

ence of the stars and the place where certain aspects of Copernicus's *De revolutionibus* were adopted after its publication in 1543. A network of Lutheran universities, especially at Wittenberg (where Rheticus was for a time a professor of mathematics) and Nuremberg (where Copernicus's book first appeared) nurtured a particular reading of Copernicus that stressed the practical side of astronomy: the use of its mathematical models to generate tables of celestial motions, and ephemerides for specific locales, in turn applicable to calendrical and prognosticatory work. Wittenberg astronomers apart from Rheticus did not take the moving Earth seriously, largely because of its physical implausibility, but they did take *De revolutionibus* seriously as a work of mathematical, technical astronomy; they learned how to switch back and forth between reference frames.

The second major framing of the issues involves aristocratic patronage and courtly settings as alternatives to the disciplinarily more restrictive university. If Copernicus's work were to be more than a set of mathematical techniques, its literal physical truth needed to be considered. Figures such as Tycho Brahe (a Danish aristocrat with strong connections to the world of the Lutheran astronomers but not a part of their institutional system) found themselves able to pursue physical and astrological paths more suited to their higher social status. Some, like Tycho, took such aspects of Copernicus seriously without always adopting them. Kepler, after having been an assistant to Tycho, replaced him, following his death in 1601, as Imperial Mathematician to the Holy Roman Emperor Rudolf II. Galileo moved from a university to a courtly setting when he became court philosopher and mathematician to the Grand Duke of Tuscany in 1610. Westman argues that an intellectually freer social environment was a feature of such settings.

The attitude and teachings of the great pedagogue, and Martin Luther's intellectual right-hand man, Philipp Melancthon were an important feature of the Lutheran academic science of the stars in the mid-16th century. It was important that Melancthon gave moderate support to astrological forecasting and rejected Pico's hard-line opposition. This reminds us of the religious and theological dimensions of the Copernican question. Official Catholic positions were generally much less accommodating to astral divination than were those of non-Catholics and less open to Copernican innovations. (Galileo's first trial, in 1605, was for casting horoscopes.) West-

man discusses the case of Christopher Clavius, a prominent Jesuit astronomer of the later 16th century, as an influential teacher and writer of textbooks who restricted his approach to astronomy to the disciplinarily narrow tradition of Copernicus's *De revolutionibus*, itself modeled on Ptolemy's *Almagest*.

The younger Galileo, as a university mathematician, had been on cordial terms with Clavius. The same could not be said of his relations with Kepler. A substantial part of Westman's book is concerned with Galileo and Kepler, individually but also regarding the contrasts between their social styles and the way these shaped their interactions. Kepler from the beginning wanted to enroll Galileo in his program to promote the Copernican model of the universe, whereas Galileo only wanted to engage Kepler if Galileo's own achievements would thereby be affirmed.

Kepler's physico-theological ideas for explaining the motions and form of the uni-

verse included attempts to restructure the physical basis of astrological prognostication. But, ironically, *The Copernican Question* presents the decline of astrological forecast as the long-drawn-out consequence of the increasing success of Copernican astronomy in the decades following Kepler's *Rudolfine Tables* of 1627. The distinctions between astrological practice and its theoretical substructure became too problematic, too difficult for a Copernican science of the stars. Newton's work answered the Copernican question in a way that simply ignored astrology.

References

1. T. S. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Harvard Univ. Press, Cambridge, MA, 1957).
2. T. S. Kuhn, *The Structure of Scientific Revolutions* (Univ. Chicago Press, Chicago, ed. 2, 1970).
3. I. B. Cohen, *The Birth of a New Physics* (Anchor, Garden City, NJ, 1960).

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ECOLOGICAL HISTORY

Pangaea Penultima

Jared Farmer

Mass extinction events get all the attention, but mass redistribution events—the biotic interchanges that occur when continents or oceans become connected or reconnected—are arguably as important in planetary history. The Trans-Beringian Interchange and the Great American

1493
Uncovering the New World Columbus Created
 by Charles C. Mann
 Knopf, New York, 2011.
 557 pp. \$30.50, C\$34.50.
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Interchange (across the Panamanian Isthmus) are two paleobiogeographic examples of this process. In the historical period, we have the Columbian Exchange. Unlike earlier biotic interchanges, the human-facilitated Columbian Exchange connected all of the continents and oceans more or less simultaneously. Species, populations, and genomes escaped the confines of former habitats with spectacular consequences. Sounding alarm, the International Union for Conservation of Nature has called this ongoing process “the great reshuffling.” Expressing wonder, Charles Mann calls it “a great unification”—a biotic

recreation of Pangaea. In *1493: Uncovering the New World Columbus Created*, Mann, a science journalist and popularizer of academic history, has composed a dense yet accessible overview of the first 500 years of this unplanned ecological farrago.

You might assume, based on its title, that *1493* continues the story of *1491*, Mann's award-winning account of indigenous America from the Pleistocene to the year before Columbus (*1*). Actually, Mann admits, his new book is designed as a follow-up to *The Columbian Exchange and Ecological Imperialism*, two seminal works (*2*, *3*) by historian Alfred Crosby. In brief, Crosby argued that the two-way transfer of plants, animals, and pathogens between the Old World and the Americas transformed both hemispheres and aided European colonialism. In his acknowledgments, Mann recounts that when he pestered Crosby to update these classics, he got this answer: “Well, if you think it's such a good idea, why don't you do it?”

1493 consists of four self-contained sections. The first three complement one another nicely: “Atlantic journeys” narrates how tobacco commodities came to Europe via Virginia and how malaria and yellow fever came to America via Africa along with disease-resistant slaves destined for tobacco and sugar plantations. “Pacific journeys” chron-

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Left behind. Within three decades of Pizarro's overthrow of the Inka empire, Spanish farmers in the Canary Islands were exporting potatoes to France and the Netherlands. Yet most of the hundreds of potato varieties bred by Andean natives are still seen only in South America.

icles how imperial China grew dangerously dependent on Peruvian silver and New World crop plants. "Europe in the world" explains how plant and animal products of South American origin, namely potatoes, guano, and rubber, undergird the industrial revolution and European imperialism despite a few major setbacks such as potato blight (the result of an invasive mold that probably arrived on a guano ship).

As Mann illustrates again and again, the Columbian Exchange cut both ways. Silver from Potosí stabilized the Chinese currency system for a time but eventually weakened the Ming Dynasty. Although sweet potatoes and maize enabled a Chinese population boom, agricultural expansion onto marginal lands also resulted in deforestation, catastrophic flooding, and social unrest. In the Caribbean, malaria and yellow fever burned through indigenous populations and European settlements without reprieve. This stark demographic reality motivated Europeans to import more African slaves, who toiled in misery but who, in the long run, leveraged their immunological advantage against slaveholders in a series of anticolonial revolutions in places such as Haiti.

Mann makes no attempt to be comprehensive. He has little or nothing to say about the oceans, the polar realm, Australia, India, or Africa beyond the Slave Coast. He gives most attention to Western Europe, the Americas, and East Asia. Mann's extensive use of Chinese language secondary sources sets him apart from most environmental historians. The author makes several detours to the present—his own field trips to China, the Philippines, and Brazil—yet he glosses over the

recent past. Mann doesn't discuss, for example, the roles of airplanes, container ships, and interoceanic canals in species shifting. His most questionable omission concerns animals. While *1493* covers mosquito-borne malaria and guano fertilizer, it passes over domesticated and invasive fauna—two of the most important components of the Columbian Exchange.

Instead, Mann devotes the book's fourth and final section ("Africa in the world") to the migration and genetic mixing of *Homo sapiens*. Here he makes some solid points—far into the colonial period, Africans and Amerindians dominated the gene pool of the New World; escaped slaves succeeded in creating large, long-lasting maroon polities outside of colonial control;

Spanish and indigenous ruling families routinely intermarried. Mann seems particularly enamored with his notion that 17th-century Mexico City, with its multiethnic, polyglot, cosmopolitan population, was the "first of today's modern, globalized megalopolises." However, after almost 300 pages on organisms and commodities, Mann's detailed treatment of intercultural relations and racial categories seems somewhat out of place. Ecologists might bristle at Mann's suggestion that human creolization is equivalent to biotic homogenization.

The book merits comparison to another high-profile work: Jared Diamond's Pulitzer Prize-winning *Guns, Germs, and Steel* (4). Compared to Diamond, Mann is a better stylist and a more generous scholar. He amply credits the many researchers—mainly historians such as J. R. McNeill, who has documented the impact of mosquito-borne disease (5), plus a few scientists such as paleoclimatologist William Ruddiman—whose work he synthesizes. Diamond, by contrast, barely acknowledged his enormous debt to Crosby. Nonetheless, whatever you may say about Diamond (historians tend to portray him as a biogeographic determinist), he did put forward a provocative argument: the orientation of continents is the ultimate explanation of human history. *Guns, Germs, and Steel* begged for debate, whereas *1493* politely invites admiration. Mann's "thesis" is simply that globalization has been going on a long time and that the Columbian Exchange explains a lot. Summarized this way, his book sounds less thought-provoking than it actually is.

For fans of long-form nonfiction, *1493* presents multitudinous delights in the form

of absorbing stories and fascinating factoids. Mann subscribes to the chain-of-surprising-events school of history. For example, did you know that Old World diseases caused devastating population losses in the Americas, which led to reforestation, which resulted in carbon sequestering, which probably intensified the Little Ice Age, which wreaked havoc on the Old World? Have you heard the story of British biopirate Sir Henry Alexander Wickham, who smuggled 70,000 tree seeds out of Brazil that became the basis for the rubber plantations of South Asia, which punctured the Brazilian rubber boom and later inspired Henry Ford to erect his own plantation town, Fordlândia, in the Amazon? Mann's book is chock-full of such nuggets. Perhaps inevitably, the parts are greater than the whole.

As a writer, Mann displays many fine qualities: evenhandedness, a sense of wonder, the gift of turning a phrase. At the same time, he sometimes resorts to clunky and clichéd literary devices: Imagine you were in an airplane in 1642; what would you see from your passenger window? His first-person travelogues seem self-indulgent and superfluous. Such memoirism doesn't add anything to a book about the creation of the modern ecological world-system.

Geologists may soon officially adopt the term "Anthropocene" to describe the current geologic epoch. Ecologists, who measure change on a different scale with different data, have an alternative term for our time: "Homogenocene." This neologism is evocative because it suggests both anthropogenic change and biotic homogenization. Mann loves the word and adopts it as his own. As a best-selling author with a premier publisher, Mann may well turn this academic concept into general knowledge. That would be a good thing. Although *1493* is not ground-breaking, it offers a welcome corrective to media pundits and their puffery about the brave new world of globalization. In fact, as Mann skillfully details, our world has been flat for over half a millennium.

References

1. C. C. Mann, *1491: New Revelations of the Americas Before Columbus* (Knopf, New York, 2005); reviewed in (6).
2. A. W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Greenwood, Westport, CT, 1972).
3. A. W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (Cambridge Univ. Press, Cambridge, 1986).
4. J. M. Diamond, *Guns, Germs, and Steel: The Fates of Human Societies* (Norton, New York, 1987).
5. J. R. McNeill, *Mosquito Empires: Ecology and War in the Greater Caribbean, 1620–1914* (Cambridge Univ. Press, Cambridge, 2010).
6. D. R. Snow, *Science* **312**, 1313 (2006).

10.1126/science.1213474