggest a strategic advantage. However, postwar research showed that some were sites of resistance and martyrdom in earlier

Figure 2. Excerpt of CORONA frame DS1050-1006DF129.

QR code for Figure 2

wars. They were symbolically important. American writer J. B. Jackson calls these intangible features the "vernacular landscape," and they can be discovered only by ground-truthing techniques such as oral histories and textual research in local sources.[8] By adding oral histories and different means of community engagement required to see vernacular landscapes, I should add that my definition of ground-truthing here is far more expansive than that used by photo interpreters.

Intervisual methods engage with ground-truthing, but they also address images as things that, especially in the digital realm, are physically and semantically in flux. Observers may understand an aerial image differently depending on what they already know from technical or vernacular sources, but an image, especially an aerial image, is itself transforming as it moves from points of original "capture"—film negatives or raw data—to prints, aggregated data, scans, and georectified layers in a GIS. Visual theorist Nicholas Mirzoeff introduced the term "intervisuality" to describe this phenomenon. He writes, "Life in the pixel zone is necessarily ambivalent, creating what might be called 'intervisuality.'"[9] For those working with aerial images in GIS, preserving metadata on transformations is essential. What might at first seem like a relatively straightforward enterprise, reading an image or comparing it with another image of the same place at a different time, can quickly snowball into multiple interpretations and derivative images. There are also dozens of operations that a GIS can perform to isolate particular elements and generate new images. It is in this highly intervisual "pixel zone" where historians can compare a set of aerial images (and scanned maps) and begin to generate new questions and interpretations. The second aerial image in this lab, a 2002 satellite image (Fig. 3), is a perfect example of a highly modified derivative image.[10]

It shows the Phu Bai area of the conflict zone, focusing on the American bases in the center and a high hill to the west. It is not a photograph

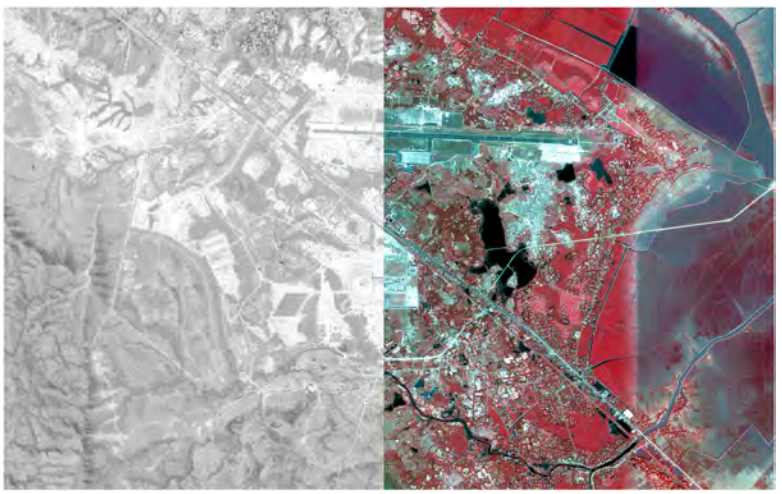
QR code for Figure 3

Figure 3. Excerpt of study area from two stitched IKONOS frames showing pan-sharpened 4-3-2 bands.

like the CORONA image but a "false color" image produced from a combination of three recorded bands of light—near-infrared (band 4), red (band 3), and green (band 2)—plus a fourth panchromatic band used to sharpen the image resolution. Denser vegetation absorbs more near-infrared light and appears darker red. Things that are blue to human eyes appear purple or black, while bare surfaces without vegetation appear white or gray. Lighter red areas describe thin vegetation such as grass or bamboo. The darkest reds to the left of the image describe Hill 180, a once-bare mountain replanted with pines after the war. Darker purples on the right of the image are rice fields inundated with water. This digital image is also not just one shot on one day but a "stitching" of two separate satellite shots using the same "false color 4-3-2" bands of light. A vertical line in the center right shows an abrupt shift in color from bright red on the left to purple on the right. This reflects pre- and postharvest of rice paddy from the left frame (January) to the right frame (March).

As with the CORONA photograph, figure 3 can be analyzed in technological and intervisual terms; however, by bringing both images into the same coordinate space in a GIS, it is possible to engage in an additional, comparative analysis that can be generative in that this sort of intervisual comparison brings new questions about conflict landscapes in the war and postwar eras. In the GIS (and on my website via QR code), figure 4 is rendered with a slider to allow the viewer to move between the two images, to consider how specific land features have changed (or not).

Comparing the two images from 1969 and 2002 and ground-truthing them with texts, oral accounts, and site visits, what storylines emerge? First, what is clear in the center of the image is that the old base geometry of roads and lots persisted. The airfield continues as Hue International Airport, and the old Phu Bai base in 2000 was converted into Phu Bai Industrial Park. This conversion story parallels a global history of



QR code for Figure 4

Figure 4. The 1969 and 2002 images, georeferenced and orthorectified.

BRAC, or Base Realignment and Closure, in the post–Cold War era. In ecological terms, very little changed in the base and airfield areas. The industrial park, in ecological terms, continued to operate like a military base, but in reverse. Raw materials came into factories, and finished goods exited them. Daily activity produced toxic substances and exposures, and the industrial zone required masses of laborers working together in tight quarters.

In the least developed areas, like Hill 180, a comparison of the two images suggests significant vegetation recovery (Fig. 5). Upon my first time seeing this in the image and before I visited the hill, I wondered whether this might be a sign of natural forest recovery. However, on subsequent trips to the area and following inquiries with local foresters, I soon learned this was not natural forest regrowth but an industrial tree plantation.

Private owners bid for wood lots here and planted them in fast-growing pulp and paper trees like Sumatran pine (*Pinus merkusii*). They periodically clear-cut parcels once the trees reach the desired size. The area at the eastern base of the hill experienced little change in vegetation because of its persistence as a firing range still operated by local military units. I unwittingly discovered this during one motorcycle tour when I drove through an open gate into an active military camp. I met confused guards, quickly retreated, and quickly realized that many old base areas continue to operate as bases under new "owners." Ground-truthing is essential to navigating active boundaries in former military zones; it requires sustained coordination with local authorities. As I developed my research during extended stays, building up my ground-based knowledge, the questions I asked of the images began to shift too. I began to focus on how new constructions like postwar reservoirs not only marked evidence of postwar economic change but in some cases also hid controversial sites from the war period. Through

QR code for Figure 5

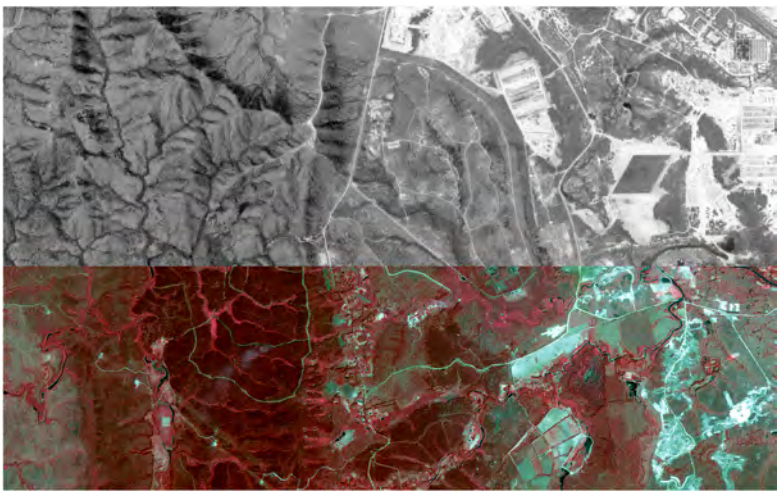


Figure 5. Vegetation on Hill 180 and adjacent military area in 1969 and 2002.

local partners, I learned of a major toxic cleanup in one area now hidden from view by a reservoir.

Khe Loi Reservoir (Fig. 6) was constructed by postwar settlers some years after the war's end. The 2002 image shows the earthen dam (bottom center) with downstream farms, while the 1969 image shows a few dirt roads, bare hills, and winding lines of creeks. While visiting Hue in 2007, I learned that when workers drained and cleaned the reservoir in 1999, they discovered a buried cache of CS (2-chlorobenzalmalononitrile), a riot-control agent (tear gas) used as a tactical chemical by US forces who dropped barrels of it in "smoke drops" from helicopters, especially over underground bunkers where the gas asphyxiated troops who struggled to reach the surface. Local partners reported that workers cleaning out the reservoir punctured some containers and, upon inhaling the powdered concentrate, received severe burns in the throat and lungs.[11] The province government, together with Vietnam's Ministry of Defense, coordinated a military forensics cleanup.

I later learned from colleagues that post-2000 concerns about buried waste sites (see Fig. 7) helped persuade provincial officials to accept my initial proposals to gather historic imagery and share it with local partners. Phu Bai Combat Base contained one of the largest explosive ordnance depots (EODs) in Vietnam, and either as part of the base transfer to the Republic of Vietnam in 1972 or during its abandonment in 1975, surplus materials were buried at various sites.[12]

Especially in conflict zones, community engagement is a vital part of ground-truthing and the sharing of research findings. Through interacting with community groups over years of study, I learned not just that Phu Bai was scarred by the Vietnam War but that the same base areas had been sites of industrial and military occupation dating back to the 1400s. In 1471, when the Le dynasty troops defeated Champa, the first military settlers came to the Phu Bai region to establish local strongholds. The *O Chau Chronicle* (1555) detailed the establishment of a barracks at Phu Bai, which became a district seat. The village was a

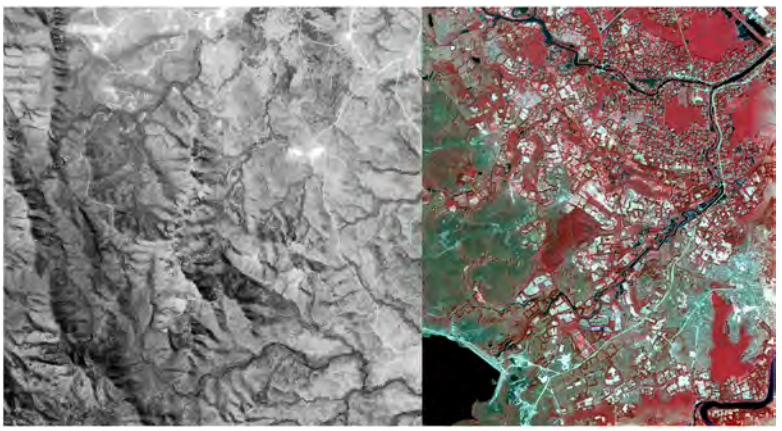


Figure 6. Hills and watersheds in 1969 (*left*) and 2002 (*right*) at Khe Loi Reservoir, site of a hazardous waste cleanup in 2001.

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center for the production of pig iron via large-scale mining and smelting operations in the hills.[13] The same ground that US soldiers camped on in 1969 had likely been occupied by many generations of soldiers before them over several centuries. Research in the province library turned up a study of iron and blacksmithing villages by local historian Bùi Thị Tân, who detailed how Phu Bai's guilds supplied the southern Vietnamese government in Hue with much of the metal for swords and muskets.[14]

Like archaeologists, I and my colleagues used imagery to look backward in time into the premodern past. Textual accounts confirmed that Phu Bai had been a military zone since the 1500s, but there were no maps or other spatial documents detailing specifically where the village's mines, kilns, or waste slag were located. Perhaps the airfield, constructed on elevated mounds of "wasteland" in 1926, was located on part of the ancient industrial space. Mining stopped in the region after the eruption of a civil war in 1772 that lasted for thirty years. Severely depleted forests and rising imports of cheaper metal goods from China limited modern efforts to restart the industry. Local sources colloquially referred to an area west of Phu Bai Village and near the military area as a "rust area" (*vùng phèn*), and village histories pointed to Quách Mountain (Hill 180) as the source for iron ore, so the mountain's base was most likely the candidate for historical smelting.[15] This possible correlation between modern and premodern waste sites added an unusual twist to the well-known storyline of American war legacies in Vietnam. A series of visits to this area turned up ferrous-red soils indicating the presence of iron.

I was unable to find pre-1945 imagery, so instead I scanned and georeferenced a 1909 topographic map to study areas of bare land in the vicinity of the Phu Bai EOD and airfield. Additional consultation with Vietnamese cadastral surveys from the early nineteenth century confirmed that the *vùng phèn* was considered "wasteland" (*đất bỏ hoang*) as early as 1825.[16]

QR code for Figure 7

Figure 7. The base of Hill 180 facing the military area, February 6, 2014. Iron-rich soils are evident in the foreground, and a low hill planted in *Acacia augustifolia* (lower elevation) and *Pinus merkusii* (ridgeline) rises in the background.

An intervisual comparison of the 1909 map and the 2002 image (Fig. 8) helped to confirm theories about the EOD area being situated on a former iron slag site, but it also suggested other environmental trends over the longer *durée*. A comparison of village hedgerows, field dikes, and levees in the village and estuary areas (right side of the image) showed almost no change over a one-hundred-year gap, and this was despite military base construction and frequent eruptions of violence from the colonial conquest in 1884 to the Vietnam War's end in 1975. These highly plastic, earthen, and plant-based structures required constant maintenance. This persistence of their geometry suggests stubborn resilience in the face of disruptions. Village life and the local agroecology persevered. The same geometry continues today.

A visual comparison on the left side of the image showed an unusual rise that today lies under the runway at Hue International Airport. Perhaps this rise of land was not some ancient dune but a leveled-out mound of alum and iron slag from several centuries of smelting activity? Perhaps the inability of farmers to farm these soils also explained why the site was selected as an airstrip and decades later as a military base? I was unable to answer these questions with colleagues at the time, and because parts of this area are highly secured, we have yet to conduct soil tests to confirm the theory.

Nevertheless, this intervisual approach underscores the highly generative effects that come from bringing aerial images into a sort of dialogue with ground-sourced and vernacular knowledge. This brief lab tour demonstrates the potential for aerial imagery through the use of GIS-based intervisual inquiry and ground-truthing to better understand the environmental history of conflict zones. An ethical and provocative intervisual method integrates ground-truthing and community-engaged research that may in turn lead to new questions and

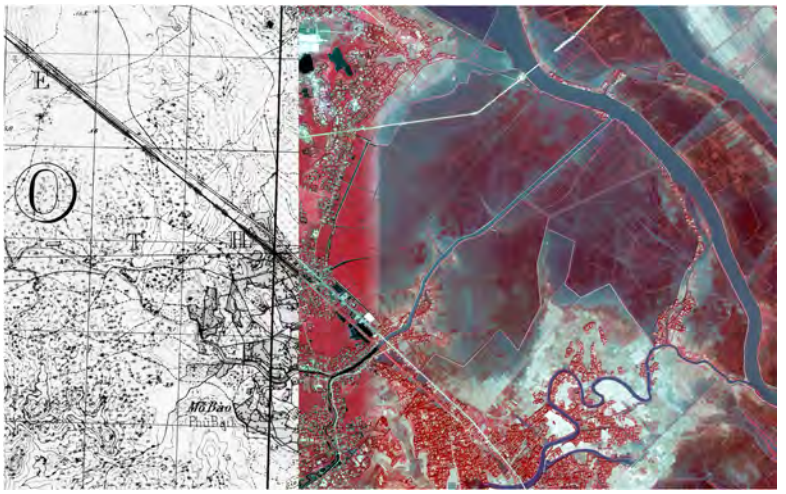

Figure 8. Airfield area and Phu Bai Village in 1909 and 2002.

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research directions. As with any archival source, how we understand it and how we use it—how we know what we know—depends on the strength of collaborations and comparisons.

David Biggs is a specialist on the environmental history of modern Vietnam and Southeast Asia, and he is professor and chair of the Department of History at the University of California, Riverside.

1 The full set can be found at https://davidbiggs.net/reading-conflict-landscapes/.
2 For a succinct overview, see the Smithsonian's National Air and Space Museum, "The Beginnings and Basics of Aerial Photography," June 21, 2023, https://airandspace.si.edu/stories/editorial/beginnings-and-basics-aerial-photography.
3 The US National Archives record group 120 consists of about sixteen thousand prints taken by the American Expeditionary Forces. See https://www.archives.gov/research/cartographic/aerial-photography/rg-120-aef-aerial-photography.
4 See, for example, Jeanne Haffner's *The View from Above: The Science of Social Space* (MIT Press, 2013).
5 Environmental historian Richard White co-established Stanford's Spatial History Project in 2007, a major venue for GIS- and imagery-based research to 2022. The site is now archived, and a static version of the site may be found at https://web.stanford.edu/group/spatialhistory/static/publications/pub29.html.
6 In Cambodia and Vietnam, for example, archaeologists in the early 1930s used the first aerial photographs to detect canals and temple complexes. Since the 1990s, they have used space imagery and ground studies to uncover networks of canals and roads at Angkor Wat. See Damian Evans, Christophe Pottier, Roland Fletcher, et al., "A Comprehensive Archaeological Map of the World's Largest Preindustrial Settlement Complex at Angkor, Cambodia," *PNAS* 104, no. 36 (2007): 14277–82.
7 Center for the Study of National Reconnaissance, *The Corona Story* (Center for the Study of National Reconnaissance, 2013), 114, https://www.nro.gov/Portals/65/documents/history/csnr/corona/TheCORONAStory.pdf. For information on CORONA image collections, see EROS Center, "Declassified Satellite Imagery—1," US Geological Survey, July 13, 2018, https://www.usgs.gov/centers/eros/science/usgs-eros-archive-declassified-data-declassified-satellite-imagery-1.
8 John Brinckerhoff Jackson, *Discovering the Vernacular Landscape* (Yale University Press, 1984).
9 Nicholas Mirzoeff, *An Introduction to Visual Culture* (Routledge, 1999), 30.
10 This image was derived from two commercial satellite images shot on March 27, 2002 (left portion), and January 1, 2002 (right portion), and provided through a grant by the GeoEye Foundation.
11 See David Biggs, *Footprints of War: Militarized Landscapes in Vietnam* (University of Washington Press, 2018), 8.
12 Today in Vietnam, Laos, and Cambodia, cleanups of buried chemicals like CS continue, often with bilateral cooperation from the United States. US Army manuals circa 1969 provided detailed recommendations for disposal, recommending burning it in quantities "greater than 25 pounds"; however, here the burials of drummed CS here were likely due to the rushed nature of the US withdrawal in 1972 or the rapid collapse of South Vietnamese defenses in 1975. See US Department of the Army, *Storage, Shipment Handling and Disposal of Chemical Agents and Hazardous Chemicals*, technical manual 3-250 (Department of the Army, 1969), 123.
13 Dương Văn An, *Ô Châu Cận Lục*, trans. Trịnh Khắc Mạnh and Nguyễn Văn Nguyện (Nhà Xuất Bản Khoa Học Xã Hội, 1997), 32.
14 Bùi Thị Tân, *Về hai làng nghề truyền thống: Phú Bài và Hiền Lương* [Regarding two traditional craft villages: Phú Bài and Hiền Lương] (Thuận Hóa, 1999).
15 Bùi Kim Chi, "Phù Bài làng xưa," *Sông Hương*, December 16, 2011, http://tapchisonghuong.com.vn/tin-tuc/p2/c15/n9543/Phu-Bai-lang-xua.html.
16 For a thorough discussion of these sources, see David Biggs, "Clearing, 'Wasting,' and Regreening: An Environmental History of Bare Hills in Central Vietnam," *Journal of Asian Studies* 77, no. 4 (2018): 1037–58.

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Ruth A. Morgan

Solar Photography

Recovering Astronomical Observations of Sunspot Activity

In his 1900 account of the activities of the Royal Observatory, Greenwich, astronomer E. W. Maunder explained the process of photographing the sun using either the nine-inch Thompson photoheliograph or the older, four-inch Dallmeyer photoheliograph: "To take a photograph of the sun will occupy about five minutes in setting the instrument, whilst the actual exposure will take but the one-thousandth part of a second. But the plate, once exposed, will have to be developed, fixed, and washed; then measured, and the measures reduced, and, *on the average*, will provide one person with work for four days before the final results have been printed and published."[1] Thanks to similar practices undertaken in British India, as well as variously in Mauritius, the Cape of Good Hope, Australia, and the United States (to compensate for England's regularly overcast conditions), Greenwich accumulated "practically a daily record of the state of the sun's surface." Commencing in 1873 and continuing for over a century, this twice daily routine of photographing the sun produced thousands upon thousands of glass plate negatives and photographs of what Maunder described as the star's "portrait."[2]

Today, these images belong to the ten million or so astronomical photographic negatives scattered across observatories and archives—a fraction of which are undergoing digitization to contribute to growing online databases of the astronomical archive, such as Germany's Archives of Photographic Plates for Astronomical Use (APPLAUSE) and the Digital Access to a Sky Century at Harvard (DASCH). Scientists are revisiting these images for time-domain astronomy, while others are scrutinizing the solar photography series and their accompanying metadata to correct time series and adjust calculations.[3] For historians

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of science, meanwhile, these photographic plates can help to shed light on the cultural and material conditions of their production, circulation, and interpretation.[4]

As environmental historians turn their gaze to our planet's place in the solar system, the abundance of surviving sun portraits becomes newly relevant to understanding how societies past have apprehended relationships (perceived or otherwise) between extraterrestrial environments and their own.[5] Although much of this scholarship has so far considered outer space in the Cold War terms of *Sputnik*, Earthrise, and Landsat, with a particular focus on the US space program, histories of earlier periods of stargazing, with their associated cultures and practices, are also coming into view. These include, I propose, the scientific and popular attribution of climatic change and variability to extraterrestrial forces, namely the sun.

As the Earth's closest star, it has literally energized human cultures for millennia—we are "children of the sun," wrote Russian geochemist Vladimir Vernadsky in his 1926 *The Biosphere*.[6] From at least the early nineteenth century, European scientists began to wonder whether changes in the sun might affect weather on Earth. Once the sunspot cycle came into view, their search for answers continued well into the twentieth century, implicating solar activity first in outbreaks of famine, then periods of drought and business cycles, and eventually the fluctuations of animal populations.[7] Maunder himself noted changes to the solar cycle in historic time, pointing out the "prolonged sunspot minimum" that would eventually become known as the "Maunder Minimum"—the period around 1645 to 1715 that marked an especially chilly phase of the Little Ice Age.[8]

The archive of such astronomical activities will indeed shed light on the scientific history of the sun-weather relationship and its learned protagonists. But what of that history beyond the observatory? This cohort had especially interested Maunder, for whom the professionalization of the Royal Astronomical Society represented the unwelcome diminution of amateur observers and enthusiasts.[9] Some surviving solar photographs might allow historians, as I sketch below, a glimpse of what those *outside* the rigors of the observatory could have realistically witnessed for themselves—in this case, in Australia. Having had their appetite for stargazing whetted by the popular astronomy of the nineteenth and early twentieth centuries, this lay audience could observe firsthand the most extravagant sunspot displays without astronomical apparatus.[10] Studying photographs of specific sunspots can enable the environmental historian to better appreciate the visual world of contemporary observers as part of the broader excavation of their situated understandings of the sun-weather relationship.

On February 10, 1917, an assistant adjusted the Dallmeyer telescope at Dehra Dun Observatory in the then United Provinces, India, to take his daily photograph of the sun. Supervised by the deputy surveyor general of the trigonometrical survey of India, he carefully wrapped the resulting photograph plate and packed it with the rest of the week's

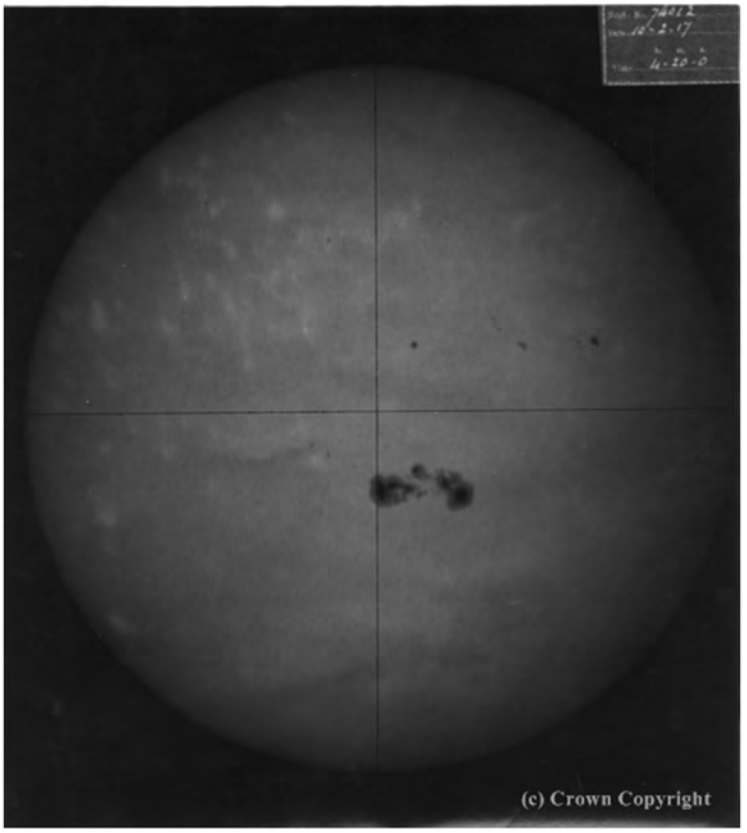

Figure 1. A contact print taken from the February 10, 1917, photograph captured at Dehra Dun Observatory. This image is held at the UK Solar System Data Centre. Courtesy of the UK Centre for Environmental Data Analysis.

plates to dispatch to the Royal Observatory in Greenwich. We know this much because a contact print of that photographic plate survives in the UK Solar System Data Centre in Oxfordshire (Figure 1).[11]

At the Royal Observatory, the photographic plates likely passed through the hands of Maunder and his wife, Annie (an accomplished observer in her own right). Although they had both retired, the couple had returned to lend their assistance during the wartime labor shortage. Surveying the photographic plates, Walter, Annie, or their fellow assistants likely deemed the Dehra Dun photographs poorer quality relative to those from the Cape and Greenwich, for no Indian plates were used to measure the position and areas of sunspots during February.[12] The better-quality photographs, however, were likely transferred to microfilm, and their plates wiped clean and resilvered for further use, on account of the wartime demand.[13] The surviving Dehra Dun photographs show sunspots making their transit across the face of the sun, forming what the Greenwich observers named Sunspot Group Number 7977 (Figure 2).[14] Spanning February 3 to 16, 1917, this "magnificent group" contained the largest maximum whole-spot area that had yet been measured at Greenwich, with the February 10 sunspot ranking

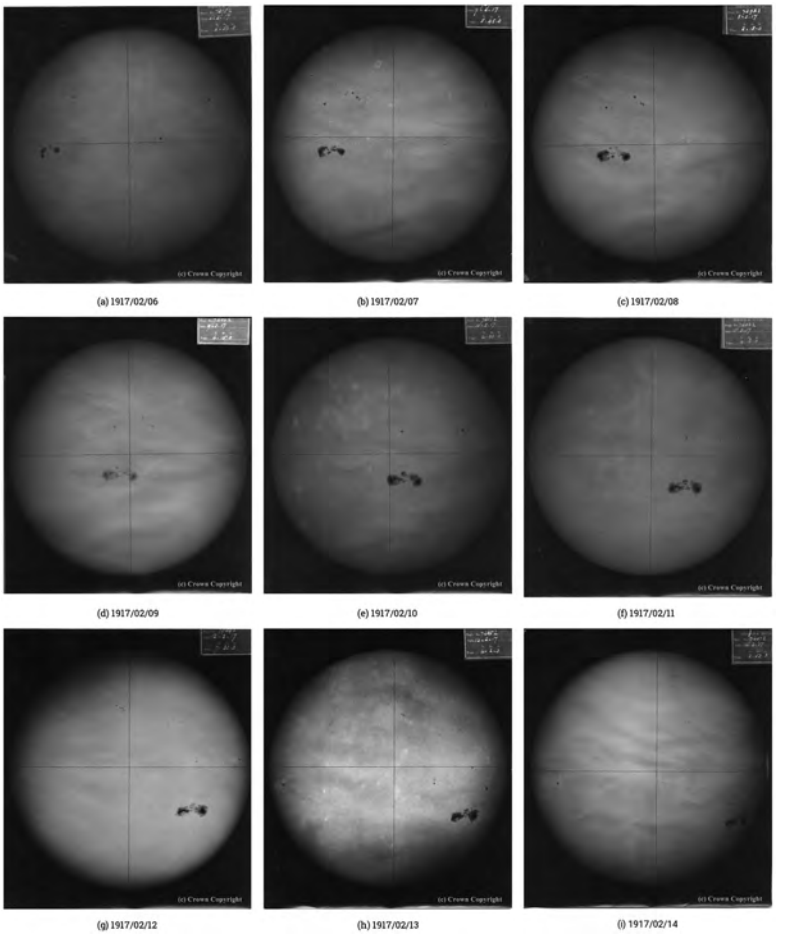

Figure 2. Contact prints taken from the photographs of February 6, 1917, to February 14, 1917, captured at Dehra Dun Observatory. These images are held at the UK Solar System Data Centre. Courtesy of the UK Centre for Environmental Data Analysis.

sixth among the daily measurements.[15] Farther north at the Stonyhurst College Observatory in Lancashire, an observer sketched the sunspot group's "life-history" from February 4 to March 14 (Figure 3),[16] while their markings were penciled at the Mount Wilson Solar Observatory across the Atlantic (Figure 4).[17]

Despite their archival and scientific importance, the sketches from Stonyhurst College and Mount Wilson convey somewhat limited insights for the environmental historian, relative at least to the Dehra Dun photographs of Sunspot Group Number 7977 (Figures 1 and 2). The sketches are the markings of the expert, drawn for further astronomical investigation. The photographs, on the other hand, offer a sight more closely resembling the view of contemporary lay observers. Sunspot Group Number 7977 was so large that it had been sighted and recorded in the ship's log of the HMS *Hilary*, about four months before it was torpedoed and sunk by a German submarine.[18]

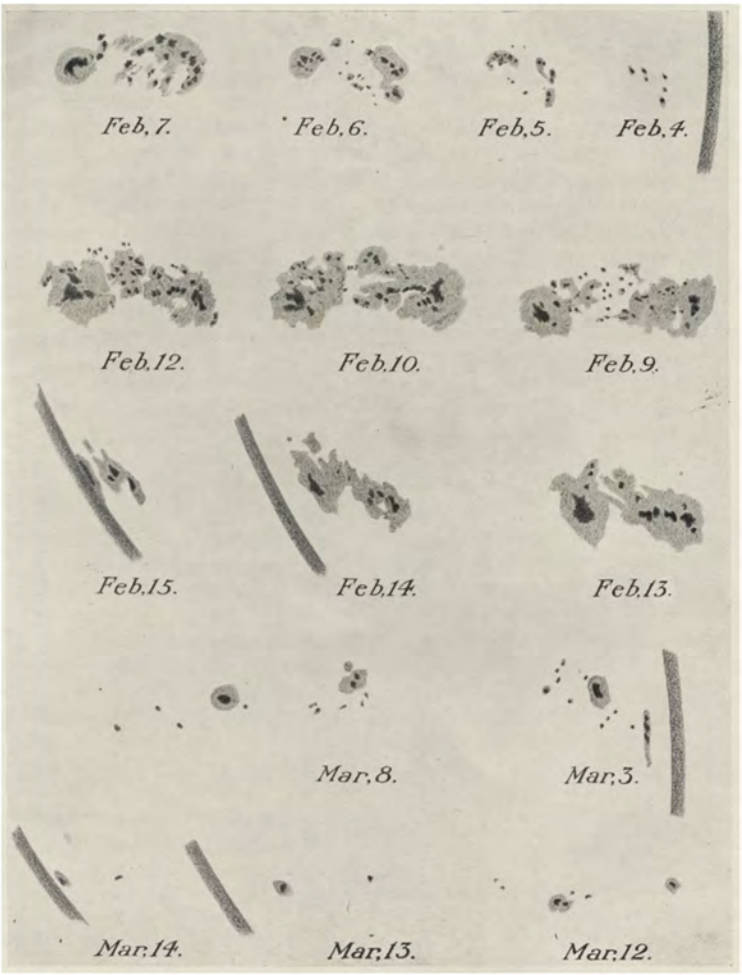

Figure 3. A sketch of Sunspot Group Number 7977 made at Stonyhurst College Observatory, UK, whose Rev. Aloysius Cortie visited Australia on his way to observe the 1911 solar eclipse from Tonga. Courtesy of Stonyhurst Archives.

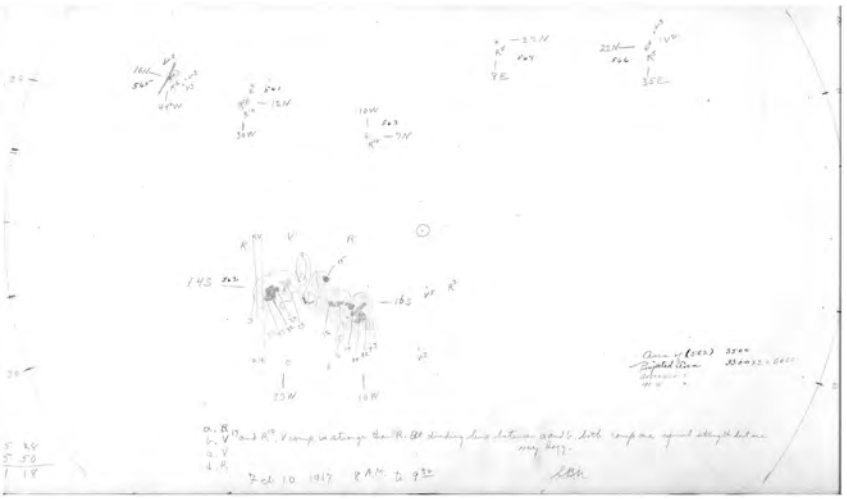

Figure 4. The annotated drawing of the sunspots visible on February 10, 1917, at Mount Wilson Observatory, California, by Seth B. Nicholson. Courtesy of Carnegie Science.

Reporting on the group's passing across the sun's central meridian, the London *Times* noted the sunspots were "plainly visible without optical aid."[19] Australian newspapers offered readers advice to see the sunspots for themselves "before sunset," with "a pair of binoculars and coloured glasses for both eyes" in Brisbane.[20] Adelaide viewers could alternatively observe the sunspots by projection, "using a pinhole in a piece of paper, which should be held a short distance from a second piece, so that the shadow is thrown on it."[21] Australian troops on the western front might also catch a glimpse "through the mist," reported the *Rising Sun* (printed for the Australian Imperial Force), allowing them to see in France what was also "visible to the naked eye" back in Sydney.[22]

To interpret the responses of contemporary lay observers to the appearance of the sunspot group of February 1917 requires further investigation. The sun itself was by now well established among settler Australians as the subject of deep nationalist investment, particularly for the growing majority of those "native-born." By the late nineteenth century, authors, artists, and photographers were offering depictions of a distinctively Australian landscape that was sunlit and warm. This notion of a "sunny south" articulated with the aspirations of a new nation, federated in 1901, and its embrace of new beginnings, where white Australia would emerge "as the Delos of a coming Sun-God's race," as one poet put it.[23] Such was the strength of this solar nationalism that the *Rising Sun* was not simply the masthead for the newly established newspaper on the western front; it was the emblem that adorned the slouch hats of the soldiers of a young nation at war.[24]

Of the reception of sunspots, much less is known. Press accounts, however, might gesture to their wider popular significance, grounded in local memory and experience. On the war front, the *Rising Sun* wondered whether the sunspots of February 1917 were "the reason" for extensive flooding in southwest Queensland.[25] A reporter for the Adelaide *Register* recalled a similar sunspot had been "visible to the naked eye" during 1914, when much of the continent's south was in the grip of drought. Heavy rain, the reporter noted, fell in the following year.[26] The dry conditions of 1914 were the most intense of a series of dry seasons reaching back to 1911 in South Australia and lingering into 1916 in parts of neighboring Victoria. Just over a decade after the devastating Federation Drought (1895–1903), named for its coincidence with the federation of the Australian colonies in 1901, dry conditions again visited the young nation. Although the drought was relatively short, at least by Australian standards, its wide reach proved devastating. Its severity caused the collapse of the national wheat crop and crippled the capacity of Australian farmers to supply the British war effort. Coinciding with the commencement of World War I, these agricultural doldrums led many young rural men to enter the armed services to escape economic hardship.[27]

The onset of the 1914 drought had been widely associated with a "considerable revival" of the appearance of sunspots. As the South Australian astronomer told the *Register*, "There were 10 great groups of spots, any one of which covered a greater area of disturbance than all the groups of 1913 combined together."[28] This revival, he further explained, marked the beginning of a new sunspot cycle, which broadly concurred with the reasoning of a local weather prophet, the renegade meteorologist Clement Wragge. Based on his observations of air pressure, Eduard Brückner's theory of thirty-five-year cycles of wet and dry seasons, and the eleven-year sunspot cycle, Wragge anticipated Australia's rainfall would "markedly increase" later in 1915, then "steadily fall off" after 1920.[29]

That large sunspots had appeared in 1917 might also have recalled a forecast delivered prior to the 1914 drought. During a brief visit to Melbourne in early 1913, English meteorologist E. Douglas Archibald shared his prediction that "the year 1917 will see the beginning of a drought period, which will extend, with more or less severity over about twenty years."[30] Lending credibility to his pronouncement were his affiliations and his claim to have accurately predicted the 1896–1900 Indian famine, drawing (like Wragge) on Brückner's theory and the sunspot cycle. On this authority, he had prepared three-day forecasts of Britain's weather for daily newspapers since the turn of the century.[31] Although the Commonwealth meteorologist dismissed Archibald's latest pronouncement, the visitor's outlook was widely disseminated.[32] Melbourne's *Weekly Times* suggested Archibald's advice "may be wisely accepted," as it might encourage farmers to better prepare for the possibility of drier conditions.

Rehearsing just some of the prognostications animating the popular press offers an indication of the considerable range of weather forecasts and theories available to Australian readers. As a Queensland editorial mused, "Will there be a drought? This is a continual question. Almost assuredly there will. But when? That is quite another matter."[33] On the subject of weather forecasting, another concluded that "we are probably less skilled than the aboriginals [sic] who came before us in this vast continent," which could be interpreted as a sign of contemporary settler awareness of Indigenous weather and solar knowledges, or, more likely, as a racialized indictment on the nation's meteorological services.[34] Reportage in the popular press also serves to suggest the lively interest in the association of sunspots and their recurrence with the weather in the first decades of the twentieth century. The opportunity to observe sunspots independently, as unusually large examples offered, afforded ordinary weather watchers entry to participate directly in an antipodean culture of popular astronomy.

Beyond the press, public lectures provided another venue for Australian sunspottery. Archibald's short visit to Australia had followed closely on the heels of the American science writer Mary Proctor. Arriving in Melbourne in July 1912, she undertook a lecture tour of eastern

Australia's capital cities and regional towns.[35] Reminding their readers that her father, the English astronomer Richard A. Proctor, had visited Australia in 1880 on a tour of his own, newspapers noted that Mary had inherited his "passionate love for her subject."[36] Among her lantern slides were pictures of the sun, including the "spots upon its surface" and "the huge masses of gaseous matter surrounding it," which helped to illustrate her lectures, while contributing further to the audience's visual repertoire of the Earth's closest star.[37]

In addition to her talks, Proctor advocated widely for the establishment of a solar observatory in Australia, or over the Tasman, in New Zealand. The contributions of the Melbourne and Sydney observatories to the Greenwich sunspot catalogs had waned since federation, and the centralization of the nation's meteorological efforts in the Commonwealth Meteorological Bureau in 1907 further diminished their influence.[38] In a "charming chat" with the *Bendigo Independent*, Proctor explained, "Astronomers studying the sun want to study it the whole 24 hours, and just now, there is a gap between India and California practically half the day. Australia would fill all that gap."[39]

By this point, a Commonwealth solar observatory had been mooted for over a decade; the Australian press had followed its fortunes closely, drawing unfavorable comparisons with well-resourced astronomical institutions of Europe, India, and the United States. Proctor's advocacy followed similar efforts by astronomers associated with the Joint Permanent Eclipse Committee and the Solar Physics Committee, who were passing through Sydney in 1911 on their way to Tonga to observe April's solar eclipse during the totality. At a welcome reception, astronomer William J. S. Lockyer of the South Kensington Solar Physics Observatory (UK) reportedly observed, "It was a curious thing for a country so dependent on sunshine as Australia that there was no observatory actually to study variations and solar changes from a local point of view."[40] Over a decade later, mired in political uncertainty and bureaucratic competition, and delayed by war, construction of the Commonwealth Solar Observatory finally got underway at Mount Stromlo in the Australian Capital Territory.[41]

Championed by esteemed astronomers and other scientists at home and abroad, its eventual realization was thanks in no small part to the popular sunspottery of Australians. In the skies, in the press, and on the stage, they closely watched for changes in the sun that might provide them some insight into the seasons ahead. Their settler sun culture almost demanded it. Contemporary photographic "sun portraits," to use Maunder's term, enables the environmental historian to venture out of the present into such solar cultures past. Doing so recognizes that the Earth's closest star also has a life history, such that the face of the sun differs from one day to the next. The photographic solar archive, albeit partial, provides a view of the sun as contemporaries might have seen and understood it.

Living and working on Ngunnawal and Ngambri Country, **Ruth A. Morgan** is the director of the Centre for Environmental History at the Australian National University, Canberra. Her most recent book is *Climate Change and International History: Negotiating Science, Global Change, and Environmental Justice* (2024).

Thank you to David Biggs, Ryan Tucker Jones, and the reviewers for their feedback and support.

1 E. Walter Maunder, *The Royal Observatory, Greenwich* (Religious Tract Society, 1900), 136 (emphasis in original).
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Shen Hou

Emerald Sea and Red Roofs

Reading Qingdao's Environmental History in Its Cityscape

When the bullet train arrives at the station in the Chinese coastal city of Qingdao, the first text message you receive will likely come from the city's visitor bureau, and read: "Red roofs, green trees, emerald sea, and blue skies welcome you to Qingdao." The bureau wants you to expect that when you step outside, you will inhale a unique scent carried by a sea breeze heavy with moisture, while your eyes will take in the characteristic red roofs of this city, starting with the

Figure 1. Qingdao's red tile roofs, green trees, emerald seas, and blue skies. Photo by Xiangui Meng.

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train station itself, a clustering of roofs that contrasts vividly with the blueness of the skies. From these material sights, you will know you are in Qingdao.

Those welcoming words appear in eight Chinese characters (绿树红瓦, 碧海蓝天), emphasizing the identifying natural and architectural colors of Qingdao.[1] Together, it is color that defines the city's uniqueness. Some architectural and cultural historians have seized on the connection between the city's history and its red roof tiles, suggesting the latter as a cultural artifact, a memory domain, and a special power space.[2] Too simply, they conclude that the red roof tiles are nothing more than "cultural artifacts."[3] However, in his groundbreaking essay "Materials Against Materiality," anthropologist Tim Ingold disagrees with that reductive approach: "We see the building and not the plaster of its walls, the words and not the ink with which they were written. In reality, of course, the materials are still there and continue to mingle and react as they have always done, forever threatening the things they comprise with dissolution or even 'dematerialization.'"[4]

This essay will argue that we need to see that the red tiles were and always will be a material artifact that mixes both natural and cultural elements, which could be read as layered archives of nature—and yet those artifacts change over time. They have a complex history. When they are added to the dominant cityscape, which features many green trees, an emerald sea, and blue skies, it becomes impossible to rigidly separate the cultural from the natural, the man-made roofs from their true status as archives deposited by nature as well as constructed by humans. We historians tend to interpret natural elements such as the sea and the trees as cultural constructions; but the red tiles, like Qingdao's cityscape in general, are at once perishable material and natural constructions, for they consist of material derived from nature and reflect people's everyday, pragmatic needs along with their visual aspirations to live harmoniously within their natural setting. This essay aims to demonstrate how those red tiles can be interpreted in part as archives of nature and then to ask what new insights we can gain about the city's environmental and cultural history. We should acknowledge that in the process of building the city, nature becomes part of our history—in this case, both Chinese and Western imperial history.

The red roofs, like the city itself, appeared along the Chinese northeastern coastline because of the Germans. Before their occupation in 1898, there had been no city here—only Chinese fishing villages. But was the color scheme purely German? It was German imperialists who founded Qingdao, but it was the Chinese, who came here to live by the thousands and then by the millions; and it was they who turned their humiliating past into a very layered urban landscape, adopting, but not uncritically, German color designs for their expanding city. They did that not because the Chinese settlers

Figure 2. Youwei Kang's residence, now a city museum, surrounded by apartment buildings. Photo by Yanying Xing.

followed Germans slavishly but because the red roofs, green trees, and sea views appealed to them, too, as the natural palette of their own twentieth-century coastal city.

Let's start our exploration of the city's material form from a house still standing at No. 5 Fushan Zhilu (福山支路) street. It is three stories high, sits on a winding hilly road, and has a red tile roof and yellow stucco walls. Less than two hundred meters away is Huiquan Beach (汇泉湾), where one can see and feel the white spray of sea waves vividly from the second-floor balcony of the house. It was one of the first buildings constructed by the German colonists. The original owner was the adjutant of the German colonial governor. Completed in 1900, the house shows not a simple German form but a material and cultural mixture. The loggia that connects the house to the sea may look Mediterranean, but also Chinese and Southeast Asian. Even though no professional architect would rank it as a major architectural work in the city, its mixed, quaint style has attracted a lot of people over the past 125 years.

On one side of the house, several large ginkgo trees stand in splendid golden color during the autumn season against the deep blue sky; on the other side rises a tall Japanese cedar, dark green, calm, and solemn. It is not clear when those trees were planted; what we know is that, like other small hills, this site was barren of all trees when the Germans first arrived. Subsequently, tree planting took priority among the German colonizers and was continued by the Japanese invaders after 1914 (when Qingdao was occupied by Japan until 1922, and became part of Japanese Empire again from 1938 to 1945). The tree-planting project continued under Republic of China and Communist governments. One of the major species introduced by the Germans was Japanese cedar, which was not fully acclimatized until 1956. Despite those origins, that tree was voted in 1988 by a Chinese populace as "the tree of the city" in Qingdao. Ginkgoes, famous for their beauty and antiquity, were native to China, so the Germans reintroduced them to the area. Much like the big house they still surround, those trees embody a blend of nature and culture, native and foreign, local and colonial.

According to some researchers, the first German house, along with many other residences built in the colonial years, was originally covered with black tiles, thus following a traditional Chinese architectural pattern. But soon the black tiles were replaced by red ones, a color and style supposedly expressing the colonists' nostalgia. But here again the story is not so simple.

When Youwei Kang (康有为), the famous reformer and intellectual of the late Qing era, visited the city for the first time in 1917, he was deeply impressed by the mix of colors and material elements: the emerald sea, blue skies, pleasant climate, and hilly cityscape. In 1923, after traveling through Japan, the Americas, India, and many European countries, he

decided to settle in Qingdao and bought the house on No. 5 Fushan Zhilu. He could walk to the rugged seacoast and the beach along the winding road within three minutes. As he explained to a friend: "[This city of] red tiles, green trees, green hills, and emerald sea, is No. 1 in China. . . . There are only red tiled new buildings, not a single black tiled old house, in the entire peninsula." Kang was highly resentful toward the German colonization of Qingdao, and later, following the Republican Revolution in 1911, he became the most prominent royalist and nationalistic conservative in China. Yet he liked the composite of red-tiled buildings set against green and blue natural surroundings. People distilled his description of the identifying elements as those eight characters that have been adopted by the Chinese city government as an official slogan.

Anti-imperialist Kang was not alone in his admiration for the Qingdao cityscape. During the 1920s, up until the outbreak of the anti-Japanese war, the city increasingly became home to many more distinguished Chinese figures. They included a few surviving Qing dynasty princes, a rising population of bankers, many literary stars, ambitious natural scientists, traditional Confucian scholars, and homecoming intellectuals from Europe, the United States, and Japan. From the summit of Xiaoyu Hill (小鱼山), where Kang's own house stood out, red roofs everywhere dominated the horizon between sky and sea. During the years 1919 to 1921, when Zishan Liu (刘子山), an immigrant from an impoverished peasant community and a self-made man who bore the moniker "Halfcity Liu" (indicating he owned nearly half of the city's real estate), chose to construct nineteen villas near his bank, he insisted on red roofs and stucco walls, following the style of his own house, a massive villa built and originally owned by a German entrepreneur running the largest tile and brick factory in Qingdao before 1914. Many who possessed sufficient money and power to follow their own way in renovating or building their homes exhibited the same behavior. Doing so meant they freely chose to adopt the colors and styles introduced by the German colonizers, even when those colors might have reminded them of China's humiliating history of foreign occupation. Thus, the Chinese put their own stamp on the cityscape.

Those elites had many opportunities to avoid being covered by red roofs. For example, when the city finally achieved its political independence in the early 1920s, it deliberately set out to decolonize its economy and culture. Many leaders called for a more distinctly Chinese nationalistic or traditional architecture in the city. The most outstanding expression of that new independence was the main building of Qingdao Aquarium, acclaimed as the first aquarium designed and built by Chinese in the whole country. It was first proposed in 1930 and completed in 1932. Located on the rocky shore west of Huiquan Beach, the aquarium was constructed in a "traditional" Chinese way, covered with . . . green tiles! Neither black nor red, but something new. Even though the very idea of an aquarium was modern and Western, promoting

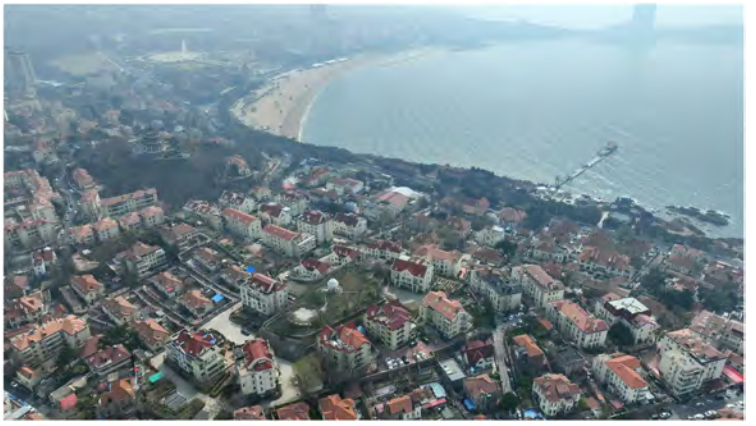

Figure 3. The view from Youwei Kang's house and Huiquan Beach in the middle. The green-roofed aquarium is next to the floating pier, invisible from this angle. Photo by Xiangui Meng.

maritime science and fostering a new ocean awareness, the builders overall sought to highlight the fact that Qingdao was now a Chinese city. But that building, along with several other houses in the same style, such as the one across the street from Kang's house on Fushan Zhilu, appeared to be submerged by the red roofs and found few followers.

Furthermore, as the old Chinese fishing village and the German colonial town continued to grow into a metropolis, with a population of nearly ten million in 2000, rich and modern, eager to regenerate its cityscape to welcome the upcoming Olympic Games in 2008 as the sole partner city of Beijing, Qingdao's government decided to transform the flat roofs of many residential buildings into sloped roofs, once again adorned with red tiles. The city would enthusiastically celebrate its glorious present, while zealously embracing a bright future, and openly criticizing its colonial past. However, it appears that the leaders of successive city generations fail to see the irony in the red tiles. The city continues to expand, with more and more patches of its sky being dyed by the red color of the roofs. Why did such bright red tiles remain so desirable through the many decades of China's decolonization?

If we read the red tiles and Qingdao cityscape as simply reminders of an imposed imperial culture, as legacies of hated colonialism, we will miss the more complex history. Red tiles may have been imposed on the Chinese landscape at first, but over generations of Qingdao planning, incorporating German, Japanese, and Chinese memes, the color red survived and became more appealing and desirable. Cultural historians call the red tiles a culture meme of Qingdao, but they are overlooking a simple truth: We humans share similar biological genes, and we build our cities as our common natural inclinations dictate, whether we are Germans, Japanese, or Chinese, colonialists or nationalists. We all share similar brains and eyes across political and cultural borders. These inherited similarities may include individual and group variations that

come from our evolutionary history of adaptation to the natural environment. But those basic mechanisms we are born with shape our reactions to color, light, and shadow, to architectural roofs and seas, having common roots.

When we grant that people may be drawn to the same designs, we can understand how a preference for tile roofs can be both a legacy of culture and nature alike—not a simple Western imposition on the Chinese. After German colonists arrived on the northern China coast, where bright sunshine is prevalent throughout the year and blue skies and seas form the eternal backdrop, and as they planted green trees on the bare hills and along the winding streets, both the Germans and the Chinese liked what they saw in this new city. They found red tiles more attractive as part of their cityscape's identity: a naturally appealing combination of seacoast, warm sunny climate, lots of moisture, and bright color. Perhaps, the Chinese, like many others, simply found the red tiles more suitable and right for the place, whether those tiles were expressions of culture or nature.

If we start looking for more basic material reasons for red tile popularity far from Germany, we may question whether the appeal of that color may have had little to do with cultural heritage. And this material appeal may have more than beauty at its core. At the northern end of the old city's Zhongshan Road (中山路), along which the Germans built up their commercial center, five roads converged to form a single intersection, covering a space half as big as a football stadium. It is known as "Dayao Gou" (大窑沟 Grand Kiln Ditch). Although neither a kiln nor a ditch exists there now, the name still evokes the early city's life and reminds us of the many ways that production, architecture, or design can occur. This place of traffic convergence was once a desolate, remnant stretch of ocean shore on which there was a small fishing village. Here one could find some traditional roofs of black tiles, although most houses, like in other villages in the area, were dwellings of wood and earth, covered with thatch. But what we can easily miss is another clue to Qingdao design.

Then the Germans arrived. At the turn of the twentieth century, this ancient place on the perimeter of Qingdao began to be replaced by kilns and chimneys, and new factories and their wood or coalburning furnaces appeared. Why? Because here was clay, a substance of earth that was excavated in great volumes from the northern hill rising next to the ditch. The clay contained a high level of natural iron ore. That geochemical composition of the clay led to a natural outcome: Iron gave the ore a reddish hue and produced red tiles and bricks. Nature intervened in this way: Black tiles consumed more fuels to reach the right temperatures. Thus, when the Germans began using red tiles for their colonial house roofs, they were not merely following German cultural tastes but reflecting the costs of energy and the natural composition of the local clay. Knowing the clay and the energy needs of different kinds of tiles that went into the shift to the style of red tiles, we may gain a fuller

understanding of the wonderfully complex architectural and aesthetic history of Qingdao.

In addition to the natural substance, the tiles have also been entangled with the city's environmental transformations in other ways. After the tiles were installed on city roofs, they collected sediments, which then became a kind of nature's archive—records of the city's sunlight, moisture, salinity, dust, and even pollutants, if we are willing to examine them through modern scientific approaches. And if we approach the city's roofs as the outcome of different people's "working practically with the material," as suggested by Ingold, we may dig more deeply into the evolving past, to see how the production process can open new insights. Doing this, argued Ingold, "offer[s] a more powerful procedure of discovery than an approach bent on the abstract analysis of things already made."[5]

Qingdao's penchant for red tiles requires us to understand more fully how artifacts can be produced before they acquire cultural meanings. We learn about natural processes that can be turned into commodities, and those commodities change, and sometimes degrade, over time. Mass-producing them has required humans not only to dig into the earth but also to find more and more energy, leading to coal replacing wood, and to change our use of natural resources, including clay, water, and sea. Understanding how artifacts began can lead us to see how humans might even generate pollution in making their roofs. Also, it can help us see that exploiting resources has harmed human bodies, including their brains and lungs, skin and bones, as their bodies have interacted with the air, dust, heat, and toxic wastes. How have those laboring in the earth experienced changes in their health and in their perception and use of the environment? How have they been influenced and shaped during this physical process of making stuff?

The story of the red tiles is not over. When Qingdao began to revive the red tile motif on its new reshaped buildings in the early twenty-first century, the tiles no longer derived from traditional oxide-heavy clay; instead, they came from a "modern" material—fiberglass shingles, which was made red by adding artificial color. Nowadays, shingles or tiles of whatever color, are made from a fiberglass base mat providing strength and flexibility, a layer of waterproofing asphalt with surface granules added for color and protection. Doing so requires new sealants along with other additives that bind those layers together. Now tiles are a chemical product, made outside the city proper to preserve Qingdao's postcard-worthy emerald sea and blue skies. A fiberglass industrial plant pollutes nature far more than the old clay mining on a hillside did. Fiberglass shingles are much lighter and less expensive than traditional clay tiles, but they do not last as long. The lifespan of the old tiles, often exceeding a century, is three to four times longer than the new substitutes. At the end of their useful life, the fiberglass roofs are not easily disposed of or recycled. How, then, can the city expect to depend on red shingles for their future of the so-called ecological civilization? The city

and its hinterlands may go through a material and cultural shift, adding to the health costs of its residents, especially its workers.

We can end this city tour as seen on the roofs and seas by visiting my parents' apartment, located on the top floor of a building perched on Fushan Mountain (浮山). The vantage point from their windows still offers a view of ships at sea; of the white crests of waves breaking over their bows; of the line where the light blue sky meets the darker blue sea; of pines, cedars, locusts, and ginkgoes; and, certainly, of the omnipresence of red tiles on sloped roofs across the urban skyline. Now dozens of new high-rise buildings are blocking the view, and the roofs of my parents' apartment buildings, which were once adorned with traditional clay tiles, are red fiberglass shingles recently replaced by the district government. When these buildings were completed in 1996, the roofs displayed the natural texture and granule of the clay tiles clearly. Previously, no skyscrapers obstructed the sea view. Back then, the skies seemed bluer, the trees greener, and the roofs redder. So my memories tell me, but then memories are only another kind of archives made up of reality, fiction, matter, and culture.

We do not live in a built environment shaped entirely by culture, nor one where artifacts come from the same old material forces of local nature and human nature. When we begin to think of red tiles as matter rather than as cultural symbol, we will realize that what shapes any city's history is not simply what we are taught to see, value, and mean. The process of intermingling and entangling with the earth and our own brings us to human senses and desires, natural forces and materials, cultural ideologies, colonialism and anticolonialism, political agencies, economic institutions, and technologies. It can open our understanding

Figure 4. Roofs outside my parents' apartment. Photo by the author.

to a history that is always evolving, always full of ambiguities, and never really finished.

Shen Hou is professor of history at Peking University. She is the author of *The City Natural: Garden and Forest Magazine and the Rise of American Environmentalism* (2013) and *Cities Without Walls: Nature and Urban Places in American History* (Chinese, 2021; English, 2024). She is now working on a book project about Pacific cities, a comparative environmental history between Qingdao and Los Angeles.

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1 There is no specific museum for red tiles in Qingdao, but some local residents have been enthusiastic about collecting the tiles to preserve the history of the city. Among them are Yongchang Li (厉永昌), Wen Wu (武文), and Miao Zheng (郑淼). They record the producer, style, and date of each piece of the red tile they collect, turning them into cherished archives. The cityscape, surmounted by so many red roof tiles, itself has become another living form of archives.

2 There is a rich body of writing devoted to Qingdao's architectural history, focusing mainly on the styles of individual houses built in the first half of the twentieth century, and tracing the transformations of the styles chronologically with little analysis of the historical context. The houses are treated as transparent artifacts. Cultural historians tend to offer the red roofs as the so-called cultural genes of the city, whose meaning needs explication. See Ming Li, *Qingdao: Laofangzi de Jiyi* [Qingdao: The memory of old houses] (Shandong Pictorial Publishing House, 2004), and Shuhua Ma, *20 Shiji Qingdao Richang Shenghuoshi* [Daily life experience in the 20th century Qingdao] (Commercial Publisher, 2019).

3 Compared to the research on Qingdao, the scholarship on Southern California's architecture is more nuanced and complex. It argues that Southern California became "a sea of red roofs" because the region has deliberately constructed its cities in the style of the Spanish Colonial Revival movement. Red tiles there are treated as cultural expressions demanding subtle analysis, including feelings of nostalgia, claims to exotic origins, and a hunger for local identity. See *Red Tile Style: America's Spanish Revival Architecture*, text by Arrol Gellner, photographs by Douglas Keister (Viking Studio, 2002); William Deverell, *Whitewashed Adobe: The Rise of Los Angeles and the Remaking of Its Mexican Past* (University of California Press, 2004); and Phoebe S. Kropp, *California Vieja: Culture and Memory in a Modern American Place* (University of California Press, 2006).

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Yiyun Peng

Reading Ramie from Plant to Fabric

Knowledge and Representation in Botanical Drawings

What do we gain by closely reading botanical drawings from before the twentieth century? How did the geographical, intellectual, and political context influence the ways in which the same plant was represented on paper? What if we read the drawings against twenty-first-century knowledge? Focusing on ramie (*Boehmeria nivea*), a fiber crop (similar to flax) native to Asia and widely cultivated in its history, this essay brings a wide array of botanical drawings produced in Asia and Europe into this History Lab forum on reading nature's archives. It proposes an approach of combining historical information and twenty-first-century botanical and craft knowledge and imagery to analyze various aspects of the nature of the important yet understudied plant as well as human agendas behind producing the plant illustrations.

Reading these drawings then leads to two intertwined analyses on (1) the plant itself through the eyes of the illustrators (i.e., how ramie was presented in different ways and what the drawings can tell us about the plant) and (2) the illustrators through the (often "biased") representation of the plant (i.e., what kind of people they were and how and why they chose to depict ramie in one way or another). The first analysis shows that, while the illustrations largely depict the plant as we perceive it today (which I'll use "accurate" to describe in this essay, acknowledging the risk of privileging twenty-first-century knowledge), they also reveal discrepancies we may deem misinterpretations, which, nonetheless, could be a faithful depiction of what illustrators saw at that time—in that case, our understanding of the plant would be refreshed. The second analysis, on the other hand, helps us better

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understand what the illustrators cared about, as they chose to exaggerate a certain part of the plant or emphasize fiber production over the plant. In other words, this is an archive of plant representations as well as human choices and actions.

Ramie has been widely used for thousands of years in Asia, primarily for fiber extraction (and also for medical use and as a food source). In particular, China has the longest history on record of using this plant that produces one of the strongest plant fibers to make everyday objects ranging from shoes to summer garments, mosquito nets, and fishing nets.[1] Other regions in Asia, including Japan, Korea, and the Malay Archipelago, produced their own ramie products, and some also engaged in ramie trade with China. By the nineteenth century, not only Asians but also European and American botanists, agriculturalists, and merchants had become interested in this plant, whose fiber presented appealing strength, fineness, durability, and productivity. In the West, people hoped that ramie could replace cotton and linen: Not only was ramie stronger than the latter two and more productive per hectare than cotton, but the cotton supply also became unstable in the nineteenth century.[2]

Because of these temporally and geographically broad interests in this plant, botanists and physicians produced drawings, and merchants commissioned illustrations alongside texts across time and space. Drawings of the plant and the production process, from plant to fabric, exist in diverse forms, including woodblock and copperplate prints and watercolor paintings. In this essay, I'll analyze a few early illustrations of the plant from China, followed by a few Western botanical drawings of ramie and European-commissioned paintings produced by a Chinese painter depicting ramie fiber production processes in China.

While ramie growers and artisans were not particularly interested in leaving their mark on paper, physicians, botanists, and entrepreneurs were attentive to keeping records and to introducing plants to a wider audience. In particular, the eleventh through thirteenth centuries in China witnessed massive productions of illustrated materia medica and left probably the earliest imagery of ramie as a medical herb in multiple versions of a lost work commonly known as *Verified and Categorized Materia Medica* (*Zhenglei bencao* 證類本草). The work, emerging around the early twelfth century, was compiled by Tang Shenwei, a physician who compiled information from two eleventh-century illustrated pharmacopeia and hundreds of other sources. In 1249, Zhang Cunhui, published one revised edition, which is one of the earliest editions we have today.[3]

The woodcut illustration of ramie in it, then, might have originated from an eleventh-century drawing, possibly edited by the 1249 publisher (Figure 1, left). Although the title of the illustration emphasizes the root, the part used for medical purposes, the illustrator(s) chose to depict the entire plant so people could easily recognize it in its natural context. This drawing illustrates ramie's relatively large leaves, one of the most distinctive features of the plant. In addition, it might have captured both female flowers (supposedly smaller and more densely

distributed racemes, possibly the budlike ones at the top of the plant in the drawing) and male flowers (supposedly clusters of a few to a dozen flowers, more sparsely distributed, possibly the starlike flowers below the female ones).[4] Among ramie plants in their natural habitat, twenty-first-century botany finds only monoecious plants (male and

Figure 1. ***Left:*** **"Ramie root," Tang Shenwei comp., Zhang Cunhui et al. ed., *Chongxiu Zhenghe jingshi zhenglei beiyong bencao* [Revised ready-to-use materia medica in the Zhenghe reign, verified from the classics and histories and categorized] (1249), *juan* 11 (vol. 7), 18b, World Digital Library.** ***Right*****: "Ramie root," Zhu Su, *Jiuhuang bencao* [Materia medica for famine relief] (1406; repr. 1555), *juan* 1B (vol. 2), 27a, World Digital Library.**

female flowers on the same plant) or female plants, so this illustration might have depicted a monoecious plant.[5] On the other hand, the illustration is somewhat misleading in portraying the root as disproportionately big and the plant as seemingly short: Ramie is a tall plant, usually five to ten feet (many Chinese texts from the eleventh century onward also acknowledge its height to be 6–8 *chi*, or 6.3–8.4 feet).[6] It also fails to mark the serration on the edge of the leaves and is inconsistent in the leaves' rib pattern—ramie leaves have a multirib feature (i.e., multiple ribs spread from the bottom of the leaf), whereas in this drawing, some leaves have multiple ribs while others have one midrib with veins extending from it.

A sixteenth-century illustration shares some traits. In 1406, Zhu Su, a prince of the Ming dynasty (1368–1644) and a botanist, published *Materia Medica for Famine Relief* (*Jiuhuang bencao* 救荒本草) in the hope of guiding people to find food during famines. Ramie root, in the work, is listed among many others as food. The 1406 edition no longer exists, but we have a few reprints, including one from 1555.[7] Like the 1249 one, this woodblock drawing (Figure 1, right), meant to emphasize the root—the edible part of the plant—shows big leaves and depicts the root as an excessively long, substantial part of the plant. Different from the former, though, it shows male flowers only—in monoecious plants, male flowers bloom first.[8] Therefore, the drawing likely depicts the early growing stage of monoecious plants of ramie, with male flowers only. Nevertheless, the portrait of the leaves and flowers, though inconsistent (some leaves being serrated and some not), fairly aligns with twenty-first-century knowledge regarding their shape and location on the plant. It also accurately captures multiple ribs stemming from the base for most leaves, unlike many other pre-nineteenth-century illustrations worldwide, which typically show only one midrib. If the 1555 edition is not too far from the original one, the accuracy likely came from the fact that the prince saw those plants: He planted four hundred or so plants in his garden and reproduced them on paper by employing painters, and thus was able to check whether their illustrations stuck to reality.[9]

Figure 2. Ramie. Wu Qijun, *Zhiwu mingshi tukao* [*Illustrated verification of the names and realities of plants*], *juan* 14, 1a, 5a, FL 51 W95 1848, Arnold Arboretum Library (Cambridge), Botany Libraries, Harvard University.

In 1848, Wu Qijun, an official and a botanist of the Qing period (1644–1912), published a work, *Illustrated Verification of the Names and Realities of Plants* (*Zhiwu mingshi tukao* 植物名實圖考). Wu made great efforts to observe the plants and painted them himself. Unlike previous materia medica, this work introduces ramie mostly as an important fiber plant across the southern Qing territory. The two drawings of ramie (Figure 2), with many details, much more vividly demonstrate the plant than previous ones. In particular, Wu's portrait of the flowers and leaves, including the ribs, veins, and margins, is astonishingly accurate, although the whole plant still appears short, possibly to save space on the page.[10] In addition, probably for the first time on record in Chinese history, Wu presented a single female plant with female inflorescences only (Figure 2, right), which differed from the previous illustrations with monoecious plants.[11]

Figure 3. ***Left*****: Ramie (the plant on the right side of the plate). Georg Everhard Rumpf,** ***Het Amboinsche Kruid-Boek*** **(*****Herbarium Amboinense*****), vol. 5 (Amsterdam and Hage, 1747), tab. 79, Biodiversity Heritage Library.** ***Right*****: Ramie (second in the upper row). Leonard Plukenet,** ***Amaltheum Botanicum*** **(London, 1705), tab. 449, Real Jardín Botánico (CSIC) digital library.**

On the other hand, ramie caught the attention of European botanists in the mid-seventeenth century. In 1653, Georg Everhard Rumpf (Rumphius), a botanist employed by the Dutch East India Company, arrived at Amboina (modern-day Ambon Island, eastern Indonesia). At some point before 1663, he began composing a work on the plants he encountered there.[12] At that time, ramie was widespread in the islands near Amboina, and he introduced it to Amboina. As he saw the living plant, its environment, and local practices dealing with this plant, not only is the textual description of ramie in this work, *Herbarium Amboinense*, far more comprehensive than all other eighteenth-century

European botanical accounts, but he also tries to present the whole plant in a vivid manner with abundant details (Figure 3, left).[13]

In 1705, English botanist Leonard Plukenet published *Amaltheum Botanicum*, which also included an illustration of ramie (Figure 3, right). One peculiar thing about this drawing is that the plant is incomplete and rootless, displayed in a rigid way, with its branches and leaves appearing flattened, spread, and arranged perfectly—in other words, a specimen rather than a plant in its natural shape. Where was this specimen from, then? The text provides a clue: Plukenet describes the plant as "the largest cluster-bearing Urtica of China, with leaves densely covered underneath with silvery fuzz. Tab. 449. fig.2. A wild plant called Má, whence is made a thread like the flax called Ma-sien. D. Cunningham."[14] D. Cunningham, or James Cunningham, was a Scottish surgeon and botanist employed by the British East India Company to work in coastal China in 1698, and he sent over to Plukenet many plant specimens.[15] Those specimens, then, most likely included one of ramie that found its way into Plukenet's work, which also adopted Cunningham's description.

Although both European illustrations incorrectly depict the leaves as having only one midrib, they, if largely faithful to the actual plants, reveal differences between the two plants. Now we know there are two main varieties of ramie (with subvarieties): commonly known as "white ramie" (leaves that are white on the underside, native mainly to East Asia) and "green ramie" (leaves green on both sides, native mainly to tropical Asia). Comparing the two drawings, the leaves of the Ambonese variety, presumably green ramie, appear narrower than those of the Chinese variety, or white ramie, which are rounder and more heart-shaped. Nonetheless, although the Chinese variety is depicted with male flowers above female flowers, recent botanists observe that female flowers are at the top of the plant, with male flowers below.[16] Whether this was a misrepresentation or an accurate depiction of a different species that existed but has not been found by us is up to interpretation, which would be an inspiring question for botanists today.

Despite the differences, a common feature of the East and West drawings is the failure to depict ramie's growth pattern: It tends to grow in clusters. As some of their attached texts point out, the plant would grow about a dozen or more stems from a rootstock, making ramie a clump of stems, while all the abovementioned drawings show either a single stem in both European ones or two or three in the Chinese ones.[17] As physicians or botanists, those authors might have been more interested in precisely capturing the micro-level botanical characters of the plant, such as leaf size and flower shape, but opted to leave out the plant's contextual appearance. This contrasts with the depiction of ramie in clusters in some later entrepreneurial works that provide guidelines for ramie cultivation.[18]

The colonial agenda shifted in the nineteenth century, when the Europeans became increasingly interested in its high-quality fiber, hoping

that it could replace cotton and linen. Unsurprisingly, then, this was also a time when people across space began to be interested in producing visual demonstrations of the process of extracting fiber from ramie, as textile products became the center of inquiry. In the early nineteenth century, Messrs. Marshall & Co., a company in Leeds, UK, imported and experimented with ramie (or China grass, as called by them) and managed to produce fiber of good quality, which won a medal at the Great Exhibition of the Works of Industry of All Nations in London in 1851, although it never became a successful business.[19]

Nonetheless, the company left another legacy, a collection of book volumes, *The Story of Ramie: From Seed to Finished Garment*, composed of sixty watercolor paintings, dated circa the early nineteenth century and made by Sunqua, a famous painter in Guangzhou (Canton), on the south coast of China. The paintings depict in detail the processes from farmers cultivating ramie to artisans weaving and dyeing the fabrics, with a short textual description attached. The text informs us that the paintings' commissioners, whose identities remain unknown to us, worked for the company and investigated ways to cultivate ramie. They had previously sent a memorandum with a pocket of seeds back to England and went to find a painter to put all the processes in vivid images on paper. The company might have sought to cultivate the plant in England or its colonies, so that it would no longer have to import it from China.[20]

The text does not mention any visit to a ramie field, and the paintings suggest it is unlikely that Sunqua, the painter, saw the plant. Rather,

Figure 4. ***Left*: Sunqua, *The Story of Ramie: From Seed to Finished Garment* (ca. 1820), book 1, painting 10, courtesy of the Science History Institute. *Right*: Ramie in the field, Liuyang, Hunan, June 15, 2019, photo by the author.**

someone might have described it and the cultivation processes to him—not only is the plant painted in a minimalist style, but it does not resemble any part of the actual plant either: The plant on paper is much shorter than the actual plant would appear by the time of harvest as a crop; the leaves are much smaller than they should have appeared; and ramie grows in clumps, not individually (Figure 4, with a 2019 photo of actual plants; both show ramie at the time of harvest). In comparison, the drawings by earlier Chinese and European botanists are more accurate.

If Sunqua grew up in Canton and rarely traveled outside the Pearl River Delta, where Canton was located, he probably had not seen any actual ramie plants. At that time, ramie was mostly grown in the uplands north of the delta, as it was sensitive to flooding, and elevation could provide natural drainage. On the other hand, the policy between 1758 and 1842, which confined the activities of Westerners to the city of Canton during the trading season and required them to stay in Macau in the winter, also made a legitimate visit outside Canton impossible for Westerners.[21] Therefore, the information about ramie, the plant, was likely collected through Chinese merchants dealing with Western merchants and possibly brought in farmers for them to interview. In this context, misunderstandings and discrepancies were almost inevitable.

Another discrepancy is that, whereas the collection shows only the process of cultivating ramie by sowing seeds, ramie plants were mostly reproduced in China by propagating mother plants' roots (which remains a widely practiced procedure today).[22] Therefore, the fact that this important piece of information is missing from the entire collection is curious. It is possible that the investigators were misinformed by local people who were wary of their agenda; they heard or witnessed only the process of growing ramie from seeds; or, since they sent back a packet of seeds, believed it was more important for them to grow ramie from seeds than from roots.

By contrast, the paintings' illustrations of processing ramie seem more detailed and accurate, indicating that the painter or the commissioners probably visited weaving and dyeing workshops, not necessarily ramie workshops, but at least silk ones (the Pearl River Delta was a famous silk producer)—the mechanics of processing silk and ramie were similar. Either way, if comparing one of the paintings depicting the process of starching (applying rice paste to the ramie threads to make them smoother) and the photo that I took in Jiangxi, China, in 2019 (Figure 5), one can see that the two are almost the same: the racks, the brush, and the way in which the threads are positioned. In short, with seeds in hand, the British, then, might have been much more interested in fiber extraction processes than in the plant itself. Even though they did not grasp the essence of reproduction by propagation and failed to provide a detailed drawing of the plant, the paintings on the production process, from threads to fabric, might have been sufficient for the British back home to gain a decent understanding of the fabric industry

Figure 5. ***Left*: Sunqua, *The Story of Ramie*, book 4, painting 2, courtesy of the Science History Institute. *Right*: Starching ramie threads, Jiangxi, China, November 4, 2019, photo by the author.**

and possibly to replicate it with their own mills to produce ramie fiber, which they did pull off.

As a historian, I am deeply grateful for the pictorial legacy left by all the illustrators. Historians mostly rely on texts, but the literature of illustrations is equally important. In the pharmaceutical world in China, for instance, it was to some degree customary to compile works largely by quoting previous texts, leading to some repeated information. New illustrations, therefore, provide contemporary information about the plant, the creators, and also ramie cultivators and fabric producers. A similar case can be found in early Western botanical works, where different images present information not only about ramie but also about the political, geographical, and intellectual context in which they were produced. They reveal not only what the plant and the industry looked like but also how the illustrators wanted to present them and why. The discrepancies among them and between the illustrations and what we perceive today also urge us to reflect on how knowledge was presented: to what degree the depictions were accurate in our eyes and whether the accuracy mattered, and to what extent we can rely on our twenty-first-century knowledge to determine the distance between what the painters saw and what they presented on paper. In all, the pictorial materials, a different genre of historical documents, while answering some questions that we have, create more that are worth asking and exploring.

Yiyun Peng is an assistant professor of history and East Asian studies at Oberlin College, working on the history of science and technology, environmental history, and the economic history of China and Asia. She

is currently working on a book manuscript, tentatively titled "A Herbaceous Economy: How Crop-Based Handicraft Industries Transformed Upland Southeast China, 1500–1970."

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1 Archaeologists found ramie fabrics that date to about 4,400 years ago. See Wang Dan, Wang Haiming, and Liu Yong, "Zhejiang Quzhou Miaoshanjian yizhi chutu shengzhuang maju chuanxiwu yanjiu" [Study of threads from rope-like horse gear excavated from Miaoshanjian ruins in Quzhou, Zhejiang], *Jianghan kaogu* 180 (2022): 115–20, here 117.

2 Asri Peni Wulandari, Vira Putri Dinda Awis, Ruly Budiono, et al., "Tensile Strength Improvements of Ramie Fiber Threads Through Combination of Citric Acid and Sodium Hypophosphite Cross-Linking," *Materials* 16, no. 13 (2023): 4758 (1 of 14); Emile Lefranc, *The Ramie: Its Origin, Its Value, Its Advantages, Its Culture, Its Extracting Process* (New Orleans: Imprimerie de la Renaissance Louisianaise, 1869), 1, 5.

3 He Bian, *Know Your Remedies: Pharmacy and Culture in Early Modern China* (Princeton: Princeton University Press, 2020), 25-28.

4 Tang Shenwei comp., Zhang Cunhui et al. ed., *Chongxiu Zhenghe jingshi zhenglei beiyong bencao* [Revised ready-to-use materia medica in the Zhenghe reign, verified from the classics and histories and categorized] (1249), *juan* 11, 18b.

5 Zhao Lining, Zang Gonggu, and Chen Jianhua, "Zhongguo zhumashu zhiwu xingbie biaoxian jiqi yanhua" [The sex phenotype and evolution in *Boehmeria* Jacq in China], *Zhongguo maye* 25, no. 5 (2003): 209–12.

6 Sinong si, *Nongsang jiyao* [Collection of important matters of agriculture and sericulture] (1316), *juan* 2, 26a-b; Deng Yuanxi, *Han shi* [History in a case] (Preface 1573), Part A, *juan* 82, 85a; Wang Xiangjin, *Er'ruting qunfang pu* [Treatise on all plants of the Er'ru Pavilion] (1629), Section of Mulberry, Bast-Fiber, and Ge (kudzu vine) (vol. 24), 11b.

7 Zhu Su, *Jiuhuang bencao* [Materia medica for famine relief] (1406; repr. 1555), *juan* 1B (vol. 2), 27a.

8 Sichuansheng Dazhuxian zhongxiaoxue jiaoyu kexue yanjiushi, *Dazhu zhuma* [Ramie in Dazhu] (Sichuan kexue jishu chubanshe, 1988), 13.

9 Xu Guangqi, *Nongzheng quanshu* [Comprehensive book on agricultural activities] (Pinglutang, 1639), *juan* 45, 17a-b.

10 Wu Qijun, *Zhiwu mingshi tukao* [Illustrated verification of the names and realities of plants] (1848), Preface, 2b-3b; *juan* 14, 1a-5a.

11 Though we cannot rule out the possibility that Wu observed a monoecious plant with male flowers already fallen off, as they more easily fall off than female ones. See Zhao et al., "Zhongguo zhumashu zhiwu xingbie biaoxian jiqi yanhua," 210.

12 H. C. D. De Wit, "In Memory of G. E. Rumphius (1702–1952)," *Taxon* 1, no. 7 (1952): 101–10, here 102–3.

13 Georg Everhard Rumpf, *Het Amboinsche Kruid-Boek* (*Herbarium Amboinense*), vol. 5 (Amsterdam and Hage, 1747), 214–15.

14 Ramie is called in China *zhu* or *zhuma*, or sometimes abbreviated as *ma*. "Ma-sien" literally means "ramie thread." Leonard Plukenet, *Amaltheum Botanicum* (London, 1705), 212. In the third edition of *Species Plantarum*, Carl Linnaeus quoted both Rumphius and Plukenet under the *Urtica nivea* entry, indicating they were one species, which was accepted and confirmed by later botanists. See Carl Linnaeus, *Species Plantarum*, 3rd ed., vol. 2 (1764), 1398.

15 Leslie Stephen, ed., *Dictionary of National Biography*, vol. 13 (Smith, Elder, & Co., 1888), 312.

16 Pratik Satya, Sabyasachi Mitra, and Deb Prasad Ray, "Ramie (*Boehmeria nivea* L. Gaud) Genetic Improvement," in *Advances in Plant Breeding Strategies: Industrial and Food Crops*, vol. 6, ed. Jameel M. Al-Khayri, Shri Mohan Jain, and Dennis V. Johnson (Springer, 2019), 115-150, here 121–22.

17 Tang, *Chongxiu Zhenghe jingshi*, *juan* 11, 19a; Zhu, *Jiuhuang bencao*, *juan* 1B, 27b; Rumpf, *Herbarium Amboinense*, 5:214. As I discussed, Wu saw the plants that he illustrated. See Wu, *Zhiwu mingshi tukao*, Preface, 2b-3b. Plukenet was the only one among them who did not see the growing plant.

18 See, for instance, John J. Barr et al., *Prospectus of Ramie Culture* (New Orleans: E. P. Brandao, 1894), 8.

19 Li Zhongqing, "Zhongguo zhuma chanye fazhan yanjiu (1860–1958)" [Study on the development of the ramie industry in China, 1860–1958] (MA thesis, Huazhong Normal University, 2013), 16; W. G. Rimmer, *Marshalls of Leeds Flax Spinners, 1788–1886* (Cambridge University Press, 1960), 193, 260.

20 The paintings and text can be found at https://digital.sciencehistory.org/collections/xz4w7ge, Science History Institute, accessed May 3, 2024.

21 Up until 1858, officially, Westerners had been allowed to stay only in the five treaty ports. After 1858, they were able to travel farther inland. See Pär Cassel, "Treaty Ports and the Foreign Community in Modern China," *Oxford Research Encyclopedia of Asian History*, May 24, 2018, https://doi.org/10.1093/acrefore/9780190277727.013.159, accessed July 6, 2026, and Liu Jialiang, "Wanqing Waiguoren fu neidi youli huoyun" [Permission for foreigners to travel in China in the late Qing], *Gugong xuekan* 15 (2015): 348–54.

22 Bao Shichen, *Qimin sishu* [Four techniques for the welfare of the people] (1872), in *Anwu sizhong* (1844; repr. 1872), *juan* 25a, 27b–28b; He Gangde, *Fujun nongchan kaolüe* [A brief survey of agricultural products in Fuzhou Prefecture), in *Xuxiu siku quanshu* (Shanghai: Shanghai guji chubanshe, 1903; repr. 2002), Grass Section I, 3a-b (835).

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