MAYA BHAGAT, ZACHARY NOWAK, ADAM SPITZIG AND KARI ROYNESDAL

(Re)Mapping the Columbian Exchange

Suggestions for an Updated Cartography[*]

▼ **ABSTRACT** Following Christopher Columbus' voyages and the ensuing colonization of the New World by Europeans, a massive multidirectional transfer of biota, diseases, technology and humans occurred between Afro-Eurasia and the Americas. This transfer, known as the Columbian Exchange, is often depicted on maps as a simplified, bidirectional, Atlantic-centred transaction between the Americas and Europe. This paper highlights the shortcomings of such cartographic depictions and posits that they impede effective teaching. We present short histories of sweet potatoes, sugarcane, maize, tomatoes and quinine and use them to illustrate the major cartographic and ideological problems of traditional Columbian Exchange maps, namely constrained geographic scope, chronological compression, non-depiction of the contemporaneous movement of important cultural, technological and biological elements, ethnocentrism and the obscuring of human consequences. Each history is accompanied by a new map of the product's diffusion, a template for future (re)mappings of the Columbian Exchange.

▼ **RÉSUMÉ** Suite aux expéditions de Christophe Colomb et à la colonisation européenne du Nouveau Monde, s'est produit un

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Maya Bhagat • Harvard College

Zachary Nowak • The Umbra Institute [corresponding author], Perugia

Adam Spitzig • Harvard University Kennedy School

Kari Roynesdal • Harvard University Graduate School of Design

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transfert multidirectionnel extraordinaire de biote, de maladies, de technologies, et de personnes, entre l'Afro-Eurasie et les Amériques. Ce transfert, communément appelé l'échange colombien, est souvent dépeint comme une simple transaction bidirectionnelle entre les Amériques et l'Europe, centrée sur l'Atlantique. Cet article souligne les défauts de ces représentations et postule qu'elles entravent l'appréhension historique. Nous présentons l'histoire de la patate douce, de la canne à sucre, du maïs, de la tomate et de la quinine pour illustrer les principaux problèmes pictographiques et idéologiques des cartes traditionnelles de l'échange colombien, soit : un cadre géographique restreint, une compression chronologique, l'absence des mouvements culturels, technologiques, et biologiques majeurs simultanés à l'échange des produits, un ethnocentrisme, et la méconnaissance des conséquences humaines. Une carte inédite accompagne l'histoire de chaque produit, comme modèle d'une nouvelle cartographie de l'échange colombien.

▼ **KEYWORDS** Columbian Exchange, Maps, Sugarcane, Maize, Tomato, Sweet potato, Quinine, Atlantic Ocean

▼ **MOTS-CLÉS** Échange colombien, Cartes, Patate douce, Canne à sucre, Maïs, Tomate, Quinine, Océan Atlantique

In 1972, Alfred Crosby gave a name to the massive transfer of biota between Afro-Eurasia and the Americas that began in 1492: the Columbian Exchange. Since the publication of Crosby's book, a multidisciplinary literature has developed assessing the Columbian Exchange's large-scale consequences for global demographics, epidemiology and rates of urbanization.[1] A popular literature on the exchange between the "Old World" and "New World", usually highlighting its positive aspects, has also developed.[2] Another significant subset of Columbian Exchange literature focuses on single crops, domesticated animals, spices and other products: their diffusion, their

1 Alfred W. CROSBY, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, CT, 1972); Nathan NUNN, Nancy QIAN, "The Columbian Exchange: A History of Disease, Food, and Ideas", *Journal of Economic Perspectives*, vol. 24, no. 2 (May 2010), pp. 163-88.

2 Nelson FOSTER, Linda S. CORDELL (eds), *Chilies to Chocolate: Food the Americas Gave the World* (Tucson, 1992); Sylvia A. Johnson, *Tomatoes, Potatoes, Corn, and Beans: How the Foods of the Americas Changed Eating Around the World* (New York, 1997).

evolution and their integration into cuisines far from their evolutionary origins. These volumes are sometimes very specific, detailing not only a given product's global trajectory, but its cultural integration in a specific country or geographic area.[3]

Critiques of the Columbian Exchange are also not uncommon. Judith Carney, for example, has written about the lack of attention, in the literature on the Exchange, to both African domesticates and East Asian domesticates that came through Africa.[4] Carney has also highlighted the underutilization of analytical lenses like gender in discussions of Columbian Exchange products. Another critique of Crosby's original model is that utility alone did not guarantee diffusion, as many product biographies assume. Diffusion was, for example, sometimes constrained by ideology, as when Europeans' beliefs about certain botanical families (e.g. Solanaceae, the deadly nightshade family, to which potatoes, tomatoes and eggplant all belong) and the fitness of root vegetables for refined palates (e.g. potatoes) limited these products' initial adoption.[5] Some spreads occurred through a non-human vector, such as the dispersal of taro and sweet potato across the Pacific Ocean. Pronatal Europeans also ignored the peacock flower, a powerful abortifacient, rather than bring it into their cornucopia.[6]

Remaining largely unexamined since Crosby's book, however, are cartographic representations of the Exchange. Because of the readability and relevance of Crosby's book, and the focus of subsequent literature on the minutiae of individual products, this *Ur*-text remains on reading lists and syllabi. I ([author 2]) am sure that I am not alone in that when I lecture on the Columbian Exchange, after my students have read Crosby, I use a graphic like Figure 1. Pictorial maps have been popular in the United States since the 1920s and this map is heir to that tradition; something like it has been used to describe the Columbian Exchange at least since the late 1990s.[7] In the following pages, we argue that this map, and other similar maps used to teach the Columbian Exchange, obscure more than they reveal.

The shortcomings of this map are evident almost immediately. The orderly, two-way flow of products across the Atlantic suggests a peaceful, almost transactional, "exchange" of biota. Europe sends wheat and gets pumpkins in return. As we will explore below, however, the process was often far from peaceful. While the route is in

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3 Michael BLAKE, *Maize for the Gods: Unearthing the 9,000-Year History of Corn* (Oakland, CA, 2015); Dietrich. DENECKE, "Innovation and Diffusion of the Potato in Central Europe in the 17th and 18th Centuries", in R. H. BUCHANAN, R. A. BUTLIN, D. MCCOURT (eds), *Fields, Farms and Settlement in Europe* (Hollywood, Ireland, 1976), pp. 60-96; David Gentilcore, *Pomodoro! A History of the Tomato in Italy* (New York, 2010); David GENTILCORE, *Italy and the Potato: A History, 1550-2000* (London, 2012).

4 Judith Ann CARNEY, Richard Nicholas ROSOMOFF, *In the Shadow of Slavery: Africa's Botanical Legacy in the Atlantic World* (Los Angeles and Berkeley, 2009); Judith A. CARNEY, "African Rice in the Columbian Exchange", *The Journal of African History*, vol. 42, no. 3 (2001), pp. 377-96; Judith CARNEY, "The African Origins of Carolina Rice Culture", *Ecumene*, vol. 7, no. 2 (2000), pp. 125-49.

5 Allen J. GRIECO, "The Social Politics of Pre-Linnaean Botanical Classification", *I Tatti Studies in the Italian Renaissance*, vol. 4 (1991), pp. 131-49; Ken ALBALA, *Food in Early Modern Europe* (Westport, CT, 2003).

6 Londa SCHIEBINGER, "Agnotology and Exotic Abortifacients: The Cultural Production of Ignorance in the Eighteenth-Century Atlantic World", *Proceedings of the American Philosophical Society*, vol. 149, no. 3 (2005), pp. 316-43.

7 Stephen J. HORNSBY, *Picturing America: The Golden Age of Pictorial Maps* (Chicago, 2017).

Figure 1. From Archer Kenna Lang, "Columbian Exchange", in *Encyclopedia of American Environmental History*, ed. Kathleen A. Brosnan. Copyright © 2011 by Facts on File, an imprint of Infobase. Reprinted with permission of the publisher.

some sense historic – it suggests the main Spanish navigation route to and from the Americas – the arrows reduce what was a transfer that occurred in thousands of ports to two points: an outgoing current from the western end of the Mediterranean (with a glancing and seemingly accidental brush of Africa) that ends in the Caribbean; and a returning current leaving from Florida, looping along the east coast of what is now the United States and Canada and arriving in the Bay of Biscay. There is a clear disconnect between the products' placement on the map and their natural point of origin (Newfoundland is not known for its pineapples). The map, curiously, includes a compass rose and mile scale, both of which seem irrelevant to its cartographic goals: no one would use it for navigating. Additionally, there are several elements that the cartographer could have chosen to represent but did not. For example, there is no chronology on this map. All the products seemingly flow at the same time, sometime perhaps just after the Spanish pilot Antón de Alaminos discovered the return route to Spain using the Gulf Stream in 1519. There is also no concept of suites of products moving together; rather, each product moves on its own. Left unsaid, too, is whether the product itself is moving, or if the arrows represent a diffusion of cultivation (or, in the case of animals, livestock raising) or simply the trade in a product. Returning to pineapples, for example, it is the fruit that sailed to Europe, rather than pineapple plants.

Of course, every map is a simplification, and every mapmaker must make choices about what to represent. The absences detailed above are not serious; they likely would have been difficult to represent on a map that is supposed to collapse a complex process into a single diagram. The collapsing, though, creates other problems. The map shows what moved (maize) but does not show what was left behind (see below the example of nixtamalization, a nutritional practice). It shows what was transplanted (sugarcane) but does not attempt to depict what systems of production (slavery) were carried alongside that plant. Of all the important foodstuffs domesticated in Africa, enumerated by Judith Carney, this map depicts exactly one: coffee.

These are not the only problems with this map. Despite decades of criticism of the Mercator projection, the map in Figure 1 – and almost all Columbian Exchange maps in a Google image search – use that projection. While Mercator maps are excellent for navigation because they show correct course degree, they badly distort the sizes of land masses. As Marshall Hodgson wrote when decrying the Mercator projection (he called it "the Jim Crow projection"), surface areas have cultural implications.[8] This is not a critique that emerged with the post-structuralist critical cartography movement of the 1990s; as early as 1943, the *New York Times* editorial desk opined that "the time has come to discard [the Mercator map] for something that represents continents and directions less deceptively".[9] Today, we use other tools for navigation, but Mercator projections are used in almost all educational contexts. Finally, and perhaps most noteworthy, this map and many others like it present an enormously parochial view of the supposedly global Columbian Exchange: only the westernmost part of the Eurasian landmass (Europe) is visible; most of Africa is cut off, as is most of South America. The Pacific is reduced to a somewhat superfluous pond (despite being the largest ocean), seemingly irrelevant for sixteenth-century biotic transfer, marginalizing the trans-Pacific movements of crops and animals that occurred contemporaneously with (and in some cases even prior to) the Atlantic exchanges.[10]

Each of these weaknesses of the oversimplified and distortionary maps food studies scholars rely on when teaching the Columbian Exchange are problematic singly. When taken together, they make a powerful case for new maps. No map can

8 Marshall G. S. HODGSON, *Rethinking World History: Essays on Europe, Islam and World History* (New York, 1993), pp. 5, 4; "Columbian Exchange - Google Search (Images)", accessed July 2022, https://www.google.com/search?q=columbian+exchange&sxsrf=ALeKk02KjdKZxMLoXuoX-ZhFazBL50VD-g:1608755666705&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiG9Kzw-eTtAhUtZN8KHdk5DMMQ_AUoAXoECBoQAw&biw=1466&bih=788.

9 "Airplanes and Maps", *New York Times*, 21 February 1943, sec. Editorials, https://www.nytimes.com/1943/02/21/archives/airplanes-and-maps.html; Notably, *The Times* was concerned with the didactic implications of the map: "We cannot forever mislead children and even college students with grossly inaccurate pictures of the world". This focus on how to use better projections to teach children was also present at that time in the professional literature. See for example Irving FISHER, "A World Map on a Regular Icosahedron by Gnomonic Projection", *Geographical Review*, vol. 33, no. 4 (1943), pp. 605-19.

10 Just as cartographic choices have unintended consequences, so too do choices about dates. Using "AD" and "BC" centres a European chronology. We use "BCE" and "CE" here, as well as "the nineteenth century", to slightly decentre that. Converting all dates into "BP" (before present) proved cumbersome with more recent spreads.

represent all the intertwined, non-linear flows that made up the Columbian Exchange – indeed, we abandoned our attempt to do so because of hopelessly overlapping (and mutually confounding) trajectories and chronologies. But the current maps impede our teaching, rendering more difficult our narration of the Exchange because they not only simplify but obscure and marginalize. Better maps are necessary: maps with less deceptive projections, with more annotations describing how products moved individually or in a suite, and with descriptions of product-related exploitative labour practices, evolving cultural contexts, and long-term ecological consequences. In the rest of this paper, we present both a critique of the existing maps as well as a set of new maps – all of which are available for free download and immediate, permission-free use at https://doi.org/10.1484/A.20281851 as well as from the Wikipedia entry for "Columbian Exchange". Our maps make use (with permission) of the award-winning AuthaGraph projection, created in 1999 by architect and designer Hajime Narukawa and his team. The various versions of this projection substantially reduce size and shape distortions of the Mercator projection while maintaining the familiar rectangular shape of the Mercator maps. Note that, on an AuthaGraph projection, continents can appear in unfamiliar places – the Americas aren't always on the left, with the Atlantic in the centre and the Pacific bisected. This is the genius of the projection – it provides the possibility of centring parts of the globe other than the North Atlantic.[11]

Below we offer short life histories of five products – sweet potatoes, sugarcane, maize, tomatoes and quinine – paired with a new map for each. Through these products, we seek to highlight the main macro-categories of the cartographic shortcomings of the traditional Columbian Exchange maps: constrained geographic scope, chronological compression, non-depiction of cultural and technological components, non-depiction of concurrent spread with other plants and the obscuring human consequences. Each product biography and map will, we hope, inspire better graphics from specialized scholars with deeper knowledge of the global trajectories of these particular plants.[12]

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11 For more on the AuthaGraph, see Hajime NARUKAWA, "About AuthaGraph World Map", AuthaGraph オーサグラフ 世界地図, accessed July 2022, http://www.authagraph.com/top/?lang=en; Liz STINSON, "This Weird Globe-Folding Map Isn't Perfect, But It's Close", *Wired*, 4 November 2016, accessed 25 April 2022, https://www.wired.com/2016/11/weird-globe-folding-map-isnt-perfect-close/; Rolf BÖHM, Wolf Günther KOCH, Werner STAMS, "Erdabbildung in neuer Form – Eine Betrachtung zu Hajime Narukawas Weltkarte", *KN - Journal of Cartography and Geographic Information*, vol. 67, no. 3 (2017), pp. 117-21.

12 The authors are not cartographers, nor are we biogeographers. We have chosen the five plants below not because we possess deep knowledge of their spread and are therefore able to depict that spread completely and in detail. This is to some extent a limitation of our expertise – we expect that the task of creating more accurate maps will have to be left to other scholars whose knowledge of these plants (and ideally of other biota) is greater than ours. Indeed, while we initially chose each product to roughly illustrate one shortcoming of the existing Columbian Exchange map (for instance, sweet potatoes to centre the Pacific Ocean and sugarcane to discuss the brutal human exploitation intrinsic to the spread), the journey of each product reveals multiple shortcomings of the existing maps. Further, different products could have been chosen to reveal drawbacks of the current map even though sweet potato, sugarcane, maize, tomato, and quinine showcase a diverse array of cartographic issues. To some extent, too, the limitations of our maps – for instance, the lack of more detail in Africa and in central and northern Asia – is also the result of archival

Sweet Potatoes

The sweet potato is considered to be an open-and-shut case of pre-Columbian contact and one which challenges the view that most product transfers occurred after 1492.[13] While the traditional view is that sweet potatoes were first dispersed from South America to Europe when Christopher Columbus returned to Spain (and to the rest of Europe, Asia and beyond), the tripartite hypothesis describes the three main dispersals of sweet potato in Oceania: one pre-Columbian transfer and two European reintroductions (one each by the Spanish and Portuguese). This challenges the Columbian Exchange paradigm in that a major transfer of a prominent crop occurred long before 1492 over the Pacific Ocean. This pre-Columbian transfer is shown on our first map, and the reintroductions on the second. The long arrows depicting the significant spread of sweet potatoes illustrate how the scope of the spread (and its timescale) of the sweet potatoes is much wider than a unidirectional transatlantic journey.

Sweet potatoes originated in South America, most likely in modern-day Peru and Ecuador. The most likely ancestor of sweet potatoes is a wild tuber called *Ipomoea trifida*. Sweet potatoes likely evolved in the pre-human era, since genetic examinations reveal that the sweet potato diverged from *I. trifida* at least 800,000 years ago, and its domestication by humans could have occurred up to 100,000 years ago.[14] Archaeological excavations in Chilca Canyon, located in the central coastal region of Peru, date the presence of sweet potato in the region to 8080 BCE. Data from other sites at Huaynuma, Casma Valley and Chillon Valley indicate that the sweet potato, in its current form, has existed since at least 2000 BCE.[15] Interestingly, since modern-day sweet potatoes are not found in the wild today, the sweet potatoes discovered at these sites were likely domesticated, hinting at a much earlier origin.

From South America, the sweet potato first spread to Oceania. Our map, centred as it is on the Pacific, reorients viewers to the centre of sweet potato domestication and initial spread (fig. 2). Archaeologists have dated the presence of the sweet potato in Oceania to as early as 50 CE, finding remnants at the Rungruw site in Yap, Micronesia and in ancient storage pits from 1000 CE in New Zealand and central Polynesia.[16] The most likely explanation for the transfer of sweet potatoes from Peru to parts of Oceania is naturally occurring long-distance dispersal. Sweet potatoes do

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silences or at least of secondary literature that has yet to be written on this subject. Our maps, while good enough (we believe) to be used in the classroom to illustrate the problems of the old maps, are offered here not as the definitive cartography of the Columbian Exchange, but rather mainly as examples to argue that the traditional Columbian Exchange map is no longer useful.

13 The chicken, with its origins in Southeast Asia, has also been investigated as a potential candidate for pre-Columbian dispersal through Polynesia to South America. There is linguistic and archaeological evidence for this transfer, but genetic investigations, although earlier refuting the possibility of pre-Columbian spread, have been reopened and are ongoing. See below, footnote 85.

14 Jacques BARRAU, *Plants and the Migrations of Pacific Peoples: A Symposium* (Honolulu, 1963), p. 120.

15 Patricia O'BRIEN, "Sweet Potatoes and Yams", in Kenneth F. KIPLE, Kriemhild Coneè ORNELAS (eds), *The Cambridge World History of Food* (New York, 2000), p. 208.

16 Patricia O'BRIEN, "Sweet Potatoes and Yams…", p. 211.

Figure 2. A revised map for the diffusion of sweet potatoes. Available for download at https://doi.org/10.1484/A.20281851 and on the Wikipedia page for the Columbian Exchange.

not float, which means that either a human or non-human agent is responsible for the spread of sweet potato. While it is possible that humans with vessels containing sweet potatoes as cargo made contact with islands in Polynesia, the disjunct pattern of plant distribution suggests a natural agent, such as the golden plover, a bird that migrates regularly between these two areas, and may have carried sweet potato seeds in its digestive tract or on mud attached to its body.[17] Further, a non-human contact is consistent with the absence of other American products, such as maize, in Polynesia. Some samples of Polynesian sweet potatoes suggest that they diverged genetically from South American sweet potatoes around 100,000 years ago. While one would expect this long parallel evolutionary history to result in different-looking varieties of sweet potato, genetic changes do not always manifest in the physical appearance of an organism.[18] Although genetic research has filled in many gaps about the journey of the sweet potato, the extent of a human role is not known, so we have not represented different mechanisms of spread on our maps.

While the sweet potato may have reached Oceania in pre-Columbian times, it was only introduced into Europe, Africa, North America and Asia post-1492. Christopher

17 Pablo MUÑOZ-RODRÍGUEZ et al., "Reconciling Conflicting Phylogenies in the Origin of Sweet Potato and Dispersal to Polynesia", *Current Biology*, vol. 28, no. 8 (2018), p. 1247.

18 Caroline ROULLIER et al., "From the Cover: Historical Collections Reveal Patterns of Diffusion of Sweet Potato in Oceania Obscured by Modern Plant Movements and Recombination", *Proceedings of the National Academy of Sciences of the United States of America*, vol. 110 (2013), p. 2205.

Columbus and Gonzalo Fernandez de Oviedo brought sweet potatoes to Europe via Spain around 1500. Subsequently, Portuguese and Spanish voyages around the world during the sixteenth century spread sweet potatoes throughout Asia and Africa.[19] Ferdinand Magellan's voyages from 1519-21, for example, introduced the sweet potato to Spanish colonies such as the Philippines and reintroduced the sweet potato to some Polynesian islands.[20] Our map depicts this trans-Pacific journey, showing how even transfer that occurred during the "Columbian" era was not solely confined to North American colonies or to the Atlantic Ocean. Portuguese voyages transported sweet potatoes from Brazil to the prominent port of Macao, and linguistic evidence indicates that they spread through Southeast Asia. Sweet potatoes entered China from overseas, from Burma and India (possibly before the accepted date of 1594), and China exported sweet potatoes to Japan in 1674 to prevent a famine. The Portuguese introduced sweet potatoes to their colony (Angola) in West Africa via Lisbon in 1571, and to East Africa (Mozambique) via Brazil around the same time. Scottish–Irish immigrants report bringing the first sweet potato to New Hampshire, USA, in 1719. It is worth noting, however, that sweet potatoes may have been observed in Virginia as early as 1610, and Native Americans were seen growing them in the South in 1773, suggesting a possible diffusion from South America before a re-introduction via Europe.[21] The sweet potato was further spread by British colonial expansion during the seventeenth, eighteenth and nineteenth centuries.[22] The traditional Columbian Exchange map depicts a one-off transfer, sweet potatoes moving from the Americas to Europe, whereas ours goes a step further to account for the reintroduction of the sweet potato to the Americas by European colonists.

Sugarcane

There is debate regarding the exact origins and early spread of the six extant species of sugarcane (*Saccharum spp.*). Recent studies using phylogenetic techniques suggest that, in Southeast Asia, a proto-sugarcane diverged from graminoid (grass-like) ancestors through natural speciation approximately 650,000 years ago and was subsequently transported by humans into Indonesia, New Guinea, Polynesia and China.[23]

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19 Ferdinand Magellan, although born Portuguese, renounced his nationality and sought sponsorship from Spain to sail West to reach Asia instead of through the East. See Patricia O'BRIEN, "Sweet Potatoes and Yams…", p. 210.

20 Many explorers, including Magellan and also Jacob Roggeveen who discovered Easter Island in 1722, and James Cook in Hawaii in 1778, encountered the cultivation of sweet potatoes by locals already. See Ibid., p. 210.

21 It seems from a description of tubers that these were sweet potatoes. See Patricia O'BRIEN, "Sweet Potatoes and Yams…", p. 211.

22 Ibid., p. 209.

23 Dyfed Lloyd EVANS, Shailesh Vinay JOSHI, "Complete Chloroplast Genomes of Saccharum Spontaneum, Saccharum Officinarum and Miscanthus Floridulus (Panicoideae: Andropogoneae) Reveal the Plastid View on Sugarcane Origins", *Systematics and Biodiversity*, vol. 14, no. 6 (2016), pp. 548-71.

Several region-specific species of sugarcane then developed.[24] Older research, by contrast, speculates that cultivable sugarcane first emerged further south, in Indonesia and/or New Guinea, as the product of human domestication, and was transported eastward into Polynesia and northward into China and India, where it speciated. Other researchers posit both Southeast Asia and New Guinea as independent centres of sugarcane domestication.[25]

Regardless of its exact provenance and early diffusion, the first modern humans, after migrating eastward from Africa, reached sugarcane's homeland in Southeast Asia approximately fifty thousand years ago. These migrating humans then carried sugarcane with them as they spread throughout Melanesia, Australasia and Polynesia – likely using it as animal fodder. Later, via trade, sugarcane spread into India, China and the Middle East. In India, sugarcane is first mentioned in religious hymns dating from the Vedic period (1500 BCE – 500 CE) and in government documents written around 300 BCE. In China, the first written references to sugar manufacturing date from the same period. Crystallization and manufacturing techniques for large-scale sugar production were likely first developed in Vedic India, spreading along trade routes both westward and eastward. Sugarcane reached Persia in the sixth century, and sugar manufacturing techniques arrived in the early seventh. Egypt began cultivating sugarcane in the mid-eighth century, particularly in the Nile delta region.[26]

Early Muslim conquests and political expansion accelerated sugarcane's Middle Eastern and Mediterranean spread. By the fifteenth century – when it was being grown in Mesopotamia, the Levant, Sicily, southern Spain, Madeira, the Canary Islands, the Cape Verde Islands, São Tomé and West Africa – sugarcane was fully integrated into Europe's agricultural economy. On São Tomé, Portuguese farmers developed plantation-centred production using African slave labour in the fifteenth century. European colonial expansion in the sixteenth through nineteenth centuries

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24 Ibid.; Keyong ZHOU, "Zhongguo Zhetang Jianshi Jian Lun Kanzhe Qiyuan (A Brief History of Cane and Sugar in China with Special Emphasis on the Origin of the Sugarcane)", *Journal of Fujian Agricultural College*, vol. 13 (1984), pp. 69-83.

25 Ernst ARTSCHWAGER, E. W. BRANDES, *Sugarcane (Saccharum Officinarum L): Origin, Classification, Characteristics, and Descriptions of Representative Clones*, vol. 122, Agriculture Handbook (Washington, DC, 1958); John DANIELS, Brian T. ROACH, "Taxonomy and Evolution", in Don Heinz (ed.), *Sugarcane Improvement through Breeding* (Amsterdam, 1987), pp. 7-84; Jock GALLOWAY, *The Sugar Cane Industry: An Historical Geography from Its Origins to 1914* (New York, 1989); Christian DANIELS, "Agro-Industries: Sugarcane Technology", in Joseph NEEDHAM (ed.), *Biology and Biological Technology*, vol. 6 (part 3), *Science and Civilisation in China* (New York, 1996).

26 James F. O'CONNELL et al., "When Did Homo Sapiens First Reach Southeast Asia and Sahul?", *Proceedings of the National Academy of Sciences*, vol. 115, no. 34 (2018), pp. 8482-90. Interestingly, older hominid species may have lived within Saccharum's range long before. *Homo erectus* remains dating from 1.7 million years ago have been found in Yunnan Province, China. Jane QIU, "How China Is Rewriting the Book on Human Origins", *Nature News*, vol. 535, no. 7611 (2016), p. 22. Our ancient congenerics may have been consuming sugarcane hundreds of thousands of years before *Homo sapiens*. John DANIELS, Christian DANIELS, "Sugarcane in Prehistory", *Archaeology in Oceania*, vol. 28, no. 1 (1993), pp. 1-7; Elizabeth ABBOTT, *Sugar: A Bittersweet History* (London, 2010); Dyfed Lloyd EVANS and Shailesh Vinay JOSHI, "Complete Chloroplast Genomes…"; Young-Goo JEONG, "The Introduction of India Sugarcane Technology in Tang Dynasty and Chinese Sugarcane Industry", *History & the World*, vol. 50 (2016), p. 203.

then carried sugarcane, and this plantation-centred production, to the major centres of American sugar cultivation: the Caribbean and tropical South America. Finally, in the eighteenth through twentieth centuries, European colonialism in the Eastern Hemisphere brought plantation-centred sugarcane production back across the globe, to tropical and subtropical Southeast Asia.[27]

Sugarcane's global diffusion highlights several problems with traditional representations of the Columbian Exchange. First – and perhaps most important – traditional graphics under-emphasize, or render invisible, the human costs associated with sugar production. The scale of human suffering associated with sugar, particularly the slave-based commercial production of the Caribbean and South America, was immense and world-changing. From 1701 to 1810, Barbados, a small Caribbean island and major sugar producer, imported 252,500 African slaves. During the same period, Jamaica imported 662,400.[28] By 1850, there were 1.7 million slaves in Brazil, totalling 17% of the country's population.[29] As summarized by Sidney Mintz in his seminal *Sweetness and Power*, to produce New World sugar "millions of human beings were treated as commodities…and were themselves consumed in the creation of wealth". Sugar-driven immiseration extended beyond the Caribbean, penetrating Africa itself. As part of the era's triangular trade, large quantities of rum, arms, textiles, metals, jewellery and other commodities were transported from the Americas to Africa to purchase slaves, suppressing local economic development and stimulating continuous slaving raids. The long-term consequences of sugar-driven slave exportation from Africa – regional poverty and reduced social trust – persist to this day.[30]

Second, by portraying a straightforwardly east-to-west transfer, traditional graphics obscure the multidirectionality of sugarcane's diffusion. While sugarcane radiated westward from its Southeast Asian homeland, spreading through the Middle East, Mediterranean and, ultimately, into the Americas, it also moved eastward, in the first millennium CE, into Melanesia, Micronesia and Polynesia, where it persisted

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27 Elizabeth ABBOTT, *Sugar*… For a discussion of the uses and diffusion of sugar in the early Islamic world, see Tsugitaka SATO, *Sugar in the Social Life of Medieval Islam* (Brill, 2015); Arlindo Manuel CALDEIRA, "Learning the Ropes in the Tropics: Slavery and the Plantation System on the Island of São Tomé", *African Economic History*, vol. 39 (2011), pp. 35-71; Jock GALLOWAY, *The Sugar Cane Industry*…; Ulbe BOSMA, Juan GIUSTI-CORDERO, G. Roger KNIGHT (eds), *Sugarlandia Revisited: Sugar and Colonialism in Asia and the Americas, 1800 to 1940* (New York, 2007).

28 Sidney W. MINTZ, *Sweetness and Power: The Place of Sugar in Modern History* (reprint edition, New York, 1986), p. 53; For a detailed history of the emergence of plantation-centred, slave-based sugar production in Barbados, see also Douglas V. ARMSTRONG, "Capitalism and the Shift to Sugar and Slavery in Mid-Seventeenth-Century Barbados", *Historical Archaeology*, vol. 53, no. 3 (2019), pp. 468-91.

29 Joaquim Norberto De Souza E. SILVA, *Investigações sobre os recenseamentos da população geral do império e de cada província de per si tentados desde os tempos coloniais Até Hoje* (São Paulo, 1986). For a detailed history of sugar plantations, slavery and socioeconomic structures in Brazil, see Stuart B. SCHWARTZ, *Sugar Plantations in the Formation of Brazilian Society: Bahia, 1550-1835* (New York, 2004).

30 Sidney W. MINTZ, *Sweetness and Power*…, pp. 43, 58; Nathan NUNN, Leonard WANTCHEKON, "The Slave Trade and the Origins of Mistrust in Africa", *The American Economic Review*, vol. 101, no. 7 (2011), pp. 3221-52.

as a peasant crop until the twentieth century.[31] Important sugarcane production techniques – including plantation-style cultivation and industrialized crystallization methods – also travelled eastward, in the nineteenth century, from Europe's Caribbean colonies to its Asian colonies. This west-to-east movement pushed sugarcane into Asian islands and sub-regions where it had not previously been farmed, a geographic expansion overlooked by the traditional graphic.[32]

Third, while the movement of sugarcane is conventionally portrayed as a one-time, transatlantic transfer, at least two distinct waves of sugarcane arrived in the New World. An ancient hybrid first developed in northern India was brought by Columbus to the Caribbean around 1500, where it became a colonial staple crop. Sweeter cultivars developed in Southeast Asia and the Pacific then travelled to the Americas in the nineteenth century, where they gradually displaced the original hybrid.[33]

Fourth, by separating it from associated technologies, the traditional Columbian Exchange graphic obscures important details concerning sugarcane's global diffusion. The physical apparatuses required for processing sugarcane and extracting sugar – including mills, presses and crystallization stills – frequently lagged behind sugarcane as it moved westward, only reaching the Middle East and Europe, for example, a century after commercial sugar.[34] Socioeconomic and governmental technologies necessary for effective sugarcane production – hierarchical plantation culture, reliable contractual enforcement, stable markets and general political security – also often travelled independently. During the Middle Ages, for example, when Arab hegemony spread throughout the Middle East and Mediterranean, the resulting "pax islamica" allowed cultivable regions with decades of only indirect exposure to sugar products to, finally, establish large-scale sugarcane production.[35] During the sixteenth century, similarly, it was European colonial governance – and its plantations, extractive mercantilist policies, global markets and legally-sanctioned slavery or indentured servitude – that propelled sugarcane's emergence as a large-scale cash crop in the Caribbean and South America. In a similar phenomenon, in Southeast Asia, after persisting as a small-scale crop for millennia, sugarcane emerged as a globally significant export only after the advent of colonial capital and industrial technologies in the nineteenth and twentieth centuries.[36] Perhaps most importantly, as described by Mintz, the technical and organizational innovations of Caribbean sugar production, independent of the

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31 Dyfed Lloyd EVANS and Shailesh Vinay JOSHI, "Complete Chloroplast Genomes…"; Jock GALLOWAY, *The Sugar Cane Industry…*, p. 197.

32 See, for example, G. Roger KNIGHT, *Sugar, Steam and Steel: The Industrial Project in Colonial Java, 1830-50* (Adelaide, 2014).

33 Jock GALLOWAY, *The Sugar Cane Industry…*, pp. 11-12.

34 Ibid., p. 33.

35 Sidney W. MINTZ, *Sweetness and Power…*, pp. 23-29. Jock GALLOWAY, *The Sugar Cane Industry…*, pp. 25-27.

36 Though note that the arrival and diffusion of colonial capital and technologies in Southeast Asia was complex, and, in places, local financial input and technological adaptation was as, or more, significant than those of the colonizers; see G. Roger KNIGHT, "Technology, Technicians and Bourgeoisie: Thomas Jeoffries Edwards and the Industrial Project in Sugar in Mid-Nineteenth-Century Java", in Ulbe BOSMA, Juan GIUSTI-CORDERO, G. Roger KNIGHT (eds), *Sugarlandia Revisited…*, pp. 31-52. For an economic

plant itself, re-traversed the Atlantic in the 1700s, catalyzing Britain and France's Industrial Revolutions.[37]

Fifth, traditional graphics under-emphasize, or render invisible, the health and environmental costs associated with sugar. While nineteenth-century sugar consumption, by providing needed calories for poor and middle-class labourers in industrializing Europe, offered some socioeconomic benefits, the net financial burden of twentieth- and twenty-first-century sugar consumption – causally linked to obesity, diabetes, cardiovascular disease, inflammation and poor dental health, among other maladies – is enormous.[38] In the United States alone, policies reducing current sugar consumption, if implemented, would generate billions of dollars in healthcare savings annually.[39] In 2016, the World Health Organization recommended a tax on sugar-sweetened beverages to mitigate the expensive and development-undermining global obesity epidemic.[40] Environmental degradation caused by sugar and sugar-ethanol production – stemming from abundant water usage, soil erosion and soil-based greenhouse gas emissions – is also often substantial.[41] By portraying sugarcane's transatlantic crossing as benign – particularly in contrast to "diseases", represented by a human skull in Figure 1 – the traditional map misleadingly underplays sugarcane's negative environmental and human health impacts.

Finally, by including only a single, static icon representing the sugarcane plant, the traditional Columbian Exchange graphic obscures sugar's changing morphology and uses. The ancient sugarcane plant that spread through Asia, the Middle East and Europe, and eventually to the Caribbean and South America, was thin, dull in colour and low in sugar. By contrast, hybrids developed in Southeast Asia in the nineteenth century, which eventually came to dominate global cultivation, had thick stalks, bright colours and high sugar content.[42] During the Palaeolithic era, sugarcane was used

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overview of sugar's emergence as a globally significant export in Southeast Asia, see Jock GALLOWAY, *The Sugar Cane Industry*…, pp. 208-17.

37 Sidney W. MINTZ, *Sweetness and Power*…, pp. 46-52. See also the remainder of Mintz's chapter "Production", where he recounts the rise of industrial sugar production in the Caribbean and makes the case that sugar plantations, especially eighteenth-century French and English operations, were both "important step[s] toward capitalism" (p. 55) and "precocious cases of industrialization" (p. 59) themselves, and that they contributed directly to the economic transformations that remade Europe in the nineteenth century.

38 Sidney W. MINTZ, *Sweetness and Power*…, pp. 148-49; Rokeya PERVIN et al., "Chapter 1 - Epidemiological Perspectives of Dietary Sugars, Salts and Fats", in Harry G. PREUSS, Debasis BAGCHI (eds), *Dietary Sugar, Salt and Fat in Human Health* (Cambridge, MA, 2020), 3-23; *Guideline: Sugars Intake for Adults and Children*, WHO Guidelines Approved by the Guidelines Review Committee (Geneva, 2015); T. MEIER et al., "Global Burden of Sugar-Related Dental Diseases in 168 Countries and Corresponding Health Care Costs", *Journal of Dental Research*, vol. 96, no. 8 (2017), pp. 845-54.

39 Yue HUANG et al., "Cost-Effectiveness of the US Food and Drug Administration Added Sugar Labeling Policy for Improving Diet and Health", *Circulation*, vol. 139, no. 23 (2019), pp. 2613-24.

40 "Fiscal Policy to Improve Diets and Prevent Noncommunicable Diseases: From Recommendations to Action", WHO (World Health Organization, March 2018).

41 Oliver CHEESMAN, *Environmental Impacts of Sugar Production* (Wallingford, 2004); Gillian EGGLESTON, *Sustainability of the Sugar and Sugar-Ethanol Industries*, vol. 1058 (Washington, DC, 2011).

42 Laurent GRIVET et al., "A Review of Recent Molecular Genetics Evidence for Sugarcane Evolution and Domestication", *Ethnobotany Research and Applications*, vol. 2 (2004), p. 10.

by Southeast Asians as animal fodder.[43] In medieval Europe, it was used by elites to display wealth in the form of large, ornate sculptures, or as an exotic spice. In the eighteenth through twentieth centuries, as loose table sugar, it was used in tea, desserts and baked goods by westerners of all classes, fuelling the establishment of New World sugar colonies.[44] In south and east Asia, until the early twentieth century, it was most widely used as a medicinal additive and an ingredient in alcoholic beverages.[45] Today, sugar is pervasive, part of many industrial food products throughout the world.[46] None of this biological and commercial dynamism is captured in the static icons of the traditional graphic.

In our maps (fig. 3 and fig. 4), we attempt to address several of the problems outlined above. First, in order to minimize the distortive geographic and temporal compression characteristic of traditional representations of the Exchange, and to more fully capture the two distinct phases of sugarcane's diffusion – westward across Afro-Eurasia into the New World, then back eastward into Southeast Asia – we created two separate graphics. Second, we highlight the central role of slavery and other forms of coerced labour in sugarcane's global diffusion by indicating, using a dotted overlay, where and when plantation-centred practices became tightly coupled with sugar production. Third, we make extensive use of arrows and dating to visualize the multidirectionality and multiwave nature of sugarcane's global diffusion. Fourth, using a dotted line, we highlight an important example of the independent movement of sugar-related technology: the transatlantic transfer of technical and organizational methodologies that ultimately catalyzed Europe's Industrial Revolution. Finally, using arrows and dating, we suggest the current spatial extent of sugarcane's agricultural and environmental impact. We invite future cartographic representations to improve upon Figures 3 and 4, and, specifically, to visualize the several above-mentioned deficiencies that are not fully addressed in our maps, namely sugarcane's human health impacts, long-term morphological changes and evolving sociocultural uses.

Maize

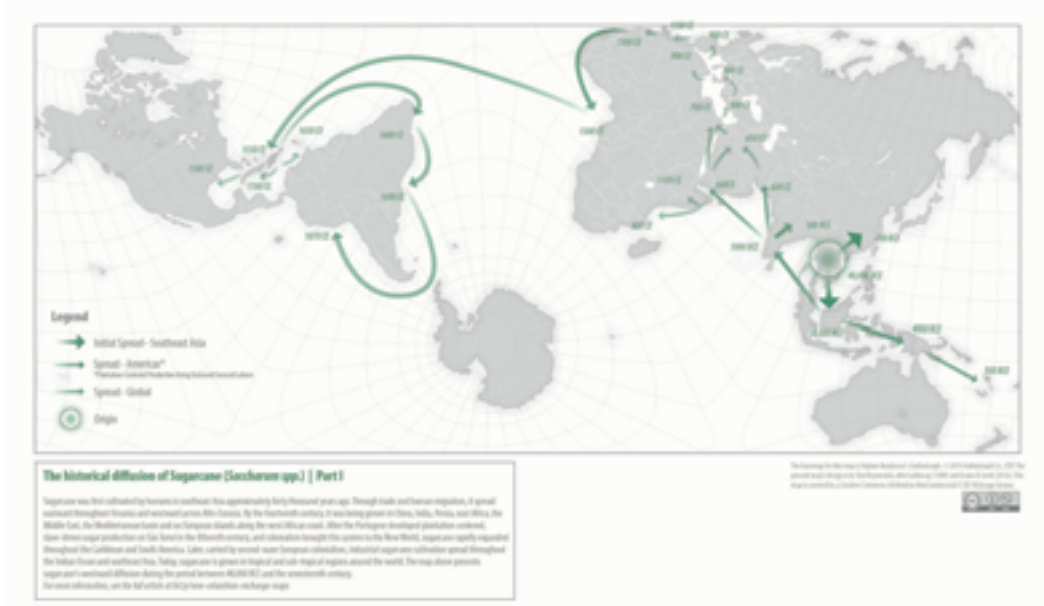
Maize's evolution and diffusion alone demand a sophisticated world map, as well as one that can represent the spread – and lack of spread – of the cultural components of the grain. Unlike other domesticated grains, maize (*Zea mays* ssp. *mays*)

43 John DANIELS and Christian DANIELS, "Sugarcane in Prehistory…".

44 Elizabeth ABBOTT, *Sugar*…, p. 5; Jock GALLOWAY, *The Sugar Cane Industry*…, pp. 4-9.

45 James MCHUGH, "Sîdhu (Úîdhu): The Sugar Cane 'Wine' of Ancient and Early Medieval India", *History of Science in South Asia*, vol. 8 (2020), pp. 36-56; though note that broader culinary uses, at least among elites in fifteenth-century sultanate India, have also been documented, see Norah M. TITLEY, *The Ni'matnama Manuscript of the Sultans of Mandu: The Sultan's Book of Delights* (London/New York, 2004).

46 Barry M. POPKIN, "Sugar Consumption in the Food and Beverage Supply across the Globe", in Michael GORAN, Luc TAPPY, Kim-Anne LE (eds), *Dietary Sugars and Health* (Boca Raton, FL, 2014), pp. 127-38.



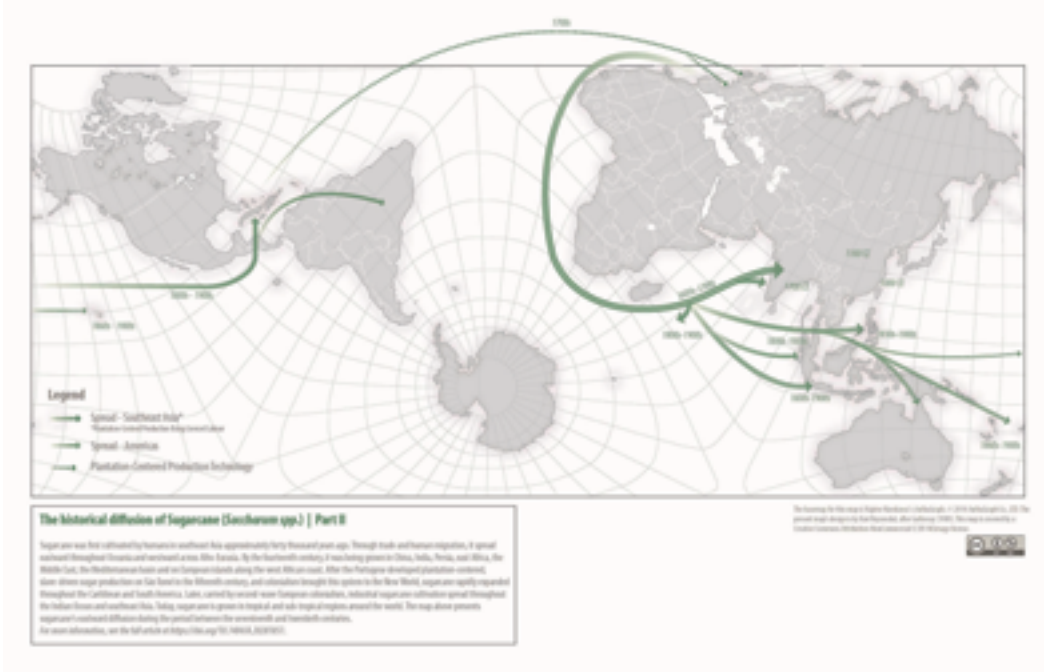


Figure 3 and 4. Two revised maps for the diffusion of sugarcane. These maps highlight the multidirectionality and human impact of sugarcane's global diffusion, and the sometimes-independent movement of related technologies and practices. Available for download at https://doi.org/10.1484/A.20281851 and on the Wikipedia page for the Columbian Exchange.

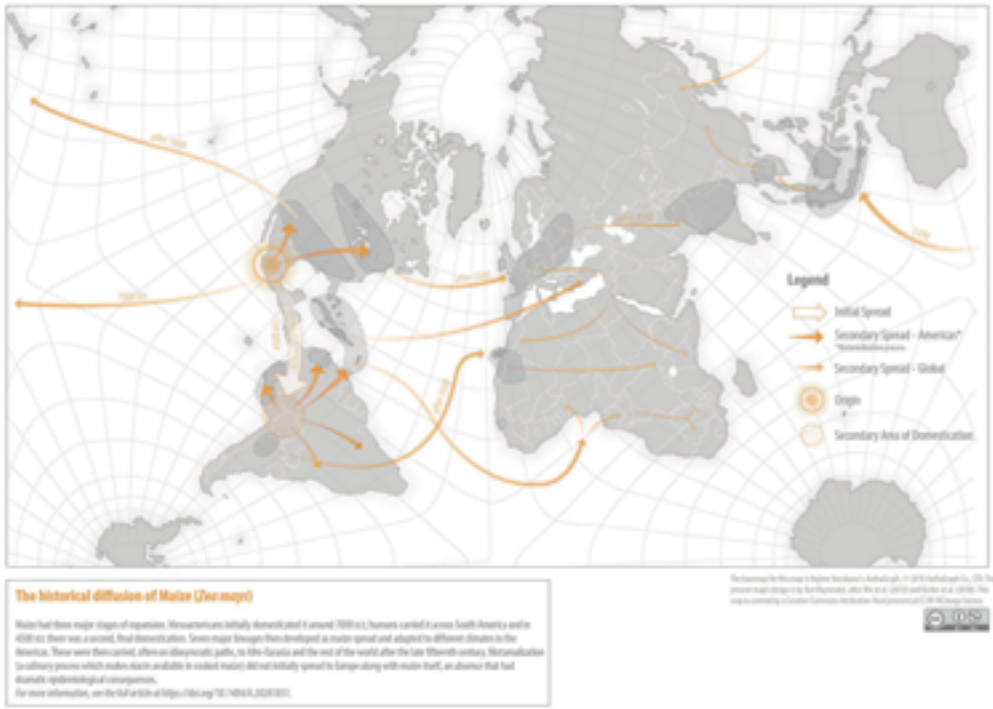


Figure 5. A revised map for the diffusion of maize. The map highlights the multiple domestication sites, the failure of Europeans to borrow nixtamalization initially, and the often-idiosyncratic paths through which maize varieties spread. Available for download at https://doi.org/10.1484/A.20281851 and on the Wikipedia page for the Columbian Exchange.

does not resemble its wild ancestor, Balsas teosinte (*Z. mays* ssp. *parviglumis*) [47]. Recent archaeogenomics have suggested that early maize's origin was in what is now Mexico's Balsas River region, which is within the current wild distribution of teosinte. Wild teosinte was artificially selected for kernel size and by around 7000 BCE, a semi-domesticated proto-maize was being cultivated in this upland area. This semi-domesticated plant was then spread by diffusion through semi-nomadic human groups and by 6000 BCE, corn was cultivated in most of Central America, South America and the Caribbean, reaching the Amazonian Basin by around 4000 to 2000 BCE.[48]

Many of the lineages of semi-domesticated maize likely died out, but a second zone of maize improvement in the southwestern Amazon led to full domestication

47 While the term "corn" is more commonly used for this product in the North American vernacular and some traditional Columbian Exchange graphics, we used "maize" since maize is closer to the Taino word *maiz*, as well as being the far more common word for *Zea mays* in languages other than English.

48 C. Wayne SMITH, Javier BETRÁN, Edward C. A. RUNGE (eds), *Corn: Origin, History, Technology, and Production* (Hoboken, NJ, 2004), pp. 4, 7.

around 4500 BCE. Here, as had occurred in the Balsas River region, maize was fully domesticated. It could no longer exchange genes with the semi-wild varieties and was no longer able to reproduce itself without human intervention.[49] These two main sites of domestication then gave rise to what biogeneticists today consider seven sub-regions, in each of which maize followed a largely separate trajectory of adaptation to local conditions. These were the Mexican highlands, the tropical lowlands (extending out to the Caribbean islands), northern South American (in what is now Columbia and western Venezuela), the Andes, middle South America, middle North America (on the Great Plains), and the northern US flints (the northern Great Plains and the northeastern rim of the continent).[50] Between 5000 and 1500 BCE, the maize cob went from less than one inch to well over six and adapted in each sub-region to differing amounts of annual daylight, precipitation and soils.[51]

Starting immediately after their arrival in the Americas, in around 1500, Europeans immediately recognized maize as an incredibly useful crop and its similarities to the grains they already ate made them quick to integrate it into their food systems. Rather than a single "New" to "Old" world introduction, maize had multiple independent introductions to Afro-Eurasia. For example, the French and Spanish who voyaged to the northern part of North America introduced the US Flint maize to northern Europe, while southern Europe mostly received maize varieties from the northern South American population; these varieties were also introduced to most of western Africa by the Portuguese in the early sixteenth century. Portuguese traders in the late fifteenth century spread the Mexican Highlands varieties to their trading partners in what is now Indonesia, from which the varieties spread through Southeast Asia, into China and even to Japan. The Portuguese later (in the seventeenth century) introduced the middle South America varieties to the Cape Verde islands, whence they spread to what is now Senegal, Gambia, Guinea and Guinea-Bissau.

The tropical lowlands (Caribbean) varieties were traded by the Spanish to the Turks, where they spread into southeastern Europe and overland to what is now Pakistan, Afghanistan and northwestern India. The US Flints varieties were introduced in the course of the nineteenth century to Egypt (displacing earlier varieties there), southeastern Africa and northeastern China. This meant both a reduction of the genetic diversity within the introduced population as well as greater differentiation between the various populations introduced in new areas.[52] An introduction meant

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49 For a short, readable summary of the latest research, see Brigit KATZ, "Rethinking the Corny History of Maize", *Smithsonian Magazine*, 14 December 2018, https://www.smithsonianmag.com/smart-news/rethinking-corny-history-maize-180971038/; Logan KISTLER et al., "Multiproxy Evidence Highlights a Complex Evolutionary Legacy of Maize in South America", *Science*, vol. 362, no. 6420 (2018), pp. 1309-13.

50 Céline MIR et al., "Out of America: Tracing the Genetic Footprints of the Global Diffusion of Maize", *Theoretical and Applied Genetics*, vol. 126, no. 11 (2013), p. 2676.

51 James F. HANCOCK, *Plant Evolution and the Origin of Crop Species* (Englewood Cliffs, NJ, 1992), p. 191.

52 Céline MIR et al., "Out of America…". The diffusion throughout the Balkans and the Muslim world is an underappreciated part of maize's spread. See Jean ANDREWS, "Diffusion of Mesoamerican Food Complex to Southeastern Europe", *Geographical Review*, vol. 83, no. 2 (1993), pp. 194-204. For more on the spread of maize in Africa, see James MCCANN, *Maize and Grace: Africa's Encounter with a New World Crop, 1500-2000* (Cambridge, 2005).

a beachhead but not necessarily a successful invasion: maize was introduced to Australia as a central part of the convict diet. After prisoner transport stopped in the mid-nineteenth century, maize disappeared from cultivation for decades as it "retained connotations of the savage, the convict and the American".[53] Finally, in addition to the much-publicized spread of hybrid varieties of maize with the 1970s Green Revolution, there were multiple introductions of hybrid varieties between the 1920s and the 1970s. These (re)introductions were influenced by the relationships between the US and recipient countries, the interests of scientists in the recipient countries and local maize culture.[54]

This sort of spread complicates the mapping of maize's travels over the millennia but also offers the cartographer the chance to tell a much richer story with many more actors – many of them indigenous. The broad sweeping arrow from Figure 1 (the image at the beginning of the article) leading from South America to Europe should be replaced by arrows indicating the multiple domestication locations, the evolution of six core maize regions and then the idiosyncratic spread across the world of these regions' varieties, as in our version of this map (fig. 5). Rather than broadening it, we've represented the spread out of the Americas as a cartographic narrowing, as the effect of the spread was a reduction in the genetic diversity of maize. A more sophisticated version of this map might even show not simply the movement of single organisms like corn, but rather the movements of suites of plants together. One of the most famous in the northeastern United States is the corn, beans and squash complex called "the Three Sisters" by the Haudenosaunee.[55] Few useful plants or animals moved alone. Yet another difficult-to-represent but important aspect of the diffusion of plants is their lack of movement or the loss of concomitant cultural aspects. For maize, a map might represent the lack of movement of the Andean regional variety outside of its range: there is little evidence that it spread outside of its very special geographic area.[56] Another non-spreading piece of the maize complex was nixtamalization, the process by which many Mesoamerican groups cooked maize kernels with lye to render niacin available. Though not every indigenous group used this technique, it was widespread. Despite the rapid adoption of maize into European food systems, this technique was not adopted; that meant that an overreliance on maize in southern and southeastern Europe led to repeated outbreaks of pellagra

53 Nancy CUSHING, "The Mysterious Disappearance of Maize", *Food, Culture & Society*, vol. 10, no. 1 (2007), p. 110.

54 Derek BYERLEE, "The Globalization of Hybrid Maize, 1921-70", *Journal of Global History*, vol. 15, no. 1 (2020), pp. 101-22.

55 Amanda LANDON, "The 'How' of the Three Sisters: The Origins of Agriculture in Mesoamerica and the Human Niche", *Nebraska Anthropologist*, vol. 40 (2008), p. 111. The extent to which the three products moved into the northeast at the same time has been revised; John P. HART, "Rethinking The Three Sisters", *Journal of Middle Atlantic Archaeology*, vol. 19 (2003), pp. 73-82.

56 Céline MIR et al., "Out of America…", p. 2680.

(caused by niacin deficiencies).[57] Our revised map (fig. 5) is an attempt to show not only what moved (the maize itself) but also what was left behind (the nixtamalization tradition).

Tomato

The tomato's slow journey from the Andean region to Central America and into the cuisines of Afro-Eurasia – and then its rapid nineteenth- and twentieth-century crisscrossing of the Atlantic – reveals some additional deficiencies in the standard maps of the Columbian Exchange. The wild relatives of the domesticated tomato, *Solanum lycopersicum*, are distributed widely across coastal and montane Ecuador and Peru. Nineteenth-century scholars thought that domesticated tomatoes evolved from wild cherry tomatoes in Peru, giving European names for that plant that included the word "Peru". In 1948, Jenkins suggested that the site of domestication was Mesoamerica, given the evidence of pre-Columbian cultivation there and absence of the same in Peru.[58] Recent genetic research has revealed that both hypotheses are partially correct: rather than being domesticated in Peru/Ecuador or in Central America, the tomato had a two-step domestication process similar to maize. After initial selection in what is now Peru and Ecuador between 8000 and 11000 BCE, early tomatoes were carried to Mesoamerica by 5000 BCE. It was during this transfer that a genetic bottleneck occurred, reducing variation and moving the plant towards being fully domesticated.[59]

The ancestral tomato that made transoceanic journeys after the Spanish invasion of the late fifteenth century was from Mesoamerica rather than northern South America. Part of the evidence is encoded in some of the European names for the plant, which derive from the Nahuatl word *tomato*, meaning roughly "round and plump". Italy early on had a love-hate relationship with the tomato. One of the earliest mentions of the tomato is in the botanical commentaries of the Sienese physician and botanist, Pietro Andrea Mattioli. He noted in his 1544 book, which included many New World species, that there was a new species of mandrake or eggplant recently brought to Italy, one that was "at first green, and when mature, the colour

57 Monica GINNAIO, "Pellagra in Late Nineteenth-Century Italy: Effects of a Deficiency Disease", trans. Amy Jacobs, *Population-E*, vol. 66, no. 3/4 (2011), pp. 583-609.

58 Véronique BERGOUGNOUX, "The History of Tomato: From Domestication to Biopharming", *Biotechnology Advances*, vol. 32, no. 1 (2014), pp. 170-89.

59 José BLANCA et al., "Variation Revealed by SNP Genotyping and Morphology Provides Insight into the Origin of the Tomato", *PLoS One*, vol. 7, no. 10 (2012), pp. 1-17; James A. JENKINS, "The Origin of the Cultivated Tomato", *Economic Botany*, vol. 2, no. 4 (1948), pp. 379-92; Hamid RAZIFARD et al., "Genomic Evidence for Complex Domestication History of the Cultivated Tomato in Latin America", *Molecular Biology and Evolution*, vol. 37, no. 4 (2020), pp. 1118-32; Yuling BAI, Pim LINDHOUT, "Domestication and Breeding of Tomatoes: What Have We Gained and What Can We Gain in the Future?", *Annals of Botany*, vol. 100, no. 5 (2007), pp. 1085-94.

of gold", and could be cooked and eaten with salt and pepper.[60] It is understandable that Mattioli thought tomatoes were a kind of eggplant as they are both species of the Solanum genus, part of what was called the Deadly Nightshade family. Botanical recognition does not equate to cultural acceptance: the response of Italians to three crucial questions about the tomato – What do you resemble? What do you taste like? What do you replace? – was largely silence, at least in the sixteenth century.[61] It is interesting to note that the same process occurred in India in the early nineteenth century: while tomatoes were referred to both with the transliterated word "tomata" and the Persian phrase for "foreign eggplant", there was little acceptance of the fruit until the British promoted its production on a large scale in the late nineteenth century.[62]

Four years after Mattioli, in 1548, the Medici court was presented with a basket of tomatoes from one of their Tuscan estates. David Gentilcore relates that the duke and his household opened the basket and "they looked at one another with much thoughtfulness".[63] If the Medici – who through their connections to the Spanish crown and their central place in trans-Mediterranean commerce – were confused by the sight of tomatoes, it reveals the plant's slow integration into Italian and broader European cuisine. Gentilcore has explored the reasons for Italians' reluctant acceptance of the "golden fruit" (*pomodoro*, the standard Italian word for tomato): the fact that the tomato trailed along the ground (lowness of stature hinted at a vegetable more fit for peasants), the tomato's botanical nearness to toxic plants, the lack of caloric density and the lack of an analogous plant (like wheat for maize) to "ease its way into the dietary regimes of the time".[64] The widespread culinary use in the rest of Europe was, similarly, quite slow despite the tomato's appearance in botanical gardens. The English traveller John Ray, in the 1660s, puts the plant on a list of "many fruits [the Italians] eat, which we either have not, or eat not in England". It is important to underline that while *some* Italians may have eaten *some* tomatoes as a condiment in the late seventeenth century, common consumption of the tomato was still more than a century away. Only in the 1770s do seeds for the tomato appear

60 Pietro Andrea MATTIOLI, *Libri cinque della historia, et materia medicinale / tradotti in lingua volgare italiana da M. Pietro Andrea Matthiolo … con amplissimi discorsi, et comenti, et dottissimi annotationi, et censure* (Venice, 1544), p. 327.

61 Divya SCHÄFER, "Exotic Tastes, Familiar Flavours. Transcultural Culinary Interactions in Early Modern India", in Gita Dharampal, Rafael Klöber, Manju Ludwig (eds), *HerStory–Historical Scholarship between South Asia and Europe: Festschrift in Honour of Gita Dharampal-Frick* (Heidelberg, 2018), p. 56.

62 Divya SCHÄFER, "Exotic Tastes…", p. 45; Utsa RAY, *Culinary Culture in Colonial India: A Cosmopolitan Platter and the Middle-Class* (Delhi, 2015), pp. 39-40.

63 David GENTILCORE, *Pomodoro! …*, p. 1.

64 Ibid., p. 26; Brandes argues that the perception of the tomato as a product of the Garden of Eden – and hence either poisonous or an aphrodisiac – was also part of its slow integration into European cuisines. Stanly BRANDES, "The Perilous Potato and the Terrifying Tomato", in Leonard PLOTNICOV, Richard SCAGLION (eds), *Consequences of Cultivar Diffusion* (Pittsburgh, 1999), pp. 85-96. See, too, Andrew Smith's many versions of the mythical eating of tomatoes on the courthouse steps by Robert Gibbon Johnson in the 1820s in the US, to prove they were not poisonous. The myth suggests that this story was at least believable in the nineteenth-century US. Andrew F. SMITH, *The Tomato in America: Early History, Culture, and Cookery* (Columbia, 1994).

in the famous Vilmorin-Andrieux seed catalogue; the famed French gourmand Jean Anthelme Brillat-Savarin wrote in 1803 that tomatoes had only recently become commonplace in Paris.[65]

Up to this point, the simplified Columbian Exchange map still seems to hold: a single, arcing line can still be drawn from northwestern South America through Mesoamerica across the ocean through Spain to Italy. A deeper look into the tomato's history renders this cartographic simplification erroneous. Tracing the route of tomatoes to the eastern edge of Eurasia requires a line leaving Mesoamerica in the opposite direction: as with maize, the tomato was introduced by the Spanish first to the Philippines, whence Arab traders likely brought it to the Southeast Asian mainland. The Chinese, like the Italian Mattioli, correctly identified it as a nightshade, referring to it initially as *fan chieh* (barbarian eggplant). In Africa, its diffusion across the continent began in several places, namely ports in Angola and Mozambique where Arab and Portuguese merchants traded.[66] The tomato's spread into the African interior is an understudied area of Columbian Exchange research and the lack of this literature complicates the depiction of that spread.

The coup de grace to the inadequate single-line map of the tomato's spread comes in the twentieth century, as our map makes clear (fig. 6). The tomato had been introduced to North America not directly from Mesoamerica but rather from Europe. The plant remained a minor part of American cuisine until the arrival of millions of Italians at the end of the nineteenth and beginning of the twentieth centuries. Initial demand for tomato paste and canned tomatoes drove Italian production and exportation to the US, but soon the US developed an agro-industrial sector mainly to satisfy the demand of these new immigrants. The "San Marzano" tomato was developed in southern Italy in the late 1910s and soon displaced almost all other varieties, at least for canning. This hegemony lasted only a few decades, until the "Roma" tomato overtook it. Ironically, this tomato was not bred near Italy's capital city, but rather just outside of the United States's capital, at the Plant Industry Station in Beltsville, Maryland. Now taken to be an heirloom by Italian-descended people all over the world, the Roma is canned at home by Italians "unaware that they are proudly reinforcing their 'Italian' heritage with a U.S. hybrid".[67]

The tomato agro-industry is an enormous part of the Italian countryside but the brightly decorated tins made for domestic markets and export obscure more transoceanic lines. Those lines begin on the coast of North Africa and some – tragically, not all – reach southern Italy. African migrant labour, despite being the subject of any number of exposés, is a central, brutal part of the tomato's Italian

65 Cited in David GENTILCORE, "Taste and the Tomato in Italy: A Transatlantic History", *Food & History*, vol. 7, no. 1 (2009), p. 131; Brillat-Savarin's comment is cited in Stanly BRANDES, "The Perilous Potato and the Terrifying Tomato…", p. 93.

66 Janet LONG, "Tomatoes", in Kenneth F. KIPLE, Kriemhild Coneè ORNELAS (eds), *The Cambridge World History of Food* (New York, 2000), pp. 351-58.

67 David GENTILCORE, "Taste and the Tomato in Italy…", pp. 137-38.

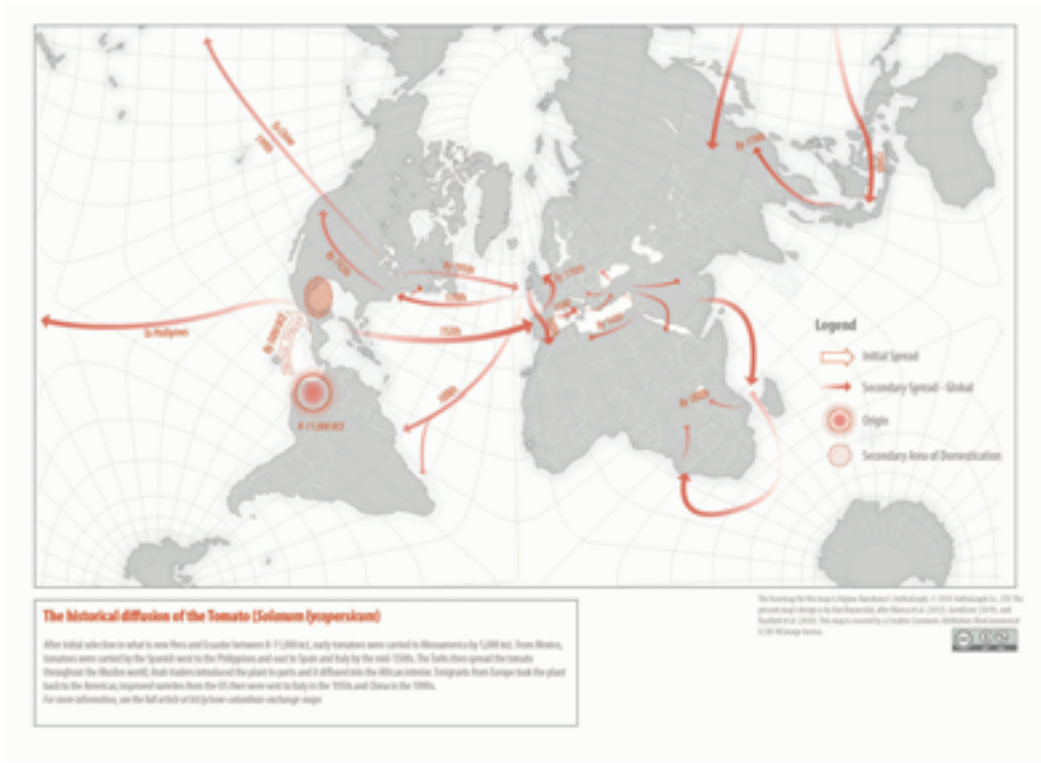

Figure 6. A revised map for the diffusion of tomatoes. This map highlights the multiple domestication sites and the multiple trans-Atlantic trajectories of tomatoes. Available for download at https://doi.org/10.1484/A.20281851 and on the Wikipedia page for the Columbian Exchange.

production, and similar lines can be drawn from Mexico to southern California. The Columbian Exchange map simplifies these complex, entangled lines and yet in doing so erases human suffering and agro-economic imperialism.[68]

Quinine

Although it has its origins in the foothills of the Andes, the story of what we today know as quinine is deeply intertwined with the history of malaria and the development of mercantile colonialism. Malaria is one of the oldest diseases to afflict humanity; while the parasite is estimated to be around 100,000 years old, humans first caught malaria from animals around 10,000 years ago in Africa or

68 Fabrizio GATTI, "I Was a Slave in Puglia", trans. Wolfgang ACHTNER, *L'Espresso*, 4 September 2006; Giovanna Faleschini LERNER, Elena PAST, "Toxic Fruits: Tomatoes, Migration, and the New Italian Slavery", *Journal of Modern Italian Studies*, vol. 25, no. 5 (2020), pp. 592-619.

Europe.[69] The spread of empire in the sixteenth and seventeenth centuries caused the spread of the European and African varieties of malaria to the Americas. Malaria is caused by four different species of microbe belonging to the *Plasmodium* genus, which have the common symptom of intermittent fever.[70] It is difficult to ascertain the exact time malaria reached the Americas, since indigenous populations were afflicted with a plethora of diseases following repeated contact with Europeans and Africans (who chose to make the transatlantic journey or were forced to) during the sixteenth century. What is certain is that that the onset of Caribbean plantation culture and the Atlantic slave trade laid the ground for the spread of malaria through the American subcontinent, which had the appropriate geography and presence of a suitable vector to transmit the disease. The low-lying coasts of Ecuador provided the perfect breeding ground for the North American variety of *Anopheles* mosquito, and sugar plantations exacerbated this growth.[71] Therefore, both imperialism and malaria established the global context required for quinine trade to flourish. The traditional Columbian Exchange graphic shows quinine travelling to Europe from the Americas, which obscures the importance of the drug in the aftermath of the spread of malaria by European imperialism. As mentioned in the introduction, tracing the spread of more than one product (or in this case, a product and a disease) made for overly complicated maps, so our revised map uses information about the spread of malaria and imperialism to trace quinine's spread, but not explicitly (fig. 7).

Quinine comes from the bark of trees of the genus *Cinchona*, which are native to the Andean highlands in Peru and Ecuador.[72] The Incas, who were in the region about 300 years before the Spanish, used the medicine by powdering it and dissolving it in water to treat common fevers (especially intermittent fevers, similar to malaria). Andean *cascarilleros*, or bark collectors, ventured into Andean forests to harvest bark, which took several years to regrow.[73] On average a sample of bark would contain at most 10% quinine. Jesuit missionaries interacted with the indigenous peoples in the Andes, and when a Jesuit at Loja, a region in modern-day Ecuador, fell ill with malaria in around 1620, the locals gave him a drink containing cinchona bark; bark was dried, powdered and dissolved in wine or water.[74] This is how the Jesuits knew the correct remedy when the Countess of Chinchon caught malaria and was on the brink of death; she later ordered the bark to be collected and brought it back with her to Spain in 1640. Once Spanish merchants arrived on the scene, the rate of extraction of cinchona bark exceeded the rate of natural reproduction, and so the Spaniards

69 Matthew James CRAWFORD, *The Andean Wonder Drug: Cinchona Bark and Imperial Science in the Spanish Atlantic, 1630-1800* (Pittsburgh, 2016), p. 47.

70 Intermittent fever is a type of fever where there are intervals of elevated and normal temperatures over the course of an illness. See Ibid., p. 47.

71 Ibid., pp. 50-51.

72 Jane ACHAN et al., "Quinine, an Old Anti-Malarial Drug in a Modern World: Role in the Treatment of Malaria", *Malaria Journal*, vol. 10, no. 1 (2011), p. 1.

73 Fiammetta ROCCO, *The Miraculous Fever-Tree: Malaria, Medicine and the Cure That Changed the World* (New York, 2012), pp. 57-59.

74 Matthew James CRAWFORD, *The Andean Wonder Drug…*, p. 63; Jane ACHAN et al., "Quinine…", p. 1.

Figure 7. A revised map for the diffusion of quinine. Note the limited diffusion of the cultivation of the tree. Available for download at https://doi.org/10.1484/A.20281851 and on the Wikipedia page for the Columbian Exchange.

often entered into trade deals with the *cascarilleros*.[75] In 1735, Charles-Marie de La Condamine, a geographer who was part of a French-Spanish expedition to Ecuador, is often credited with the discovery of the particular variety of cinchona which give a high concentration of the medicine, but a local named Fernando de la Vega in fact made this discovery. This was no easy feat – healers and locals who used cinchona bark had to be very skilled in order to find the correct plants in the forest, identify the parts of the tree with the best bark and harvest it without damaging the environment. Since he wrote the first written account of cinchona bark, La Condamine was recognized as the discoverer by Enlightenment Europe, which also displays a lack of respect for the ingenuity of the locals. The Spanish established plantations with this variety of cinchona in their South American colonies.

Quinine's value as a commodity made it an object of scientific interest. Purified quinine replaced the bark concoction as the standard treatment for malaria when the French scientists Pierre Pelletier and Joseph Caventou invented a chemical process in 1820 to extract quinine-containing compounds from cinchona bark.[76] This discovery had great financial potential, but early nineteenth-century cinchona plantations were largely located in the newly independent South American republics of Peru, Ecuador,

75 Fiammetta ROCCO, *The Miraculous Fever-Tree*…, p. 57.
76 Jane ACHAN et al., "Quinine…".

Colombia and Bolivia; these former Spanish colonies restricted exports to maintain a monopoly on cinchona. The European powers encouraged explorers to smuggle seeds out illegally to then be planted in their own colonies, where the subtropical to tropical climates provided more favourable conditions to cinchona.[77] However, cinchona was also notoriously difficult to grow and, because of its financial value, when one country figured out how to cultivate smuggled cinchona seeds, it kept the knowledge to itself; therefore, the success of cinchona in a colony depended a lot on the ingenuity of local farmers and agricultural scientists in botanical gardens.[78] Our map challenges the Columbian Exchange paradigm by illustrating how cinchona was spread mostly to colonies rather than to mainland Europe. While cinchona exhibits an oceanic spread, our map also partly shows the spread of cinchona plantations over land.

In the 1850s, the British transported smuggled cinchona seeds to India from South America. British cinchona cultivation was largely concentrated in the Nilgiri hills of South India, close to Ootacamund. Scores of local labourers died clearing up the thick highland forests, as the hills were filled with dangerous wildlife and were characterized by rather harsh climates.[79] Meanwhile, British soldiers stationed in India often consumed tonic water as a preventative measure against malaria. Medicinal tonic water at the time contained only carbonated water, which was seen as a potential cure for scurvy, and a large proportion of quinine; since the quinine was bitter, soldiers took to adding gin and lemon slices to their tonic water, inventing the gin and tonic.[80] Although cinchona cultivation proved to be a commercial failure in India, it was a political success, and was largely replaced with tea by planters after the 1880s. This left the world market for quinine largely to the Dutch who had obtained high quinine-yield seeds from a British merchant named Charles Ledger in 1872; they successfully cultivated cinchona in Java and the rest of the Dutch East Indies, supplying 90% of the world supply by 1940.[81] Quinine was also grown in the German colony of Tanganyika in East Africa in the 1900s, in southern Vietnam by the French after years of experimentation in the 1920s, in Japanese-controlled Taiwan by 1922, and in the US territory of the Philippines from 1927 onwards.[82] Quinine bark first arrived in China in 1693 when Jesuit missionaries used the drug to cure the

77 Matthew James CRAWFORD, *The Andean Wonder Drug…*, p. 60.

78 Yubin SHEN, "Cultivating China's Cinchona: The Local Developmental State, Global Botanic Networks and Cinchona Cultivation in Yunnan, 1930s–1940s", *Social History of Medicine*, vol. 34, no. 2 (2019), pp. 577-91.

79 V. R. MURALEEDHARAN, "Quinine (Cinchona) and the Incurable Malaria: India *c.* 1900-1930s", *Parassitologia*, vol. 42, no. 1-2 (2000), p. 92.

80 Kim WALKER, Mark NESBITT, *Just the Tonic: A Natural History of Tonic Water* (London, 2019).

81 Charles Ledger was a British clerk working in Lima in the 1830s, and he saved a drowning man, named Manuel Incra Mamani, who then offered to become his servant. In 1865, Mamani helped Ledger procure seeds of a Cinchona variety whose bark had 70% quinine-containing compounds to send back to England; Mamani was arrested and beaten to death while stealing seeds in 1871, while the species was named *Cinchona ledgeriana* in honor of Ledger. See J. H. HOLLAND, "Ledger Bark and Red Bark", *Bulletin of Miscellaneous Information*, vol. 1932, no. 1 (1932), pp. 1-17.

82 Yubin SHEN, "Cultivating China's Cinchona…", p. 577.

emperor Kangxi, and in the early 1900s, China imported 8-10 tons of quinine pills per year. The nationalist regime received cinchona seeds from the Dutch in 1924 (after years of refusal to trade) and cultivation ensued in the Yunnan province during the 1930s and 1940s. Achieving quinine self-sufficiency allowed the Chinese government to establish its legitimacy through the modernization of agriculture and handling of malaria epidemics in the southwest regions.

In 1942, the Japanese Empire invaded the Dutch East Indies, which pressured the Allied Powers to resort to synthetic medicines as a substitute for quinine. In the early 1900s, German scientists synthesized anti-malarials in an attempt to capitalize on the market for quinine, producing pamaquine in 1926 and chloroquine in 1934; while chloroquine was passed to sister companies in the US, the US Army selected pamaquine for use during World War II.[83] Artemisinin was isolated from the wormwood *Artemisia annua* (known as Qinghao by Chinese herbalists) by Chinese scientists in 1972. Today, artemisinin-based combination therapy (ACT) is considered to be more effective than quinine, but the limited availability of ACT therapy and resistance to other anti-malarials mean that quinine is generally maintained as a backup treatment in malaria-affected areas. Some varieties of red cinchona introduced in the Pacific Islands such as Hawai'i, Tahiti and Galapagos, initially as economic plants, have been found naturalized and are aggressive invasive species, while ironically, this variety is an endangered species in its native Ecuador.[84]

Our map (fig. 7) reveals another cartographic shortcoming, which we too have had a difficult time remedying: the cartographic distinction between areas of domestication, production and consumption. For many products, these spaces can either be separate or can overlap – tomatoes were domesticated in South America, now grow there, and are still consumed by South Americans. Because cinchona cultivation is limited to a very particular climatic zone, its main areas of production after the 1850s were far from its place of origin and also from many of quinine's consumers. Production areas overlapped with consumption areas due to quinine's role in allowing malaria-inflicted European soldiers to control empires, and the politics of who actually consumed quinine (soldiers, as opposed to local farm workers) in these areas is also difficult to represent on the maps. Some products have also changed forms of consumption as they have spread – quinine is an excellent example of this process, as it started as an export of various species of cinchona bark, then a specific cinchona seed, then an ingredient in gin and tonic, followed by the purified chemical molecule known as quinine.

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83 German scientists were well-placed to do this research as Germany underwent a laboratory revolution before other European powers. See Arjo Roersch VAN DER HOOGTE, Toine PIETERS, "From Colonial Agro-Industrialism to Agro-Industrialism: Game Changing Evolution of the Dutch Transoceanic Cinchona-Quinine Enterprise (1940s–1960s)", *Itinerario*, vol. 40, no. 1 (2016), pp. 105-25; Stanley OAKS, Jr., "Drug Discovery and Development", in Stanley OAKS, Jr. et al. (eds), *Malaria: Obstacles and Opportunities* (Washington, DC, 1991), p. 116.

84 Heinke JÄGER, "Biology and Impacts of Pacific Island Invasive Species: *Cinchona Pubescens* (Red Quinine Tree) (Rubiaceae)", *Pacific Science*, vol. 69, no. 2 (2015), pp. 133-53.

Conclusions

In this article we have presented the complicated evolutionary and social trajectories of five products often depicted on Columbian Exchange maps. The point of our surveys of these products and our remapping of their spread is not to present a definitive portrait of any particular product or a definitive map of the last ten millennia – none of the four authors are biogeographers. Rather, the text and our new maps support our central argument, that the most-used maps of the Columbian Exchange obscure more than they reveal. In reducing the Exchange to a timeless, trans-(North)Atlantic snapshot, these maps leave out much of what makes the Exchange such an important and complicated process.

Because of the scope of this article, we had to leave out many other products that would have illustrated the omissions of the Mercator-based Exchange map. The spread of chickens out of Southeast Asia into Polynesia and quite possibly to pre-Columbian South America would have made for another Pacific-centric map.[85] Cassava, a South American root that accounts for a third of carbohydrate calories in the tropics, is stunningly absent from Figure 1 and many like it. Its absence, as well as the absence of many African contributions to New World food systems, reinforces the Jim Crow connotations of these maps.[86] Cotton's massive expansion across the globe during and after the American Civil War – and with its expansion, the spread of coercive, brutal labour systems – is another historical elision these maps make.[87] Bell peppers and chili peppers did not contribute many calories or create new systems of labour, but together they did reshape cuisines and offered valuable nutrients.[88] We recognize the complexity of the maps that would be needed to show some of these spreads: imagine trying to trace the spread of the genus *Equus* into the Americas, its extinction, its reintroduction in the late fifteenth century, and its impact on the

85 There is an on-going debate about the chicken's arrival in South America. See the following for a sample: Yi-Ping LIU et al., "Multiple Maternal Origins of Chickens: Out of the Asian Jungles", *Molecular Phylogenetics and Evolution*, vol. 38, no. 1 (2006), pp. 12-19; Alice A. STOREY et al., "Radiocarbon and DNA Evidence for a Pre-Columbian Introduction of Polynesian Chickens to Chile", *Proceedings of the National Academy of Sciences of the United States of America*, vol. 104, no. 25 (2007), pp. 10335-39; Jaime GONGORA et al., "Indo-European and Asian Origins for Chilean and Pacific Chickens Revealed by MtDNA", *Proceedings of the National Academy of Sciences of the United States of America*, vol. 105, no. 30 (2008), pp. 10308-13; Vicki A. THOMSON et al., "Using Ancient DNA to Study the Origins and Dispersal of Ancestral Polynesian Chickens across the Pacific", *Proceedings of the National Academy of Sciences of the United States of America*, vol. 111, no. 13 (2014), pp. 4826-31; A. LUZURIAGA-NEIRA et al., "On the Origins and Genetic Diversity of South American Chickens: One Step Closer", *Animal Genetics*, vol. 48, no. 3 (2017), pp. 353-57.

86 See especially Judith A. CARNEY, Richard N. ROSOMOFF, *In the Shadow of Slavery*…

87 Sven BECKERT, "Emancipation and Empire: Reconstructing the Worldwide Web of Cotton Production in the Age of the American Civil War", The American Historical Review, vol. 109, no. 5 (2004), pp. 1405-38.

88 Stefan Halikowski SMITH, "In the Shadow of a Pepper-Centric Historiography: Understanding the Global Diffusion of Capsicums in the Sixteenth and Seventeenth Centuries", *Journal of Ethnopharmacology*, vol. 167 (2015), pp. 64-77; Lei GUANG, "The Peripatetic Chili Pepper: Diffusion of the Domesticated Capsicums since Columbus", in *Agriculture and Rural Connections in the Pacific* (Milton Park, UK, 2006), pp. 75-88.

native people of the North American plains.[89] And think of the relatively static map of the peacock flower, which did not move much, an example of a stubbornly stable biogeography rather than one that was taken up and replanted, its stasis notable for equally important historical-cultural reasons.[90]

Our conclusion is that the oversimplified, misleading and problematically Eurocentric Columbian Exchange maps, like the one depicted in Figure 1, retain some pedagogic value in terms of an at-a-glance summary, but only when paired with other maps like ours, or extensive classroom discussions (like the ones we imagine already happen) about these maps' shortcomings. We refrained from combining the maps for the five products we selected to make a new summary map due to the complexity of the maps for each individual product. Maps are at different scales for a reason: we propose that the old Columbian Exchange maps be a point of departure rather than a map of the territory. The complicated stories that crossed and recrossed the globe during the last ten millennia demand a more fine-grained cartographic approach than the Mercator projections we have all been forced to use in our teaching. We think students could be shown both maps and then asked about how their differences tell different stories. It might lead to a more meta discussion of cartography and how cartographers subtly make arguments about what is important and what is not, and how this could implicitly influence our points of view. Similarly, the comparison of our maps and the simplified ones could be the beginning of an exercise on renaming the Columbian Exchange – does "exchange" really describe what happened? Either way, we believe a new set of maps is crucial to a more holistic conception of the massive global transfer of biota that has so shaped the modern world.

89 Pita KELEKNA, *The Horse in Human History* (New York, 2009); Debbie BUSBY, Catrin RUTLAND, *The Horse: A Natural History* (Princeton, 2019).

90 Londa SCHIEBINGER, "Agnotology and Exotic Abortifacients…"; Theodore HYMOWITZ, Jack R. HARLAN, "Introduction of Soybean to North America by Samuel Bowen in 1765", *Economic Botany*, vol. 37, no. 4 (1983), pp. 371-79.