Catching Cowpox: The Early Spread of Smallpox Vaccination, 1798–1810

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SUMMARY: The introduction of smallpox vaccination after the publication of Edward Jenner's *An Inquiry into the Causes and Effects of Variolae Vaccinae* depended on the spread of cowpox, a relatively rare disease. How Europeans and their colonial allies transported and maintained cowpox in new environments is a social and technological story involving a broad range of individuals from physicians and surgeons to philanthropists, ministers, and colonial administrators. Putting cowpox in new places also meant developing new techniques and organizations. This essay focuses on the actual practices of vaccination and their environmental contexts in order to illuminate the dynamic exchanges of materials, images, and ideas that made the spread of vaccination possible.

KEYWORDS: smallpox vaccination, cowpox, vaccine technologies, visual language/ medical illustrations, environmental history of disease

The global spread of diseases, with the exception of deliberate attempts at biological warfare, has been largely unconscious and unintended. Occurring for the most part prior to the acceptance of the germ theory of disease, the globalization of disease was primarily an inadvertent byproduct of European expansion and trade.[1] An important, if not unique,

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1. Alfred Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (Cambridge: Cambridge University Press, 1986); Jared Diamond, *Guns, Germs, and Steel: The Fate of Human Societies* (New York: W. W. Norton, 1997); William H. McNeill, *Plagues and Peoples* (New York: Doubleday, 1976).

exception to this pattern of globalization can be found in the early history of smallpox vaccination. Introduced by the English doctor Edward Jenner in his 1798 pamphlet *An Inquiry into the Causes and Effects of Variolae Vaccinae*, vaccination was the procedure of infecting a healthy individual with cowpox in order to prevent a subsequent case of natural smallpox. Unlike other diseases, cowpox was deliberately spread from England by physicians, surgeons, and others, but not without difficulty. Cowpox, in contrast with smallpox and measles, did not travel well. The first attempts to transfer cowpox, a relatively rare and geographically specific disease, from its place of origin generally failed. And yet, by 1810, vaccination using cowpox lymph had been established, at least for a time, in parts of Europe, Asia, and North and South America. The concerted effort to spread cowpox as a beneficial prophylaxis thus provides a very different perspective on the globalization of disease.

Exploring how Europeans and their colonial allies transported and maintained cowpox in new environments is a social and technological story involving a broad range of individuals from physicians and surgeons to philanthropists, clergy, and colonial administrators.[2] Putting cowpox in new places also meant developing new tools, methods, and organizations. This essay will focus on the practices of vaccination and their environmental contexts in order to illuminate the dynamic exchanges of materials, images, and ideas that made the spread of vaccination possible.

Part One: Smallpox and Cowpox

Alfred Crosby and other historians have emphasized how quickly smallpox spread in the wake of European exploration, beginning in the fifteenth century, and how powerful an advantage this disease was to Europeans.[3] Because it did not need alternative hosts, smallpox could establish itself in so-called virgin communities through human-to-human contact. By the sixteenth century, smallpox had become one of the leading killers and certainly one of the most dreaded diseases worldwide.

By contrast, catching cowpox was hard; it was a disease that infrequently affected humans. Early on in his medical career in the western county of Gloucestershire, Jenner had noticed and recorded a few cases

2. The literature on colonial science is extensive. For a recent, helpful review on British colonial science, see Mark Harrison, "Science and the British Empire," *Isis*, 2005, *96*: 56–63.

3. Crosby, *Ecological Imperialism* (n. 1); Donald Hopkins, *Princes and Peasants: Smallpox in History* (Chicago: University of Chicago Press, 1983); Ian Glynn and Jenifer Glynn, *The Life and Death of Smallpox* (Cambridge: Cambridge University Press, 2004).

of milkmaids and farm laborers who had had cowpox and were immune to smallpox. In 1796, in an experiment that later became famous, Jenner inserted cowpox in a scratch made on the arm of a boy named James Phipps. Jenner used lymph he had extracted from a pustule on the hand of Sarah Nelmes, who had contracted cowpox from milking an infected cow named Blossom. Phipps experienced a mild case of cowpox, and when he was later inoculated with smallpox, he exhibited no illness. This deliberate human-to-human transfer of cowpox distinguished Jenner's trial from earlier instances in which individuals had contracted cowpox directly from infected cows. In his *Inquiry*, Jenner presented case histories of twenty-three individuals who had either been deliberately infected with cowpox or had contracted cowpox naturally and who were later exposed to smallpox without ill effect.

Besides cowpox's power to confer immunity, Jenner was also aware of its relative rarity. After his vaccination of Phipps, he had to suspend his investigations for nearly two years because cowpox disappeared from Gloucestershire. In order to explain this absence, Jenner undertook a study of the natural history of cowpox. In fact, the title of the draft of his 1798 pamphlet was "An Inquiry into the Natural History of a Disease, known in the Western Counties of England particularly of Glostershire [*sic*] under the name of the Cow Pox."[4] The disease, he thought, derived from another, closely related affliction called horse grease.[5] Jenner reasoned that farm laborers unknowingly transferred horse grease from infected horses to cows' teats and thereby created the disease called cowpox. Cowpox thus depended on the prevalence of horse grease and on the work habits of farmers. This transfer from horse to cow took place only in areas where farmhands worked with both types of animals, and this was somewhat unusual, because women usually milked the cows whereas men worked the horses. "In Ireland, & in Scotland," Jenner observed, "where the Men Servants do not milk, the disease is also unknown."[6] Cowpox, according to Jenner, was the result of infection from a horse through human hands.

Jenner's theory about the relationship between horse grease and cowpox was generally rejected by his contemporaries. Even today there

4. Wellcome MS 3019, Wellcome Library, London.

5. Jenner's claims about the connection between horse grease and cowpox came under heavy scrutiny and were generally dismissed. One voice of support came from Dr. John Loy, who carried out several experiments and distinguished between two types of horse grease, one that could cause cowpox and another that could not. John G. Loy, *An Account of Some Experiments on the Origin of the Cow-Pox* (Whitby, 1801).

6. Jenner to Jean de Carro, 27 November 1799, in *Letters of Edward Jenner and Other Documents Concerning the Early History of Vaccination*, ed. Genevieve Miller (Baltimore: Johns Hopkins University Press, 1983), p. 10.

remains a longstanding debate over what disease or diseases were actually used in vaccination. Some historians have argued that most early vaccinations used an attenuated form of smallpox.[7] Twentieth-century analyses of available vaccines showed them to be composed of *vaccinia*, a virus distinct from both smallpox and cowpox and not presently found in nature. The microbiologist Derrick Baxby has undertaken the most thorough scientific investigation of the various strains of vaccine and has postulated that *vaccinia* might be related to a now extinct form of horsepox.[8] To complicate matters further, Baxby and historians Jennifer Keelan and Sanjoy Bhattacharya have argued that several different microbes, along with several different techniques, were used under the broad banner of smallpox vaccination.[9] In this article, I contend that Jenner and his contemporaries believed that there was one true cowpox and that they went to great lengths to secure its propagation and distribution. They referred to cowpox lymph as a virus—literally, a poison. They knew that lymph applied to a scratch in the skin had the power to infect. How they controlled and managed this new power is the key historical question.

The place where Jenner first found cowpox was in rural Gloucestershire, and his pamphlet spurred physicians and surgeons to look for cowpox in their own farmyards. In 1801, for example, John Underwood, a physician working at the naval hospital in Madras in India, reported a cow infected with smallpox and a horse with greasy heels, but inoculations made with lymph taken from both the cow and the horse failed to take.[10] Likewise, the American physician Benjamin Waterhouse was unsuccessful in his efforts to vaccinate using lymph from infected cows he found in Massachusetts.[11] Other doctors, however, were not so eager to try untested

7. Peter Razzell, *Edward Jenner's Cowpox Vaccine: The History of a Medical Myth* (Firle, England: Caliban Books, 1977); Margaret Schibuk, "The Search for Vaccinia" (Ph.D. diss., Harvard University, 1986).

8. Derrick Baxby, "Inoculation and Vaccination: Smallpox, Cowpox, and Vaccinia," *Med. Hist.*, 1965, *9*: 383–85; Baxby, *Jenner's Smallpox Vaccine: The Riddle of Vaccinia Virus and its Origin* (London: Heinemann Educational, 1981).

9. Jennifer Keelan, "The Canadian Anti-Vaccination Leagues, 1872–1892" (Ph.D. diss., University of Toronto, 2004); Sanjoy Bhattacharya, Mark Harrison, and Michael Worboys, *Fractured States: Smallpox, Public Health and Vaccination Policy in British India, 1800–1947* (New Delhi: Orient Longman, 2005).

10. John Underwood, Surgeon to His Majesty's Naval Hospital, Madras, to Edward Jenner, 28 February 1801, in John Baron, *The Life of Edward Jenner, M.D.*, 2 vols. (London: Henry Colborn; vol. 1, 1827; vol. 2, 1838), 1: 411.

11. Philip Cash, *Dr. Benjamin Waterhouse: A Life in Medicine and Public Service, 1754–1846* (Sagamore Beach, Mass.: Boston Medical Library and Science History Publications, 2006), p. 158.

cowpox lymph. After the Genevan physician Jean De Carro failed in his search for cowpox in Austria, he confessed to Jenner: "It does not appear that cows in any part of the great Austrian Monarchy are subject to that disease; and even if they were I should not be bold enough to inoculate with their matter, as it appears that more veterinary knowledge than I have is necessary to distinguish the various diseases of cows."[12] As De Carro explained, taking lymph directly from a diseased cow was difficult because cowpox was hard to distinguish from other bovine diseases, which is why Jenner and other early vaccinators looked for infected milkmaids and farmhands.

One early investigator who succeeded in the hunt was the Milanese physician Luigi Sacco. In the autumn of 1800 he discovered a new source of cowpox.[13] "After long researches," Sacco reported to Jenner in 1801, "I have at last found the virus indigenous in Lombardy; and with this virus there have already been more than eight thousand inoculations performed with the most happy success."[14] Indeed, Sacco would continue to be a major supplier of cowpox lymph to vaccinators in Europe and abroad over the next several years.

As Sacco's letter attests, Lombardy and Gloucestershire were anomalies. Cowpox was hard to find, geographically speaking. Baxby has asserted that cowpox is found only in Great Britain and Western Europe.[15] It was also sporadic, making it temporally rare.[16] The rarity of cowpox, in contrast to the prevalence of smallpox, had direct consequences for the preventive techniques associated with each. Inoculation (also known as variolation)—the procedure of inducing a mild case of smallpox by inserting lymph taken from a pock on someone with an active case of smallpox into a scratch made on the arm of a healthy individual—could be performed anywhere smallpox was present. The practice of inoculation thus depended solely on the communication of knowledge about the technique. The practice of vaccination, however, depended on transmitting not only knowledge about the technique but, more importantly, on the

12. De Carro to Jenner, in Baron, *Life of Edward Jenner* (n. 10), 1: 337; cited in Schibuk, "The Search for Vaccinia" (n. 7), p. 53.

13. Yves-Marie Bercé, *Le chaudron et la lancette: Croyances populaires et médecine preventive* (Paris: Presses de la Renaissance, 1984), p. 267.

14. Luigi Sacco to Edward Jenner, Milan, 16 October 1801, in Baron, *Life of Edward Jenner* (n. 10), 1: 453.

15. Baxby, *Jenner's Smallpox Vaccine* (n. 8), p. 3.

16. Writing almost three decades later in 1827, John Baron, Jenner's biographer, asserted that cowpox had been located in eighteen English counties, including Devon, Dorset, Somerset, and Hampshire. Baron, *Life of Edward Jenner* (n. 10), 1: 239.

availability of cowpox itself. Because the natural occurrence of cowpox was sporadic and geographically specific, most would-be vaccinators depended on a foreign source of cowpox lymph.[17] In the early years, these sources were generally limited to Gloucestershire, Lombardy, and London. Establishing vaccination, then, was more difficult than establishing inoculation because of these environmental constraints.

Part Two: Transporting Cowpox

Because infected cows were hard to find, early vaccinators focused their efforts on methods of transporting cowpox lymph. They developed a complex technology composed of a variety of medical techniques and tools, practitioners, institutions, and patients.[18] The techniques changed in response to initial failures to transport and maintain the cowpox lymph in new environments. Information was exchanged privately through correspondence and formally through numerous publications, including pamphlets, journal articles, and broadsides. Doctors and surgeons were among the first vaccinators, but the practice did not remain confined to medical circles for very long. A broader public, including elite families, philanthropists, clergy, military leaders, and government bureaucrats, became actively involved in the spread of cowpox. Many supporters were motivated by Enlightenment ideals of humanitarianism and progress, by economic goals of reducing depopulation and increasing productivity, or by military concerns about keeping soldiers and sailors healthy.

Early reports of the numbers of patients vaccinated in Europe, Latin America, and Ceylon suggest that many individuals were willing to undergo the procedure.[19] Historian Deborah Brunton has argued that because the techniques of inoculation and vaccination were practically the same, the upper and middle classes in Britain, who had already widely accepted inoculation (variolation), were willing to embrace the new procedure.[20] In India, by contrast, vaccination was regarded as a foreign (i.e., British) import and as something completely different from the indig-

17. Even Jenner at times had to rely on nonlocal sources of cowpox lymph. C. W. Dixon, *Smallpox* (London: J. & A. Churchill, 1962), p. 268.

18. Jennifer Keelan and Sanjoy Bhattacharya, Mark Harrison, and Michael Worboys have carefully analyzed the different techniques of vaccine production and methods of vaccination in their work on vaccination in Canada and India, respectively: Keelan, "The Canadian Anti-Vaccination Leagues" (n. 9); Bhattacharya, Harrison, and Worboys, *Fractured States* (n. 9).

19. See below for examples from Naples, Lombardy, and Mexico.

20. Deborah Brunton, "Pox Britannica: Smallpox Inoculation in Britain, 1721–1830" (Ph.D. diss., University of Pennsylvania, 1990), pp. 191–93.

enous practice of inoculation. This perception hindered the acceptance of vaccination.[21] The French scholar Anne Marie Moulin has described the early reactions to vaccination in Algeria, Tunisia, Egypt, and Brazil as ranging from "mild enthusiasm to resistance."[22]

Although these examples suggest a level of opposition to vaccination, well-organized and widespread resistance to vaccination did not develop until the mid-nineteenth century.[23] Part of the reason for a lack of opposition early on may have had to do with the circumstances of circulation. The early geographical spread of vaccination was essentially haphazard, determined largely by personal contacts and private interests, with the notable exceptions of two ambitious colonial projects, the Spanish Balmis expedition (1803–6) and the British Mediterranean expedition (1801–2), to be discussed below.[24]

The key to vaccination's early spread was transporting lymph. Lymph was distributed through private correspondence networks as well as through official channels. Some of these networks can be retraced through extant letters and artifacts, but most cannot. Individuals who wanted a supply of cowpox often tried many channels, because the chances that the cowpox would arrive ineffective were high. Judging from correspondence and the pamphlet literature, it appears that many well-informed and curious individuals forwarded cowpox lymph and information about vaccination as the latest novelty along with other news.

21. Neils Brimnes, "Variolation, Vaccination, and Popular Resistance in Early Colonial South India," *Med. Hist.*, 2004, *48*: 199–228, p. 218; David Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India* (Berkeley: University of California Press, 1993), ch. 3.

22. Anne Marie Moulin, "La Vaccine hors d'Europe. Ombres et lumières d'une victoire," *Bull. Acad. Natl. Med.*, 2001, *185*: 785–95, p. 785.

23. For Britain, see Dorothy Porter and Roy Porter, "The Politics of Prevention: Anti-Vaccinationism and Public Health in Nineteenth-Century England," *Med. Hist.*, 1988, *32*: 231–52; Nadja Durbach, *Bodily Matters: The Anti-Vaccination Movement in England, 1853–1907* (Durham: Duke University Press, 2005); and J. R. Smith, *The Speckled Monster: Smallpox in England, 1670–1970, With Particular Reference to Essex* (Chelmsford: Essex Record Office, 1987). For Canada, see Keelan, "The Canadian Anti-Vaccination Leagues" (n. 9). For France, see Bercé, *Le chaudron et la lancette* (n. 13) and Pierre Darmon, *La Longue Traque de la Variole: Les pionniers de la médecine preventive* (Paris: Librairie Académique Perrin, 1986). For Germany, see Claudia Huerkamp, "The History of Smallpox Vaccination in Germany: A First Step in the Medicalization of the General Public," *J.Contemp. Hist.*, 1985, *20*: 617–35. For Sweden, see Peter Sköld, *The Two Faces of Smallpox: A Disease and its Prevention in Eighteenth- and Nineteenth-Century Sweden,* Report No. 12 from the Demographic Database, Umeå University, 1996.

24. John Z. Bowers, "The Odyssey of Smallpox Vaccination," *Bull. Hist. Med.,* 1981, *55*: 17–33; Darmon, *La Longue Traque* (n. 23), ch. 9, pp. 175–98.

The word *vaccination* was not coined until 1803, and before it became widely adopted, multiple terms, such as *cowpox inoculation*, *cowpoxing*, and *kine-pock inoculation*, were in circulation.[25] Similarly, the lymph used in vaccinations was variously referred to as *cowpox*, *cowpox lymph*, *cowpox virus*, *vaccine lymph*, or, simply, *matter*. It was transported in three ways: in a dried state, in a fluid state, and by vaccinated individuals. The first method to be tried was taken directly from the practice of inoculation (variolation), and it involved sending a thread that had been soaked in cowpox lymph and then dried. George Pearson, an Edinburgh-trained physician to Saint George's Hospital in London, was one of the first to try this method. In 1799, he sent 200 impregnated threads taken from vaccinated patients in the London Smallpox and Inoculation Hospital to medical men throughout Britain, continental Europe, and elsewhere.[26] Jenner, too, sent vaccine threads. In July 1800, for example, he forwarded a thread to the Reverend John Clinch, an old school friend who worked as a missionary in Trinity Harbour, Newfoundland. "Lest the threads sent you by George [Pearson] should not take effect," Jenner explained, "I have inclosed a bit more, newly impregnated with the cow-pox virus; use it like a small-pox thread; but small as it is, divide it into portions, that you may multiply your chance of infecting. Wet it before insertion, or rather moisten it."[27] Unlike most early efforts to ship cowpox lymph, Jenner's thread proved effective, and Clinch vaccinated his own children and some seven hundred other persons in Newfoundland.[28]

Threads were convenient because they were small, lightweight, and easily sent by post. But their failure rate was great, so early vaccinators tinkered with other techniques. In his 1801 pamphlet, *Instructions for Vaccine Inoculation*, Jenner recommended preserving dried cowpox lymph "between two plates of glass . . . The virus, thus preserved . . . may easily be restored to its fluid state by dissolving it in a small portion of cold water, taken up on the point of a lancet . . ."[29] News of this method spread quickly. In 1802, Lady Elizabeth Amherst Hale, a prominent figure in Montreal, Lower Canada, specifically requested that cowpox be sent "between two pieces of glass" from England in hopes that its efficacy would be pre-

25. Richard Dunning, a Plymouth surgeon, coined the term *vaccination*. See Richard Fisher, *Edward Jenner, 1749–1823* (London: André Deutsch, 1991), p. 76.

26. Fisher, *Edward Jenner* (n. 25), p. 88; Baxby, *Jenner's Smallpox Vaccine* (n. 8), pp. 118–23.

27. Jenner to John Clinch, Cheltenham, 15 July 1800, in Baron, *Life of Edward Jenner* (n. 10), 2: 324.

28. Fisher, *Edward Jenner* (n. 25), p. 110; Cash, *Benjamin Waterhouse* (n. 11), pp. 127–28.

29. Edward Jenner, *Instructions for Vaccine Inoculation* (London: D. N. Shury, 1801), p. 1.

served.[30] She later reported that three attempts to vaccinate her son had failed and that she was resigned to "give him the small pox [by inoculation] as it is very much round the town, & every attempt of sending the vaccine matter has failed this Year, which seems very unaccountable."[31]

Cowpox could also be transmitted in a fluid state, using a practice developed years earlier by inoculators, who had stored smallpox lymph on the end of a lancet when they traveled from one community to another. Early vaccinators, however, met with difficulties. Cowpox lymph that had been preserved on a lancet had to be used within two to three days; otherwise, the lancet rusted. Jenner attributed the rust to the fact that "the Vaccine fluid is much more aqueous than the Variolous." The propensity to rust, he pronounced, "has been one of the most common causes of the numerous errors committed in Vaccine Inoculation." To avoid rusting, expensive lancets of gold, silver, or platinum had to be specially made. Vaccinators also developed less costly quills and ivory points, "shaped like the tooth of a comb" in Jenner's words, on which lymph could be collected and transported. The point was dipped into the lesion, and the fluid was allowed to dry. The precious lancets and points were then stored in larger quills or wrapped in paper to protect the cowpox matter.[32]

Occasionally both dry and fluid methods were tried. The Baltimore surgeon James Smith reported that he had received "some [cowpox] on thread, some on Glass, & some on the Point of the lancette." But only one successful vaccination resulted from using all three sources. Smith did not specify which method preserved the efficacy of the vaccine matter, but the failure of the other two clearly shows that transporting cowpox lymph remained a difficult task.[33]

Getting effective cowpox lymph to hot climates proved especially difficult. Jenner, eager to establish vaccination in the British colonies, tried to ship lymph to India but failed; it arrived ineffective, and in one case was lost altogether due to shipwreck.[34] It was not until 31 March 1802

30. Elizabeth Amherst Hale to William Pitt Amherst, 14 November 1802, in *"The Rising Country": The Hale-Amherst Correspondence, 1799–1825*, ed. Roger Hall and S. W. Shelton (Toronto: The Champlain Society, 2002), p. 126.

31. Hale to Amherst, 30 March 1803, in *"The Rising Country"* (n. 30), pp. 110, 133.

32. Letter from Edward Jenner and John Ring to the Earl of Hardwick, 21 March 1803, copied in Royal Jennerian Society Board of Directors, Minutes of the Royal Jennerian Society for the Extermination of Small Pox, Wellcome MS 4302, pp. 88–91, Wellcome Library, London.

33. James Smith to Edward Jenner, 14 May 1807, Wellcome MS 5232, Wellcome Library, London.

34. The *Queen East Indiaman* was lost at sea. Baron, *Life of Edward Jenner* (n. 10), 1: 408. Also see Michael Bennett, "Passage Through India: Global Vaccination and British India, 1800–5," *J. Imp. Commonw. Hist.*, 2007 *35*: 201–20.

that Jean De Carro successfully shipped lymph to Bombay via Baghdad. De Carro, a Genevan who had received his M.D. from Edinburgh and who practiced medicine in Vienna, became one of the staunchest supporters of Jenner on the continent.[35] It was through De Carro's efforts that vaccination was introduced in Austria, Poland, Greece, and the cities of Venice and Constantinople.[36] In a letter to Jenner, De Carro carefully described his successful shipping technique. First he saturated lint with cowpox lymph and then placed the lint between two pieces of glass, one concave, one flat. He then sealed it with oil. "To prevent the access of light," De Carro continued, "I commonly fold it in a black paper, and when I was desired to send to Baghdad, I took the precaution of going to a wax-chandler's, and surrounded the sealed-up glasses with so much wax as to make balls. With this careful manner it arrived *still fluid* on the banks of the Tigris."[37]

In the southern United States, hot climates presented similar difficulties. From his home in Monticello, Virginia, Thomas Jefferson was eager to try vaccination, so he wrote to Benjamin Waterhouse. Waterhouse, a Rhode Island native who had studied medicine in London, Edinburgh, and Leiden and who held the chair in the theory and practice of physic at Harvard Medical School in Cambridge, Massachusetts, had been the first person to perform a successful vaccination in the United States. Waterhouse tried twice to send cowpox lymph to Jefferson from Massachusetts, but both times it had arrived in Virginia ineffective. In response, Jefferson designed a new container: An inner chamber would hold the fluid lymph, while a surrounding chamber, filled with cool water, insulated the lymph from heat.[38] Waterhouse adopted Jefferson's method, but he continued to ship cowpox lymph using threads and glass as well.[39]

James Smith, in Baltimore, also faced the "almost insuperable difficulty of keeping the matter active" during the steamy months of July and August. In 1803, Smith started to preserve cowpox scabs, which he would later moisten with a drop of water prior to insertion.[40] This method allowed Smith to maintain a supply of cowpox and to avoid the difficul-

35. Bercé, *Le chaudron et la lancette* (n. 13), pp. 20–22.

36. He received lymph from George Pearson and Luigi Sacco.

37. Jean De Carro to Edward Jenner, Vienna, 22 April 1803, in Baron, *Life of Edward Jenner* (n. 10), 1: 430.

38. Fisher, *Edward Jenner* (n. 25), p. 111; Cash, *Benjamin Waterhouse* (n. 11), ch. 12.

39. Cash, *Benjamin Waterhouse* (n. 11), p. 203.

40. Smith to Jenner (n. 33).

ties associated with transportation. It is not clear why this method was not widely adopted.[41]

The challenges raised by transporting and maintaining effective cowpox lymph led vaccinators to ponder the effects of new environments on the vaccine matter. Clearly heat destroyed the lymph's power to infect, but were there more subtle effects? Waterhouse sought to evaluate whether the New England climate had affected the lymph's nature. In an early example of how cowpox circulated between the Old and New Worlds, using some cowpox lymph he had received from England, Waterhouse vaccinated patients in Massachusetts and then sent some vaccine threads harvested from these individuals back to England. Jenner vaccinated successfully with Waterhouse's threads and concluded that the cowpox had maintained its original character.[42] Waterhouse also wondered whether local climate would affect the symptoms associated with vaccination. He noted that even in "the greater dryness of our [New England's] atmosphere, and extraordinary heat," his vaccinated patients experienced symptoms similar to those described by Jenner and other English authors.[43]

There were other, more expeditious, methods for ascertaining the genuineness and efficacy of cowpox once it arrived in a new location. For physicians, surgeons, and other practitioners who had not directly witnessed vaccination, pamphlets and engravings provided invaluable guidance. Jenner's *Inquiry* (1798) and his *Instructions for Vaccine Inoculation* (1801), along with other pamphlets such as C. R. Aikin's *A Concise View of All the Most Important Facts which have hitherto appeared concerning the Cow-Pox* gave clear instructions and details concerning the method and course of vaccination.[44] Unusual or atypical symptoms warned medical

41. According to Dixon, dried cowpox scabs could harbor live virus for many months: Dixon, *Smallpox* (n. 17), p. 162. In her book on the introduction of vaccination into Japan, Ann Jannetta documents that efforts to transmit cowpox lymph to Japan failed. It was not until 1849, when dried cowpox scabs were imported, that successful vaccinations were performed in Japan. See Jannetta, *The Vaccinators: Smallpox, Medical Knowledge, and the "Opening" of Japan* (Stanford, Calif.: Stanford University Press, 2007).

42. Benjamin Waterhouse, *A Prospect of Exterminating the Small Pox. Part II, Being a Continuation of a Narrative of Facts Concerning the Progress of the New Inoculation in America* (Cambridge, 1802), p. 78.

43. Benjamin Waterhouse, *A Prospect of Exterminating the Small-Pox; Being the History of the Variolae Vaccinae, or Kine-Pox, Commonly Called the Cow-Pox; as It Has Appeared in England: With an Account of a Series of Inoculations Performed for the Kine-Pox, in Massachusetts* (Cambridge, 1800), p. 19. Historians have argued that the symptoms of vaccination were much more severe in India because of differences in procedure and vaccine matter. See Bhattacharya, Harrison, and Worboys, *Fractured States* (n. 9), pp. 58–59.

44. See, for example, Thomas Paytherus, *A Comparative Statement of Facts and Observations Relative to the Cow Pox,* 2nd ed. (London: Shury, 1801); and George Kirkland, *Thirty Plates of Small Pox and Cow Pox Drawn From Nature* (London: Johnson, 1802).

practitioners that the vaccination might not have been successful and helped to determine whether the cowpox was genuine or spurious.

The predominant identifying symptom of a successful vaccination was the appearance of a lesion at the site of vaccination. Jenner had included four colored plates in his *Inquiry*, including the one of Sarah Nelmes's hand. Many artists made similar drawings illustrating the appearance of vaccination lesions on successive days. Other plates compared the lesions from inoculated and vaccinated patients, so that smallpox inoculators would know what to expect when they vaccinated their patients.[45] These plates were distributed along with the cowpox lymph and printed instructions. Waterhouse, for example, sent David Ramsay, a physician in Charleston, South Carolina, cowpox lymph, instructions, and one of Jenner's "admirably colored engravings, transcending all verbal description" of the course of cowpox.[46]

Waterhouse also solicited from Jenner several engravings of the cowpox lesion on Africans in order to facilitate the evaluation of vaccination among slaves in the United States. Jenner obliged Waterhouse, and in the spring of 1801, Waterhouse sent the engravings along with a copy of Aikin's pamphlet to now-President Thomas Jefferson:

> [These engravings are] exact pictures of the kine-pock pustule, in all its stages, from the third day to the final termination, painted with surprising justness, together with similar representations of the small-pox, on corresponding days. The dark coloured picture, is a representation of the kine-pock on the skin of the *negro*.[47]

Waterhouse's appealing to Jenner as the authority, rather than relying on local expertise, reflected not so much the deference of a colonial physician but the need for an agreed-on standard etiology for the cowpox. Illustrations and descriptions thus played critical roles in the transfer and spread of vaccination.[48]

Part Three: Maintaining Cowpox

After the cowpox arrived in a new location, it was generally maintained through arm-to-arm transfer. Jenner had developed the technique of

45. C. R. Aikin, *A Concise View of All the Most Important Facts which have hitherto appeared concerning the Cow-Pox*, 2nd ed. (London: R. Phillips, 1801).

46. Waterhouse, *Prospect for Exterminating the Small Pox. Part II* (n. 42), p. 78.

47. Ibid., pp. 25–26.

48. For a recent overview of the importance of visual language to science and medicine, see "Focus: Science and Visual Culture," *Isis*, 2006, *97*: 75–120.

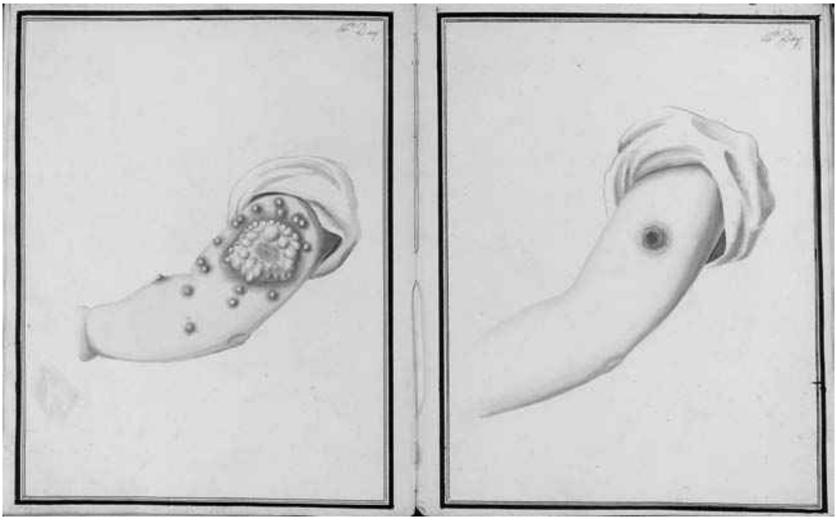

Figure 1. Engraving (in color) comparing the smallpox inoculation and cowpox vaccination on the fourteenth day following incision. (Source: George Kirkland [1802], Wellcome Library, London.)

arm-to-arm transfer in 1798, when he vaccinated his neighbors in the small town of Berkeley in Gloucestershire. He noted in his *Inquiry*: "These experiments afforded me much satisfaction. They proved that the matter in passing from one human subject to another, through five gradations, lost none of its original properties."[49] Lymph was generally harvested between the sixth and tenth day following vaccination. The vaccinator would puncture a lesion and remove lymph on the tip of the lancet, which would then be inserted into a small incision made on the arm of a healthy individual.[50]

Until the technique of harvesting lymph directly from calves and heifers was developed in the 1850s and 1860s, arm-to-arm transfer remained one of the primary means by which cowpox was maintained. But there were problems with this technique. Lancing the lesion to collect lymph exposed the patient to erysipelas, an infectious skin disease, and to other infections. By the mid-nineteenth century, physicians began arguing that syphilis could be transmitted, and in India, it was feared that leprosy was

49. Edward Jenner, *An Inquiry into the Causes and Effects of Variolae Vaccinae* (London, 1798), p. 44.

50. For a late-nineteenth-century description of this process, see Keelan, "The Canadian Anti-Vaccination Leagues" (n. 9), p. 74.

spread by this means.[51] Arm-to-arm vaccination also violated ideas of bodily integrity, which was why those with little power, foundlings and the poor, were generally used as sources for lymph.[52]

In the early days of vaccination, the main difficulty facing arm-to-arm transmission was its reliability: cowpox could and often did disappear if the chain of infection was broken. In 1800, for example, De Carro sent cowpox lymph to Constantinople, where it was used by European families. But by 1802, the virus was lost, and De Carro had to ship a new supply.[53] Similarly, in Veracruz, Mexico, 1,350 persons were vaccinated within two months in 1804, but that success left no unexposed individuals to maintain the cowpox, and thus it disappeared.[54]

A few doctors tried to maintain a supply of cowpox by using animals. In 1799, Woodville inoculated a cow with cowpox and then later successfully vaccinated patients at the London Smallpox Hospital with lymph harvested from the cow.[55] This technique of using cows to maintain cowpox, however, was rarely successful until the second half of the nineteenth century. Likewise, efforts by some vaccinators to inoculate cows with smallpox in order to create cowpox generally failed.[56]

The best method for maintaining cowpox remained arm-to-arm transfer, but this required sustained effort, which, in practice, was better accomplished by institutions than by individuals. This fact was recognized early on. In June 1799, George Pearson established the London Vaccine-Pock Institution. Pearson's institution offered free vaccinations to the poor and supplied cowpox lymph to any vaccinator who requested it. In February 1800, the Edinburgh Publick Dispensary established a vaccine institute, and in Glasgow, the Faculty of Physicians and Surgeons' Hall became the de facto vaccination clinic.[57] Later that year, the Comité Central de Vac-

51. Bhattacharya, Harrison, and Worboys, *Fractured States* (n. 9), p. 43.

52. See Brimnes, "Variolation" (n. 21); Durbach, *Bodily Matters* (n. 23).

53. Baron, *Life of Edward Jenner* (n. 10), 1: 416.

54. Michael M. Smith, "The 'Real Expedición Marítima de la Vacuna' in New Spain and Guatemala," *Trans. Am. Philos. Soc.*, 1974, *64*: 1–74, n. 25.

55. This practice became known as retrovaccination: William Woodville, *Reports of a Series of Inoculations for the Variolae Vaccinae, or Cow-pox; With Remarks and Observations on this Disease, Considered as a Substitute for the Small-Pox* (London, 1799), reprinted in Edgar March Crookshank, *History and Pathology of Vaccination,* 2 vols. (Philadelphia: P. Blackiston, Son, & Co., 1889), 2: 34–35, 62–64; discussed in Baxby, *Jenner's Smallpox Vaccine* (n. 8), pp. 95–96. Darmon wrote that Sacco also successfully vaccinated a cow with cowpox in Milan: Darmon, *La Longue Traque* (n. 23), p. 319.

56. Baxby, *Jenner's Smallpox Vaccine* (n. 8), pp. 154–56; Schibuk, "The Search for Vaccinia" (n. 7), pp. 111–39; Keelan, "The Canadian Anti-Vaccination Leagues" (n. 9), pp. 81–89. For India, see Bhattacharya, Harrison, and Worboys, *Fractured States* (n. 9), pp. 37–40.

57. Fiona A. Macdonald, "Vaccination Policy of the Faculty of Physicians and Surgeons of Glasgow, 1801 to 1863," *Med. Hist.*, 1997, *41*: 291–321, 298–301.

cine opened a vaccination hospital in Paris. The Paris vaccination hospital served as the center for extensive trials of the procedure and distributed the cowpox lymph in Paris and to surrounding areas.[58] In places where inoculation was well established, such as London and Stockholm, inoculation hospitals were converted into vaccination clinics.[59]

Institutions were thus crucial to the spread of vaccination. They provided the best means with which to maintain cowpox through successive vaccinations. Vaccinators were no longer reliant on foreign sources of lymph and the vicissitudes of transportation. Vaccine institutes and hospitals soon appeared around the world. In colonial Ceylon, for example, the British surgeon Thomas Christie recommended that the colonial medical superintendents oversee the maintenance of cowpox by arm-to-arm transfer because it was "of the utmost importance that the virus should be kept up in an uncontaminated state."[60] By September 1802, medical superintendents began establishing vaccination stations throughout the island.[61]

In March 1802, Smith set up a vaccination clinic in Baltimore, and that same year a group of physicians created the New York Institute for the Inoculation for the Kine-Pock.[62] In Montreal, Elizabeth Hale's husband inadvertently created a vaccination clinic when he gave an employee a bottle of wine to improve his health. The wine did so much good for the worker that:

> he said I must be 'un Grand Medecin,' & if I advised the Cow Pox, his children should be innoculated. They were so, & did well, & having soon proved that they resisted the Small Pox, the Public opinion has undergone such a Revolution, that Subjects enough have been found to keep the disorder alive till now.[63]

58. *Rapport du Comité Central de Vaccine, Établi à Paris par la Société des souscripteurs pour l'examen de cette Découverte* (Paris: de l'Imprimerie de Guilleminet, an XI [1803]). On the vaccination trials, see Andrea Rusnock, "Medical Statistics and Hospital Medicine: The Case of Smallpox Vaccination," *Centaurus*, 2007, *49*: 337–59.

59. For Stockholm, see Peter Sköld, "The Key to Success: The Role of Local Government in the Organization of Smallpox Vaccination in Sweden," *Med. Hist.*, 2000, *45*: 201–26, 207.

60. Extract from the Report of Thomas Christie, Esq., 8 Sept. 1802; in Minutes of the Medical Committee of the Royal Jennerian Society, Wellcome MS 4304, Wellcome Library, London.

61. Bennett, "Passage Through India" (n. 34), p. 12.

62. John B. Blake, *Public Health in the Town of Boston, 1630–1822* (Cambridge: Harvard University Press, 1959), p. 180; Cash, *Benjamin Waterhouse* (n. 11), p. 219.

63. John Hale to William Pitt Amherst, 25 March 1804, in "*The Rising Country*" (n. 30), p. 158.

In this case, Hale maintained cowpox in Lower Canada through the willing cooperation of the public.

But how did other physicians get patients to return to the clinic? One method was to insist that it was necessary for the vaccinator to inspect the lesions one week following the procedure in order to ascertain that the vaccination was successful; at this time, lymph could be drawn off. More heavy-handed measures were also adopted. In Glasgow, parents had to put down a deposit of 1 shilling (1801) and later 2 shillings (1806) to be refunded only when the child was returned to the clinic.[64] In Boston, Waterhouse resorted to paying parents to vaccinate their children in order to keep a supply of cowpox.[65] The collection of lymph was a controversial point (literally) in vaccination technology.[66]

Arm-to-arm transfer was also employed during long sea voyages, and arguably, these were the most spectacular examples of the success of this method to maintain effective cowpox lymph. The most famous vaccination voyage was the Balmis expedition. King Carlos IV of Spain, a keen supporter of medicine, had read Jenner's pamphlet and wanted "to ameliorate the havoc wrought by the frequent smallpox epidemics in his dominions of the Indies" and to prevent depopulation of the Spanish colonies.[67] The royal surgeon Francisco Xavier Balmis was put in charge of the expedition. Launched in 1803, Balmis began with twenty-two foundlings under the age of ten from the Casa de Niños Expósitos in Santiago de Compostela. He sequentially vaccinated them in pairs as the ship sailed from Spain to the New World. Additional foundlings were recruited as the expedition continued around the world. At each port of call, Balmis distributed cowpox lymph along with his pamphlet *Tratado histórico y práctico de la vacuna* (1803), which contained instructions and colored engravings of the vaccination lesion.[68] He had 2,500 copies of his pamphlet printed specifically for this purpose.[69] By relying on arm-to-arm vaccination, the Balmis expedition succeeded in bringing cowpox to Cuba, Mexico, Guatemala, Panama, Argentina, Chile, Peru, Philippines, and China.

Balmis also tried to establish vaccine institutes in these colonies in order to maintain cowpox. In Mexico City, the capital of Spain's wealthiest colony, administrators planned to use the Casa de Niños Expósitos. One hundred and sixty-four foundlings (under one year of age) would be taken from the thirty-one wards of Mexico City, and four would be vaccinated

64. Macdonald, "Vaccination Policy" (n. 57), p. 300.
65. Cash, *Benjamin Waterhouse* (n. 11), p. 229.
66. Durbach, *Bodily Matters* (n. 23).
67. Cited in Hopkins, *Princes and Peasants* (n. 3), p. 224.
68. Smith, "The 'Real Expedición'" (n. 54).
69. Ibid., pp. 18, 20.

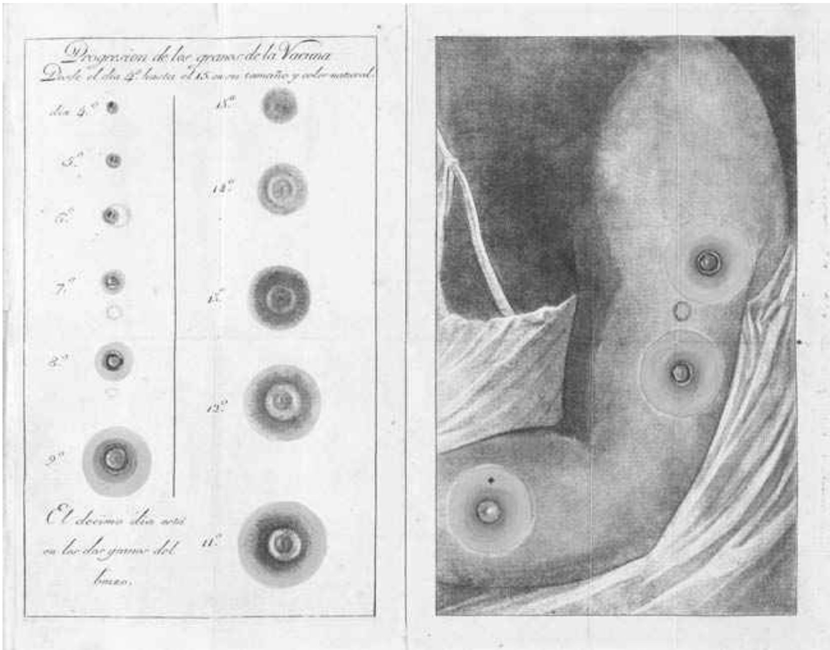

Figure 2. Color plate showing pustule on successive days following vaccination. (Source: Francisco Xavier de Balmis, *Tratado histórico y prático de la vacuna* [Madrid, 1803], Wellcome Library, London.)

every nine days. This routine would assure a constant and reliable source of cowpox that could then be distributed to practitioners throughout Mexico. These detailed plans were not followed, however, although other vaccine boards and institutes were subsequently established in Mexico City, Oaxaca, Guatemala, and Manila, as well as other locations in the Spanish colonies, in the wake of Balmis's expedition.[70]

A similar vaccination voyage, although smaller in scope than the Balmis expedition, was organized by the British government. In July 1801, two military physicians, John Walker and J. H. Marshall, set sail from Portsmouth to British colonies and military garrisons in the Mediterranean.[71] They landed first at Gibraltar and vaccinated the soldiers stationed there. They then sailed to Minorca and Malta and introduced vaccination to those islands. Walker sailed to Egypt with Sir Ralph Abercrombie and "vaccinated all the seamen and soldiers of the expedition," while Marshall

70. Ibid., p. 28.

71. J. H. Marshall was Jenner's neighbor; Fisher, *Edward Jenner* (n. 25), p. 106.

went on to Naples and Palermo and vaccinated both British soldiers and Sicilians.[72] On his return, in January 1802, Marshall reported to Jenner: "The cow-pox was introduced at Palermo, in the island of Sicily, where the ravages of the small-pox had always been experienced with unusual violence, and in which city eight thousand persons had perished the preceding year from that destructive malady alone. Here it was also adopted with enthusiastic ardour. . . ."[73] Marshall continued, "At Naples I found the inclinations of the inhabitants, from the accounts they had received from Palermo, favourable to its practice. An Hospital for the inoculation of the Jennerian disease was immediately established, and every endeavour used to extend its benefits through the kingdom."[74]

In addition to sea voyages, land expeditions provided another path for the spread of cowpox. President Thomas Jefferson gave some cowpox lymph to Meriwether Lewis and William Clark to take on their explorations west of the Mississippi River. Antoine Saugrain, the only practicing physician in St. Louis when Louisiana was purchased by the United States from France in 1803, received some cowpox lymph from Lewis and Clark and began to vaccinate individuals free of charge, including Native Americans.[75] Saugrain's free vaccination program established cowpox in the Mississippi valley roughly a decade after Jenner published his *Inquiry*. In his 1802 pamphlet, Waterhouse stated that he had "planted the true vaccine disease directly in the Province of Maine; in New Hampshire; in the state of Vermont, Rhode Island, Connecticut, New York, Virginia, South Carolina, Georgia, Kentucky, and Tennessee; and in every part of Massachusetts . . . The physicians in the state of Pennsylvania, Delaware, North Carolina, and Maryland, were supplied from my stock, through Mr. Jefferson."[76] Whether he was the source of Lewis and Clark's cowpox lymph, his botanical metaphor was telling. Just as botanists at Kew in London or at the Jardin des Plantes in Paris carefully cultivated species foreign to Europe, so doctors and surgeons cultivated cowpox in the vaccine institutes.[77] These institutions proved more reliable than shipping lymph in a dried or fluid state and hence were key to the global spread of cowpox.

72. Baron, *Life of Edward Jenner* (n. 10), 1: 395–401, p. 401.

73. Dr. Marshall to Edward Jenner, Paris, 26 January 1802 in Baron, *Life of Edward Jenner* (n. 10), 1: 402–3.

74. Ibid., pp. 402–3.

75. Hopkins, *Princes and Peasants* (n. 3), p. 270.

76. Waterhouse, *Prospect for Exterminating the Small Pox. Part II* (n. 42), p. 37.

77. On colonial botany, see Londa Schiebinger and Claudia Swan, eds., *Colonial Botany: Science, Commerce and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2005).

Conclusion

In histories of disease, smallpox is portrayed as an invasive species, spreading quickly and widely in new environments. It crosses borders easily and ravages indigenous human populations. Human carriers have been primarily to blame for this, but infected blankets and clothing have also been implicated. All that has been needed to spread smallpox were vulnerable groups of humans.

Such was not the case for cowpox. Like other biota transferred from their native soils to distant climes, cowpox depended on careful methods of transportation and cultivation suited to new environments. In short, the globalization of cowpox required vaccination. Vaccination initially involved sending cowpox from England around the world. The initial techniques of using threads, glass plates, or special lancets and points continued to be used and in some cases, were modified by adding insulation, but they were frequently replaced with fresh lymph gathered by arm-to-arm transmission at specifically created vaccine institutes. The success of these institutes varied considerably: some relied on financial incentives, others on the use of foundlings, and at least one relied on a bottle of wine. Arm-to-arm transfer made local doctors and surgeons autonomous practitioners less dependent on foreign supplied lymph. Nonetheless, a steady circulation of correspondence, pamphlets, illustrations, and individuals between Europe and the rest of the world helped to ensure the genuineness of the cowpox and the efficacy of vaccination.

Still, vaccination began as an English export regardless of where it might end up, a point made clear by the commemoration of the 200th anniversary of Jenner's discovery. The British government issued a stamp with a drawing of Blossom the cow. Neatly hidden in the cow's markings is a picture of Jenner inoculating a boy, presumably James Phipps. In the background, the milkmaid Sarah Nelmes shoulders two buckets of milk. The iconography of vaccination could not be made clearer. Vaccination was an English invention that depended on West Country dairy cows and represented the tranquil charms of rural life. This iconography of vaccination underscores its specific environmental origin, and yet vaccination, like the stamp on which it was depicted, was a technology that could travel around the world, provided it had the necessary system.

Figure 3. British 1999 Vaccinating Child 20p stamp, (Source: Stamp Designs @ Royal Mail Group Ltd. Reproduced by kind permission of Royal Mail Group Ltd. All rights reserved.)

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