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The Columbian Exchange: A History of Disease, Food, and Ideas

Nathan Nunn and Nancy Qian

The Columbian Exchange refers to the exchange of diseases, ideas, food crops, and populations between the New World and the Old World following the voyage to the Americas by Christopher Columbus in 1492.

The Old World—by which we mean not just Europe, but the entire Eastern Hemisphere—gained from the Columbian Exchange in a number of ways. Discoveries of new supplies of metals are perhaps the best known. But the Old World also gained new staple crops, such as potatoes, sweet potatoes, maize, and cassava. Less calorie-intensive foods, such as tomatoes, chili peppers, cacao, peanuts, and pineapples were also introduced, and are now culinary centerpieces in many Old World countries, namely Italy, Greece, and other Mediterranean countries (tomatoes), India and Korea (chili peppers), Hungary (paprika, made from chili peppers), and Malaysia and Thailand (chili peppers, peanuts, and pineapples). Tobacco, another New World crop, was so universally adopted that it came to be used as a substitute for currency in many parts of the world. The exchange also drastically increased the availability of many Old World crops, such as sugar and coffee, which were particularly well-suited for the soils of the New World.

The exchange not only brought gains, but also losses. European contact enabled the transmission of diseases to previously isolated communities, which

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caused devastation far exceeding that of even the Black Death in fourteenth-century Europe. Europeans brought deadly viruses and bacteria, such as smallpox, measles, typhus, and cholera, for which Native Americans had no immunity (Denevan, 1976). On their return home, European sailors brought syphilis to Europe. Although less deadly, the disease was known to have caused great social disruption throughout the Old World (Sherman, 2007).

The effects of the Columbian Exchange were not isolated to the parts of the world most directly participating in the exchange: Europe and the Americas. It also had large, although less direct, impacts on Africa and Asia. European exploration and colonization of the vast tropical regions of these continents was aided by the New World discovery of quinine, the first effective treatment for malaria. Moreover, the cultivation of financially lucrative crops in the Americas, along with the devastation of native populations from disease, resulted in a demand for labor that was met with the abduction and forced movement of over 12 million Africans during the sixteenth to nineteenth centuries (Lovejoy, 2000; Manning, 1990).

The Columbian Exchange has provided economists interested in the long-term effects of history on economic development with a rich historical laboratory. Economic studies have thus far mainly focused on how European institutions, through colonialism, were transplanted to non-European parts of the world. The seminal papers by Engerman and Sokoloff (1997), La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1997, 1998), and Acemoglu, Johnson, and Robinson (2001) examine the effects that European contact, taking the form of formal and informal colonial rule, had on other societies.[1]

In this paper, we attempt to broaden the scope of economic studies of the Columbian Exchange by studying aspects of the exchange that have received less attention. First, we pay particular attention to the effects that the exchange had on the Old World, rather than examining outcomes in the New World. Second, rather than concentrating on the effects of the exchange that work through institutional and political structures, we focus on the less-studied, but no less-important channels; namely, the biological exchange of food crops and disease. Our hope is that our broad descriptive overview of some of the neglected aspects of the Columbian Exchange will spur further more-rigorous studies of the long-term consequences of these aspects of the exchange.

We are aware of only a handful of empirical papers that either focus on the effect of the exchange on the Old World or focus on channels other than legal institutions. Acemoglu, Johnson, and Robinson (2005) examine the effects of the three-corner Atlantic trade on Europe. They argue that the profits from the trade strengthened the merchant class, which resulted in stronger probusiness institutions and increased economic growth. Two studies have recently explored the effects from

[1] Subsequent studies have since added to the understanding of the long-term effects of colonial rule and European contact on New World Societies. See for example Mitchener and McLean (2003), Berkowitz and Clay (2005, 2006), Acemoglu, Bautista, Querubin, and Robinson (2008), Dell (2008), and Nunn (2008a), as well as the review by Nunn (2009).

the botanical exchange. In Nunn and Qian (2009), using a generalized difference-in-differences empirical strategy, we find that the introduction of potatoes to the Old World resulted in a significant increase in population and urbanization. Our finding complements earlier research by Mokyr (1981) that estimates the effects of the potato on population growth within Ireland. Hersh and Voth (2009) examine the benefits that arose from the increase in land for cultivating the Old World crops coffee and sugar after 1492. According to their calculations (see their table 9), the increased availability of sugar increased English welfare by 8 percent by 1850, while the greater availability of coffee increased welfare by 1.5 percent.

In the following section, we examine the most devastating and unfortunate consequences of the Columbian Exchange, which arose from the exchange of disease between the Old and New Worlds. Next, we turn to the effects of the exchange that arose from the transfer of foods between the New and Old Worlds. We then examine the indirect consequences of the exchange on Africa and Asia. The final section of the paper offers concluding thoughts.

Disease

The Spread of Disease from the Old World to the New

The list of infectious diseases that spread from the Old World to the New is long; the major killers include smallpox, measles, whooping cough, chicken pox, bubonic plague, typhus, and malaria (Denevan, 1976, p. 5). Because native populations had no previous contact with Old World diseases, they were immunologically defenseless. Dobyns (1983, p. 34) writes that "before the invasion of peoples of the New World by pathogens that evolved among inhabitants of the Old World, Native Americans lived in a relatively disease-free environment. . . . Before Europeans initiated the Columbian Exchange of germs and viruses, the peoples of the Americas suffered no smallpox, no measles, no chickenpox, no influenza, no typhus, no typhoid or parathyroid fever, no diphtheria, no cholera, no bubonic plague, no scarlet fever, no whooping cough, and no malaria."

Although we may never know the exact magnitudes of the depopulation, it is estimated that upwards of 80–95 percent of the Native American population was decimated within the first 100–150 years following 1492 (Newson, 2001). Within 50 years following contact with Columbus and his crew, the native Taino population of the island of Hispanola, which had an estimated population between 60,000 and 8 million, was virtually extinct (Cook, 1993). Central Mexico's population fell from just under 15 million in 1519 to approximately 1.5 million a century later. Historian and demographer Nobel David Cook estimates that, in the end, the regions least affected lost 80 percent of their populations; those most affected lost their full populations; and a typical society lost 90 percent of its population (Cook, 1998, p. 5).

The uncertainty surrounding the exact magnitude of the depopulation of the Americas arises because we don't know the extent to which disease may

have depopulated the regions beyond the initial point of contact before literate European observers made physical contact with these populations (Dobyns, 1993). If disease traveled faster than the explorers, it would have killed a significant portion of native populations before direct contact, causing first-hand accounts of initial population sizes to be biased downward. The result is that 1491 population estimates for the Americas have varied wildly, from a lower-bound estimate of approximately 8 million (Kroeber, 1939) to an upper-bound estimate of over 110 million people (Dobyns, 1966). Surprisingly, despite decades of research, the range of the estimates has not narrowed, and no clear consensus has emerged about whether the true figure lies closer to the high or low end of the range. For examples of the opposing views, see Henige (1998) and Mann (2005).

Syphilis: A New World Disease?

There are very few examples of disease being spread from the New World to the Old.[2] The most notable exception, and by far the most controversial, is venereal syphilis. Biologist Irwin Sherman (2007) lists venereal syphilis as one of the twelve diseases that changed the world. This may seem surprising, given that today venereal syphilis is a nonfatal disease that is effectively treated with penicillin. However, this was not always the case. Early on, in the late fifteenth and early sixteenth centuries, the disease was frequently fatal, and its symptoms were much more severe. They included genital ulcers, rashes, large tumors, severe pain, dementia, and eventual death. Over time, as the disease evolved, its symptoms changed, becoming more benign and less fatal. By the seventeenth century, syphilis had developed into the disease that we know today (Crosby, 2003, pp. 151–53).

Two theories of the origins of venereal syphilis exist. The first, referred to as the "Columbian hypothesis," asserts that the disease-causing agent *Treponema pallidum* originated in the New World and was spread in 1493 by Christopher Columbus and his crew, who acquired it from the natives of Hispaniola through sexual contact. Upon return to Spain, some of these men joined the military campaign of Charles VIII of France and laid siege to Naples in 1495. Encamped soldiers exposed the local populations of prostitutes, which amplified disease transmission. Infected and disbanding mercenaries then spread the disease throughout Europe when they returned home. Within five years of its arrival, the disease was epidemic in Europe. Syphilis reached Hungary and Russia by 1497; Africa, the Middle East, and India by 1498; China by 1505; Australia by 1515; and Japan by 1569 (Crosby, 1969; Dennie, 1962; Harrison, 1959; Snodgrass, 2003; Sherman, 2007).

The second theory, the "pre-Columbian hypothesis," asserts that the disease had always existed in the Old World, and the fact that there were no accounts of the disease prior to the 1490s is because prior to this time it had not been differentiated

[2] One reason for this is that Eurasian societies had domesticated more animals than societies of the Americas. Since many deadly human diseases originated as diseases among animals, this resulted in more disease originating in and being spread from Europeans to Native Americans, rather than vice versa (Diamond, 1997).

from other diseases with similar symptoms (Cockburn, 1961, 1963; Hackett, 1963, 1967; Holcomb, 1934, 1935). Proponents of the pre-Columbian hypothesis cite pre-Exchange accounts of disease symptoms similar to venereal syphilis, as well as skeletal remains with scars that are similar to scars left by syphilis. The debates over the true origins of venereal syphilis have been a direct consequence of the difficulty in distinguishing venereal syphilis from other diseases that had similar symptoms and left similar bone scars (Parrot, 1879; Steinbock, 1976; Williams, 1932; Wright, 1971; Verano and Ubelaker, 1992).

Recent findings from phylogenetics (the evolutionary study of the genetic relatedness of different populations of organisms) have added valuable evidence to the mystery of the origins of venereal syphilis. The evidence supports the Columbian hypothesis that venereal syphilis is in fact a New World disease. The recent study by Harper et al. (2008) found that the bacterium causing venereal syphilis arose relatively recently in humans and is most closely related to a variation of the tropical disease yaws found in a remote region of Guyana, South America. This relationship is most consistent with venereal syphilis, or some early ancestor, originating in the New World. After decades of debate, this powerful study showed that venereal syphilis was indeed a New World disease.

The Transfer of New World Foods to the Old World

The transfer of foods between the Old and New Worlds during the Columbian Exchange had important consequences for world history. Historian Alfred Crosby (1989, p. 666) describes the significance of the transfer of food crops between the continents, writing: "The coming together of the continents was a prerequisite for the population explosion of the past two centuries, and certainly played an important role in the Industrial Revolution. The transfer across the ocean of the staple food crops of the Old and New Worlds made possible the former."

There are two channels through which the Columbian Exchange expanded the global supply of agricultural goods. First, it introduced previously unknown species to the Old World. Many of these species—like potatoes, sweet potatoes, maize, and cassava (also known as manioc)—resulted in caloric and nutritional improvements over previously existing staples. Other crops such as tomatoes, cacao, and chili peppers were not by themselves especially rich in calories, but complemented existing foods by increasing vitamin intake and improving taste. In many instances, the New World foods had an important effect on the evolution of local cuisines. Chili peppers gave rise to spicy curries in India, to paprika in Hungary, and to spicy kimchee in Korea. Tomatoes significantly altered the cuisine of Italy and other Mediterranean countries. Second, the discovery of the Americas provided the Old World with vast quantities of relatively unpopulated land well-suited for the cultivation of certain crops that were in high demand in Old World markets. Crops such as sugar, coffee, soybeans, oranges, and bananas were all introduced to the New World, and the Americas quickly became the main suppliers of these crops globally.

Table 1
The World's Most Popular Foods in 2000

Average Daily Consumption (calories)		*Annual Production (millions of tonnes)*		*Land Harvested (millions of hectares)*	
Rice	567	*Sugar cane*	*1,252.5*	Wheat	215.5
Wheat	527	Rice	598.8	Rice	154.1
Sugar	*196*	**Maize**	**592.5**	**Maize**	**137.0**
Maize	**147**	Wheat	585.9	*Soybeans*	*74.4*
Potatoes	**60**	**Potatoes**	**328.7**	*Barley*	*54.5*
Cassava	**42**	Sugar beet	247.1	*Sorghum*	*41.0*
Sorghum	*32*	**Cassava**	**176.5**	*Millet*	*37.1*
Sweet Potatoes	**29**	*Soybeans*	*161.3*	Rapeseed	25.8
Millet	*29*	**Sweet potatoes**	**138.7**	**Sunflower seed**	**21.1**
Soybeans	*17*	*Barley*	*133.1*	**Potatoes**	**20.1**
Bananas	*14*	Oil palm fruit	120.4	*Sugar cane*	*19.5*
Coconuts	12	**Tomatoes**	**108.9**	**Cassava**	**17.0**
Apples	9	Watermelons	76.5	Oats	12.7
Tomatoes	**8**	*Bananas*	*64.9*	*Coffee, green*	*10.8*
Oranges	*8*	Grapes	64.8	Coconuts	10.6
Rye	7	*Oranges*	*63.8*	Chick peas	10.1
Yams	7	Apples	59.1	Oil palm fruit	10.0
Onions	7	*Sorghum*	*55.8*	Rye	9.8
Plantains	*7*	Coconuts	52.9	**Sweet potatoes**	**9.7**
Barley	*7*	Onions, dry	49.8	Olives	8.3
Other Notable New World Foods:					
Cacao Beans	**3**	**Eggplants**	**27.2**	**Cacao beans**	**7.6**
Pineapples	**2**	**Sunflower seed**	**26.5**	**Natural rubber**	**7.6**
		Chillies/peppers, green	**20.9**	**Tobacco**	**4.2**
		Pineapples	**15.1**	**Tomatoes**	**4.0**

Source: The data are from the FAO's ProdSTAT and Consumption Databases. See ⟨http://faostat.fao.org/⟩.
Notes: All figures are for the year 2000. Bold type indicates a New World food crop. Italics indicate an Old World crop for which more than 26 percent of current world production is in the New World (26 percent is the fraction of arable land that is located in the New World). The table does not report the consumption of oils. Among oils, the fourth most consumed oil, sunflower oil, is derived from sunflowers, a New World crop.

The extent to which foods indigenous to the New World today comprise an important portion of the world's diet is illustrated by Table 1, which reports the world's most popular foods in 2000. The first list reports foods with popularity measured by the average consumption of calories per person per day. Because this measure may overstate the popularity of high-calorie food crops, we also provide rankings based on production and land under cultivation. These are reported in the second and third lists. Foods that are indigenous to the New World are reported in bold text. From the table it is clear that today New World foods are an important part of our diets. Although the two most consumed crops (by any of the three measures) are Old World crops (either rice, wheat, or sugar), many of the next-most-important crops are from the New World. Four New World crops that

make it into the top ten by two or more measures are maize, potatoes, cassava, and sweet potatoes; tomatoes rank among the top 15 by two different measures. Also high on the list are a number of additional New World foods such as chili peppers and cacao, which despite not being consumed in large quantities, are of central importance to the cuisines of many countries.

Staple Crops: Potatoes, Sweet Potatoes, Maize, and Cassava

The exchange introduced a wide range of new calorically rich staple crops to the Old World—namely potatoes, sweet potatoes, maize, and cassava. The primary benefit of the New World staples was that they could be grown in Old World climates that were unsuitable for the cultivation of Old World staples. Crosby (2003, p. 177) writes: "The great advantage of the American food plants is that they make different demands of soils, weather and cultivation than Old World crops, and are different in the growing seasons in which they make these demands. In many cases the American crops do not compete with Old World crops but complement them. The American plants enable the farmer to produce food from soils that prior to 1492, were rated as useless because of their sandiness, altitude, aridity, and other factors."

This benefit of New World crops has resulted in their adoption in all parts of the world. This is shown by Table 2, which reports the top consuming countries for different New World foods. The New World crop maize has been widely adopted by a number of Old World countries including Lesotho, Malawi, and Zambia. The average person in Lesotho consumes an astonishing 1,500 calories per day from maize. Even more widely adopted than maize is cassava. The top ten cassava-consuming countries are all from the Old World. Although both foods do have their imperfections—for example, a diet of too much maize causes *pellagra* and consumption of insufficiently processed cassava results in *konzo*—they provide sustenance for millions of people around the world today. The table also shows that sweet potatoes have been widely adopted in the Old World and today are most heavily consumed in the Solomon Islands, Rwanda, Burundi, Uganda, and China.

The New World crop that arguably had the largest impact on the Old World is the potato. Because it provides an abundant supply of calories and nutrients, the potato is able to sustain life better than any other food when consumed as the sole article of diet (Davidson and Passmore, 1965, p. 285). Humans can actually subsist healthily on a diet of potatoes, supplemented with only milk or butter, which contain the two vitamins not provided by potatoes, vitamins A and D (Connell, 1962; Davidson and Passmore, 1965). This, in fact, was the typical Irish diet, which although monotonous, was able to provide sufficient amounts of all vitamins and nutrients (Connell, 1962). The potato was also adopted as a core staple in many other parts of the World. As shown by Table 2, this nutritious crop has been so widely embraced by Old World populations that today the top consumers of potatoes are all Old World countries.

Recently, two studies have attempted to estimate empirically the benefits that arose from the introduction of the potato. Mokyr (1981) examines variation across

Table 2
Top Consuming Countries for Various New World Foods
(average calories per capita per day)

Maize		*Cassava*		*Sweet Potatoes*	
Country	*Consumption*	*Country*	*Consumption*	*Country*	*Consumption*
Lesotho	**1,508**	**Congo, Dem. Rep.**	**925**	**Solomon Islands**	**457**
Malawi	**1,151**	**Congo**	**688**	**Rwanda**	**330**
Mexico	1,093	**Angola**	**668**	**Burundi**	**293**
Zambia	**1,058**	**Mozambique**	**650**	**Uganda**	**228**
South Africa	**924**	**Ghana**	**639**	**China**	**106**
Zimbabwe	**903**	**Benin**	**470**	**Timor-Leste**	**64**
Guatemala	835	**Liberia**	**451**	**Madagascar**	**59**
Timor-Leste	**808**	**Togo**	**393**	Cuba	57
El Salvador	772	**Madagascar**	**382**	**Tanzania**	**57**
Kenya	**766**	**Central African Rep.**	**374**	Haiti	45
Potatoes		*Tomatoes*		*Pineapples*	
Country	*Consumption*	*Country*	*Consumption*	*Country*	*Consumption*
Belarus	**320**	**Greece**	**68**	Costa Rica	84
Latvia	**258**	**Libya**	**47**	**Thailand**	**26**
Estonia	**255**	**United Arab Emirates**	**45**	**Kenya**	**20**
Lithuania	**248**	**Egypt**	**44**	**Philippines**	**14**
Ukraine	**248**	**Turkey**	**42**	**Samoa**	**11**
Poland	**242**	**Italy**	**38**	**Venezuela**	**10**
Portugal	**221**	**Lebanon**	**33**	Antigua and Barbuda	8
United Kingdom	**221**	**Tunisia**	**32**	**Australia**	**8**
Russian Federation	**217**	**Israel**	**29**	**Malaysia**	**8**
Ireland	**209**	Cuba	26	**Swaziland**	**8**

Source: The data are from the FAO's Consumption Database. See ⟨http://faostat.fao.org/⟩.
Notes: The table reports average consumption per capita for the top ten countries consuming each New World Crop. Bold text indicates consumption of Old World countries.

counties in Ireland and estimates that the cultivation of the potato did spur population growth. In Nunn and Qian (2009), we also examine the effects of the potato on population growth but do so for the entire Old World. Using a difference-in-differences estimation strategy, we compare the pre- and post-adoption differences in population growth of Old World countries that could adopt the potato with Old World countries that could not. We find that the potato had a significant positive impact on population growth, explaining 12 percent of the increase in average population after the adoption of the potato. We also estimate the effect the potato had on urbanization, a measure that is closely correlated with GDP. We find that 47 percent of the post-adoption increase in urbanization is explained by the potato.

We now turn to a discussion of crops that provide fewer calories, but are no less important to Old World cuisines: capsicum peppers, tomatoes, cacao, and vanilla, and two less healthy New World crops, coca and tobacco.

Capsicum Peppers

The capsicum pepper originated in the areas that today are Bolivia and southern Brazil. By the arrival of the Europeans, the plant had migrated to Mesoamerica and the Caribbean. *Capsicum annuum*, which was domesticated in Mesoamerica, is the ancestor to most of the peppers commonly consumed today: the cayenne pepper, bell peppers, and the jalapeño pepper. A second variety, *Capsicum frutescens*, first cultivated in the Amazon basin, gives us the tabasco pepper (Andrews, 1992, 82–83).

By 1493, capsicum peppers had arrived in Spain and Africa. They then reached the East Indies by 1540 and India by 1542 (Andrews, 1993a, 1993b). In Hungary, paprika, the spice made from grinding dried fruits of the capsicum pepper, is first mentioned in 1569. Paprika has since been widely adopted in a variety of Hungarian dishes, including goulash, and today is the country's national spice (Halasz, 1963). The capsicum has also had a significant impact on the cuisine of many other countries. In South and South East Asia, some form of pepper is used in the base of almost every dish (for example, curries). In China, cuisine in the southwest (like Sichuan, Guizhou, and Hunan) are defined by uses of certain chili peppers. In Korea, a side dish of spicy kimchi is consumed with every meal.

Capsicums provide several health advantages. First, they are very nutritious. By weight, they contain more vitamin A than any other food plant, and they are also rich in Vitamin B. If eaten raw, capsicums provide more vitamin C than citrus fruits. Capsicums also contain significant amounts of magnesium and iron (Andrews, 1992, p. 285). Chilies, of course, are not eaten in vast quantities, but for populations with traditional diets deficient in vitamins and minerals, even a small amount can be important. Second, capsicums also aid digestion. Capsaicin, an alkaloid uniquely found in capsicums, is an irritant to the oral and gastrointestinal membranes when ingested (Viranuvatti, Kalayasiri, Chearani, and Plengvanit, 1972). This causes an increase in the flow of saliva, which eases the passage of food through the mouth to the stomach and increases gastric acids, which aid in the digestion of food (Solanke, 1973). If ingested in large quantities, this same alkaloid can cause oral burning, which can be removed by casein (Henkin, 1991). (Since casein is most readily available from milk and yoghurt, it is not surprising that many spicy diets, such as those from South Asia, pair chilies with milk and yoghurt.) Finally, capsaicin is now being utilized in medicine to treat pain, respiratory disorders, shingles, toothache, and arthritis (Rozin, 1990). Research into its various properties is ongoing.

Tomatoes

Tomatoes are a fruit that originated in South America. Botanists believe that approximately 1,000 years before the Spanish arrived in the Americas, an unidentified wild ancestor of the tomato made its way north and came to be cultivated in South and Central America (Smith, 1994, p. 17). The tomato is first mentioned in European texts in 1544. Mathiolus described how tomatoes, *pomi d'oro* (golden apple), were eaten in Italy with oil, salt, and pepper, suggesting that the first tomatoes in Europe were yellow and not red (Gould, 1983, pp. 30–53). European cultivation became

widespread in the ensuing decades in Spain, Italy, and in France. The first documented authentic recipe in Italy appeared in 1692 in an early Italian cookbook, *Lo scalco alla moderna*, by Antonio Latini. Tomatoes were brought to Asia by Spaniards who visited the Philippines in 1564. However, in China, where they were regarded as foods of the "southern barbarians," they were not cultivated until the twentieth century (Anderson, 1988, p. 94). In North Africa, English travelers reported that Spanish *tomates* were cultivated in fields of North Barbary as early as 1671 (McCue, 1952, p. 330).

One of the difficulties in consuming tomatoes was that they did not preserve well. Ripe tomatoes can become putrid within days in hot climates. The canning process helped increase the shelf life of the tomato to several months, but prior to 1890, it was a costly manual process. The mechanization of canning at the turn of the twentieth century significantly lowered the cost of this process and resulted in a significant increase in tomato consumption (Gould, 1983, pp. 30–53).

Tomatoes have truly become a global food. As shown in Table 2, nine of the top ten tomato-consuming countries are Old World countries. Greece consumes the most tomatoes per capita, followed by other Mediterranean and Middle Eastern countries. Italy, known for its use of tomato sauces with pasta and on pizza, ranks sixth on the list. Table 3 lists the top ten producers of some New and Old World foods. The top producers of tomatoes are listed in panel A of the table; eight of the top ten producers are Old World countries, with only two New World countries, Brazil and Mexico, breaking the list of top tomato producers.

Although not particularly rich in calories, tomatoes are an important source of vitamins, particularly vitamins A and C. The tomato has been so thoroughly adopted and integrated into Western diets that today it provides more nutrients and vitamins than any other fruit or vegetable (Sokolov, 1993, p. 108). Medical researchers have also recently discovered a number of additional health benefits from tomato consumption. Recent research has found that lycopene, a powerful antioxidant contained in cooked or canned tomatoes, has properties that may help reduce cancer (for example, Basu and Imrhan, 2007). Although research is still in progress, the American Cancer Society has already begun to promote increased consumption of tomatoes as a potential method for cancer prevention.

Cacao

The Codex Mendoza—an Aztec record of administration and description of daily life, written approximately 20 years after the Spanish conquest of Mexico—documents that by the time Cortes arrived, chocolate was being cultivated by farmers in the Yucatan and was traded in large quantities throughout the Empire (Prescott, 1843, p. 11; West, 1992, p. 108). Historical records indicate that Columbus first brought back specimens of cacao pods to King Ferdinand I after his second voyage to the New World. Outside of the Americas, cacao was first cultivated in 1590 by the Spanish off the coast of Africa on the island of Fernando Po (West, 1992, pp. 110–111). At first, it was used in expensive chocolate drinks, mainly confined to aristocratic courts. From Spain, it spread to Italy, and then to France via the royal marriage of Philip III's daughter, Ana of Austria, with Louis XIII. In England,

Samuel Pepys, the renowned seventeenth century diarist, records that chocolate drinks changed from being novelty drinks to a regular luncheon beverage of the middle class during his lifetime (McLeod, 2001).

The Spanish held a monopoly on production and trade of cacao up until the seventeenth century when the French began cacao production in Martinique and Saint Lucia. The Dutch also began production of cacao in Indonesia, which was the Dutch East Indies at the time. Even today, as shown by Panel A of Table 3, Indonesia remains one of the largest producers of cacao beans. Cacao cultivation came late to mainland Africa, with Cameroon and Ghana being the first cultivators in the late 1870s and 1880s (West, 1992, pp. 116–18). But today, the West African countries of Cameroon, Cote d'Ivoire, Ghana, and Nigeria are among the world's largest producers of cacao beans, with Cote d'Ivoire being the largest producer in the world (again, see Panel A of Table 3).

While chocolate is most popularly consumed as a condiment, candy or dessert, cacao is also a high energy food known for lifting psychological effects. Pure chocolate, which is more than half cocoa butter, has a higher energy output per unit of weight than most other carbohydrate- or protein-rich foods. This has made it an important food for physically taxing expeditions where travelers needed to minimize the food carried. For example, in Roald Amundsen's trek to the South Pole, his men were allocated 4,560 calories per day, of which over 1,000 came from cacao (West, 1992, pp. 117–18).

Plain Vanilla

Vanilla was completely unknown to the Old World prior to 1492, but despite having little nutritional importance, it has become so widespread and so common that in English its name is used as an adjective to refer to anything that is "plain, ordinary, or conventional." Vanilla comes from the tropical forests of eastern and southern Mexico, Central America, and northern South America. It is from the fruit of *Vanilla planifolia*, the only species of the orchid family that produces edible fruit. Neither the vanilla flower nor its fruit, which takes the shape of a long pod, naturally has any noticeable flavor or scent. Vanilla pods must be fermented to produce the chemical compound vanillin, which gives the pods their distinctive vanilla flavor and scent (Rain, 1992, p. 37).

It is unclear whether vanilla was first brought back to Spain by Cortes or another Spanish traveler. In any case, it achieved popularity quickly in Spain, where factories were using it to flavor chocolate by the second half of the sixteenth century. Like chocolate, it was considered a luxury for the wealthy. King Phillip II was known to have drunk vanilla-flavored chocolate as a nightcap. It was also quickly adopted by aristocratic circles in other parts of Europe. Queen Elizabeth I of England was also known to have been a frequent user of vanilla products (Rain, 1992, p. 40).

In the eighteenth century, the French began to use it widely as a flavoring for confectionaries and ice, and also as a scent for perfumes and tobacco. French colonial islands began to attempt to systematically cultivate cuttings of the plant taken from the Americas. However, because of a lack of proper insects for pollination,

Table 3
Largest Producers of New and Old World Foods
(millions of tonnes unless otherwise indicated)

Panel A: Ten Largest Producers of New World Foods

Potatoes		*Chili Peppers, Dry*		*Chili Peppers, Green*	
Country	*Production*	*Country*	*Production*	*Country*	*Production*
China	**66.32**	**India**	**0.98**	**China**	**9.44**
Russia	**33.98**	**China**	**0.21**	Mexico	1.73
India	**24.71**	**Pakistan**	**0.17**	**Turkey**	**1.48**
Poland	**24.23**	**Bangladesh**	**0.14**	**Spain**	**0.95**
United States	23.30	**Ethiopia**	**0.12**	United States	0.91
Ukraine	**19.84**	**Viet Nam**	**0.08**	**Indonesia**	**0.73**
Germany	**13.69**	Peru	0.06	**Nigeria**	**0.72**
Belarus	**8.72**	Mexico	0.06	**Egypt**	**0.43**
Netherlands	**8.23**	**Myanmar**	**0.05**	**South Korea**	**0.39**
UK	**6.64**	**Nigeria**	**0.05**	**Italy**	**0.36**
Tomatoes		*Cacao Beans*		*Tobacco*	
Country	*Production*	*Country*	*Production*	*Country*	*Production*
China	**22.32**	**Côte d'Ivoire**	**1.40**	**China**	**2.56**
United States	11.56	**Ghana**	**0.44**	**Brazil**	**0.58**
Turkey	**8.89**	**Indonesia**	**0.42**	**India**	**0.52**
Italy	**7.54**	**Nigeria**	**0.34**	United States	0.48
India	**7.43**	Brazil	0.20	**Zimbabwe**	**0.23**
Egypt	**6.79**	**Cameroon**	**0.12**	**Turkey**	**0.20**
Spain	**3.77**	Ecuador	0.10	**Indonesia**	**0.15**
Iran	**3.19**	**Malaysia**	**0.07**	**Greece**	**0.14**
Brazil	2.98	**Papua New Guinea**	**0.05**	**Italy**	**0.13**
Mexico	2.67	Colombia	0.04	Argentina	0.11
Vanilla (1,000s tonnes)		*Natural Rubber*		*Maize*	
Country	*Production*	*Country*	*Production*	*Country*	*Production*
Indonesia	**1.68**	**Thailand**	**2.38**	United States	251.85
Madagascar	**0.88**	**Indonesia**	**1.50**	**China**	**106.18**
China	**0.65**	**Malaysia**	**0.93**	Brazil	31.88
Mexico	0.26	**India**	**0.63**	Mexico	17.56
Comoros	**0.14**	**China**	**0.48**	Argentina	16.78
Tonga	**0.13**	**Viet Nam**	**0.29**	**France**	**16.02**
Turkey	**0.10**	**Côte d'Ivoire**	**0.12**	**India**	**12.04**
Uganda	**0.04**	**Nigeria**	**0.11**	**South Africa**	**11.43**
French Polynesia	**0.04**	**Liberia**	**0.11**	**Italy**	**10.14**
Réunion	**0.03**	Brazil	0.09	**Indonesia**	**9.68**

initial attempts ended in failure (Bruman, 1948, pp. 371–72). It was not until after 1836, when Belgian botanist Charles Morren was able to hand-pollinate vanilla orchids, that the French were successfully cultivating plants that flowered (Morren, 1838). As shown in Panel A of Table 3, the French colonial islands of Réunion and

Table 3 (continued)

Panel B: Ten Largest Producers of Old World Foods

Sugar Cane		*Coffee (Green)*		*Soybeans*	
Country	*Production*	*Country*	*Production*	*Country*	*Production*
Brazil	**327.70**	**Brazil**	**1.90**	**United States**	**75.06**
India	299.23	Viet Nam	0.80	**Brazil**	**32.73**
China	69.30	**Colombia**	**0.64**	**Argentina**	**20.14**
Thailand	54.05	Indonesia	0.55	China	15.41
Pakistan	46.33	Côte d'Ivoire	0.38	India	5.28
Mexico	**44.10**	**Mexico**	**0.34**	**Paraguay**	**2.98**
Australia	38.16	**Guatemala**	**0.31**	**Canada**	**2.70**
Cuba	**36.40**	India	0.29	**Bolivia**	**1.20**
Colombia	**33.40**	Ethiopia	0.23	Indonesia	1.02
United States	**32.76**	**Honduras**	**0.19**	Italy	0.90

Oranges		*Bananas*	
Country	*Production*	*Country*	*Production*
Brazil	**21.33**	India	14.14
United States	**11.79**	**Ecuador**	**6.48**
Mexico	**3.81**	**Brazil**	**5.66**
India	2.67	China	5.14
Spain	2.62	Philippines	4.93
Italy	1.88	Indonesia	3.75
Iran	1.84	**Costa Rica**	**2.18**
Egypt	1.61	**Mexico**	**1.86**
Pakistan	1.33	Thailand	1.75
China	1.18	**Colombia**	**1.61**

Source: Data are from the FAO's ProdSTAT Database.
Notes: The table reports the ten countries that are the largest producers of Old World and New World food crops. Bold text indicates an Old World country producing a New World food crop, or a New World country producing a Old World food crop. All production figures are in millions of tonnes for the year 2000, except for Vanilla which are reported in thousands of tonnes.

French Polynesia and the former colonial island of Comoros continue to be large suppliers of vanilla today. Mexico also continues to be a large producer of vanilla, although its production is exceeded by Indonesia, Madagascar, and China.

Tobacco

It is believed that Native Americans began to use tobacco around the first century BCE. There is no evidence that Native Americans ever consumed tobacco recreationally. It was instead used as a hallucinogen during religious ceremonies and as a painkiller. Ramon Pane, a monk who accompanied Columbus on his second voyage, gave lengthy descriptions about the custom of smoking tobacco. He described how natives inhaled smoke through a Y-shaped tube. The two ends were placed in the nostrils and the third end over a pastille of burning leaves. Although the exact manner of smoking differed between regions within the

Americas, the practice of smoking tobacco appears to have been universal (Penn, 1901, pp. 5–11).

Tobacco was quickly adopted by Europeans. At first tobacco was regarded and consumed only as a medicine. In 1560, the French ambassador to Portugal, Jean Nicot de Villemain (from whom the term "nicotine" originates), proclaimed that tobacco had a panacea of medicinal properties. In 1561, Nicot sent tobacco leaves to Catherine de Medici, the Queen of France. She was so impressed with the plant that she decreed that tobacco be called Herba Regina (the Queen's Herb). In England, tobacco was first introduced by Sir John Hawkins and his crew in the 1580s. It was chiefly used by sailors, including those employed by Sir Francis Drake. By the beginning of the seventeenth century, tobacco had spread to all parts of Europe (Brooks, 1952, p. 16).

Besides being consumed, tobacco has also been used as currency at various times. In 1619, the Virginia legislature rated high-quality tobacco at three shillings per pound and in 1642 made it legal tender (Henry, 1894, p. 64; Scharf, 1879, p. 220). In Maryland, nearly all business transactions, including debts, fines, and fees, were conducted in terms of tobacco. For example, fees for marriage licenses were paid in tobacco, and laws imposed fines measured in pounds of tobacco (Scharf, 1879, pp. 37–38, 48). In 1776, during the American Revolutionary War, the revolutionary government of America used tobacco as collateral for part of its loans from France. Tobacco's use as currency was not isolated to the American colonies. In Japan, Buddhist monks used tobacco seeds as a method of payment along their long pilgrimages (Brooks, 1952, p. 34).

In the twentieth century, tobacco consumption began to increase dramatically around the time of World War I, when cigarettes were commonly called "soldier's smoke." Beginning in the 1950s, medical researchers began to discover negative health effects from smoking. In 1964, the U.S. Surgeon General published a report on the health consequences of smoking titled *Smoking and Health* (Cochran, Farber, Frieser, Furth, Hickman, Le Maistre, Schuman, Seevers, Bayne-Jones, and Burdette, 1964). This report was an important stimulus for the extensive antismoking campaigns that developed over the next four decades. Although smoking rates have declined in developed countries, tobacco consumption continues to rise in many less-developed countries (Jha, 1999, pp. 13–20). As an example, in China between 1992 and 1996 alone, per capita cigarette consumption increased by 50 percent, from 10 to 15 cigarettes per day. According to the World Health Organization, tobacco is currently the leading cause of preventable death (Mackay, Eriksen, and Shafey, 2006). It is estimated that one in every ten adult deaths is due to tobacco consumption. Driven by the rising rates of smoking in developing countries, this figure is expected to worsen to one in every six adults within the next two decades (Jha, 1999, p. 22).

Coca

Coca leaves are grown from bushes native to the Andes. The leaves contain alkaloids that can be extracted to produce commercial cocaine. The use of coca leaves has a long history. During the Incan Empire, they were chewed during

religious rituals. Early Spanish settlers adopted this practice and brought it back to Europe. Many notable figures, such as Sigmund Freud, became regular users and active proponents of its ability to increase creativity and stamina, and decrease hunger. Freud supposedly began using it after hearing of the Belgian army's experiments in giving coca extracts to its soldiers, who performed better on less food over longer periods of time. The most famous legal use of coca is undoubtedly with the soft drink Coca-Cola, which initially contained marinated coca leaves. The soft drink was invented by Atlanta pharmacist Jon Pemberton as a stimulating beverage that served as a substitute for alcohol at a time when the sale of alcohol was illegal in Atlanta (Hobhouse, 2005, pp. 310–13).

Today, cocaine is one of the most highly traded illegal substances in the world. Although the consumption of cocaine has spread to all corners of the globe, only three New World countries—Colombia, Peru, and Bolivia—produce the world's supply of coca leaves. In 2008, Colombia produced 62 percent, Peru produced 28 percent, and Bolivia produced 10 percent of the world's supply (U.N. Office on Drugs and Crime, 2008, p. 70). The coca industry accounts for a significant portion of income in these countries. It is estimated that the coca leaf by itself accounts for 2.3 percent of Bolivia's GDP, and 16 percent of its total agricultural production (U.N. Office on Drugs and Crime, 2008, p. 233). In Colombia, a country with a much larger economy, the analogous numbers are smaller, but still significant: 0.5 and 5 percent (U.N. Office on Drugs and Crime, 2009, p. 6).

Improved Cultivation of Old World Foods in the New World

After Columbus' voyages to the Americas, it was soon discovered that certain Old World crops were very well-suited to New World climates. In many cases, the Old World crops were grown much more productively in the New World soils and climates than they were grown back home. Table 1 indicates in italics Old World crops that today have more than 26 percent of their total production in the New World. We choose a 26 percent cut-off because this is the fraction of arable land located in the Americas. Therefore, the table highlights Old World crops for which a disproportionate share of output (normalized by arable land) is produced in the New World. Because the Americas have 16 percent of the world's population, on a per capita basis as well, these foods are disproportionately produced in the Americas.

The fact that Old World crops flourished in the New World, and New World crops flourished in the Old, is not just coincidence. It is, in part, the result of two aspects of the Columbian Exchange. First, both the New World and the Old World contain continents that lie on a North–South orientation and span nearly all degrees of latitude. Because climates change most drastically as one moves North–South, rather than East–West, this helped to ensure that New World plants could find an Old World climate similar to their native climate and vice versa. Second, a benefit also arose from the two regions being isolated for thousands of years. The isolation caused separate evolutions of plants, parasites, and pests. Therefore, transplanted

crops often flourished because they were able to escape the pests and parasites that had coevolved with them in their native habitat. Because of the greater prevalence of pests and parasites in tropical regions, tropical plants benefited most from being transplanted (Dean, 1987, pp. 59–60). This benefit partially explains why today 57 percent of the production of coffee (which originated in the Old World) is produced in the New World, and why 98 percent of natural rubber is produced in the Old World from transplanted rubber trees originally from the New World. Numerous other examples of transplanted crops exist. For example, the Americas currently produce 84 percent of the world's soybeans, 65 percent of its oranges, and 35 percent of its bananas.

Sugar Cane

The most striking example of an Old World crop that could be much more effectively cultivated in the New World is sugar cane. Most of the world's land suitable for sugar cultivation lies in the Americas, particularly in Latin America and the Caribbean. Sugar cane was first carried to the New World (from the Spanish Canary Islands) on Columbus' second voyage in 1493 and was first cultivated in Spanish Santo Domingo (Dominican Republic). By 1509, enslaved Africans were being imported to the island, and by 1516, sugar was being exported to Europe. Soon after, the Portuguese also brought sugar cane across the Atlantic, and by 1526, sugar was being exported from Brazil to Lisbon (Mintz, 1985, pp. 32–33). Beginning in the last two decades of the sixteenth century, the interests of the Dutch, English, and French also turned to sugar production. Between 1630 and 1660, the Dutch, English, and French began to found their own sugar colonies. The climate in the Americas provided such an advantage to New World sugar producers that by 1680, sugar cane production was dominated by the New World (Galloway, 2005, pp. 78–83).

One consequence of the large-scale production of sugar in the Americas was that, for the first time in human history, there was a large enough supply of the commodity that it could be consumed by the commoner in Europe. In England, the annual per capita consumption of sugar increased by 20-fold between 1663 and 1775, and it increased a further five-fold between 1835 and 1935 (Sheridan, 1974, p. 21, Burnett, 1966, p. 274). Sugar, providing a cheap and easy source of calories for the growing urban working class in Europe, was first consumed in tea and other hot drinks. During the nineteenth century, sugar consumption further increased as processed foods—such as jams, cakes and biscuits, canned vegetables and fruits, relishes, and white bread—became more common (Galloway, 2005, pp. 6–9).

It is hard to overstate the importance of sugar for the European masses. Hersh and Voth (2009) estimate that the increase in sugar availability between 1600 and 1850 increased English welfare by an amazing 8 percent. Anthropologist Sidney Mintz (1985, p. 180) even goes so far as to put forth a hypothesis about the importance of sugar for creating an industrial working class in the United Kingdom. He writes that sugar, "by provisioning, sating—and, indeed, drugging—farm and factory workers, sharply reduced the overall cost of creating and reproducing the metropolitan proletariat."

Today, as shown in Panel B of Table 3, Brazil is the world's largest supplier of sugar cane. Other New World countries that are also top producers include Mexico, Cuba, Colombia, and the United States. Global production of sugar cane in 2000 was 1,252 million tonnes. Of this, 45 percent was produced in the Americas, with Latin America and the Caribbean accounting for 94 percent of the New World production.

Indirect Consequences of the Columbian Exchange

Quinine: The New World's "Gift" to Europe's Old World Colonies

Quinine, an important medicinal "gift" from the New World, had significant consequences for the relationship between Europe and its tropical Old World colonies, particularly its African colonies. Quinine and related anti-malarial alkaloids (quinidine, cinchonine, cinchonidine) are derived from the bark of cinchona trees native to the Andes. The trees grow in scattered clumps in the eastern mountainous forests of Colombia, Ecuador, Peru, and Bolivia between 10 degrees north and 20 degrees south at elevations between 800 to 3,400 meters (Brockway, 1979, p. 108). Quinine was the first effective treatment of malaria caused by *Plasmodium falciparum*, the protozoan parasite that is transmitted between mammals by the female *Anopheles* mosquito. Quinine works by inhibiting plasmodium reproduction.

The use of quinine as a prophylactic was first discovered in 1841 by Dr. Thomas R. H. Thomson; the findings were later published in *The Lancet* (Thomson, 1846). The British government, amidst the expansion of its empire into many malaria-ridden regions, and seeing the potential benefits of quinine, encouraged the Royal Society to research the properties of quinine and explore the possibilities of farming it outside of the Andes. In 1858, the British Botanical Gardens (headed by Kew Gardens, London) began the "cinchona transfer project" that aimed to ensure a stable, adequate, and cost-effective quinine supply to the colonizers of the British Empire by buying, stealing, bribing, and smuggling cinchona plants and seeds out of the Andes to London and colonial gardens in Ceylon and India (Brockway, 1979, pp. 115–17). The British were successful in transferring plants to Kew Gardens in London, Calcutta, and the Nilgiri Hills of India. Within decades, production was also expanded to Singapore and Dutch Java. Estimates suggest that by 1880, enough was produced to supply ten million people with a daily dose (Hobhouse, 2005, p. 28).

The exact importance of quinine's use as an anti-malarial alkaloid is still being established by historians, but the evidence suggests that it was an important "tool of empire" and significantly enhanced Europe's ability to colonize tropical regions of the globe. Although debated (for example, by Etemad, 2007), the traditional historiography recognizes quinine as having facilitated European survival in malaria-ridden regions during the age of exploration and colonial expansion (Headrick, 1981). The standard view is that Europe's colonization of Africa would have been virtually impossible without quinine. Curtin (1961, p. 110) notes that "between 1819 to 1836 the average annual death rate per thousand mean strength

of European troops on the West African coast was 483 for enlisted men, and 209 for officers. Between 1881 and 1897 the annual average death rate for officials was 76 in the Gold Coast and 53 in Lagos. . . . since there were no further medical reforms between the 1850's and the 1880's comparable to quinine prophylaxis or the abolition of dangerous treatments, it is fair to assume that the medical reforms of the 1840's reduced European mortality on shore by at least half and perhaps more." Curtin concludes that "the history of tropical Africa would certainly have been very different if European mortality had continued at the old rate."

Rubber in the Heart of Darkness

Natural rubber is made from latex, which is produced when certain plants are cut or punctured. Although rubber can be made from many different plants from around the world, the only commercially viable rubber plants are the *Hevea* rubber tree from Central and South America, and a wild vine that grows in West-Central Africa.

Historically, Africans made little use of rubber, except as an adhesive to fasten spearheads and arrowheads to their shafts (Loadman, 2005, p. 139). Native Americans, on the other hand, had developed methods to prevent the latex from decaying, which was accomplished by smoking the latex over fires to form spools of usable crude rubber. The rubber was used to create a wide range of items that were of central importance in their daily lives: hoods, boots, tents, balls, torches, jars, containers, syringes, toys, breastplates, rubber-headed drum sticks, and adhesives (Brockway, 1979, pp. 144–45).

Europeans did not recognize the benefits of rubber until 1770, when French naturalist Charles Marie de La Condamine noticed its use by Amazon natives. The first commercial use of rubber was in the production of shoes, primarily from New England, in the early nineteenth century. However, the real boom for the rubber industry did not occur until the process of "vulcanization" was discovered. This process includes heating the rubber and combining it with other chemicals to produce a more stable product with a wider range of uses (Hobhouse, 2003, pp. 127–30).

Between 1851 and 1881 the world production of rubber increased from 2,500 to 20,000 tons annually (Hobhouse, 2003, p. 129). This boom, although significant, was modest compared to what was to come. The following three decades witnessed an explosion in the demand for rubber. Hobhouse (p. 130) describes the rubber boom, which lasted from 1880 to 1910, writing that "rubber became the most important, most market-sensitive, most sought-after new commodity in the world." The rising demand for rubber was first driven by the rise of electricity, since rubber was used as an insulator. The demand was also fed by the need for rubber to produce rubber tires for bicycles, and later for motorcycles and cars.

During this period, rubber production increased rapidly, doubling every three to five years (Hobhouse, 2003, pp. 130–37). This was accomplished, in part, by an increase in supply from tropical regions outside of the Americas. In 1876, 70,000 *Hevea* rubber tree seeds were taken from Amazonia to Kew Botanical Gardens in Ceylon and Singapore by Sir Henry Wickham (Loadman, 2005,

pp. 81–107). This was the genesis of the rubber industry that now exists in all of Asia. (The current domination of the rubber industry by Asian countries is evident in Panel A of Table 3—the top six producers of natural rubber are all Asian countries.) A second supplier of rubber during the period, one which became the most notorious example of European exploitation in sub-Saharan Africa, was the Congo region of West Central Africa. Here grew the only other indigenous plants that were able to provide commercially viable sources of natural rubber. Between 1900 and 1908, during the height of the boom, between 4,500 and 6,000 tons of rubber were exported each year from the Congo Free State.

The atrocities and human costs that were suffered in the production of rubber are well known and well documented (for example, Hothschild, 1998). In attempts to force natives to gather rubber, villages were burnt, groups were massacred, and hostages were taken, who were then typically starved and physically disfigured. The population of the Congo is estimated to have been about 25 million prior the rubber boom, in the 1880s. In 1911, after the peak of the boom, the population was 8.5 million, and in 1923 after the completion of the boom, it was 7.7 million. If one compares the population losses relative to the production of rubber, an astonishing conclusion is reached: an individual was "lost" from the Congo for every ten kilograms of rubber exported (Loadman, 2005, pp. 140–41).

Forced and Voluntary Migrations to the Americas

Between the sixteenth to nineteenth centuries, over twelve million Africans were shipped to the Americas during the transatlantic slave trade, the largest involuntary migration in human history (Lovejoy, 2000; Manning, 1990; Nunn, 2008b). The trade was fueled by the high demand for labor in the Americas, which was driven, at least in part, by two aspects of the Columbian Exchange: The first was the spread of Old World diseases to Native Americans, which resulted in extremely low population densities in the New World. The second was the cultivation of highly prized Old World crops, such as sugar and coffee, which were particularly well-suited to New World soils and climates.

The forced movement of African slaves to the Americas reached its height in the eighteenth century. In the nineteenth century, the flow of slaves slowed, first as a result of the British Slave Trade Act of 1807 that banned imports of slaves into British colonies, and later because of the British Slavery Abolition Act of 1837, which abolished any use of slave labor within the British colonies.

In response to the abolition of the slave trade, many employers resorted to bonded labor contracts as a way to obtain a continued supply of cheap labor. Most of the migration occurred between Europe's Old and New World colonies. Caribbean plantations provided the main demand for laborers from French Indochina and the British colonies in Asia. For example, over half a million indentured laborers were moved from the Indian subcontinent to the British Caribbean during the nineteenth century and the beginning of the twentieth century (Williams, 1962, p. 100). China, after its forced opening to the West upon losing the Opium Wars (in 1842 and 1860), provided another important source of indentured labor. Employers

of these "coolies" included guano pits, cotton and sugar industries in Peru, sugar cane fields in Cuba (following the abolition of slavery in 1886), and railways in the United States and British Columbia (Campbell, 1923).

Although most indentured laborers entered servitude voluntarily, many parallels can be drawn between the harsh conditions of slavery and those faced by the indentured laborers (Northrop, 1995, pp. 4–10). For example, many would die on the voyage to the Americas, where crowded conditions and malnutrition made the laborers vulnerable to disease (for example, Castro de Mendoza, 1989, p. 45). And like slaves who were denied the rights of ordinary citizens, indentured laborers were often denied the right to naturalize and obtain citizenship after their contracts were over.

The nineteenth and twentieth centuries also witnessed a dramatic increase in voluntary migrations from the Old World. Between 1851 and 1924 alone, 45 million people migrated from the Old World to the Americas, with the majority, 34 million, choosing to migrate to the United States. Those that migrated to Latin America primarily went to Argentina and Brazil. Between 1850 and 1940, 7 million went to Argentina and 4.5 million to Brazil (Crosby, 2003, pp. 214–15).

A recent data construction effort by Putterman and Weil (2009) provides comprehensive estimates of the magnitudes of post-1492 population flows from the Old World to the New World. The authors construct a matrix showing the share of a country's current population (in 2000) whose ancestors were originally from other countries of the world. Using this matrix, we are able to calculate, for the 27 New World countries in their sample, the share of their current populations originally from the Old World. These figures are reported in the first column of Table 4.[3] The share ranges from 26 percent for Guatemala, to 100 percent for the New World island economics of Haiti, Jamaica, and Trinidad and Tobago. In the second and third columns of the table, we further disaggregate the Old World category, reporting explicitly the population shares from Africa and from Europe. (The remaining share, not reported, is for Asia and Oceania.) For many countries, most of their current population is from either Africa (for example, 98 percent for Haiti) or Europe (for example, 91 percent for Uruguay or 84 percent for Argentina).

Concluding Thoughts

The aim of this paper has been to provide a historical overview of the Columbian Exchange, with a particular emphasis on aspects of the exchange that have generally been neglected by economists. The New World provided soils that were very suitable for the cultivation of a variety of Old World products, like sugar and coffee. The increased supply lowered the prices of these products

[3] For all of the fine details, including data sources and calculation procedures, see Putterman and Weil (2009), as well as their online appendices, which are available at ⟨http://www.econ.brown.edu/fac/Louis_Putterman/world%20migration%20matrix.htm⟩.

Table 4
Origins of New World Populations

	Share of population in 2000 that is of:		
Country	*Old World origin*	*African origin*	*European origin*
Haiti	1.00	0.98	0.02
Jamaica	1.00	0.89	0.08
Trinidad and Tobago	1.00	0.46	0.07
Cuba	0.98	0.34	0.63
Canada	0.97	0.02	0.76
Dominican Republic	0.96	0.44	0.52
Uruguay	0.96	0.04	0.91
Guyana	0.95	0.39	0.00
Argentina	0.95	0.02	0.84
Brazil	0.91	0.16	0.19
United States	0.90	0.10	0.68
Puerto Rico	0.82	0.16	0.66
Costa Rica	0.70	0.09	0.60
Venezuela	0.69	0.14	0.55
Panama	0.64	0.13	0.45
Colombia	0.63	0.17	0.46
Chile	0.63	0.01	0.59
Belize	0.61	0.17	0.40
Nicaragua	0.60	0.09	0.51
Paraguay	0.54	0.01	0.52
El Salvador	0.50	0.00	0.50
Honduras	0.48	0.02	0.46
Ecuador	0.39	0.07	0.32
Mexico	0.38	0.07	0.30
Peru	0.36	0.06	0.28
Bolivia	0.28	0.01	0.27
Guatemala	0.26	0.04	0.22

Source: Data are from Louis Putterman and David Weil's World Migration Matrix, 1500–2000 Version 1.1. ⟨http://www.econ.brown.edu/fac/Louis_Putterman/world%20migration%20matrix.htm⟩.
Note: The table shows the proportion of the population of New World Countries in 2000 that were descendents of individuals living in the Old World, Africa, and Europe in 1500. See Putterman and Weil (2009) for full details.

significantly, making them affordable to the general population for the first time in history. The production of these products also resulted in large inflows of profits back to Europe, which some have argued fueled the Industrial Revolution and the rise of Europe (Inikori, 2002; Acemoglu, Johnson, and Robinson, 2005). The Old World also gained access to new crops that were widely adopted. Potatoes were embraced by the Irish and the eastern European societies, chili peppers by the cultures of South and Southeast Asia, tomatoes by Italy and other Mediterranean societies, and tobacco by all nations of the world.

The exchange also had some extremely negative impacts. Native American populations were decimated by Old World diseases. This depopulation along

with the production of valuable Old World crops like sugar cane and coffee then fueled the demand for labor that gave rise to the transatlantic slave trade. The result was the forced movement of over twelve million slaves from Africa to the Americas and devastating political, social, and economic consequences for the African continent. Following the slave trade, the African continent was divided and brought under European colonial rule, an event that some have argued would have been impossible without the discovery of quinine in the New World. Moreover, the knowledge of how to harvest and process rubber, learned from natives of the Andes, had particularly regrettable consequences for those in Africa's Congo region.

Our hope is that this broad overview will spur further research examining the neglected aspects of the exchange. One interesting question that is particularly relevant for the exchange is the effect that diseases had on domestic institutions, social structures, and development generally. The recent book by Mann (2005) argues that the New World was much more politically, economically, and technologically developed than scholars have presumed, and one reason for this mischaracterization is the large negative impacts Old World diseases had on New World societies.

The study by Hersh and Voth (2009) provides estimates of English welfare gains from the increased supply of sugar and coffee that arose after the discovery of New World virgin soils. Their study makes one wonder about the welfare gains that arose from the introduction of various New World crops. For example, what were the welfare gains from tomatoes in Italy, maize in Lesotho, chili peppers in Asia, or cassava in West-Central Africa? Another interesting avenue of research is to exploit the introduction of new food crops to examine the effects of agricultural productivity and health on paths of development. Our findings in Nunn and Qian (2009) suggest that the improvement in agricultural productivity from the introduction of potatoes had significant effects on historic population growth and urbanization. This raises the natural question of whether the adoption of potatoes brought any additional effects. For example, how did the introduction of the new food crop affect health outcomes? Given the evidence that the introduction of potatoes eased population pressures and increased incomes, it is natural to ask whether the adoption of potatoes had any effect on conflict or warfare. If so, how did this in turn affect state formation and subsequent institutional development?

These examples provide a small sample of the many questions that one could investigate to further our understanding of the effects of the Columbian Exchange. These questions lie in virgin soils, waiting to be explored.

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