Virgin Soils Revisited

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THE decimation of American Indian populations that followed European arrival in the Americas was one of the most shocking demographic events of the last millennium. Indian populations declined by as much as 95 percent in the first century after the arrival of Christopher Columbus, prompting one historian to conclude that "early America was a catastrophe—a horror story, not an epic."[1] This collapse established the foundation for the subsequent social and political developments of American history. Since the earliest encounters of colonization, colonists and their descendants have struggled to explain how and why depopulation occurred. They have debated the role of race, politics, and even genocide. All have concluded that infectious diseases, introduced by Europeans and Africans, played a decisive role. American Indians suffered terrible mortality from smallpox, measles, tuberculosis, and many other diseases. Their susceptibility led to American Indian decline even as European populations thrived.

Discussions of the epidemiological vulnerability of American Indians rose to prominence with the work of William McNeill and Alfred W. Crosby in the 1970s. Both argued that the depopulation of the Americas was the inevitable result of contact between disease-experienced Old World populations and the "virgin" populations of the Americas. As Crosby defined them in 1976, "Virgin soil epidemics are those in which the populations at risk have had no previous contact with the diseases that strike them and are therefore immunologically almost

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[1] John M. Murrin, "Beneficiaries of Catastrophe: The English Colonies in America," in Eric Foner, ed., *The New American History*, rev. ed. (Philadelphia, 1997), 4.

defenseless." His theory provided a powerful explanation for the outcomes of encounter between Europeans and indigenous groups, not just in the Americas but throughout the world. Since Crosby's analysis of virgin soil epidemics appeared in the *William and Mary Quarterly,* countless writers have cited his definition and attributed the devastation of American Indian populations to their immunologic inadequacy. As argued in Jared Diamond's Pulitzer Prize-winning *Guns, Germs, and Steel,* "The main killers were Old World germs to which Indians had never been exposed, and against which they therefore had neither immune nor genetic resistance." Such assertions, which apply the intuitive appeal of natural selection to the demographic history of the Americas, dominate academic and popular discussions of depopulation.[2]

Even as Crosby's model of virgin soil epidemics remains a central theme of the historiography of the Americas, it has been misunderstood and misrepresented. Crosby actually downplayed the "genetic weakness hypothesis" and instead emphasized the many environmental factors that might have contributed to American Indian susceptibility to Old World diseases, including lack of childhood exposure, malnutrition, and the social chaos generated by European colonization.[3] Subsequent historians, however, have often reduced the complexity of Crosby's model to vague claims that American Indians had "no immunity" to the new epidemics. These claims obscure crucial distinctions between different mechanisms that might have left American Indians vulnerable. Did American Indians lack specific genes that made Europeans and Africans, after generations of natural selection, more resistant to smallpox and tuberculosis? Did they lack antibodies that their Eurasian counterparts acquired during childhood exposure to endemic infections? Were their immune systems compromised by the malnutrition, exhaustion, and stress created by European colonization? These different explanations, blurred within simple claims of no immunity, have very different implications for our understanding of what was responsible for this demographic catastrophe.

It is now possible to revisit the theory of virgin soil epidemics and reassess the many possible causes of American Indian susceptibility to European pathogens.[4] The confusion can be untangled by surveying and

[2] Crosby, "Virgin Soil Epidemics as a Factor in the Aboriginal Depopulation in America," *William and Mary Quarterly,* 3d Ser., 33 (1976), 289; Diamond, *Guns, Germs, and Steel: The Fates of Human Societies* (New York, 1997), 211–12.

[3] Crosby, "Virgin Soil Epidemics," 292.

[4] For a challenge of another aspect of virgin soil theory, the assumption that new epidemics caused Indian cultures and religions to wither as quickly as Indian bodies, see Paul Kelton, "Avoiding the Smallpox Spirits: Colonial Epidemics and Southeastern Indian Survival," *Ethnohistory,* 50 (Fall 2003).

resynthesizing diverse research about Indian depopulation. A review of the literature of colonization shows the prevalence of simplistic assertions of no immunity and their possible ideological appeals. It also demonstrates the importance of defining the specific claims contained within the theory of virgin soil epidemics and evaluating each of them separately. Recent immunological research has clarified the different mechanisms that can compromise human immunity. Parallel work by biological anthropologists, archaeologists, and historians has elucidated the details of the mortality of specific Indian populations. Taken together, this work suggests that although Indians' lack of prior exposure might have left them vulnerable to European pathogens, the specific contribution of such genetic or developmental factors is probably unknowable. In contrast, the analyses clearly show that the fates of individual populations depended on contingent factors of their physical, economic, social, and political environments. It could well be that the epidemics among American Indians, despite their unusual severity, were caused by the same forces of poverty, social stress, and environmental vulnerability that cause epidemics in all other times and places. These new understandings of the mechanisms of depopulation require historians to be extremely careful in their writing about American Indian epidemics. If they attribute depopulation to irresistible genetic and microbial forces, they risk being interpreted as supporting racial theories of historical development. Instead, they must acknowledge the ways in which multiple factors, especially social forces and human agency, shaped the epidemics of encounter and colonization.

Even a cursory survey of the literature on encounter and colonization reveals countless claims that American Indians died because they lacked immunity to Old World pathogens. The "epidemiologically pristine" Indians were "immunologically naïve."[5] With "no immunity," they were "biologically defenseless."[6] As a result, they fell victim to "the

[5] William A. Starna, "The Biological Encounter: Disease and the Ideological Domain," *American Indian Quarterly,* 16 (1992), 513; Arthur E. Spiess and Bruce D. Spiess, "New England Pandemic of 1616–1622: Cause and Archaeological Implication," *Man in the Northeast,* 34 (1987), 77.

[6] David E. Stannard, "Disease and Infertility: A New Look at the Demographic Collapse of Native Populations in the Wake of Western Contact," *Journal of American Studies,* 24 (1990), 329, 346. Scores of similar accounts exist. Here is a partial listing since 1990: Colin G. Calloway, *New Worlds for All: Indians, Europeans, and the Remaking of Early America* (Baltimore, 1997), 33; Paul H. Carlson, *The Plains Indians* (College Station, Tex., 1998), 8; James H. Cassedy, *Medicine in America: A Short History* (Baltimore, 1991), 5; A. D. Cliff, P. Haggett, and M. R. Smallman-Raynor, "Island Populations: The Virgin Soil Question," in *Island Epidemics* (Oxford, 2000), 120; Lawrence I. Conrad et al., *The Western Medical Tradition: 800 B.C.-A.D. 1800* (Cambridge, 1995), 225–26, 474, 486; Noble David Cook and W. George Lovell, eds., *"Secret Judgments of God": Old World Disease in Colonial Spanish*

greatest known demographic catastrophe in the history of the world."[7] Spaniards and other Europeans, meanwhile, had "almost universal immunity" to the diseases that devastated American populations.[8] Such assertions of American Indian immunological inadequacy appear in books and articles devoted to Indian population history, in histories that discuss depopulation in passing, and in surveys or other works intended for general audiences. These assertions of no immunity leave readers to guess whether the susceptibility arose from genetic handicaps, from lack of exposure to diseases as children, or from detrimental effects of colonization. Writers who ignore these crucial distinctions dodge the question of historical responsibility.

Some writers distinguish between inherited and acquired immunity, only to suggest that Indians lacked both.[9] Other writers discount the

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America (Norman, Okla., 1991), xv; Francis Jennings, *The Founders of America: How Indians Discovered the Land, Pioneered in It, and Created Great Classical Civilizations; How They Were Plunged into a Dark Age by Invasion and Conquest, and How They Are Reviving* (New York, 1993), 383; Charles C. Mann, "1491," *Atlantic Monthly* (Mar. 2002), 43; Adrienne Mayor, "The Nessus Shirt in the New World: Smallpox Blankets in History and Legend," *Journal of American Folklore,* 108 (Winter 1995), 58; Murrin, "Beneficiaries of Catastrophe," 7; Linda A. Newson, "Old World Epidemics in Early Colonial Ecuador," in Cook and Lovell, eds., *"Secret Judgments of God,"* 88; Gregory H. Nobles, *American Frontiers: Cultural Encounters and Continental Conquest* (New York, 1997), 41; Mary Beth Norton et al., *A People and a Nation: A History of the United States,* brief ed., vol. A: *To 1877,* 4th ed. (Boston, 1996), 18; John Steckley, "Developing a Theory of Smallpox: Huron Perceptions of a New Disease," *Arch Notes,* 90 (Jan.-Feb. 1990), 17; Ian K. Steele, *Warpaths: Invasions of North America* (New York, 1994), 22; Rebecca Storey, *Life and Death in the Ancient City of Teotihuacan: A Modern Paleodemographic Synthesis* (Tuscaloosa, Ala., 1992), 43; Ronald Takaki, "The Tempest in the Wilderness: The Racialization of Savagery," *Journal of American History,* 79 (1992), 907; Alan Taylor, *American Colonies* (New York, 2001), 42; Patrick Tierney, *Darkness in El Dorado: How Scientists and Journalists Devastated the Amazon* (New York, 2000), 56; Daniel H. Usner, Jr., *Indians, Settlers, and Slaves in a Frontier Exchange Economy: The Lower Mississippi Valley before 1783* (Chapel Hill, 1992), 16; Richard White, "Western History," in Foner, ed., *New American History,* 208; Edwin Williamson, *The Penguin History of Latin America* (New York, 1992), 13, 84–85; and Ronald Wright, *Stolen Continents: The Americas Through Indian Eyes Since 1492* (Boston, 1992), 13–14.

[7] Murrin, "Beneficiaries of Catastrophe," 7.

[8] Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, Conn., 1972), 57. See also William H. McNeill, *Plagues and Peoples* (New York, 1977), 184; Neal Salisbury, "The Indians' Old World: Native Americans and the Coming of Europeans," *WMQ,* 3d Ser., 53 (1996), 458; and David S. Landes, *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor* (New York, 1998), 169.

[9] Jerry H. Bentley, *Old World Encounters: Cross-Cultural Contacts and Exchanges in Pre-Modern Times* (New York, 1993), 183; Robert Boyd, *The Coming of the Spirit of Pestilence: Introduced Infectious Diseases and Population Decline among Northwest Coast Indians, 1774–1874* (Seattle, 1999), 17; White, *The Middle Ground: Indians, Empires, and Republics in the Great Lakes Region, 1650–1815* (Cambridge, 1991), 41.

contribution of genetic factors and instead emphasize the vulnerability that resulted from lack of prior exposure. William Cronon, for instance, notes that "what the Indians lacked was not so much genetic protection from Eurasian disease—though this may have been a partial factor—as the historical experience as a population to maintain *acquired* immunities from generation to generation."[10] Many historians also acknowledge that the social chaos of encounter (such as famine, overcrowding, warfare, stress) left American Indians vulnerable. Colin Calloway describes how epidemics "cut down economic productivity, generating hunger and famine, which rendered those who survived one disease more vulnerable to affliction by the next. New diseases combined with falling birth rates, escalating warfare, alcoholism, and general social upheaval to turn Indian America into a graveyard."[11] Amid this jumbled mix of explanations of American Indian demise, few provide substantial evidence to back up what are essentially intuitive assertions about Indian immunity. Even fewer attempt to evaluate the relative contributions of different factors.

All too often this ambiguity produces stark emphasis on powerful and inevitable forces of natural selection. In such explanations, the absence of natural selection by serious pathogens in precontact America left the "genetically-virgin" American Indians vulnerable to Old World pathogens. Crosby, after emphasizing environmental causes of Indian depopulation, later described how thousands of years of disease exposure in Eurasia had created an Old World "superman" with "an impressive assortment of genetic and acquired adaptations to diseases anciently endemic to Old World civilizations." According to Francis Jennings, American Indians never had a chance: "If there is any truth to biological distinctions between the great racial stocks of mankind, the Europeans' capacity to resist certain diseases made them superior, in the pure Darwinian sense, to the Indians who succumbed." Richard White

[10] Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York, 1983), 85. See also James Axtell, *Beyond 1492: Encounters in Colonial North America* (New York, 1992), 105; Elizabeth A. Fenn, *Pox Americana: The Great Smallpox Epidemic of 1775–82* (New York, 2001), 23, 27; Karen Ordahl Kupperman, *Indians and English: Facing Off in Early America* (Ithaca, 2000), 34; McNeill, *Plagues and Peoples,* 3–4, 8, 184–85; and Russell Thornton, *American Indian Holocaust and Survival: A Population History Since 1492* (Norman, Okla., 1987), 47.

[11] Calloway, *New Worlds for All,* 37. See also Cook, *Born to Die: Disease and New World Conquest, 1492–1650* (Cambridge, 1998), 166–67; Cronon, *Changes in the Land,* 88; Newson, "Highland-Lowland Contrasts in the Impact of Old World Diseases in Early Colonial Ecuador," *Social Science and Medicine,* 36 (1993), 1194; Stannard, "Disease and Infertility," 341, 346–47, 349; Taylor, *American Colonies,* 38–39; Michael K. Trimble, "The 1837–1838 Smallpox Epidemic on the Upper Missouri," in Douglas W. Owsley and Richard L. Jantz, eds., *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence,* (Washington, D. C., 1994), 82–87; and White, *Middle Ground,* 41.

agrees: New World populations "had not been selected over time for resistance to such diseases."[12] Similar claims of inevitability appear throughout the historical literature. Diseases "careened unchecked through the 'virgin soil' populations."[13] European and African microbes "acquired an inevitable momentum that quickly made human motivation all but irrelevant."[14] American Indians were "doomed to die."[15]

One final case demonstrates the pervasive nature of such immunological determinism: Jared Diamond's *Guns, Germs, and Steel.* Diamond sought to answer a deceptively simple question: "Why did history unfold differently on different continents?" How did Europeans come to assert dominion over the rest of the world? Diamond knew that this quest would take him across treacherous ground: "In case this question immediately makes you shudder at the thought that you are about to read a racist treatise, you aren't: as you will see, the answers to the question don't involve human racial differences at all."[16] This turns out not to be the case.

Diamond asks his readers to join him in turning back the clock to 11,000 B. C. Nothing then could have predicted European success. However, "different rates of development on different continents" produced "technological and political inequalities" by A. D. 1500. Diamond attributes these different rates to one simple fact: while the dominant geographic axes of Africa and the Americas run north-south, the dominant axis of Eurasia runs east-west. "Around those axes turned the fortunes of history." The east-west orientation of Eurasia allowed the dissemination of crops, animals, and technologies of food production. The whole continent became one giant pool of genetic and cultural sharing. Latitudinal gradients and geographic obstacles blocked such exchange in the Americas. The more rapid development of surplus food production in Eurasia fueled craft specialists, technologies, bureaucracies, standing armies, fleets, exploration, and conquest. The dense settlements and domesticated animals of Eurasian agriculture also exposed people to animal microbes and facilitated the emergence of epidemic diseases. The initial cost of those infections produced a lasting benefit:

[12] J. S. Cummins, "Pox and Paranoia in Renaissance Europe," *History Today,* 38 (Aug. 1988), 28; Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (Cambridge, 1986), 34; Jennings, *The Invasion of America: Indians, Colonialism, and the Cant of Conquest* (Chapel Hill, 1975), 22; White, *Middle Ground,* 41.

[13] Axtell, *The Invasion Within: The Contest of Cultures in Colonial North America* (New York, 1985), 96. See also Mayor, "Nessus Shirt," 74–75n19, and Steele, *Warpaths,* 84.

[14] Murrin, "Beneficiaries of Catastrophe," 5.

[15] In both Calloway, *New Worlds for All,* 33, and White, *Middle Ground,* 41.

[16] Diamond, *Guns, Germs, and Steel,* 9.

"Those humans then evolved substantial resistance to the new diseases." Americans, who never became "one huge breeding ground for microbes," did not. The result of European arrival in the Americas was predestined: "When such partly immune people came into contact with others who had had no previous exposures to the germs, epidemics resulted in which up to 99 percent of the previously unexposed population was killed."[17]

According to Diamond, all of history thus followed from geography. Time and time again he emphasizes that race had nothing to do with it: "History followed different courses for different peoples because of differences among peoples' environments, not because of biological differences among peoples themselves."[18] The many blurbs that adorn editions of *Guns, Germs, and Steel* similarly highlight the antiracist contribution of Diamond's work. Paul Ehrlich believes that "the book demolishes the grounds for racist theories of history." Crosby agrees: Diamond "has done us all a great favor by supplying a rock-solid alternative to the racist answer." Published reviews of *Guns, Germs, and Steel* follow these leads.[19] Yet despite this praise, the book asserted a theory grounded in supposed racial differences between Americans and Europeans.[20] Though Diamond acknowledges that all groups of humans might have been immunologically similar in 11,000 B. C., he argued that they were very different by A. D. 1500. When Spanish conquistador

[17] Ibid., 16, 92, 191, 212. See also Taylor, *American Colonies,* 30–31, 41–42.

[18] Diamond, *Guns, Germs, and Steel,* 25.

[19] Ibid., back cover of 1997 edition (Ehrlich), leading page of 1999 edition (Crosby). Of more than 40 reviews of *Guns, Germs, and Steel* examined, nearly all praised Diamond for providing an alternative to racist theories of world history. For representative examples, see Sharon Begley, "Location, Location . . . A Real-Estate View of History's Winners and Losers," *Newsweek,* 129 (June 16, 1997), 47; Thomas M. Disch, "A Crescendo of Inductive Logic," *New Leader,* 80 (Mar. 10, 1997), 19–20; "Geographical Determinism," *The Economist,* 344 (July 19, 1997), R4-R5; review of *Guns, Germs, and Steel,* in *New Yorker,* 73 (Mar. 31, 1997), 101; and Colin Renfrew, "Human Destinies and Ultimate Causes," *Nature,* 386 (Mar. 27, 1997), 339–40.

[20] Other critical reviews have not addressed this point. For examples, see James M. Blaut, "Environmentalism and Eurocentrism," *Geographical Review,* 89 (July 1999), 391–408 (focused on geographic determinism); Brian Ferguson, review of *Guns, Germs, and Steel, American Anthropologist,* 101 (Dec. 1999), 900–01 (Diamond ignores culture, society, politics); and McNeill, "History Upside Down," *New York Review of Books,* 44 (May 15, 1997), 48–50. Three reviewers actually criticize Diamond for downplaying the importance of racial differences: Laurence Hurst, "Sex, War and the Pox," *New Scientist,* 155 (Aug. 30, 1997), 40–41; Mark Ridley, "The Uselessness of Zebras," *TLS: The Times Literary Supplement,* Nov. 14, 1997, 6; and J. Philippe Rushton, review of *Guns, Germs and Steel* in *Population and Environment,* 21 (Sept. 1999), 99–107. Only two reviews comment on Diamond's implicitly racial arguments, and neither recognizes their pervasive presence: Bruce Mazlish, "Big Questions? Big History?" *History and Theory,* 38 (May 1999), 232–48, and Steve Sailer, "Why Nations Conquer," *National Review,* 49 (May 19, 1997), 51–52.

Francisco Pizarro met Inca emperor Atahuallpa at Cajamarca in 1532, the people whom each represented had genetically different immune systems with different susceptibilities. One had immunity to certain diseases, the other did not. What had been contingent facts of geography in 11,000 B. C. had become internalized facts of biology by A. D. 1500. The different histories of Eurasians and Americans, environmental in origin, had become embedded in their immune systems.[21]

Diamond, like so many others who have ignored the complexities of depopulation in favor of the elegance of immunological determinism, provoked scarce outcry from critics. The ability of a racial theory of disease susceptibility to slip unnoticed into Diamond's explicitly antiracist theory of history hints at how deeply embedded such theories are in the stories we tell about post-Columbian America.[22] Why have assertions of no immunity been propagated so uncritically? They have many possible sources of appeal.

One explanation may be that scientific arguments have an unassailable cachet in historical writing that forces historians to downplay or ignore other factors. The theory of immunological vulnerability applies the intuitive authority of natural selection to a challenging historical problem and efficiently explains a decisive episode in human history.[23] Its explanatory power seems like just another of the many accomplishments of twentieth-century biomedicine. After all, nearly every week another team of scientists announces that they have identified yet

[21] Jennings made a similar argument in *Invasion of America,* 22.

[22] The term "race" requires clarification. Careful writers, including McNeill, Diamond, and (but not always) Crosby, avoid the politically charged term by discussing specific historically and geographically defined populations. American Indians at the time of contact, for instance, were a distinct group compared to Europeans and Africans. It is possible to discuss virgin soil epidemics without ever mentioning race. However, many authors (especially in popular forums) discuss race and racial difference as though they were real and self-evident categories. This position has gained support from genetic analyses of human populations that show a "general agreement" between popularly and genetically defined human subpopulations: Noah A. Rosenberg et al., "Genetic Structure of Human Populations," *Science,* 298 (Dec. 20, 2002), 2381–85. Such work has re-energized controversies about the relevance of race as a salient category in medical science: Richard S. Cooper, Jay S. Kaufman, and Ryk Ward, "Race and Genomics," *New England Journal of Medicine,* 348 (Mar. 20, 2003), 1166–70; Esteban Gonzàlez Burchard et al., "The Importance of Race and Ethnic Background in Biomedical Research and Clinical Practice," ibid., 1170–75. Casual use of race, however, introduces unneeded political baggage into debates about human health and disease, confusing an already complicated picture. I avoid race, racial, or racist as much as possible except where those terms are introduced by my sources.

[23] For a similar argument, see Francis J. Brooks, "Revising the Conquest of Mexico: Smallpox, Sources, and Populations," *Journal of Interdisciplinary History,* 24 (Summer 1993), 9–10.

another gene that increases a person's risk for a specific disease. But cachet cannot explain everything. Crosby's 1976 article, as well as subsequent research in the anthropology of depopulation, all describe the diversity of factors, biological and social, that contributed to depopulation. Moreover, many historians are suspicious of scientific claims of authority, and most are enamored of complexity and contingency. Deference to scientific explanations does not account for the appeal of "no immunity" in historical writing.

No immunity could have appealed to historians for historiographical reasons: it undermined dominant theories of academic history in the 1960s. According to the analyses of Fernand Braudel, Eric Hobsbawm, and many others, economic determinism ruled human affairs. In response, historians in the 1970s sought alternative historical forces. Some found the environment, others found disease, especially the ravages of epidemics among nonimmune populations. Epidemics appealed to McNeill for exactly the same reason that they repelled earlier historians: diseases, "independent of human intention," "spoiled the web of interpretation and explanation through which their art sought to make human experience intelligible." Following this lead, recent historians have turned to epidemic history as an alternative to traditional world histories dominated by Euroamericans. Disease, seeming to act "independent of human agency," not only scoured indigenous populations, but also provided powerful resistance to colonizing armies and exacted a high toll from colonizers.[24]

At the same time, McNeill, Crosby, and other historians utilized virgin soil theory to turn this appeal on its head. If, at first glimpse, epidemics seemed to defy historical causation, then no immunity restored causation and meaning. The depopulation of the Americas was no random event. Instead, the epidemics occurred because of specific and understandable historical forces: different diseases and resistances had evolved in long-isolated populations. When Europeans and Americans came together, in a contingent but inevitable encounter, widespread epidemics were the logical outcome. Theories of no immunity allowed Diamond and the others to fit epidemics into grand narratives of historical evolution.

Perhaps the idea that Indian depopulation can be explained by the Indians' lack of immunity took hold because it served an ideological

[24] McNeill, *Plagues and Peoples,* 196. For epidemics as an alternative to Euroamerican agency, see Terence Ranger, "To Fiji with Measles," *London Review of Books,* 21 (Feb. 4, 1999), 30. For similar arguments by environmental historians, see Donald Worster, "Transformations of the Earth: Toward an Agroecological Perspective in History," *JAH,* 76 (1990), 1088, 1090. For political debates within environmental history, see the discussions by Worster, Crosby, White, Carolyn Merchant, Cronon, and Stephen J. Pyne in *JAH,* 76 (1990), 1087–1147.

purpose. White physicians in South Africa, for instance, used virgin soil theory to explain the prevalence of tuberculosis among African mine workers. Randall Packard has argued that "virgin soil theory appears to have been accepted more for its instrumentality than for its basis in historical fact." By blaming the disease on biological inadequacies of Africans, the theory "provided defenders of the status quo in South Africa with a means of deflecting attention from the appalling conditions under which Africans lived and worked."[25] Historians do not share the politics of the South African physicians or use virgin soil theories as a justification for either Euroamerican hegemony or current disparities in health status between American Indians and the general population. Instead, the theories are used to explain an event long since past. But since this historic event, the depopulation of the Americas, had such profound implications and retains political currency, it should not be surprising that theories of immunological determinism in the American context also have "instrumentality," deflecting attention away from moral and political questions.

For example, many authors who promote claims of no immunity castigate Europeans for their treatment of American Indians. Yet despite the broader critiques in which these claims are embedded, theories of immunological determinism can still assuage Euroamerican guilt over American Indian depopulation, whether in the conscious motives of historians or in the semiconscious desires of their readers. Despite the five hundred years that separate us from Columbus, many still feel the shock of the Columbian encounter. The power of this guilt transformed the potential celebration of the Columbian Quincentenary into a moment of mourning and self-doubt.[26] No immunity helps by representing depopulation as the inescapable product of historical-immunological forces that had been brewing for millennia. Contact between the populations was inevitable, if not by Columbus then by someone else. Epidemics could not have been prevented. No one should be blamed. As Thomas Sowell describes it, "the unwitting spread of diseases is morally neutral." Such efforts to turn depopulation into a blameless event have provoked fierce outcries from critics. David Stannard argues that "by focusing almost entirely on disease, by displacing responsibility for the mass killing onto an army of invading microbes, contemporary authors increasingly have created the impression that the eradication of those tens of millions of people was inadvertent."[27]

[25] Packard, *White Plague, Black Labor: Tuberculosis and the Political Economy of Health and Disease in South Africa* (Berkeley, 1989), 32.

[26] Rozanne Dunbar Ortiz, "Aboriginal People and Imperialism in the Western Hemisphere," *Monthly Review,* 44 (Sept. 1992), 1–2.

[27] Sowell, *Conquest and Cultures: An International History* (New York, 1998), 327; Stannard, *American Holocaust: Columbus and the Conquest of the New World*

Virgin soil theory, again showing remarkable flexibility, can also be used to mitigate guilt by shifting responsibility for depopulation either onto, or away from, the American Indians. Some historians, such as Crosby, list behavioral factors that increased the Indians' vulnerability to European pathogens, citing everything from ignorance of contagion to sweat baths, fatalism, and suicide. If the mortality caused by virgin soil epidemics can be traced to unwise Indian behaviors, then Europeans (and their descendants) are less culpable. But the theory also has appeal for an opposite reason. Immunological determinism has been used as an argument against supposed failures of American Indian culture. Historians had long credited the easy conquests by Hernán Cortès and Pizarro to superior European military technology, strategy, and leadership. In such traditional histories, ignorant and gullible Aztecs and Incas never stood a chance. But by emphasizing the power of epidemics, historians can make an opposite claim. The Aztecs and Incas, both powerful and sophisticated societies, would have been formidable adversaries had they not been devastated by the irresistible power of smallpox. As Karen Kupperman argues, "It was really European diseases and not superior European technology which defeated the Indians in the early years." But by emphasizing no immunity to divert blame from American Indian cultures and institutions, these well-meaning theorists transfer responsibility to American Indian bodies.[28]

Theories of immunological determinism also resonate with familiar narratives. While historical writers do not explicitly endorse these older myths, the virgin soil stories they tell unintentionally perpetuate powerful narrative patterns. First, they tell a story of purity infiltrated and destroyed by corruption. They portray American Indians as a pristine population ruined by diseased Europeans. Indians' ancestors, so the story goes, survived the arctic wastes of the Bering Sea and Canadian tundra. They were purified, not by fire, but by ice. When they settled the Americas, they were a disease-free population moving into an Edenic paradise. This purity, which allowed the nondevelopment of their immune systems, left them vulnerable to the diseases of urban Europeans and tropical Africans. Although they were doomed, they were at least doomed by purity. Meanwhile, the fact that Europeans had been so diseased for so long became their greatest source of strength.[29]

(New York, 1992), xii. However, Stannard himself cited Hawaiians' nonimmunity as a contributing factor to their decline in the 19th century. Stannard, "Disease and Infertility," 325–50.

[28] Crosby, "Virgin Soil Epidemics," 296–99; Kupperman, *Settling With the Indians: The Meeting of English and Indian Cultures in America, 1580–1640* (Totowa, N. J., 1980), 5. See also Crosby, *Columbian Exchange,* 48–53, and Diamond, *Guns, Germs, and Steel,* 210–11.

[29] For an example, see Taylor, *American Colonies,* 41–42.

Second, the narrative of a purifying journey presents American Indian vulnerability as the product of their prior triumph over adversity. Their migration from Asia throughout the Americas was a remarkable accomplishment, though with an eventually costly consequence. Similar narratives of susceptibility after surviving adversity are common. Africans, who survived the dangerous environment of the malarial tropics, were left with sickle cell anemia. Descendants of slaves, who survived the rigors of the Middle Passage, were left vulnerable to hypertension.[30]

Third, the theory utilizes narratives of virginity. Some early colonists and historians portrayed America as a "virgin land, or wilderness, inhabited by nonpeople called savages," ripe for settlement by Europeans. Recognition that America had been full of people, the American Indians, forced the abandonment of this myth. Others, initially impressed by the health and skills of the Indians, only came to see the Indians as weak and vulnerable after observing their susceptibility to European diseases. Virgin soil theory combines these older narratives, replacing a virgin, vacant land with a land filled with virgin, vulnerable people. It presents American Indians as weak, defenseless, susceptible, female. It presents Europeans as aggressive, strong, resilient, male. Virgin Indians were helpless before the thrust of European pathogens. Their bodies provided fertile soils for the growth of European seeds. These gendered arguments parallel arguments that American soils provided fertile fields for European crops and animals and that American environments served as fertile lands for transplanted European societies.[31]

Finally, despite the explicit moral and political sympathies of most historians, modern theories of immunological determinism have striking similarities to Puritan theories of providence. Colonial records contain abundant evidence for providential interpretation of American Indian

[30] For a discussion of how African Americans in the 1960s and 1970s reformulated sickle cell anemia as proof of their fitness to their ancestral environment, see Keith Wailoo, *Dying in the City of the Blues: Sickle Cell Anemia and the Politics of Race and Health* (Chapel Hill, 2001), 106, 114–18, 144–47, 182–89. For hypertension and the slave trade, see Thomas W. Wilson and Clarence E. Grim, "Biohistory of Slavery and Blood Pressure Differences in Blacks Today: A Hypothesis," *Hypertension,* 17 (Jan. 1991, supplement), 1–122. For a refutation, see Philip D. Curtin, "The Slavery Hypothesis for Hypertension among African Americans: The Historical Evidence," *American Journal of Public Health,* 82 (1992), 1681–86.

[31] Jennings, *Invasion of America,* 15. For changing European attitudes toward Indians, see Joyce E. Chaplin, *Subject Matter: Technology, the Body, and Science on the Anglo- American Frontier, 1500–1676* (Cambridge, Mass., 2001). For the fertile reception of European plants and animals, see Crosby, *Ecological Imperialism,* and Elinor G. K. Melville, *A Plague of Sheep: Environmental Consequences of the Conquest of Mexico* (Cambridge, 1994).

epidemics, from John Smith ("it seemes God hath provided this Country for our Nation, destroying the natives by the plague") to Cotton Mather ("the woods were almost cleared of those pernicious creatures, to make room for a *better growth*"). Historians often emphasize this one aspect of Puritan responses, portraying theological reactions as perverse indifference to Indian suffering.[32] The implication is that we would have responded with less judgment and more compassion. But assertions that Indians had no immunity to European disease resemble Puritan providentialism, replacing theology with molecular biology. Puritans argued that Indian corruption (paganism) left them vulnerable to the wrath of God, manifested through epidemics. Virgin soil theorists argue that Indian purity (immunological naïveté) left them vulnerable to contact with Europeans, again manifested through epidemics. The implications are similar. Both assert that the outcome was inevitable and unstoppable. Both emphasize the inherent inferiority of victims, absolving observers of responsibility for the mortality and of responsibility to intervene.

Although most of the mortality occurred hundreds of years ago, it remains a relevant event: Euroamericans are the beneficiaries of the deaths of tens of millions of American Indians; Africans were enslaved and brought to the Americas to provide labor as Indians died. Virgin soil theory attempts to isolate the present from the horrors of the past by describing American Indian depopulation as the product of a unique immuno-historical moment. But by ignoring the social factors that created disease during the Columbian encounter, the theory makes it easier to ignore those same factors where they operate today.[33]

The theory of virgin soil epidemics, with its multifaceted appeal, emerged gradually over centuries of observation of American Indian epi-

[32] Smith, *Advertisements for the Unexperienced Planters of New England, or Any Where* (1631), in Philip L. Barbour, ed., *The Complete Works of Captain John Smith* (1580–1631), 3 vols. (Chapel Hill, 1986), 3:275; Mather, *Magnalia Christi Americana; or, The Ecclesiastical History of New-England* (1732), 2 vols. (Hartford, 1853), 1:51. For historians' fetish for Puritans' providential responses, see Calloway, ed., *Dawnland Encounters: Indians and Europeans in Northern New England* (Hanover, N. H., 1991), 12; Cronon, *Changes in the Land,* 126; Kupperman, *Settling with the Indians,* 6; and Alden T. Vaughan, *New England Frontier: Puritans and Indians, 1620–1675* (Norman, Okla., 1995; orig. pub. 1965), 104. I discuss the role of such providential explanations in Puritan society in *Rationalizing Epidemics: Meanings and Uses of American Indian Mortality since 1600* (Cambridge, Mass., forthcoming).

[33] This is true for all cases in which social factors generate disparities in health status, as well as the specific case of the few remaining "virgin soil" populations. As late as 1998, experts estimated that 55 groups of isolated South American Indians had yet to encounter Europeans, Africans, and their pathogens; Magdalena Hurtado et al., "The Epidemiology of Infectious Diseases among South American Indians: A Call for Guidelines for Ethical Research," *Current Anthropology,* 42 (2001), 425–32.

demics. Recognition of the demographic catastrophe always generated attempts at explanation. Bartolomé de Las Casas blamed Spanish murder and mayhem: the Spaniards behaved "like ravening beasts, killing, terrorizing, afflicting, torturing, and destroying the native peoples."[34] Thomas Morton credited divine intervention: "The hand of God fell heavily upon them. . . . the place is made so much the more fitt, for the English Nation to inhabit in, and erect in it Temples to the Glory of God." French and Spanish observers, less brazen in their understanding of God's providence, attributed the mortality to "secret, but ever adorable, judgments of God." Disease, such a powerful presence during colonization, dominated their explanations. Morton, for instance, believed that the hand of God did its work by means of "the Plague." Some early colonists suspected that Europeans were the source of these diseases. Hierosme Lalemant observed that where Jesuit missionaries "were most welcome, where we baptized most people, there it was in fact where they died the most."[35] But most blamed the mortality on its victims. Edward Winslow traced "manifold diseases" among the Massachuset to their "living in swamps and other desert places."[36] Moravian missionary John Heckewelder emphasized the "vicious and dissolute life" produced by alcohol.[37] Physician O. M. Chapman cited disregard of the laws of hygiene: Sioux mortality was "the measure of their transgressions."[38]

Behavioral explanations became increasingly implausible in the nineteenth and twentieth centuries. As the demographic collapse continued and American Indians seemed destined for extinction, observers began to question the idea that misbehavior could have been so fatal.

[34] Las Casas, *The Devastation of the Indies: A Brief Account* (1552), trans. Herma Briffault (Baltimore, 1992), 29.

[35] Morton, *New English Canaan* (1632), in Peter Force, ed., *Tracts and Other Papers, Relating Principally to the Origin, Settlement, and Progress of the Colonies of North America* . . . (1836–1847), 4 vols. (New York, 1947), 2:18–19; Lalemant, "Relation of What Occurred in the Mission of the Hurons" (1640), in Reuben Gold Thwaites, ed., *The Jesuit Relations and Allied Documents: Travels and Explorations of the Jesuit Missionaries in New France, 1610–1791,* 73 vols. (Cleveland, 1896–1901), 19:93. Both Lalement and Pedro de Liévano (c. 1577), dean of the Cathedral of Guatemala, used the phrase "secret, but ever adorable, judgements of God." De Liévano, quoted in Lovell, "Disease and Depopulation in Early Colonial Guatemala," in Cook and Lovell, eds., *"Secret Judgments of God,"* 77.

[36] Winslow, *Good Newes from New England* (1624), in Alexander Young, ed., *Chronicles of the Pilgrim Fathers of the Colony of Plymouth, from 1602 to 1625,* 2d ed. (Boston, 1844), 346.

[37] Heckewelder, *History, Manners, and Customs of the Indian Nations Who Once Inhabited Pennsylvania and the Neighbouring States* (1819), (Philadelphia, 1876), 221.

[38] Chapman, physician report, in "Report of Agent for Yankton Agency," in *Annual Reports of the Department of the Interior for . . . 1904. Indian Affairs* . . . (Washington, D. C., 1905), 342.

Seeking a new mechanism to explain the magnitude of the depopulation, historians, physicians, and anthropologists found their solution in theories of racial susceptibility to disease. Observers of public health in the late nineteenth century turned to racial differences to explain patterns of disease, such as why Jews resisted tuberculosis, Chinese immigrants suffered from plague, and African Americans had syphilis.[39] American Indians provided abundant material for such theorizing. A. B. Holder observed of the Crow: "Their resistance to disease is much less than that of the civilized races, I have seen the evidence at the bedside, in watching them yield and die from diseases that I felt sure any stout white man had easily thrown off." Commissioner of Indian Affairs W. A. Jones noted that since the Indians had only recently been exposed to measles and pneumonia, they had "not yet acquired any immunity." Woods Hutchinson found that they provided "a highly susceptible host" for tuberculosis.[40]

Throughout the twentieth century, historians increasingly recognized that indigenous populations in the Americas and around the globe suffered dramatic susceptibility to European diseases. In 1909, Herbert Williams described how "many times new epidemic diseases from Europe have spread over America and have been very fatal to the Indians." Physician George Bushnell found striking parallels between the fates of Indians and other "races nearly 'virgin' so far as tuberculosis is concerned." By 1937, Sherburne Cook could assert that the vulnerability of aboriginal populations worldwide was "a matter of general knowledge."[41] Postwar

[39] Allan M. Brandt, "Racism and Research: The Case of the Tuskegee Syphilis Study," *Hastings Center Report,* 8 (Dec. 1978), 21–29; Alan M. Kraut, *Silent Travelers: Germs, Genes, and the "Immigrant Menace"* (Baltimore, 1994), 78–96, 136–65; Nancy Krieger, "Shades of Difference: Theoretical Underpinnings of the Medical Controversy on Black/White Differences in the United States, 1830–1870," *International Journal of Health Services,* 17 (1987), 259–78; Charles E. Rosenberg, "The Bitter Fruit: Heredity, Disease, and Social Thought in Nineteenth-Century America," *Perspectives in American History,* 8 (1974), 189–235.

[40] Holder, "Papers on Diseases among Indians," *Medical Record,* 42 (Aug. 13, 1892), 178; Jones, "Report of the Commissioner of Indian Affairs," in *Annual Reports of the Department of the Interior for . . . 1904,* 36; Hutchinson, "Varieties of Tuberculosis According to Race and Social Condition," *National Association for the Study and Prevention of Tuberculosis: Transactions of the Annual Meeting,* 3 (1907), 199.

[41] Williams, "The Epidemic of the Indians of New England, 1616–1620, with Remarks on Native American Infections," *Johns Hopkins Hospital Bulletin,* 20 (1909), 340; Bushnell, *A Study in the Epidemiology of Tuberculosis, With Especial Reference to Tuberculosis of the Tropics and of the Negro Race* (New York, 1920), 35; Cook, *The Extent and Significance of Disease among the Indians of Baja California, 1697–1773* (Berkeley, 1937), 1. At about this time, medical authorities in South Africa were identifying the local Africans as virgin populations; Packard, *White Plague, Black Labor,* 4, 22–23.

authors followed this lead. Henry Dobyns, for instance, described American Indians as "a virgin population of susceptible individuals lacking immunities."[42] Aidan Cockburn gave historians' theories the authority of evolutionary biology, arguing that American Indian decimation was "the typical reaction of a 'herd' to a pathogen not previously experienced."[43]

The assumption that natural selection had left Europeans with inherited resistance to many diseases, and American Indians without it, was eminently plausible. In the 1950s and 1960s, evolutionary biologists and population geneticists modeled the differential survival of individuals whose genes conferred benefits in specific environments. As Cockburn described, "Infection with a pathogen reduces the survival capacity of the host, and all other factors being equal, the host with the most resistance is the one most likely to survive. If this resistance is inherited, then natural selection can be expected to produce a population more and more resistant to the prevalent pathogens."[44] The protective benefit of sickle cell trait against malaria became a centerpiece of the burgeoning field of evolutionary genetics.[45]

Such theories found logical application in the fate of American Indians. Centuries of smallpox, measles, and plague seemed certain to have selected European populations that carried resistance genes. American Indians, who lived without epidemics, would have lacked these protections. Their unprecedented mortality, from Aztecs to Alaskans, seemed to prove the theory. Bruce Trigger could describe American Indian depopulation as a "cruel and fantastic example of natural selection." However, initial studies of virgin soil populations found that their immune systems worked normally. In 1968, geneticist James Neel studied the first outbreak of measles among isolated Yanomami populations in Venezuela and Brazil. Although mortality rates were high, he found no evidence of innate Indian susceptibility to measles.[46]

[42] Dobyns, "An Outline of Andean Epidemic History to 1720," *Bulletin of the History of Medicine,* 37 (1963), 494. For similar claims, see C. H. Haring, *The Spanish Empire in America* (New York, 1947), 43, and John Duffy, "Smallpox and the Indians in the American Colonies," *Bulletin of the History of Medicine,* 25 (July-Aug. 1951), 327.

[43] Cockburn, "The Evolution of Infectious Diseases," in Cockburn, ed., *Infectious Diseases: Their Evolution and Eradication* (Springfield, Ill., 1967), 90.

[44] Ibid., 104. McNeill echoed this: see *Plagues and Peoples,* 272n3.

[45] This connection served many agendas, from the desire of molecular biologists and population geneticists to make contributions to medicine, to the needs of the growing black identity movement; Wailoo, *Dying in the City of the Blues,* 106, 114–18, 144–47, 182–89.

[46] Trigger, "Comments," on Dobyns, "Estimating Aboriginal American Population: An Appraisal of Techniques with a New Hemispheric Estimate," *Current Anthropology,* 7 (Oct. 1966), 440; Neel et al., "Notes on the Effects of

The discrepancy between the intuitive appeal of natural selection and the preliminary studies of virgin populations left historians in a difficult position. These tensions appear clearly in Crosby's 1976 article, which articulated the modern form of the theory of virgin soil epidemics. Crosby's opening assertion that lack of prior exposure left American Indians "immunologically almost defenseless" and the Darwinian tone of his other work jarred with the article's concluding emphasis on environmental causes of Indian susceptibility: "The scientific community inclines towards the view that Native Americans have no special susceptibility to Old World diseases that cannot be attributed to environmental influences, and probably never did have."[47] Furthermore, although Crosby could list a wide range of factors that might have contributed to no immunity, he could not substantiate his intuitive claims or evaluate the relative contribution of different factors. As a result, Crosby's work has been cited as both proof of immunological weakness and as evidence against it.[48]

Since 1976, however, historians, archaeologists, biological anthropologists, and medical scientists have generated a vast amount of relevant new data. It is now possible for historians to update the popular, if confused, virgin soil theory and produce a more precise and powerful model of American Indian depopulation. This effort must begin by disentangling the theory's different components. As defined by Crosby, virgin soil theory makes four basic claims. The first three are descriptive: many American Indians died, they died of European diseases, and they had not been previously exposed to those diseases. The last is an argument of cause and effect: virginity left them vulnerable. Each claim must be assessed individually.

Much of the difficulty that historians have had with explanations of depopulation arises from the unprecedented magnitude of the event. The earliest records of colonization show that massive mortality began quickly

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Measles and Measles Vaccine in a Virgin-Soil Population of South American Indians," *American Journal of Epidemiology,* 91 (1970), 418–29. For debates about Neel's role in these epidemics, see Tierney, *Darkness in El Dorado,* 53–82, and "Perspectives on Tierney's *Darkness in El Dorado,*" *Current Anthropology,* 42 (Apr. 2001), 265–76.

[47] Crosby, "Virgin Soil Epidemics," 291. In other writings on depopulation, Crosby emphasized the lack of immunity without discussing contributing social factors: *Columbian Exchange,* 39, 52, 57; "'God . . . Would Destroy Them, and Give Their Country to Another People . . . ,'" *American Heritage,* 29 (Oct./Nov. 1978), 39.

[48] Crosby as the authority on immunological determinism: Fenn, *Pox Americana,* 25–26; Kupperman, *Indians and English,* 34; Salisbury, "Indians' Old World," 458; White, "Western History," 208. Crosby as the authority on social disruption: Axtell, *Beyond 1492,* 237; Chaplin, *Subject Matter,* 158; Calvin Martin, *Keepers of the Game: Indian-Animal Relationships and the Fur Trade* (Berkeley, 1978), 49–50.

among American Indians. The Arawak of Santo Domingo bore the first assault, with their population falling from as many as 3,770,000 in 1496 to 125 in 1570.[49] Every new encounter brought new epidemics. Disease spread along existing Indian trade routes and moved even more quickly than the conquistadors. Smallpox, introduced to Mexico by Cortès, reached the Incan empire before Pizarro. This process continued for centuries. In the seventeenth century, epidemics followed the French into New France and the English into New England. As settlers moved across North America in the eighteenth and nineteenth centuries, tribe after tribe experienced outbreaks. Hawaiians, spared extensive contact until the nineteenth century, saw their population decline from possibly 800,000 in 1778 to 40,000 in 1885. As recently as the 1940s and 1960s, new highways and new missionaries brought new diseases to previously isolated tribes from Alaska to Amazonia.[50]

Colonists, stunned by the decimation they observed, attempted to estimate the magnitude of the mortality. Daniel Gookin interviewed surviving Massachuset and estimated that 90 percent had died. Cotton Mather asserted that the "prodigious pestilence . . . carried away not a *tenth,* but *nine parts* of *ten,* (yea, 'tis said, *nineteen* of *twenty*) among them."[51] Systematic efforts to measure Indian populations began in the nineteenth century. An 1877 report to the Commissioner of Indian Affairs struggled to determine whether or not American Indians were doomed to extinction.[52] In the 1930s, A. L. Kroeber compiled estimates of Indian populations at the time of first contact with Europeans. He calculated a total population of 8.4 million for the western hemisphere, with only 900,000 living in North America. After World War II, Woodrow Borah, Sherburne Cook, and Henry Dobyns revisited this estimate. They argued that Kroeber ignored the disease-induced decline that occurred between European arrival in the Americas and their contact with each tribe. Estimating this loss at over 95 percent, Dobyns pro-

[49] Cook, *Born to Die,* 22–23; Newson, "Indian Population Patterns in Colonial Spanish America," *Latin American Research Review,* 20 (1985), 46. Taylor provides a lower, but still severe, estimate of initial population and subsequent mortality, 300,000; Taylor, *American Colonies,* 38.

[50] Stannard, "Disease and Infertility," 325–50 (Hawaii); McNeill, *Plagues and Peoples,* 171 (Alaska); Neel et al., "Notes on the Effects of Measles," 418–29 (Amazonia).

[51] Gookin, *Historical Collections of the Indians in New England; of Their Several Nations, Numbers, Customs, Manners, Religion and Government, before the English Planted There* (c. 1680) (Leicester, Mass., 1970; orig. pub. 1792), 9–12; Mather, *Magnalia Christi Americana,* 1:51.

[52] S. N. Clark, "Are the Indians Dying Out? Preliminary Observations Relating to Indian Civilization and Education," in *Annual Report of the Commissioner of Indian Affairs to the Secretary of the Interior for the Year 1877* (Washington, D. C., 1877), 487–520.

posed a precontact population of 112 million for the hemisphere and 18 million for North America.[53] Efforts by archaeologists and paleopathologists to resolve this debate have only narrowed the range for North America to between 2 and 12 million, and enormous problems exist with all of the estimates. With estimates of hemispheric population ranging between 8 and 112 million, estimates of total mortality range between 7 and 100 million. Die-off ratios (pre- vs. postcontact population) range between 2:1 and 50:1.[54] Whatever the exact numbers, the mortality was unprecedented and overwhelming.

Ambiguities about the pace of mortality, the role of epidemics, and the identity of epidemics further cloud the issue. The bulk of the mortality occurred in the first century after sustained contact (the sixteenth century in Central and South America; the seventeenth to nineteenth centuries in North America and the Pacific islands). Though catastrophic, 90 or even 95 percent mortality could have resulted from a subtle imbalance in births and deaths that led to a 2–3 percent annual decline.[55] While this might have happened in some areas, other areas clearly suffered dramatic collapse. Las Casas described how the population of Santo Domingo plummeted precipitously after Spanish arrival. John Smith, who sailed the New England coast in 1614, found it "well inhabited with a goodly, strong and well proportioned people." Five years later, Thomas Dermer found only "some antient Plantations, not long since populous now utterly void."[56] Similar accounts of rapid and severe

[53] The disparate estimates reflect different assumptions about the nature of American Indian life. Low estimates assume that precontact disease, unsophisticated social arrangements, and limited exploitation of ecological potential kept populations low. High estimates assume little precontact disease, limited warfare, high fertility, and full utilization of the ecological potential of American environments; European epidemics wiped out 95% of these populations before European censuses. See Michael H. Crawford, *The Origins of Native Americans: Evidence from Anthropological Genetics* (Cambridge, 1998), 33–39; Dobyns, "Estimating Aboriginal American Population," 395–416; Dobyns, *Their Number Become Thinned: Native American Population Dynamics in Eastern North America* (Knoxville, 1983); David Henige, *Numbers from Nowhere: The American Indian Contact Population Debate* (Norman, Okla., 1998); Ann F. Ramenofsky, *Vectors of Death: The Archaeology of European Contact* (Albuquerque, 1987), 1–21; and Douglas H. Ubelaker, "Patterns of Demographic Change in the Americas," *Human Biology,* 64 (June 1992), 361–79.

[54] Newson, "Indian Population Patterns," 41–74; Stannard, "Disease and Infertility," 325–26; Dean R. Snow, "Microchronology and Demographic Evidence Relating to the Size of Pre-Columbian North American Indian Populations," *Science,* 268 (16 June 1995), 1601–04; Taylor, *American Colonies,* 40.

[55] For a population of initial size P_0 and a growth rate of r, the population at time t can be calculated simply: $P=P_0e^{rt}$ To find the rate needed to produce 90% loss over 100 years, rearrange the equation and solve for r to get a rate of 2.3%.

[56] Las Casas, *Devastation of the Indies,* 29–31; Smith, *A Description of New England . . .* (1616), in Barbour, ed., *Complete Works of Captain John Smith,* 1:330; Dermer to Samuel Purchas, 1619, in Purchas, ed., *Hakluytus Posthumus, or Purchas His*

mortality emerged time and time again, from the "destroying angel" of smallpox in 1837 that converted the North American interior "into desolate and boundless cemeteries," to epidemics of measles, whooping cough, and meningitis in Alaska in 1942 and 1943.[57]

Though epidemics did bring rapid decimation to many groups, they did not monopolize the mortality. Europeans and Americans killed countless American Indians through war, starvation, neglect, and even hunting. Some commentators have accused Columbus of introducing four centuries of genocide.[58] However, with account after account describing appalling epidemics from Quebec to Peru, it is impossible not to assign a dominant role to infectious diseases. In some cases, diseases struck populations weakened by the chaos of colonization. In others, they spread by trade or with isolated missionaries, wreaking havoc on seemingly intact Indian groups. As Diamond argues, "Their destruction was accomplished largely by germs alone."[59]

Because of the importance of these epidemics, physicians and historians have long struggled to diagnose each epidemic. Colonists often identified the outbreaks as fevers, plague, or smallpox. Modern researchers have exhaustively reviewed these descriptions to establish specific diagnoses, with varying success.[60] Whatever the exact pathogens, many of the diseases arrived in the Americas with the Europeans (or, as has recently been suggested, with the Chinese): American Indians, from the Huron to the Maya, claimed to have had little disease before European arrival.[61] Some historians have used these claims and selected

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Pilgrimes (1625), 20 vols. (Glasgow, 1906), 19:129. Empty villages did not necessarily mean dead Indians: they might have withdrawn from the coast as part of their normal seasonal migrations, in response to the epidemics, or in response to the threat posed by Europeans.

[57] Quoted in H. Evans Lloyd, preface to Maximilian, Prince of Wied, *Travels in the Interior of North America,* in Reuben Gold Thwaites, ed., *Early Western Travels, 1748–1846,* 32 vols. (Cleveland, 1904–1906), 22:33. For Alaska, see McNeill, *Plagues and Peoples,* 181.

[58] For genocide, see Thornton, *American Indian Holocaust and Survival;* Ortiz, "Aboriginal People and Imperialism," 1–13; Stannard, *American Holocaust;* and Ward Churchill, *Indians Are Us? Culture and Genocide in Native North America* (Toronto, 1994), 11–63. For hunting Indians, see Lee Miller, ed., *From the Heart: Voices of the American Indian* (New York, 1995), 306.

[59] Diamond, *Guns, Germs, and Steel,* 373–74. See also Calloway, *New Worlds for All,* 33; Dobyns, "Estimating Aboriginal American Population," 413–14; and McNeill, *Plagues and Peoples,* 180–81.

[60] For these debates, see Timothy L. Bratton, "The Identity of the New England Indian Epidemic of 1616–19," *Bulletin of the History of Medicine,* 62 (Fall 1988), 351–83; Spiess and Spiess, "New England Pandemic," 71–83; and Williams, "Epidemic of the Indians of New England," 340–49.

[61] For Mayan claims, see the account of Chilam Balam of Chumayel, quoted in Crosby, *Columbian Exchange,* 36. For Huron claims, see Paul le Jeune, "Relation of

paleopathological evidence to assert that American Indians lived in a "disease free paradise."[62] This paradise may even have been of the Indians' making. James Shreeve argues that American Indians doomed themselves when they hunted the large mammals of North America to extinction: "If those first Native Americans had been less adept hunters, their descendants might have been able to domesticate the indigenous American horse and camel, providing them with an invisible arsenal of microbes of their own when Columbus made his first fateful landing thousands of years later."[63] These notions have been weakened by careful analyses of skeletal remains that have documented the existence of a host of diseases before European arrival. However, American Indians before Columbus do seem to have been spared from the ravages of smallpox, measles, influenza, bubonic plague, diphtheria, typhus, cholera, scarlet fever, whooping cough, and malaria.[64] These new diseases caused considerable mortality.

Despite disagreements over the subtleties of the pace, role, and diagnosis of the epidemics, consensus has long existed that American Indians suffered severe mortality from epidemics caused by newly introduced European pathogens. In this limited sense, American Indians were a virgin soil. Controversy begins with the arguments of cause and effect. Did virginity make Indians vulnerable? Did centuries of isolation from Eurasian pathogens leave them with ill-equipped immune systems? Many writers assert that lack of exposure left American Indians without genetic protections, acquired immunities, or both. These claims merit careful scrutiny.

The exceeding complexity of the human immune system provides a daunting obstacle to historians who want to understand American

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What Occurred in New France in the Year 1637," (1638) in Thwaites, ed., *Jesuit Relations,* 11:193. For the possibility that the Chinese beat the Europeans to America and brought diseases with them, see Gavin Menzies, *1421: The Year China Discovered America* (New York, 2003), 114, 412, and Crawford, *Origins of Native Americans,* 88.

[62] Ortiz, "Aboriginal People and Imperialism," 2. For similar claims, see McNeill, *Plagues and Peoples,* 176; Martin, *Keepers of the Game,* 48–49; and Cronon, *Changes in the Land,* 85.

[63] Shreeve, "Dominance and Submission," *New York Times Book Review,* June 15, 1997, 13. For the Arctic passage, see Cronon, *Changes in the Land,* 85; Storey, *Life and Death in the Ancient City of Teotihuacan,* 42–43; and Taylor, *American Colonies,* 41. For a discussion and critique of the theory, see Crawford, *Origins of Native Americans,* 51–52. For the role of animals and cities, see Cronon, *Changes in the Land,* 85; Diamond, *Guns, Germs, and Steel,* 213; McNeill, *Plagues and Peoples,* 178; Taylor, *American Colonies,* 41; and Williams, "Epidemic of the Indians of New England," 241.

[64] Howard S. Russell, *Indian New England Before the Mayflower* (Hanover, N. H., 1980), 35, 104–05; Stannard, *American Holocaust,* 53; Taylor, *American Colonies,* 41; Ubelaker, "Patterns of Demographic Change," 364.

Indian susceptibility. It is easier to remain above the molecular fray and make simple claims of no immunity. In the years since McNeill and Crosby began emphasizing the importance of disease and immunity in human history, humans (and their immune systems) have faced perhaps the gravest challenge yet: HIV and AIDS. The epidemic has fueled unprecedented research into the structure and function of the immune system, which has produced crucial insights that can help resolve the uncertainties that have confounded earlier discussions of American Indian depopulation.

Human tissues, seen from a microbe's perspective, provide a rich variety of nutrients. Even in health, humans support a fertile ecosystem of microorganisms, with a typical person harboring more bacteria than human cells. Four broad classes of microorganisms can make their home in human tissues. Bacteria, which play a series of useful roles (such as in digestion), cause many infections, from strep throat and pneumonia to cholera, anthrax, and tuberculosis. Viruses range from the nuisance of the common cold to the devastation of polio, smallpox, and HIV. Viral pneumonia and diarrhea remain the leading infectious causes of death worldwide. Fungi, responsible for dandruff and yeast infections, can also cause severe pulmonary and systemic infections. The last group, lumped together as parasites, include the single- and multi-celled organisms responsible for malaria, giardia, and countless other infestations.[65] In the absence of functioning immune systems, human bodies would be overrun with microorganisms.

In response to this challenge, animals developed elaborate systems of surveillance and protection that keep most parts of the body sterile (such as the brain, liver, kidneys, muscles, bones, and blood), and the other parts of the body colonized but healthy (skin, lungs, mouth, stomach, intestines).[66] The skin and other body surfaces provide the first line of defense, with secretions, barriers, and normal colonizing microorganisms that usually prevent dangerous pathogens from entering the body. Once inside the body, microorganisms face an immune system composed of specialized cells and chemicals. The cellular immune system includes lymphocytes (B-lymphocytes make antibodies; T-lymphocytes

[65] Writers sometimes confuse these groups, for example discussing the "smallpox bacillus." See Stannard, *American Holocaust,* 77.

[66] *The New England Journal of Medicine* published a series of review articles on immunology that are accessible to nonexpert, but motivated, readers: Peter J. Delves and Ivan M. Roitt, "The Immune System: First of Two Parts," *N. Eng. J. Medicine,* 343 (July 6, 2000), 37–49; Delves and Roitt, "The Immune System: Second of Two Parts," ibid., 343 (July 13, 2000), 108–17; Ruslan Medzhitov and Charles Janeway, Jr., "Innate Immunity," ibid., 343 (Aug. 3, 2000), 338–44; Rolf M. Zinkernagel, "Maternal Antibodies, Childhood Infections, and Autoimmune Diseases," ibid., 345 (Nov. 1, 2001), 1331–35.

organize immune responses and can kill microbes directly) and phagocytes (cells, such as neutrophils, monocytes, and macrophages, that can ingest and destroy microbes or infected cells). The humoral immune system, so named because its chemical components can be separated from the cellular immune system, includes antibodies (which recognize and label invading microbes), cytokines (which modulate immune responses), and complement (which can identify microbes, modulate responses, and kill microbes directly).

The components interact in many ways. Each human cell produces specific proteins and carbohydrates and ingests others from its environment. Some of these molecules are broken down into small pieces, bound to structures known as the major histocompatibility complex (MHC), and then displayed on the outer surface of the cell, a process known as antigen presentation. Lymphocytes and macrophages travel throughout the body and evaluate the presented antigens. If they detect foreign antigens, they can respond by proliferating, by releasing antibodies or cytokines, or by attacking the microbe directly. Some components of the immune system specialize in detecting and removing intracellular pathogens (viruses and certain bacteria), while other components specialize in dealing with extracellular pathogens (parasites and most other bacteria).

Immune function hinges on the ability to distinguish self from non-self.[67] A body needs an immune system that leaves normal, healthy cells intact, but that recognizes and kills pathogenic bacteria, parasites, and viruses, as well as cells that have been invaded by viruses or intracellular bacteria. The distinction between self and non-self is made by two different mechanisms, which characterize the "innate" and the "adaptive" components of the immune system. Innate (sometimes labeled "natural") immunity is based on the ability of phagocytes, natural killer cells, and complement to recognize a small set of antigens (fragments of proteins, carbohydrates, or nucleic acids) produced only by bacteria or other microorganisms (for example, components of bacterial cell walls and specific forms of bacterial DNA and RNA). This system quickly recognizes and responds to many pathogens regardless of whether they have been encountered before. The adaptive (often confusingly labeled "acquired") immune system, in contrast, is not preprogrammed to respond to pathogens. Instead, through a process of random genetic rearrangements,

[67] Although immunologists treat the distinction of self versus non-self as self-evident, this concept has an interesting historical and philosophical development. See Alfred I. Tauber and Scott H. Podolsky, "Frank Macfarlane Burnet and the Immune Self," *Journal of the History of Biology,* 27 (1994), 531–73. Confusion between self and non-self and an unbalanced immune system contribute to allergies and autoimmune disease. See Stuart E. Turvey, "Atopic Diseases of Childhood," *Current Opinion in Pediatrics,* 13 (Oct. 2001), 487–95.

each lymphocyte generates a different antibody or antigen receptor. An individual's millions of lymphocytes generate an extraordinary diversity of antibodies and receptors that recognize nearly every conceivable antigen (both self and non-self, but a healthy immune system quickly learns to ignore self antigens). This system responds slowly to initial infection with a specific pathogen. On subsequent encounters, however, it responds much more rapidly, potentially preventing symptomatic reinfection.

The technical distinctions between innate and adaptive immunity correlate loosely with the popular distinctions between "genetic" and "acquired" immunity. At some level, both components are genetic. The processes that generate the antibodies of adaptive immunity are encoded in our genes. However, the specific antibodies produced by individuals are not subject to natural selection: every person generates the full diversity of antibodies; the specific antibodies produced by an individual at any moment are purely a function of that individual's prior exposures; and the specific antibodies that are active against relevant pathogens are not passed genetically from one generation to the next (though transient antibody protection is passed from mother to child across the placenta and in breast milk). In contrast, the components of innate immunity are subject to natural selection. An individual whose preprogrammed innate receptors respond more powerfully to local pathogens has a survival advantage. Over time, innate immunity can evolve and achieve a better fit with the local burden of infectious diseases. Other components of the immune system also evolve. Different MHC molecules have different affinities for microbial antigens, affecting how well these antigens are presented to innate and adaptive receptors. Variations in other molecules expressed by macrophages, lymphocytes, or other tissues can change susceptibility to infection. Each of these forms of heritable difference provides substrate for natural selection. Meanwhile, microbes undergo a parallel process of natural selection to evade these evolving defenses.[68]

This emerging model of immune function has many implications for understanding American Indian susceptibility to European pathogens. The frequently stated claims of no immunity, as well as occasional comparisons of American Indians to people with AIDS or other immunodeficiencies, have no substance.[69] With the exception of persons born with rare genetic immune diseases, all humans can mount a power-

[68] Medzhitov and Janeway, "Innate Immunity," 338–39.

[69] For comparisons of American Indians and Hawaiians to people with AIDS or other immunodeficiencies, see Hurtado et al., "Epidemiology of Infectious Diseases," 429; Stannard, "Disease and Infertility," 339; and Tierney, *Darkness in El Dorado,* 56.

ful defense against viruses, bacteria, fungi, and parasites. No one is immunologically defenseless, and authors who make claims of no immunity probably do not mean them this literally. Instead, they presumably mean that Indians' lack of prior exposure to Old World pathogens left them with deficient immunity compared to Europeans. Several possible forms of deficient immunity might have existed. First, American Indians might have lacked specific genes that gave Europeans resistance to specific diseases. Second, they might have had general immunodeficiencies that left them vulnerable to a range of infections. Third, their genetic homogeneity might have left them vulnerable to adaptable pathogens. Fourth, regardless of their state of innate immunity, they might have initially lacked adaptive immunity to Old World diseases. Fifth, they might have suffered from synergistic effects of simultaneous infections. Each different mechanism of impaired immunity must be assessed separately.

Knowledge of the links between genetics and immunity has been transformed in the years since scientists recognized the connection between malaria and sickle cell disease. Geneticists have continued to study the immune responses of isolated human populations. New techniques of molecular biology and epidemiology have identified a range of genetic mechanisms that mediate responses to infectious diseases. Such studies have shown how different versions of a gene (each known as an allele) and the receptors, cytokines, and MHC molecules that they encode can make a host more or less vulnerable to infection. Many gene-disease connections have been proposed.[70] Sickle cell trait, thalassemia (another inherited anemia), G6PD deficiency (an enzyme involved in glucose metabolism), and specific MHC alleles protect Africans, Mediterraneans, and Asians against malaria. The Tay-Sachs mutation, which causes a rapidly progressive neurological disease in children who possess two copies of the gene, granted protection against tuberculosis to Ashkenazi carriers of a single copy. Cystic fibrosis protected northern Europeans against cholera. Specific MHC alleles have been associated with infection by hepatitis B, hepatitis C, dengue, and HIV. A recently discovered mutation in a macrophage receptor confers protection against HIV to Europeans who possess it.[71] Smallpox left tan-

[70] For overviews, see Diamond, *Guns, Germs, and Steel,* 201, and Adrian V. S. Hill, "The Immunogenetics of Human Infectious Diseases," *Annual Review of Immunology,* 16 (1998), 593–617.

[71] Sarah A. Tishkoff et al., "Haplotype Diversity and Linkage Disequilibrium at Human *G6PD:* Recent Origin of Alleles That Confer Malarial Resistance," *Science,* 293 (July 20, 2001), 455–62; D. M. Rodman and S. Zamudio, "The Cystic Fibrosis Heterozygote—Advantage in Surviving Cholera?" *Medical Hypotheses,* 36 (Nov. 1991), 253–58; Mary Carrington et al., "*HLA* and HIV-1: Heterozygote Advantage and *B*35–Cw*04* Disadvantage," *Science,* 283 (Mar. 12, 1999), 1748–52; Hill, "Immunogenetics and Genomics," *Lancet,* 357 (June 23, 2001), 2037–41; J. Claiborne

talizing clues about its impact on human genetics before its eradication in the 1970s. A study of children in India found that severe smallpox mortality—a case-fatality rate of 52 percent—was not distributed randomly. Instead, children who had type A blood had seven times the risk of contracting smallpox and twice the risk of dying from smallpox than children with other blood types. Such evidence convinced Diamond that infectious diseases shaped human genetic evolution: "Natural selection is not a theoretical postulate, but a grimly continuing reality."[72] Dozens of genes have now been associated with resistance or susceptibility to infectious diseases.

Tuberculosis has been studied most carefully. Specific genes that modify the behavior of lymphocytes and macrophages appear relevant for resistance to initial infection, while others influence the progression of the disease.[73] In mouse models, a single mutation in one gene undermines macrophage function and increases susceptibility to infection with the bacteria that cause tuberculosis.[74] Human variants of this macrophage gene have been shown to increase the risk of active tuberculosis.[75] Many other genes influence the impact of tuberculosis, including MHC alleles, cytokines, and the vitamin D receptor.[76] These genetic differences provide possible mechanisms for the described racial differences in susceptibility to tuberculosis.[77]

Aspects of this work could be relevant for the study of American Indian susceptibility. Continuing study of the Yanomami has suggested that they are a virgin soil for tuberculosis. The disease struck them with an unusually high attack rate and with atypical symptoms, "indicating a high susceptibility to disease." Detailed studies of their immune responses showed that they had weak cellular immunity, leaving their "immune system ill-equipped to handle the bug." Researchers concluded that the "immunologically naïve" Yanomami demonstrated how "the

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Stephens et al., "Dating the Origin of the *CCR5–Δ32* AIDS-Resistance Allele by the Coalescence of Haplotypes," *American Journal of Human Genetics,* 62 (June 1998), 1507–15.

[72] Diamond, "A Pox upon Our Genes," *Natural History,* 99 (Feb. 1990), 30.

[73] Christian G. Meyer, Jürgen May, and Klaus Stark, "Human Leukocyte Antigens in Tuberculosis and Leprosy," *Trends in Microbiology,* 6 (Apr. 1998), 153.

[74] Rima McLeod et al., "Immunogenetics in the Analysis of Resistance to Intracellular Pathogens," *Current Opinion in Immunology,* 7 (1995), 544–46.

[75] Richard Bellamy et al., "Variations in the *NRAMP1* Gene and Susceptibility to Tuberculosis in West Africans," *N. Eng. J. Medicine,* 338 (Mar. 5, 1998), 640–44.

[76] These are reviewed in Marc Lipsitch and Alexandra O. Sousa, "Historical Intensity of Natural Selection for Resistance to Tuberculosis," *Genetics,* 161 (Aug. 2002), 1599–1607.

[77] For one claim of racial difference in tuberculosis susceptibility, see William W. Stead et al., "Racial Differences in Susceptibility to Infection by *Mycobacterium tuberculosis,*" *N. Eng. J. Medicine,* 322 (Feb. 15, 1990), 422–27.

human immune system first responded to *M. tuberculosis* eons ago."[78] A study of an American Indian family in Canada found a specific genotype associated with the macrophage gene that increased tuberculosis risk tenfold.[79] Such work provides suggestive evidence that American Indians might have lacked protective genes that Europeans possessed. It provides an initial foundation for the conclusions of many historians that American Indians were vulnerable because their isolation from Old World plagues had "prevented natural selection of resistant survivors and their descendants."[80]

However, claims of natural selection producing resistant human populations have many limitations. Despite the assumptions about indigenous populations worldwide having particular susceptibility to Eurasian pathogens, scientists have not documented any "racial susceptibility" to smallpox or chicken pox. The social and economic disruptions that accompanied new diseases have confounded analyses of initial responses to measles and tuberculosis.[81] One fundamental question is whether these diseases have existed long enough to allow natural selection to produce significant differences in specific populations' resistance to different diseases. Many diseases, including measles, influenza, and smallpox, emerged with the first cities. Smallpox and measles likely did not reach Europe until the second or third century A. D. Plague first struck Europe in the mid-fourteenth century. Could resistant Eurasians have evolved by the sixteenth century, in time to have a competitive advantage against American Indians? This seems unlikely.[82]

[78] Sousa et al., "An Epidemic of Tuberculosis with a High Rate of Tuberculin Anergy among a Population Previously Unexposed to Tuberculosis, the Yanomami Indians of the Brazilian Amazon," *Proceedings of the National Academy of Sciences,* 94 (Nov. 25, 1997), 13227 ("high susceptibility"), 13231 ("immunologically naïve"); Kathleen Fackelmann, "Tuberculosis Outbreak: An Ancient Killer Strikes a New Population," *Science News,* 153 (Jan. 31, 1998), 73 ("first responded"), 75 ("ill-equipped").

[79] Celia M. T. Greenwood et al., "Linkage of Tuberculosis to Chromosome 2q35 Loci, Including *NRAMP1,* in a Large Aboriginal Canadian Family," *American Journal of Human Genetics,* 67 (Aug. 2000), 405–14.

[80] Jennings, *Founders of America,* 130.

[81] No "racial susceptibility": Abram S. Benenson, "Smallpox," in Alfred S. Evans, ed., *Viral Infections of Humans: Epidemiology and Control,* 3d ed. (New York, 1989), 642; Thomas H. Weller, "Varicella-Herpes Zoster Virus," in Evans, ed., *Viral Infections,* 669. Social confounding: Francis Black, "Measles," ibid., 459; Masahiro Kushigemachi, Lawrence J. Schneiderman, and Elizabeth Barrett-Connor, "Racial Differences in Susceptibility to Tuberculosis: Risk of Disease after Infection," *Journal of Chronic Disease,* 37 (1984), 853–60.

[82] In the 1970s Francis Black estimated that acute epidemic diseases, which require human populations of certain threshold sizes, had only been present for 200 generations, too short a time for significant natural selection: Black, "Infectious Diseases in Primitive Societies," *Science,* 187 (Feb. 14, 1975), 515–18. For recent refinements of this estimate, see Lipsitch and Sousa, "Historical Intensity of Natural

Specific hypotheses also erode under scrutiny. The selective advantage of carriers of cystic fibrosis against cholera seems far-fetched since cholera did not appear in Europe until 1832.[83] Although researchers have linked several genes to tuberculosis susceptibility, they explain only a small amount of the apparent genetic component and their clinical relevance remains unclear.[84] When data do not turn out as expected, scientists have turned to post hoc explanations to support their faith in natural selection. One group identified variations in a receptor used by malaria parasites to enter red blood cells. People deficient in this receptor should, in theory, be resistant to malaria. The opposite turned out to be true. The researchers had to conclude that "unidentified selection pressures" explained the prevalence of this costly deficiency.[85]

Explanations of American Indian susceptibility run into similar difficulties. Diamond's discussion of type A blood and smallpox susceptibility has little relevance for American Indians, who are nearly all type O.[86] Immunologist Francis Black has found that the Yanomami and other virgin tribes of the Amazon valley mount normal immune responses against measles, as well as against vaccines for measles, mumps, rubella, polio, yellow fever, pneumonia, and bacterial meningitis. His team concluded that "deficiency at the immunogenetic loci we have examined cannot explain the poor survival of New World people."[87] Although other researchers have found that the Yanomami did mount atypical responses to tuberculosis, they admit that this could simply reflect the high burden of parasitic infections among the Yanomami, something that activates humoral immunity at the expense of cellular immunity.[88] Physicians have

Selection," 1599–1607; Paul Schliekelman, Chad Garner, and Montgomery Slatkin, "Natural Selection and Resistance to HIV: A Genotype That Lowers Susceptibility to HIV Extends Survival at a Time of Peak Fertility," *Nature,* 411 (May 31, 2001), 545–46; Stephens et al., "Dating the Origin," 1513; and Tishkoff et al., "Haplotype Diversity," 455–62.

[83] Cystic fibrosis heterozygotes may have had protection against non-cholera secretory diarrheas, which likely did exist in Europe. See Sherif E. Gabriel, response to Paul Fontelo, "Protection Against Cholera," *Science,* 267 (Jan. 27, 1995), 440.

[84] Bellamy, "Identifying Genetic Susceptibility Factors for Tuberculosis in Africans: A Combined Approach Using a Candidate Gene Study and a Genome-Wide Screen," *Clinical Science,* 98 (2000), 245–50; Greenwood et al., "Linkage of Tuberculosis," 406, 414.

[85] Timothy J. Aitman et al., "Malaria Susceptibility and *CD36* Mutation," *Nature,* 405 (June 29, 2000), 1015–16.

[86] Diamond, "A Pox upon Our Genes," 26–30.

[87] Black, Gerald Schiffman, and Janardan P. Pandey, "HLA, Gm, and Km Polymorphisms and Immunity to Infectious Diseases in South Amerinds," *Experimental and Clinical Immunogenetics,* 12 (1995), 214. See also Black, "An Explanation of High Death Rates among New World Peoples When in Contact with Old World Diseases," *Perspectives in Biology and Medicine,* 37 (Winter 1994), 294–95.

[88] Hurtado et al., "Epidemiology of Infectious Diseases," 426; Sousa et al., "Epidemic of Tuberculosis," 13231.

long observed that American Indians and Alaskan natives have high susceptibility to certain bacteria, especially *Haemophilus* and *Streptococcus*. Yet despite extensive study it remains unclear to what extent these differences reflect genetic vulnerabilities or social conditions such as malnutrition, overcrowding, and exposure to recurrent infections.[89] Even if tuberculosis resistance genes prove relevant now, it will be difficult, perhaps impossible, to connect them to specific outbreaks of tuberculosis in the nineteenth or twentieth centuries.

A second potential mechanism is that American Indian evolution amid the (alleged) relative health of America enabled the persistence of inherited immune deficiencies that left Indians vulnerable to a wide range of infections. The Navajos and Jicarilla Apaches, for instance, have an increased incidence of a serious inherited immunodeficiency. This disease leaves its victims vulnerable to viral, bacterial, and fungal infections; most die within the first years of life unless they receive aggressive medical treatment. While such immune deficiencies have been described among some groups, they are not widespread among American Indians. It is also unclear whether such inherited immune deficiencies contributed to demographic collapse, or resulted from random genetic fluctuations among the ensuing remnant populations.[90]

The third potential mechanism of inherited vulnerability arises from genetic homogeneity. American Indians have long been known to be remarkably homogeneous for type O blood. Subsequent study has found similarly limited variability for a series of different genes, especially a limited diversity of MHC molecules.[91] Francis Black suggests that this lack of genetic diversity left New World populations more susceptible to certain infections. Measles, for instance, can adapt itself to the immune system of its host. If its next host has a similar immune system (that is, a similar assortment of MHC molecules), then the infection will be more virulent. When faced with a population of genetically similar individuals, measles "can adapt to each population as a whole and cause unusual damage." Based on this theory, Black argues that "limited genetic diversity, not 'bad genes' may be the fatal chink in the immunological armor of the New World people."[92] Recent studies have also found that limited

[89] John B. Robbins and Rachel Schneerson, "Evaluating the Haemophilus Influenzae Type b Conjugate Vaccine PRP-D," *N. Eng. J. Medicine,* 323 (Nov. 15, 1990), 1415–16.

[90] Robert P. Erickson, "Southwestern Athabaskan (Navajo and Apache) Genetic Diseases," *Genetics in Medicine,* 1 (May-June 1999), 151–57.

[91] Crawford, *Origins of Native Americans,* 88–148. However, he noted that new DNA markers have shown more diversity than previous estimates.

[92] Black, "Why Did They Die?" *Science,* 258 (Dec. 11, 1992), 1739–40; Black, "Explanation of High Death Rates," 301 ("can adapt"); Black et al., "HLA, Gm, and Km Polymorphisms," 215 ("limited genetic diversity"). This theory has been picked

diversity of MHC molecules can leave individuals more susceptible to other infections, including HIV and hepatitis B.[93] While such theories are plausible and supported by specific evidence, they remain only speculation about the impact of measles, smallpox, and tuberculosis on American Indians.

The fourth mechanism of no immunity distinguishes between innate and adaptive immunity. In some cases, most familiarly with chicken pox but also with smallpox and measles, the protection provided by antibodies of the adaptive immune system prevents reinfection after an initial episode. In early modern Europe, where these viruses were endemic, most people were exposed as infants and children. Since many viral infections are milder in children, since infants receive some protection from maternal antibodies, and since parents could provide nursing care, most children survived these childhood infections and developed adaptive immunity. In settings where the diseases were not endemic, terrible mortality could ensue. Iceland, for instance, supported too small a population to allow smallpox to persist as an endemic infection. When it was introduced in 1707 after a long absence, it killed 36 percent of the population (18,000 out of roughly 50,000) in a single year. Similarly high mortality occurred when smallpox was introduced intermittently into Boston and other British colonies during the eighteenth century.[94]

American Indian populations easily could have experienced severe epidemics because of their initial lack of adaptive immunity. The entire population of Indian villages, young and old, would have been vulnerable to the first appearance of smallpox, measles, or other infections. Few people might have been healthy enough to provide nursing care, tend the crops, or maintain essential subsistence activities.[95] Many of these infections also cause more severe mortality in adults than in children. This would have been especially damaging since these adults were responsible for crucial social roles.[96] Each of these factors, the result of

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up by some historians: Fenn, *Pox Americana,* 26–27, 141; Robert McCaa, "Spanish and Nahuatl Views on Smallpox and Demographic Catastrophe in Mexico," *Journal of Interdisciplinary History,* 25 (1995), 419–20.

[93] Carrington et al., "*HLA* and HIV-1," 1748–52; Hill, "Defence by Diversity," *Nature,* 398 (Apr. 22, 1999), 668–69.

[94] Benenson, "Smallpox," 634; Zinkernagel, "Maternal Antibodies," 1331.

[95] Crosby, "Virgin Soil Epidemics," 293–96.

[96] Some historians have argued that influenza and other epidemics single out young adults for the highest mortality, stripping vulnerable societies of their most productive individuals. In fact, most infections have U-shaped mortality curves: high in infants, low in school-aged children and adolescents, then increasing steadily with age: Benenson, "Smallpox," 641; Anne A. Gershon, "Measles Virus (Rubeola)," in Gerald L. Mandell, John E. Bennett, and Raphael Dolin, eds., *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases,* 5th ed. (Philadelphia, 2000), 1801–09; Weller, "Varicella-Herpes Zoster Virus," 668.

absent adaptive immunity, could have produced high mortality regardless of American Indian innate immunity.

The magnitude of this effect depends on two crucial factors. First, which diseases were truly new to American Indians? Smallpox, measles, and influenza likely did arrive in the Americas with Europeans. Analysis of American Indian skeletal remains, however, has shown that many diseases existed in pre-Columbian America, including tuberculosis and pneumonia, and possibly herpes, chicken pox, and other viruses.[97] As one review concludes, "The concept of a pristine, disease-free, pre-Columbian New World environment is no longer credible."[98] As a result, the breadth of American Indian adaptive immune vulnerability remains unclear. Second, the notion of truly protective immunity only applies to a small number of viral infections. Influenza, which shifts its antigens over time, can reinfect individuals even in endemic areas. Other viruses, such as those that cause common colds or gastroenteritis, can infect the same individual over and over again. Most bacterial diseases, meanwhile, generate little or no protective immunity: individuals can suffer endless recurrences of skin infections or pneumonia. Although these diseases, especially viral pneumonia and diarrhea, are less visible in the historic record than smallpox and measles, they might have been dominant causes of mortality for which adaptive immunity might not have been relevant.[99]

The last mechanism depends on disease synergy. When Europeans arrived, they brought many new diseases to the Americas. Epidemics of

[97] Many authors list tuberculosis, treponematosis, pneumonia (streptococcus), staphylococcus, typhoid, shigellosis, salmonella, leishmaniasis, Chagas' disease, toxoplasmosis, amebiasis, giardiasis, tinea, blastomycosis, tapeworm, whipworm, pinworm, roundworm, and hookworm. See Suzanne Austin Alchon, *Native Society and Disease in Colonial Ecuador* (Cambridge, 1991), 20–24; Boyd, *Coming of the Spirit of Pestilence,* 15; and Starna, "Biological Encounter," 512. These diseases were found in some places; they were not likely endemic everywhere.

[98] Arthur C. Aufderheide, "Summary on Disease before and after Contact," in John W. Verano and Ubelaker, eds., *Disease and Demography in the Americas,* (Washington, D. C., 1992), 165. For other rebuttals of the disease-free paradise, see Calloway, *New Worlds for All,* 25; Clark Spencer Larsen, "In the Wake of Columbus: Native Population Biology in the Postcontact Americas," *Yearbook of Physical Anthropology,* 37 (1994), 109, 114; Ubelaker, "Patterns of Demographic Change," 372; or many of the other essays in Verano and Ubelaker, eds., *Disease and Demography.*

[99] For the impact of common bacterial pathogens on a disease-experienced population, see Walsh McDermott, with David E. Rogers, "Social Ramifications of Control of Microbial Disease," *Johns Hopkins Medical Journal,* 151 (1982), 305. In 1990, viral pneumonia and diarrhea remained the leading causes of infectious deaths. See Christopher J. L. Murray and Alan D. Lopez, eds., *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020* (Cambridge, Mass., 1996), 176. It is tempting, but impossible, to extrapolate this prevalence back to pre-contact America.

measles, smallpox, and influenza often circulated simultaneously among American Indians. When new diseases reached a village, not only could everyone fall sick at the same time, but every person could suffer from several infections. As was well demonstrated with the influenza pandemic of 1918, co-infection with multiple pathogens (in that case, viral and bacterial pneumonia) can have synergistic effects on mortality. Some diseases also cause immune suppression. Measles, for instance, suppresses cellular immunity and leaves its victims more vulnerable to other diseases, especially tuberculosis.[100] Although synergistic epidemics could have contributed to American depopulation, the magnitude of the synergy remains unknown.

Taken as a whole, recent immunological research offers many clues about the state of Indian immunity. American Indians could certainly mount immune responses to European pathogens. Perhaps their "naïveté" left them without protective genes, making them incrementally susceptible. Perhaps their homogeneity left them vulnerable to adaptable pathogens. Research about these questions continues on the cutting edge of immunology. It is possible that definitive evidence of demographically significant resistance genes will emerge. The historical experiment, however, has run its course. European and American populations mixed for over five hundred years before scientists could study them adequately. The opportunity for further research on first contact populations remains remote. As a result, the state of virgin immunity will forever remain contested. This leaves the literature on genetics and immunity promising, but unsatisfying.[101] Genetic arguments of population-wide vulnerability must therefore be made with great caution. Other immunological mechanisms remain plausible, but problematic. Initial lack of adaptive immunity likely left American Indian societies vulnerable to certain pathogens, but certainly not to all of them, and adaptive immunity does not seem to have been relevant for the dominant causes of mortality in developing societies.

[100] Eric T. Sandberg, Mark W. Kline, and William T. Shearer, "The Secondary Immunodeficiencies," in E. Richard Stiehm, ed., *Immunologic Disorders in Infants and Children,* 4th ed. (Philadelphia, 1996), 553–601; Christopher L. Karp et al., "Mechanism of Suppression of Cell-Mediated Immunity by Measles Virus," *Science,* 273 (July 12, 1996), 228-31.

[101] The phenomena of obesity demonstrate the impact of social factors even on diseases that have strong genetic components. Studies have shown that 50% to 90% of the variance of obesity can be attributed to genetics. But the expression of genetic tendencies depends on social context: famine will prevent the expression of obesity, regardless of genetic predilection. Similarly, the prevalence of obesity in the United States has increased rapidly over recent decades, in the absence of significant genetic change; Gregory S. Barsh, I. Sadaf Farooqi, and Stephen O'Rahilly, "Genetics of Body-Weight Regulation," *Nature,* 404 (Apr. 6, 2000), 644–51.

Furthermore, the mechanisms of adaptive immunity, along with the impact of simultaneous and successive synergistic infections, emphasize the importance of the disease environment, and not only the population itself, in shaping a population's susceptibility to infection. Other features of the environment, defined broadly, also have profound effects on immunity. A population's physical, social, economic, and political environments all interact to create patterns of vulnerability, regardless of its genetic substrate.

Such vulnerabilities have long been recognized. Even as observers began asserting racial arguments of disease susceptibility in the nineteenth century, they saw that a wide range of social factors created susceptibility to epidemic disease. After studying an outbreak of measles among the indigenous populations of Fiji in 1875, W. Squire concluded, "We need invoke no special susceptibility of race or peculiarity of constitution to explain the great mortality." He blamed social conditions, especially "want of nourishment and care." In 1909, anthropologist Aleš Hrdlička reached a similar conclusion about American Indians: "Doubtless much of what now appears to be greater racial susceptibility is a result of other conditions." Sherburne Cook came to believe that disease amongst indigenous populations worldwide "acted essentially as the outlet through which many other factors found expression."[102]

Malnutrition provides the most obvious, and prevalent, demonstration of the links between social conditions, environmental conditions, and disease. In addition to causing deficiency diseases, such as rickets and pellagra, malnutrition increases susceptibility to infection. Some vitamin deficiencies cause skin breakdown, eroding the first barrier of defense against infection. Protein deficiencies impair both cellular and humoral responses. Malnutrition during infancy and childhood has particularly devastating effects on subsequent immune function. Certain diseases have more specific connections to nutrition. Malnutrition, especially vitamin A deficiency, increases mortality from measles. Malnourished children are more likely to die from chicken pox. Such interactions create "a vicious circle. Each episode of infection increases the need for calories and protein and at the same time causes anorexia; both of these aggravate the nutritional deficiency, making the patient even more susceptible to infection." Understanding these relationships, scientists have realized that malnutrition "is the most common cause of secondary immunodeficiency in the world."[103]

[102] Squire, "Reports of Societies: The Epidemiological Society," *Medical Times and Gazette,* 1 (1877), 324; Hrdlička, *Tuberculosis among Certain Indian Tribes of the United States* (Washington, D. C., 1909), 31; Cook, "The Significance of Disease in the Extinction of the New England Indians," *Human Biology,* 45 (Sept. 1973), 506. See also August Hirsch, *Handbook of Geographical and Historical Pathology,* trans. Charles Creighton (London, 1883–1886), 167.

[103] Sandberg, Kline, and Shearer, "Secondary Immunodeficiencies," 565. See also Black, "Measles," 451; Gershon, "Measles Virus (Rubeola)," 1805; and Weller, "Varicella-Herpes Zoster Virus," 674.

Historians have thoroughly documented the impact of malnutrition on disease susceptibility.[104] Such connections have clear importance for American Indians, who faced both disease and social disorder following European colonization. As Cronon describes, villages disrupted by disease and social breakdown "often missed key phases in their annual subsistence cycles—the corn planting, say, or the fall hunt—and so were weakened when the next infection arrived."[105] This would have been particularly damaging for the many populations that eked out only a precarious subsistence before European arrival. Although some writers have described American Indians living in bountiful harmony with their environment, archaeologists and physical anthropologists have shown that many groups were terribly malnourished. The accomplishments of the Mayan civilization might have been undone by climate change, crop failures, and famine. Disease, malnutrition, and violence made Mesoamerican cities as unhealthful as their medieval European counterparts, with life expectancies of 21 to 26 years. The Arikaras had life expectancies as low as 13.2 years. Careful study of skeletal remains has found widespread evidence of nutritional deficiencies, with health conditions worsening in the years before contact with Europeans.[106] Baseline malnutrition, especially in the large agricultural societies in Mexico and the Andes, left American Indians vulnerable—at the outset—to European diseases.[107] When the conditions of colonization disrupted subsistence, the situation only grew worse.

Malnutrition may be the most obvious factor, but it was only one of many. Environmental historians have shown how physical environments

[104] For an overview, see Robert Dirks, "Famine and Disease," in Kenneth F. Kiple, ed., *The Cambridge World History of Human Disease* (Cambridge, 1993), 157–63. For a specific example (tuberculosis during the siege of Paris), see David S. Barnes, *The Making of a Social Disease: Tuberculosis in Nineteenth-Century France* (Berkeley, 1995), 6–9. Malnutrition remains the major risk factor for mortality worldwide, accounting for 11.7% of the attributable risk (compared to 6% for tobacco, 5.8% for hypertension, 5.3% for sanitation and hygiene, and 1.5% for alcohol). See Murray and Lopez, *Global Burden of Disease,* 311.

[105] Cronon, *Changes in the Land,* 88. See also Chaplin, *Subject Matter,* 158, and White, "Western History," 208.

[106] John H. Coatsworth, "Welfare," *American Historical Review,* 101 (1996), 1–12 (general discussion); Crawford, *Origins of Native Americans,* 53 (Arikara); Larsen, "In the Wake of Columbus," 109–54 (worsening health); Storey, *Life and Death in the Ancient City of Teotihuacan,* 253–66 (cities); Ann L. W. Stodder et al., "Cultural Longevity and Biological Stress in the American Southwest," in Richard H. Steckel and Jerome C. Rose, eds., *The Backbone of History: Health and Nutrition in the Western Hemisphere* (Cambridge, 2002), 481–505 (ill-health).

[107] Steckel and Rose, "Patterns of Health in the Western Hemisphere," in Steckel and Rose, eds., *Backbone of History,* 563–79. While agricultural societies (e.g., Mexico, Andes) experienced poor health, rural areas (e.g., coastal Georgia, Brazil) did better. Societies with a pre-contact life expectancy of 40 years could more easily absorb new pathogens than societies with a life expectancy of 20 years; S. Ryan Johansson and Owsley, "Welfare History on the Great Plains: Mortality and Skeletal Health, 1650 to 1900," in Steckel and Rose, eds., *Backbone of History,* 556.

can leave populations susceptible to disease. Lowland Ecuadorians, weakened by endemic parasites and intestinal diseases, were more vulnerable to European infections than their highland compatriots. After Spanish arrival in Mexico, a "plague of sheep" destroyed Mexican agricultural lands and left Mexicans susceptible to famine and disease. Colonization introduced a host of damaging changes in New England. Deforestation led to wider temperature swings and more severe flooding. Livestock overran Indian crops and required pastures and fences, leading to frequent conflict and widespread seizure of Indian land. Europeans also introduced pests, including blights, insects, and rats. All of these changes fueled rapid soil erosion and undermined the subsistence of surviving Indian populations. More dramatic environmental events also wreaked havoc. Drought, earthquakes, and volcanic eruptions undermined resistance to disease in Ecuador in the 1690s. A devastating hurricane struck Fiji in 1875, exacerbating the measles outbreak there. As one observer commented, "Certainly for the last 16 years there has been experienced no such weather, and nothing could be more fatal to a diseased Fijian than exposure to it."[108]

Historians and anthropologists have also documented many cases in which the varied outcomes of specific populations depended on specific social environments. The Lamanai Mayas, heavily colonized by the Spanish regime, had higher mortality than the more isolated Tipu Mayas. While much of Peru suffered severely, the region of Huamanga lost only 20 percent of its population between 1532 and 1570, the result of "a high birth rate, the relative immunity of remote high-altitude areas to disease, shrewd politics, and good luck." The Pueblos suffered when "the endemic problems of drought and famine were superimposed upon the economic disruption caused by the Spanish drain on food and labor." Severe outbreaks of smallpox and erysipelas in Peru from 1800 to 1805 reflected a combination of drought, crop failures, famines, mining failures, and economic collapse. The introduction of specific epidemics reflected specific historical events. Dauril Alden and Joseph Miller traced outbreaks of smallpox from West African droughts, through the middle passage of the slave trade, to Brazil. Measles raced down the political hierarchy in Fiji in 1875 as a series of conferences carried news of a treaty with the British empire, along with the virus, from the royal family to regional and local leaders throughout the island.[109] Local variability and

[108] Newson, "Highland-Lowland Contrasts," 1191–94 (Ecuador); Melville, *Plague of Sheep* (Mexico); Cronon, *Changes in the Land,* 107–56 (New England); Alchon, *Native Society and Disease in Colonial Ecuador;* "Occasional Correspondent" to *The Times,* Apr. 23, 1875, quoted in Cliff, Haggett, and Smallman-Raynor, "Island Populations," 163 (Fiji).

[109] Larsen, "In the Wake of Columbus," 137 (Maya); Steve J. Stern, *Peru's Indian Peoples and the Challenge of Spanish Conquest: Huamanga to 1640,* 2d ed. (Madison,

contingency led Linda Newson to conclude that "levels of decline and demographic trends were influenced by the size, distribution, and character of populations, especially their settlement patterns, social organization, and levels of subsistence."[110] Even in the late twentieth century, specific social factors left isolated indigenous populations vulnerable to European pathogens. Magdalena Hurtado, who has witnessed first-contact epidemics in South America, emphasizes the adverse consequences of "sedentism, poverty, and poor access to health care."[111]

Studies of North American tribes in the nineteenth and twentieth centuries have found similar local variability. Geographer Jody Decker shows how a single epidemic among the northern Plains tribes had disparate effects, "even for contiguous Native groups," depending on "population densities, transmission rates, immunity, subsistence patterns, seasonality and geographic location." Drought and famine left the Hopis particularly susceptible to an epidemic in 1780. The Mandans suffered severely from smallpox in 1837: famine since the previous winter had left them malnourished, and cold, rainy weather confined them to their crowded lodges. When smallpox struck, they had both high levels of exposure and low levels of resistance. As Clyde Dollar concludes, "It is no wonder the death rate reached such tragically high levels." Once North American tribes came under the care of the federal governments in the United States and Canada, they often suffered from malnutrition and poor sanitation. Mary-Ellen Kelm, who has studied the fates of the Indians of British Columbia, concludes that "poor Aboriginal health was not inevitable"; instead, it was the product of specific government policies.[112]

1993), 44 (Huamanga); Stodder and Debra L. Martin, "Health and Disease in the Southwest before and after Spanish Contact," in Verano and Ubelaker, eds., *Disease and Demography,* 63 (Pueblo); Enrique Tandeter, "Crisis in Upper Peru, 1800–1805," *Hispanic American Historical Review,* 71 (1991), 40–51; Alden and Miller, "Unwanted Cargoes: The Origins and Dissemination of Smallpox via the Slave Trade from Africa to Brazil, c. 1560–1830," in Kiple, ed., *The African Exchange: Toward a Biological History of Black People* (Durham, N. C., 1987), 35–109; Cliff, Haggett, and Smallman-Raynor, "Island Populations," 148–56 (Fiji).

[110] Newson, "Highland-Lowland Contrasts," 1194. See also Newson, "The Demographic Collapse of Native Peoples of the Americas, 1492–1650," *Proceedings of the British Academy,* 81 (1993), 247–88.

[111] Hurtado et al., "Epidemiology of Infectious Diseases," 428. See also Marcos Cueto, *The Return of Epidemics: Health and Society in Peru during the Twentieth Century* (Burlington, Vt., 2001).

[112] Decker, "Depopulation of the Northern Plains Natives," *Social Science and Medicine,* 33 (1991), 383; Fenn, *Pox Americana,* 162, 187; Dollar, "The High Plains Smallpox Epidemic of 1837–38," *Western Historical Quarterly,* 8 (Jan. 1977), 29; Kelm, *Colonizing Bodies: Aboriginal Health and Healing in British Columbia, 1900–50* (Vancouver, 1998), 177. See also Maureen K. Lux, *Medicine That Walks: Disease, Medicine, and Canadian Plains Native People, 1880–1940* (Toronto, 2001).

Comparative studies have particular power for demonstrating the local specificity of depopulation. Stephen Kunitz has shown that Hawaiians suffered more severely than Samoans, a consequence of different patterns of land seizure by colonizing Europeans. The Navajo did better than the neighboring Hopi because their pastoral lifestyle adapted more easily to the challenges imposed by American settlers. In these cases similar indigenous populations encountered similar colonizers, with very different outcomes: "The kind of colonial contact that occurred was of enormous importance." Kunitz's cases demonstrate that "diseases rarely act as independent forces but instead are shaped by the different contexts in which they occur."[113]

Paralleling this work, some historians have begun to provide integrated analyses of the many factors that shaped demographic outcomes. Any factor that causes mental or physical stress—displacement, warfare, drought, destruction of crops, soil depletion, overwork, slavery, malnutrition, social and economic chaos—can increase susceptibility to disease.[114] These same social and environmental factors also decrease fertility, preventing a population from replacing its losses.[115] The magnitude of mortality depended on characteristics of precontact American Indian populations (size, density, social structure, nutritional status) and on the patterns of European colonization (frequency and magnitude of contact, invasiveness of the European colonial regime). As anthropologist Clark Spencer Larsen argues, scholars must "move away from monocausal explanations of population change to reach a broad-based understanding of decline and extinction of Native American groups after 1492."[116]

The final evidence of the influence of social and physical environments on disease susceptibility comes from their ability to generate remarkable mortality among even the supposedly disease-experienced Old World populations. Karen Kupperman has documented the synergy of malnutrition, deficiency diseases, and despair at Jamestown, where 80 percent of the colonists died between 1607 and 1625. Smallpox mortality,

[113] Kunitz, *Disease and Social Diversity: The European Impact on the Health of Non-Europeans* (New York, 1994), 5, 73. See also Crawford, *Origins of Native Americans,* 41–49.

[114] Cook, "Interracial Warfare and Population Decline among the New England Indians," *Ethnohistory,* 20 (Winter 1973), 1–24; McCaa, "Spanish and Nahuatl Views," 429; Newson, "Indian Population Patterns," 47–65; Snow and Kim M. Lanphear, "European Contact and Indian Depopulation in the Northeast: The Timing of the First Epidemics," *Ethnohistory,* 35 (Winter 1988), 17; Trimble, "1837–1838 Smallpox Epidemic," 82; Ubelaker, "Patterns of Demographic Change," 364–69.

[115] Stannard, "Disease and Infertility," 325–50; Ubelaker, "Patterns of Demographic Change," 364.

[116] Larsen et al., "Population Decline and Extinction in La Florida," in Verano and Ubelaker, eds., *Disease and Demography,* 35. See also Larsen, "In the Wake of Columbus," 124.

nearly 40 percent among Union soldiers during the Civil War, reflected living conditions and not inherent lack of innate or adaptive immunity. Mortality among soldiers infected with measles, which exceeded 20 percent during the United States Civil War, reached 40 percent during the siege of Paris in the Franco-Prussian War.[117] Poverty and social disruption continue to shape the distribution of disease, generating enormous global disparities with tuberculosis, HIV, and all other diseases.

Is it possible to quantify the variability, to delineate the relative contribution of potential genetic, developmental, environmental, and social variables? Detailed studies have documented "considerable regional variability" in American Indian responses to European arrival.[118] Many American Indian groups declined for a century and then began to recover. Some, such as the natives of the Bahamas, declined to extinction. Others, such as the Navajo, experienced steady population growth after European arrival. More precise data exist for select groups. Newson, for instance, has compiled data about die-off ratios, the proportion of those who died to those who survived. While die-off ratios were as high as 58:1 along the Peruvian coast, they were lower (3.4:1) in the Peruvian highlands. In Mexico they varied between 47.8:1 and 6.6:1, again depending on elevation. They ranged from 5.1:1 in Chiapas to 24:1 in Honduras and 40:1 in Nicaragua.[119] Mortality rates from European diseases among South Pacific islanders ranged between 3 percent and 25 percent for measles, and 2.5 percent to 25 percent for influenza.[120] Such variability among relatively homogeneous populations, with die-off ratios differing by an order of magnitude, most likely reflects the contingency of social variables. But most of these numbers are, admittedly, enormous: a 4:1 die-off ratio indicates that 75 percent died. Why did so many populations suffer such high baseline mortality? Does this reflect a shared genetic vulnerability, whose final intensity was shaped by social variables? Or does it reflect a shared social experience, of pre-existing nutritional stress exacerbated by the widespread chaos of encounter and colonization? Both positions are defensible.

The variability of outcomes reflected in the different fates of different Indian populations provides powerful evidence against the inevitability of mortality. It undermines popular claims, made most influentially by Henry Dobyns, that American Indians suffered universal

[117] Kupperman, "Apathy and Death in Early Jamestown," *JAH,* 66 (1979), 24–40; Crosby, "Virgin Soil Epidemics," 292–93 (smallpox); Squire, "Reports of Societies," 324 (measles).

[118] Ubelaker and Verano, "Conclusion," in Verano and Ubelaker, eds., *Disease and Demography,* 281.

[119] Newson, "Indian Population Patterns," 42–44.

[120] Cliff, Haggett, and Smallman-Raynor, "Island Populations," 147.

mortality from infectious diseases.[121] Noble David Cook, for instance, argues that the vulnerability was so general that Indians died equally whatever the colonial context, "no matter which European territory was involved, regardless of the location of the region. It seemed to make no difference what type of colonial regime was created."[122] Such assertions, which reduce the depopulation of the Americas to an inevitable encounter between powerful diseases and vulnerable peoples, do not match the contingency of the archaeological and historical records. These, instead, tell a story of populations made vulnerable.

One could argue that the differences in American and European disease environments, the nutritional status of precontact Americans, and the disruptions of colonization created conditions in which disease could only thrive. Only a time traveler equipped with a supply of vaccines could have altered the demographic outcomes.[123] But it is also possible that outcomes might have been different. Suppose Chinese explorers, if they did reach the Americas, had introduced Eurasian diseases in the 1420s, leaving American populations two generations to recover before facing European colonization. Suppose smallpox struck Tenochtitlan after Cortés's initial retreat and not during his subsequent siege of the city. An epidemic then might have been better tolerated than during the siege. Or suppose that the epidemics of 1616–1617 and 1633–1634 struck New England tribes during the nutritionally bountiful summers and not during the starving times of winter (or perhaps it was because of those starving times that the epidemics tended to appear in winters). The historic record of epidemic after epidemic suggests that high mortality must have been a likely consequence of encounter. But it does not mean that mortality was the inevitable result of inherent immunological vulnerability.

Consider an analogous case, the global distribution of HIV/AIDS. From the earliest years of the epidemic, HIV has exhibited striking disparities in morbidity and mortality. Its prevalence varies between sub-Saharan Africa and developed countries and between different populations within developed countries. Few scientists or historians would argue that these disparities between African and Europeans or between urban minorities and suburban whites exist because the afflicted populations have no immunity to HIV. Instead, the social contingency of HIV on a local and global scale has long been recognized.[124]

[121] Compare Dobyns, *Their Number Become Thinned,* 13–16, to a critique, Alden and Miller, "Unwanted Cargoes," 37.

[122] Cook, *Born to Die,* 5.

[123] This story of science fiction has been told in Orson Scott Card, *Pastwatch: The Redemption of Christopher Columbus* (New York, 1996).

[124] Jones and Allan M. Brandt, "AIDS, Historical," in Joshua Lederberg, ed., *Encyclopedia of Microbiology,* 2d ed., vol. 1. (San Diego, 2000), 104-15, esp. 114.

We should be just as cautious before asserting that no immunity led to the devastation of the American Indians.

Historians and medical scientists need to reassess their casual deployment of deterministic models of depopulation. The historic record demonstrates that we cannot understand the impact of European diseases on the Americas merely by focusing on Indians' lack of immunity. It is certainly true that epidemics devastated American Indian populations. It is also likely that genetic mechanisms of disease susceptibility exist: they influence the susceptibility of American Indians—and everyone else—to infectious disease. What remains in doubt is the relative contributions of social, cultural, environmental, and genetic forces. Even when immunologists demonstrate that a wide variety of genes contribute to susceptibility to infectious disease, it will likely remain unknown how these factors played out among American Indians in past centuries. Demographic data, meanwhile, provide convincing evidence of the strong impact of social contingency on human disease. This uncertainty leaves the door open for the debates to be shaped by ideology.[125]

Although unprecedented in their widespread severity, virgin soil epidemics may have arisen from nothing more unique than the familiar forces of poverty, malnutrition, environmental stress, dislocation, and social disparity that cause epidemics among all other populations. Whenever historians describe the depopulation of the Americas that followed European arrival, they should acknowledge the complexity, the subtlety, and the contingency of the process. They need to replace homogeneous and ambiguous claims of no immunity with heterogeneous analyses that situate the mortality of the epidemics in specific social and environmental contexts. Only then can they overcome the widespread public and academic appeal of immunologic determinism and do justice to the crucial events of the encounter between Europeans and Americans.

[125] My own perspective is shaped by awareness of how social factors determine contemporary patterns of disease, by skepticism of the relevance of increasingly detailed genetic information, and by concern that observers often seek to blame victims to avoid responsibility for disparities in health status.