Dear Readers,

Thank you for taking the time to engage with this essay, which is adapted from a much longer draft chapter in my current book project, (very) tentatively titled Water, Steam, and Philadelphia's Eighteenth-Century Anthropocene.

The book uses traces efforts to provide potable water and to manage rainwater in Philadelphia from William Penn's plans for the city in the early 1680s to the city's decision to create a water-powered waterworks at Fairmount. Benjamin Henry Latrobe's 1798 proposal to cool and cleanse the air, wash the streets, and provide potable water for the city of Philadelphia serves as a central moment in this story because that project claimed that it would not only supply water for "culinary use" but that it would enable systematic street washing and, most ambitiously, the cooling and cleansing of the city's air.

This essay focuses most heavily on the context of climate thinking in Philadelphia at the time of Latrobe's proposal, leaving out, except briefly, my analysis of Latrobe's thinking about his own plan, which I provide in another chapter.

I again thank you all for reading and eagerly await our discussion.

Climate Anxiety, Climate Ambition, and Philadelphia's Waterworks

In 1798, Benjamin Latrobe offered a plan to control Philadelphia's temperature and alter its atmosphere while supplying the city with "a sufficiency of wholesome water for culinary purposes." "Fountains," which, despite their extravagant sounding name were "merely … a short wooden pipe, set perpendicularly into the main, and stopped by a cock," provided "the only means of cooling the air." These "fountains" operating in unison would shoot significant quantities of water into the air and do so at sufficient pressure to disperse water particles widely. "The air produced by the agitation of water is of the purest kind," he wrote, "and the sudden evaporation of water, scattered through the air, absorbs astonishing quantities of heat,—or to use the common phrase, creates a great degree of cold." When properly distributed around the city, the effect might be dramatic. To achieve this ambitious vision required a commitment to a relatively new technology: there was, Latrobe warned, nothing "capable of producing the proposed effect with constancy, certainty and adequate force, excepting the *Steam-engine*."[1]

Less than a year later, the Delaware and Schuylkill Canal Company, who had previously held the right to supply Philadelphia with water, claimed that the only reason the city had selected Latrobe's plan was for its promise to cool the air of the city. In response, Latrobe abruptly abandoned the claim. He had, he wrote, "said no such thing" and had only promised "pure water." Despite citing a note on the virtues of river water, which was directly adjacent to his claims about fountains as mechanisms to cool the air, he decried any discussion of cooling as an effort "to charge me with extreme silliness."[2]

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[1] Benjamin Henry Latrobe, *View of the Practicality and Means of Supplying the City of Philadelphia with Wholesome Water* (Philadelphia, 1799), 3–5; 18–19.

[2] William Sansom, *Address of the Committee of the Delaware and Schuylkill Canal Company* (Philadelphia: John Ormrod, 1799), 17; Benjamin Henry Latrobe, *Remarks on the Address of the Committee of the Delaware and Schuylkill Canal Company* (Philadelphia: Zachariah Poulson, Jr, 1799), 8–9; Atmosphere had not been mentioned in

Although short-lived, Latrobe's plan to cool and cleanse the air deserves serious consideration. English plans to alter climate in North America were widespread and consistent features both of promotional writing in support of settlement schemes and in natural philosophical correspondence, but these were overwhelmingly rural, often focused on the climatic effects of deforestation, drainage, and other landscape transformations categorized as "improvement."[3] Latrobe's scheme stands out for its focus on transforming atmosphere in the built environment, for its use of steam technology and urban infrastructure to accomplish it, and because it predated the development of a global climate science in the nineteenth century.[4]

Latrobe's plan emerged at a particular moment of climate uncertainty and climate anxiety, particularly in North America.[5] Tension, anxiety, and uncertainty existed alongside increasingly precise instrumental measurements and the gathering of weather data and new work in chemistry. Their nexus was the point from which new ambitions to manage climate through technology and infrastructure emerged. When they did so, it was, as Latrobe put it, as "innovations" or "as projects," terms that, by the eighteenth century implied capacious efforts to overcome natural

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the initial publication outlining the need for a new supply and the merits of the Delaware and Schuylkill Canal Company. See *Report of the Joint Committee of the Select and Common Councils on the Subject of Bringing Water to the City* (Philadelphia: Zachariah Poulson, Jr, 1798), 3–4.

[3] Jan Golinski, "American Climate and the Civilization of Nature," in *Science and Empire in the Atlantic World*, ed. James Delbourgo and Nicholas Dew (New York: Routledge, 2008), 153–74; Anya Zilberstein, *A Temperate Empire: Making Climate Change in Early America*, 1 edition (New York, NY, United States of America: Oxford University Press, 2016).

[4] The architectural historian Catherine Bonier provided the most thorough engagement with Latrobe's climate ambitions. See Catherine Bonier, "Benjamin H. Latrobe's Philadelphia Waterworks of 1801: Instrument and Expression of American Equilibrium" (PhD, Philadelphia, PA, University of Pennsylvania, 2015), 158–207; Philipp Lehmann, *Desert Edens: Colonial Climate Engineering in the Age of Anxiety*, (Princeton: Princeton University Press, 2022), 2–10 Lehmann notes the presence of the desire for climate control in the eighteenth century but argues that these ambitions only shifted into more concrete plans later in the nineteenth century. See pgs. 5-6. Deborah R. Coen, *Climate in Motion: Science, Empire, and the Problem of Scale* (Chicago: University of Chicago Press, 2018), 1–3; 5–7; 10–13; 16–20; On urban climatology as a field of study and the continued relevance of the city in climate science, see Vladimir Janković, "A Historical Review of Urban Climatology and the Atmospheres of the Industrialized World," *WIREs Climate Change* 4, no. 6 (November 2013): 539–53; On the importance of "smaller-scale narratives" in discourses about the Anthropocene, see Jan Golinski, "Debating the Atmospheric Constitution: Yellow Fever and the American Climate," *Eighteenth-Century Studies* 49, no. 2 (2016): 161.

[5] Golinski, "Debating the Atmospheric Constitution."

limitations without certainty in their success.[6] These projects reveal that rather than having "tumbled into" an Anthropocene defined as "an unintended consequence of human choices," early Americans embraced atmospheric agency.[7]

Climate, Disease, and Uncertainty

In November 1766, the Board of Managers and the physicians of the Pennsylvania Hospital met at the house of Dr. Thomas Bond, one of the institution's founders, to hear him read an essay on his plan for a series of clinical lectures. Bond emphasized the importance of climate and weather in medical practice. "The climate is sometimes productive to severe Epidemic Diseases in the Summer & Fall," but Philadelphia was not inherently sickening. "The Atmosphere that Surrounds us is fine," he asserted, "and the air we breath [sic], free, pure, and Naturally healthy." With the right approach Philadelphia's physicians could "wipe this Stain out of the American Escutcheon and rescue their Country from such frequent calamities."[8]

Bond was confident: preventing epidemics was "more within the limits of human precaution than has generally been imagined." Philadelphia had eliminated the "common Sewer of Filth" at Dock Creek. Recent laws for paving the streets and "indefatigable industry and skill of the Commissioners in executing them" had already eliminated other "neglected Sources of putrefaction." "An Exact register of the Weather, and of the prevailing Diseases" along with his own insights from private practice would enable him to precisely how weather caused or increased vulnerability to illness. All that he needed was a "Meteorological Apparatus" at the hospital, a request the Board of Managers enthusiastically granted, ordering the physicians to

[6] Benjamin Henry Latrobe, "Report on the Subject of Steam Engines" (May 27, 1803), APS.Archives.III.1, Box 4, American Philosophical Society (APS); Vera Keller and Ted McCormick, "Towards a History of Projects," *Early Science and Medicine* 21, no. 5 (2016): 429; 435–36; 440–42.
[7] Dipesh Chakrabarty, *The Climate of History in a Planetary Age* (Chicago: University of Chicago Press, 2021), 34.
[8] "Board of Managers Minutes, 14 May 1764 - 1 May 1769" (n.d.), 278–79; 283–84, Pennsylvania Hospital Archives, Mss.Film.1204, Reel 1, vol. 3, APS.

"employ some careful and Skilful person to take down observations on the State of the Air and Weather and duly to register the same."[9]

Attempts to record, compare, and assess more precise meteorological data proved difficult, however, rendering endeavors like the one Bond had proposed challenging. The New England minister Samuel Williams warned about the difficulties understanding weather in a set of meteorological observations sent to the American Philosophical Society in 1774. After reporting annual quantities of rainfall and "exhalations," he wrote that the significance of such numbers could not be determined without longer series of observations in the same place to determine whether any individual year reflected a pattern or was an anomaly. This was part of a broader problem. "Meteorological diaries" taken across the colonies "might be of use to point out the origin, order, and extent of the winds; the several changes and variations of the seasons; their influence and effect in causing and removing disorders; the present state, and any future alterations of the climate." Unfortunately, "we have as yet but few accurate observations in America." Williams believed that weather could cause or stop disease outbreaks, but worried that there without enough weather diarists and without standardized instruments and observation practices that this relationship would remain obscure.[10]

Worries about the reliability and standardization of meteorological instruments were common in eighteenth-century Europe, but there were distinct worries about North American measurements that point to a larger anxiety about the continent's climate. A letter from the *philosophe* the Marquis de Condorcet to the American Philosophical Society inquired whether "the height of the mercury in the barometer the same conformity with the change of weather as

[9] "Board of Managers Minutes, 14 May 1764 - 1 May 1769," 284–85; 289–90.
[10] Samuel Williams, "Meteorological Observations Taken in New England, 1771 and 1773," Meteorological Material, 551.5.M56, no. 6, APS; Samuel Williams, "Experiments on Evaporation, and Meteorological Observations Made at Bradfield in New-England," *Transactions of the American Philosophical Society* 2 (1786): 122; 135.

in our continent." "Generally speaking," he assumed, the pattern would be true, but "there may be some inequality capable of throwing a great light upon the meteorological science, a science still in its infancy." Small variations in the functioning of the barometer might reflect meaningful differences in how the atmosphere worked in different parts of the world, he mused, "since we do not know what part in the Alterations in the weight of the atmosphere is owing to the effect of the celestial bodies [and] what part is owing to local causes."[11]

Some weather observers, like prominent Philadelphia Quaker Israel Pemberton, Jr., whose surviving journals stretch 1748 to 1778, made few efforts to opine on significance or comparative intensity of weather. He filled tables with morning and evening temperatures[12], a barometer reading, wind direction, and "weather," a heading under which he provided very brief qualitative descriptions such as "fair," "foggy," "cloudy," or "sunny." His only additional notes reported when the Delaware River froze, something that he also mentioned in his correspondence. He did not treat the frozen river as abnormal, with rare exceptions such as December 23, 1758, when the morning and evening temperatures were 19º and 23º F and "A very intense Frost…render'd Delaware unnavigable." He did not apply similar labels to other days with similar or lower thermometer readings. On February 22, 1773, he offered his most detailed comparative commentary, calling the day where his thermometer readings were 0º, 13º, and 11º "most Intense Frost that has been known for several years."[13] He offered no comparable

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[11] "Minutes of the American Philosophical Society Held at Philadelphia for Promoting Useful Knowledge, 1769 - 1774," 169–70, APS.Archives.I.5, 1769 - 1774, APS; Hasok Chang, *Inventing Temperature: Measurement and Scientific Progress* (New York: Oxford University Press, 2004).

[12] There were significant problems with the consistency and translatability of eighteenth-century temperature recordings for reasons Hasok Chang explores in detail. Here, I have reproduced the measurements from contemporary sources without an effort to standardize them. Chang, *Inventing Temperature*, 57–102.

[13] Israel Pemberton, "Diary of the Weather at Philadelphia" (1748), Meteorological Material, 551.5.M56, no. 1, vol. 1, APS; Pemberton, "Meteorological Observations at Philadellphia" (1760), *ibid*, vol. 2; Pemberton, "Meteorological Observations at Philadelphia" (1769), *ibid*, vol. 3; Pemberton, "Meteorological Observations at Philadelphia, December 1770 - 24 July 1772" (1772), *ibid*, vol. 6; IPemberton, "Register of the Weather" (1772),

commentary on high temperatures and never made any connection to disease, despite his and his family's early and significant connection with Pennsylvania Hospital.

Printed, widely circulated copies of meteorological observations were often similarly vague. Peter Legaux, a French vintner living just outside Philadelphia, produced meteorological tables for *The Columbian Magazine* from 1786 to 1789. Until April 1789, his tables recorded temperature in both Fahrenheit and Réaumur scales; barometric readings; prevailing wind direction; a tally of days of rain, thunder, snow, "tempest," and aurora borealis; and very concise qualitative descriptions of the weather such as "fair." The tables also contained records of monthly high, low, and average temperature and barometer readings, and qualitative summary assessments of the month's weather. In April 1789, the format of the *Magazine*'s tables shifted to include total monthly rainfall and a space for "Prevailing Sickness." Legaux had been using blank printed tables with these categories available since at least February, but April marked the first time they appeared in print. That same month he wrote to Benjamin Franklin, hopeful that his observations might contribute to a wider culture of meteorological observation and analysis in Philadelphia.[14]

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ibid, vol. 7; Pemberton, "Register of the Weather" (1773), *ibid*, vol. 9, APS; Pemberton, "Meteorological Observations about 2 Miles West of Philadelphia, September 1774 - April 1775" (1775), *ibid*, vol. 10, APS; Pemberton, "Register of the Weather" (1775), *ibid*, vol. 11, APS; Pemberton, "A Meteorological Register near Philadelphia" (1775), APS.Archives.III.1, OS, APS; Pemberton, "Meteorological Observations about 2 Miles Westerly of Philadelphia, 16 April - 31 December 1776" (1776), Meteorological Material, 551.5.M56, no. 1, vol. 15, APS; Pemberton, "Meteorological Register from January 1775 to June 1777," Mss.B.P274, Series One, APS; Pemberton, "Meteorological Observations near Philadelphia, 1777 - May 1778" (1778), Meteorological Material, 551.5.M56, no. 3, APS; "Israel Pemberton to Eleazer Sheldon" (February 17, 1746), Israel Pemberton Letterbook D, Mss.380.P36, p. 499, APS; "Israel Pemberton to Capt. Daniel Rees" (January 1, 1746), *ibid*, p. 493; "Israel Pemberton to Jonathan Hunt" (December 26, 1748), *ibid*, p. 491.

[14] Peter Legaux, "Meteorological Observations Made at Springmill, 13 Miles NNW. of Philadelphia, 409'N. Month of November, 1786," *The Columbian Magazine* (*TCM*), November 1786; Legaux, "Meteorological Observations … December, 1786," *TCM*, December 1786; Legaux, "Meteorological Observations … January, 1787," *TCM*, January 1787; Legaux, "Meteorological Observations … February, 1787," *TCM*, February 1787; Legaux, "Meteorological Observations … March, 1787," *TCM*, March 1787; Legaux, "Meteorological Observations … April, 1787," *TCM*, April 1787; Legaux, "Meteorological Observations … July, 1787," *TCM*, July 1787; Legaux, "Meteorological Observations … September, 1787," *TCM*, September 1787; Legaux, "Meteorological Observations … October,

The appearance of "Prevailing Sickness" in the published tables did not, however, signal a clear or coherent effort to explain a connection between weather and disease to readers. In April 1789, the prevailing meteorological conditions were "very cold, rainy and unfavourable for every thing" and Philadelphia saw "great mortality among the children…occasioned by the measles." Was it the generally "unfavourable" weather or some specific events—the "tempest" on the 10th, the successive "hot" days on the 14th-15th, or the "cold, overcast, unfavourable weather" on the 28th—that were correlated with or contributed to Philadelphia's increase in childhood measles? The connection to healthy months was similarly unclear; "fair, variable, moist, very vegetative, and stormy" July produced no sickness whatsoever. Readers were left to make their own presumptions about the "very fair, very hot, and very pleasant" August, the last month in which the magazine ran Legaux's observations, since he left the section on diseases blank, along with much of the rest of the table.[15]

1787," *TCM*, October 1787; Legaux, "Meteorological Observations … November, 1787," *TCM*, November 1787; Legaux, "Meteorological Observations … February, 1788," *TCM*, February 1788; Legaux, "Meteorological Observations … March, 1788," *The Columbian Magazine*, March 1788; Legaux, "Meteorological Observations … April, 1788," *TCM*, April 1788; Legaux, "Meteorological Observations … May, 1788," *TCM*, May 1788; Legaux, "Meteorological Observations … July, 1788," *TCM*, July 1788; Legaux, "Meteorological Observations … August, 1788," *TCM*, August 1788; Legaux, "Meteorological Observations … September, 1788," *TCM*, September 1788; Legaux, "Meteorological Observations … October, 1788," *TCM*, October 1788; Legaux, "Meteorological Observations … November, 1788," *TCM*, November 1788; Legaux, "Meteorological Observations … January, 1789," *TCM*, January 1789; Legaux, "Meteorological Observations … February, 1789 with an Explanation of the Foregoing Table," *TCM*, February 1789; Peter Legaux, "Meteorological Observations …March, 1789," *TCM*, March 1789; Legaux, "Meteorological Observations … April, 1789," *TCM*, April 1789; Peter Legaux, "Observations Météorologiques Faites à Springmill [Pennsylvania]" (1789), Mss.551.5.L52, APS; "Peter Legaux to Benjamin Franklin" (April 2, 1789), Manuscript Archives of The College of Physicians of Philadelphia, 1787-1847, CPP 1, pg. 65, Historical Medical Library of the College of Physicians of Philadelphia (HML); Elaine LaFay, "Looking at the Weather: The Politics of Meteorological Data," *Harvard Data Science Review* 5, no. 3 (July 27, 2023): 2–5.

15 Patricia Cline Cohen, *A Calculating People: The Spread of Numeracy in Early America* (New York: Routledge, 1999); Martin Öhman, "The Statistical Turn in Early American Political Economy: Mathew Carey and the Authority of Numbers," *Early American Studies* 11, no. 3 (Fall 2013): 486–515; Asheesh Kapur Siddique, "The Archival Epistemology of Political Economy in the Early Modern British Atlantic World," *The William and Mary Quarterly* 77, no. 4 (2020): 673–74; Legaux, "Meteorological Observations...April, 1789"; Legaux, *Meteorological Observations … May, 1789* (Philadelphia, 1789); Legaux, "Meteorological Observations …July, 1789," *TCM*, July 1789; Legaux, "Meteorological Observations … August, 1789," *TCM*, August 1789.

The Irish-American printer and author Mathew Carey's competing *American Museum* attempted to solidify the connection between weather and disease in print, running a narrative explanation alongside its meteorological tables for two years after *The Columbian Magazine* ceased its brief attempt to do so. Even with the longer, narrative explanations, the connection remained uncertain. Observations from April and May 1790 provided a brief, general summary of weather from Philadelphia and cities in New York and Connecticut before discussing competing practices for smallpox inoculation. July's observations offered more clarity. "Dysenteries and choleras" were prevalent, particularly after warm days when people had incautiously gone to sleep with windows open and few coverings "whereby the perspiration became suddenly checked." Neither the table nor the narrative description gave insight into which days may have been the dangerously warm ones—that label never appeared in the table and the narrative described the month as "remarkable for calm and moderate weather," albeit with "very low" barometer readings and other movements in the instrument despite "no weather to authorize it."[16]

Fall saw the emergence of a clearer explanation: changing weather produced an increase in disease. In September, "changes in the temperature of the air from cold to heat, which often happened during this month, and sometimes in one day, made the town continue to be sickly." Anyone with a "delicate state of health apt to be injured by these vicissitudes" needed to take special precautions such as wearing flannel shirts. The alternation of cool and warm weather caused "the usual disease of the season, the bilious remitting fever" to take on "inflammatory symptoms." October saw the similarly variable weather conditions, particularly "frequent and

[16] "Observations on the Weather and Diseases for April, 1790," *The American Museum, or, Universal Magazine (Am. Mus.)*, May 1790; "Observations … May 1790," *Am. Mus.*, June 1790; "Observations … July, 1790," *Am. Mus.*, September 1790.

pretty sudden" temperature shifts and inconsistent precipitation, and thus more bilious remitting fever. Similarly, in November, "the variable weather during this month, occasioned most of the diseases that prevailed, to be of an inflammatory nature." In the December observations, the author noted that "the variable and inconstant weather" led to the appearance of "every species of inflammatory complaint." Indeed, the January observations explicitly claimed that variation was the most important factor in determining disease. That month was not "so severe" as December, despite the expectation that January should be the coldest month of the year, but the weather was "quite as disagreeable, and if possible more changeable."[17]

The relationship between variable weather and inflammatory diseases, however, began to grow fuzzier in 1791. March began "clear and pleasant" but then saw some rain. Even on those days, however, "the sun now and then shone out in the afternoon." There was one day with a 33.3º variation between low and high temperatures, and the author noted that variations like it were rare. Despite this, the diseases were "various; no particular one, influenced by the sensible qualities of the air, predominated." April had similarly variable weather "but was much more warm and dry." The prevalence of consumption, however, owed more to "the influence of civilization on the habits and manners of our country" and "the rapid progress to an excess of refinement and luxury" than to the state of the air.[18] After a period during autumn and winter in which variable weather seemed to bring on predictable shifts in diseases, the relationship became more uncertain, even with similarly categorized weather.

The author warned readers against drawing on "single and unconnected cases," which produced unreliable results "of little service to the interests of medicine," but his own method of

[17] "Observations … September, 1790," *Am. Mus.*, October 1790; "Observations … October, 1790," *Am. Mus.*, November 1790; "Observations … November, 1790," *Am. Mus.*, December 1790.
[18] "Observations … March, 1791," *Am. Mus.*, April 1791; "Observations…April, 1791," *Am. Mus.*, May 1791.

analysis was uncertain and inconsistent. June 1791 was a "dry, warm, and fair" month where "the influence of the sensible qualities of the air, in the production of diseases, was very remarkable." In a month where high temperatures never exceeded 76º and where there was only one five-day period where they were over 70º, "the long continued and violent heat of the weather" helped to bring on "some violent acute disease" in patients with chronic issues or "a general debility." Heat likewise seemed to be a significant issue in the "dry and warm" July, where the average temperature was 77.7ºF with a high temperature of 95.7º and 24 days with a high temperature over 80º. That month, the "greatest part of the acute complaints…could be readily traced to the influence of the weather, on the body." Commentary on the next month, however, called this into question. "Cool mornings and evenings" and "the interposition of frequent rains and light winds tended in some measure to lessen the heat of the weather," leading to an average heat of 67.1º but with only four days with highs below 80º over the month. September had double the rain of August "and sufficiently made up for the deficiency observed in May, June, and July" and "was in general very pleasant" despite "frequently cloudy and cool days." Nonetheless, there was "little variety" in the observed diseases in August or September, only a slight decline in September "owing to the influence of the moderation of the heat, and the invigoration in consequence of the succession of cooler weather."[19] The mismatch between the quantitative data in the weather tables and his qualitative descriptions left it difficult to determine what "heat" or "cool" meant or what weather trends might be significant.

Different weather patterns in the autumn of 1791 from 1790, ones the author explicitly acknowledged, seem to have had little effect on seasonal diseases. October of 1791 was "much more moderate than at this time in the preceding year," he claimed, despite the table labelling the

[19] "Observations … June, 1791," *Am. Mus.*, July 1791; "Observations … July, 1791,"*Am. Mus.*, August 1791.

month "variable, cloudy, and rainy." The purported moderation did not lead to a lack of disease or to diseases unrelated to atmospheric conditions. Instead, diseases that "depended on the influence of the sensible qualities of the air, were much more numerous, than during September." By December, when the observations and data from November were published, the narrative description of October's weather had shifted to adopt the table's description to contrast October with November's "dry, windy, and cold" weather in which "variations in the temperature of the air were also pretty frequent." These weather conditions "had an obvious influence in the production of diseases," but those diseases were "not numerous." December was similarly mild, with temperatures "by no means severe, and not in any measure to be compared" with the previous year. The mild weather produced an ambiguous set of diseases. There were those "of the inflammatory type" but also "of an opposite description." Chronic conditions "were aggravated on the advance of the season."[20] The reports correlating weather and disease ceased suddenly and without explanation in 1792, while the meteorological tables remained. The interplay of the tables and the narrative accounts had been, at turns, minimal, complicated, and contradictory. It gave a sense that weather played a known and critical role in collective health but how it did so remained elusive.

Meteorological Observations and Yellow Fever

The outbreak of yellow fever in 1793 saw some Philadelphians look to understand the relationship between climate and disease with greater urgency, but many questions remained. Mathew Carey's first effort to narrate Philadelphia's 1793 yellow fever outbreak reproduced the tensions present in the "Observations." It was "particularly worthy of attention" that, while "all the hopes of the citizens rested on cold and rain," the outbreak "was extinguished with hardly

[20] "Observations … October, 1791," *Am. Mus.*, November 1791; "Observations … November, 1791," *Am. Mus.*, December 1791; "Observations … December, 1791," *Am. Mus.*, January 1792.

any rain, and a very moderate degree of cold." After the sharp drop in infections in October, weather returned late in the month that was "as warm as many of the most fatal [days]," but infections did not return in significant numbers. The surprising lack of correlation between weather and disease prompted a moment of skepticism. Yellow fever, Carey wrote, "has set human wisdom and calculation at defiance." Despite this, he was unwilling to completely abandon the thought of some connection between weather and disease. His *Short Account* ended with reprinted tables of mortality and weather observations. Carey presented these tables without any interpretation. Even after he warned that the connection between weather and disease had become fuzzy, Carey hoped the data spoke for itself.[21]

Jacob Hiltzheimer, who, after emigrating from Germany, served as a Philadelphia Street Commissioner and was repeatedly elected to the Pennsylvania State Assembly, kept an extensive diary that provides insights into how one Philadelphian attempted to understand weather and disease. From 1783 until his death from yellow fever in 1798 he included comments on the weather in each day's entry and close observations of both the natural and built environments, remarking on the meaning flowering dates of trees from year to year and on the impacts of rain on the city's sewers and drainage ditches.[22] Hiltzheimer remained in Philadelphia during every yellow fever outbreak of the 1790s, including the one in 1798 that killed him, continuing his weather observations throughout. During the fall of 1793, he began recording notes on mortality alongside his customary weather notes but offered minimal commentary on potential connections. On the 26th of September, he remarked on the lack of "much wished for rain." He

[21] Matthew Carey, *A Short Account of the Malignant Fever, Lately Prevalent in Philadelphia* (Philadelphia: Matthew Carey, 1793), 72.
[22] Jacob Hiltzheimer, "Journal, 1784 - 1785," 16 May 1785; 23 August 1785., Mss.B.H56d, Vol. 14, APS. Hiltzheimer's journal is neither paginated nor foliated and is instead organized by date.

and other Philadelphians hoped for it because "the ground is Very dry and it is said that a hard Rain and cool weather would immediately Lessen the contagion."[23]

Hiltzheimer did attempt to draw some ideas to mitigate the disease from this purported connection. In early October he reported, "I saw Several of the Water Engines watering the Streets by the request of M. Clarkson, Mayor of the City." The process of "Wetting" began 10 days earlier, just after his entry lamenting the "very warme" weather and Hiltzheimer was optimistic. He had "a great opinion" for this action, which he believed "must make it healthier" by reducing the effects of a "Long Dry spell." While these "engines" might offer some mitigation, they did not eliminate the problems posed by drought and Hiltzheimer continued to wish for rain. Only on November 1st had it come in sufficient quantities for him to "find by enquirey that the deaths have Generally Lessened in the City and Suburbs." Carefully and tentatively but in his estimation, empirically, he had found a correlation between precipitation and the rates of infection and death from yellow fever.[24]

After these early comments, however, any hints at a connection between weather and disease disappeared from his journal until 1798. When he again recorded illness and mortality statistics in his diary, there was no speculation on weather patterns and the course of the outbreak. From the 10th to the 16th of August, he reported "very warm," "exceeding warm," and "Very Close Sultry" weather that grew worse each day as numbers of sick and dead Philadelphians rose. He may, however, have continued to hold some of his earlier optimism about the mitigating or even curative power of water. In a conversation "about the Present Sickness," Hiltzheimer reported discussing the potential costs to complete the Delaware and

[23] Jacob Hiltzheimer, "Journal, 1793-1794," 26 September 1793, Mss.B.H56d, Vol. 23, APS.
[24] Jacob Hiltzheimer, "Journal, 1793-1794," 21, 22, and 26 September 1793; 2, 3, and 12 October 1793, Mss.B.H56d, Vol. 23, APS.

Schuylkill Canal Company's proposed route from Norristown to Philadelphia "to bring the water into the city for the great Benefit of its Health."[25]

In 1785, Benjamin Rush offered a theory on the relationship between atmosphere and the diseases of Pennsylvania to the American Philosophical Society. "Heat and moisture" in the summer created "febrile miasmata" but "frosts as well as heavy rains in the autumnal months never fail to put a stop to the progress of intermittents." The "dry summers" from 1780 to 1782 and "wet springs" of 1784 and 1785—comparative assessments for which Rush's point of comparison is unclear—led to a cycle of drying and wetting the soil around creeks and rivers that increased "generation and exhalation" of fever-inducing miasmas. Ultimately, however, Pennsylvania was becoming "more sickly" from colonists' careless land "clearance," which he distinguished from "cultivation." Pestiferous marshy miasmata could, however, be reduced. Trees "mechanically" reduced and blocked exhalations and "chemically" filtered "unhealthy air and discharge[d] it in a highly purified state."[26] Rush saw a complex relationship between weather and fevers and maintained a large place for human action.

This emerged, in part, from Rush's ongoing efforts understand the relationship between disease and weather. Rush kept notes for this project in a series of four notebooks, three of which survive, running from 1779-1794. These notes show Rush's ambition to realize the goal set out by Thomas Bond in 1766, attempting to draw specific connections between disease and daily weather. In doing so, however, Rush found himself posing questions about how, why, and occasionally, if weather affected disease. His first notebook, covering the decade between 1779

[25] Jacob Hiltzheimer, "Journal Commencing March 26th, 1794 and End March 7th, 1795," 11 October 1794, Mss.B.H56d, Vol. 24, APS; Hiltzheimer, "Journal Commencing 1st January 1798, End September 4th 1798," 10, 11, 16, and 20 August, Mss.B.H56d, Vol. 28, APS.

[26] Benjamin Rush, "An Enquiry into the Cause of the Increase of Bilious and Intermitting Fevers in Pennsylvania, with Hints for Preventing Them," *Transactions of the American Philosophical Society* 2 (1786): 207–10.

and 1789, contained broad thoughts drawing on specific events, down to daily weather, but was organized non-chronologically. The effect of this organization was to emphasize the consistency of Rush's swings between confidence and uncertainty rather than to show a pattern of changing thought over the decade.

In some cases, the connection between weather and illness was direct and obvious. In winter 1789, "Palsies" had been "very common" and measles had emerged in the suburbs and began to spread. There had been "alternate ice and thaws all winter," he noted, "hence wet feet—One of its causes." 50º temperatures on March 1st produced similarly dangerous conditions—"the streets in streams of water," he jotted, "measles prevail."[27] July 1783 ended with a week of stifling heat: "extremely warm - The glass for 3 days at 94 1/2º - little or no air." During this time, Rush reported, 30 people had died "from the heat alone and drinking cold water." Horses suffered similarly notable heat-related mortality with 16 perishing in the same period, with one "saved by throwing cold water on her for an hour or two." He identified specific symptoms—faintness, "heaviness at the heart," and "a general numbness"—as markers of "death from heat." Drinking cold water caused stomach cramps that exacerbated the harm of temperature. "Extreme heat" also "disposed" elderly patients to apoplexy.[28]

His explanations, however, were not always so definitive, and fevers seem to have proved particularly troubling. In 1780, a "true bilious remittent" tore through the city, beginning in Society Hill and the neighborhoods on Front Street below the "drawbridge," by that point a stone structure over Dock Creek, before spreading north and west to "every part of the town" and, eventually, the Northern Liberties. The progression was rapid and violent—"scarcely a family

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[27] Benjamin Rush, "Epidemic and Chronic Diseases, Volume 1, 1779-1789," 30, Yi2/7263 #1, Vol. 88, Library Company of Philadelphia (LCP).
[28] Rush, 88–90.

escaped" and "all ages even infants - both sexes - blacks and strangers were equally affected with the disorder." Even minor changes in the weather "such as cold or moisture" or in personal behavior ("eating or drinking—a fright, passion, &c") "roused the fever into Action." The progress of the "Front Street fever," as Rush noted it was called, only began to slow in October. He reported that event thus: "The weather since the 7th of October cool - rainey and times comfortable. - The [temperature] about 60º - The fever declined very much." This led him to a question: "Was the Rain for 7 days the cause of the fever declining?"[29]

Answering it was not easy. Writing on a different fever dating near the British occupation of Philadelphia, hasty notes conveyed uncertainty and frustration. There were "many causes given for this disorder," and he struggled to isolate the crucial one. "Cold," he asked, "No[,] appeared in August - before the cold weather came on. The cold of September only excited the miasmata into Action." Instead "marsh effluvia" brought on "when the British came in" must, he reasoned, have been a more significant cause than weather because the fever had "its beginning in the parts of the town most exposed to the meadows viz. Society Hill and Front Street."[30] By the end of this section, Rush had concluded that weather sometimes induced or arrested epidemics through a range of different mechanisms but that it was not always a cause, let alone the primary cause.

Short runs of chronological, granular observations reveal similar patterns of thought to his contemporaries. The summer of 1782 was "uncommonly cool and dry" with a drought "greater than was ever known in the memory of the oldest man." Wildfires raged through New Jersey's pinelands; salt water extended far up into the Delaware, springs and wells ran dry, and

[29] Rush, 41; 46; 60–61; Bill Double, "Scenic Stream to City Sewer: Dock Creek from 1682 - 1849" (Philadelphia: Division of Cultural Resource Management of Independence National Historical Park, 2013), 5-7 (on the name "drawbridge" and its location).
[30] Rush, "Epidemic and Chronic Diseases, Volume 1, 1779-1789," 76–77.

"the fields were beds of dust." Nonetheless, "the season was healthy." In the fall, however, as drought conditions persisted, the "bilious remitting fever" manifested with "great pains in the bones and all the symptoms of the fever of 1779 only in a milder degree." Rush described this year to the American Philosophical Society, but his notes some uncertainty around the healthy summer before the uniquely sickly fall.[31] Rush showed his confidence in the direct effects of weather on health but found indirect causation compelling but more difficult to trace conclusively. These tensions intensified during the yellow fever outbreaks of 1793 and 1794.

Rush began his most sustained investigations on the relationship between weather and yellow fever in his notes for September 1793 as he began to hypothesize that local environmental conditions caused the disease. "Why does it appear always in the middle of August?" he asked, "Why after very hot summers? … Does cold pursue it with its usual hostility and destroy it even under the form of contagion as well as exhalation?" Rush answered these questions with a hypothesis—"Cold attacks both bilious and yellow fever because both the Offspring of heat."[32]

Further consideration suggested to him that the relationship between yellow fever and temperature was not that simple. The disease was "encreased by coolness but checked by cold - perhaps it is increased too by moisture but checked by water." "Hot summer" joined Rush's list for the fever's "remote cause" alongside such "dryness of the weather that Spring and Wells failed in many places," but "a chilly night" or "cold" could be "exciting causes." He claimed his observation that "cool weather increased [yellow fever's] violence" as evidence that those who sought "to depreciate my mode of practice" were wrong.[33]

[31] Rush, 82; 85–86.
[32] Benjamin Rush, "An Account of Epidemic Diseases Began August 1 1793 with Some Chronic Diseases Added," fols. 12; 16r; 24r–25r, Yi2/7263 #3, Vol. 89, LCP The note on hot weather in mid-August came on pg. 11, just before Rush's notebook shifts from page to folio numbers.
[33] Rush, fols. 30v; 50; 52v; 66r; 127v.

At his most desperate, he simply began looking to daily weather events for any possible respite. On September 30th, after noting a significant increase in mortality, Rush lamented "Alas!" after low clouds in the morning promised but did not deliver precipitation. Faced with cloudy skies in the morning on October 15th, Rush wailed "O! that God would descend upon our city in plentiful showers of rain! The mortality of the disease from all Accounts is still unabated." A few hours later when "the heavens ha[d] opened," Rush responded "Blessed – Blessed be God for it!" "A clean cold morning, with N.W. Wind" on October 16th was accompanied with reports of recovered patients. Rush copied part of a 1747 letter to Philadelphia below this observation: "the weather is now become much cooler and those under the disorder revive." After "warm weather" saw the disease "revived" on the 18th, Rush greeted the 19th with an observation and a prayer "The Sky is overcast. God grant more rain, and cold weather!" When faced with a day where his thermometer read 68º at 6PM but mortality remained low, Rush concluded "it would seem that the disease had been arrested by a supernatural power, for its mortality was always greatest in warm days." By November, Rush sought to substantiate what had begun as desperate prayers, assembling a list of references to temperature, climate, weather, and fevers from Hippocrates to recent works on the West Indies.[34]

The profound sense of uncertainty in Rush's notes, particularly those from late-August 1793, offers essential context to understand his thinking about race, climate, vulnerability, and yellow fever. Rush played a crucial public role in efforts to persuade Black Philadelphians to remain in the city to serve as nurses, clean the streets, and bury the dead. In September, Rush wrote to the Methodist minister and abolitionist leader Richard Allen, drawing on their friendship and Rush's participation in anti-slavery politics in Philadelphia, to request that Allen mobilize

[34] Rush, fols. 87r; 98r; 101r; 119r; 131–132; 177v.

Black Philadelphians to aid the sick since the "malignant and contagious fever… infects white people of all ranks but passes by persons of your color." Rush's his notes reveal far deeper uncertainty about purported racial immunity than his letter to Allen or his published remarks. Crucially, these uncertainties were present in the days before Rush wrote to Allen on the "obligation to offer your services" or made a similar case in the press. Rush's notes on epidemic disease from 1779 to 1789 had reported that both "blacks" and "strangers" had suffered from the "Front Street fever" of 1780, indicating that he had already tested theories of Black immunity against his own observations. On August 30th, Rush recorded that he consulted with "Mr. Duke" about the 1762 yellow fever in Philadelphia. Duke apparently told him that it was "was less violent when taken by Contagion than from exhalation. No negro took it." The very next day, however, Rush scribbled a grim note that undercut Duke's recollections: "The whole city yellow eyes - even negroes." Rather than an expression of an erroneous belief that Rush would eventually repudiate, his letter to Allen showed a willingness to suppress uncertainty.[35]

Almost immediately, Rush began noting that Black Philadelphians suffered from yellow fever and did so significantly. His entry for September 25th noted a group of "infected black people, among them Richard Allen" were seeking treatment. In October, he reiterated, "Many Negroes died and many were sick." After "citizens" began "crowding into town" in November, Allen told Rush "that he had buried three persons with the yellow fever last week." At the beginning of 1794, Rush reported the grim toll: "The negroes lost only 67 in 1792 but 305 in

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[35] "Benjamin Rush to Richard Allen" (September 2, 1793), Yi2 7251, Vol. 38, no. 32, LCP; Rush, "An Account of Epidemic Diseases Began August 1 1793 with Some Chronic Diseases Added," fols. 20; 35r; Rush, "Epidemic and Chronic Diseases, Volume 1, 1779-1789," fol. 41; Benjamin Rush, *An Account of the Bilious Remitting Yellow Fever, as It Appeared in the City of Philadelphia, in the Year 1793* (Philadelphia: Thomas Dobson, 1794), 94–97; Rana A. Hogarth, *Medicalizing Blackness: Making Racial Difference in the Atlantic World, 1780-1840* (Chapel Hill: University of North Carolina Press, 2017), 25–28; Naramore, *Benjamin Rush, Civic Health, and Human Illness in the Early American Republic*, 150; Rush's willingness to draw on theories of differential racial immunity and vulnerability was in keeping with the broader trends that Katherine Johnston has identified. Johnston, *The Nature of Slavery: Environment and Plantation Labor in the Anglo-Atlantic World*.

1793." In his printed remarks, Rush claimed that he had been "led to believe that the negroes in our city would escape it" by "many writers" but that "not long after these worthy Africans undertook the execution of their humane offer…I was convinced I was mistaken." This change from the notes he "hastily copied" for his published work acknowledged an error but attributed it to his acceptance of a medical consensus about racial immunity rather than the far more insidious possibility that he had ignored his own observations and knowingly asked Black Philadelphians to court risk in the hope of white gratitude.[36]

Rush's thinking on race, immunity, and yellow fever helped to persuade him that the disease was "generated in our city" rather than imported. This extremely controversial opinion led hostile conversations and complaints that he was threatening the city's commerce and reputation by suggesting that Philadelphia had an unhealthy climate. Rush, however, sought to define the relationship very tightly between weather conditions and yellow fever and, in doing so, to argue that such conditions could exist anywhere, not only in very hot climates or exclusively in the New World and could affect anyone, regardless of their race or previous infection. "Similar degrees of heat," he claimed, were "capable of producing [yellow fever], together with all its various modifications, in every part of the world." Even England and Ireland, which were "seldom *hot* enough to generate a contagious yellow or bilious fever," were "*warm* enough to favour the propagation of an imported contagion of that disorder." Indeed, many seventeenth-century plague outbreaks "resembled in most of their symptoms the West India and *North American* yellow fever." This meant there was nothing particular about "the climate of our

[36] Rush, "An Account of Epidemic Diseases Began August 1 1793 with Some Chronic Diseases Added," fols. 48v; 107r; 147r; 152v; 162r; Rush, *An Account of the Bilious Remitting Yellow Fever, as It Appeared in the City of Philadelphia, in the Year 1793*, 95–97; iii; On the logic of gratitude and Rush's embrace of it, see Hogarth, *Medicalizing Blackness: Making Racial Difference in the Atlantic World, 1780-1840*, 30.

country" that produced the disease.[37] Weather might create the conditions for epidemic diseases like yellow fever; climate did not.

According to Rush, just as yellow fever could emerge anywhere the pestiferous nexus of heat and putrefied matter existed, it could affect anyone exposed to those noxious conditions. In August 1794, Rush told the Inspectors of Health "not to alarm the city" after some cases emerged since yellow fever "was not contagious" and instead to "clean the gutters of the city and to fill up or drain the ponds in its neighborhood." Stagnant water and dirty gutters obsessed him. During one particularly passionate entry he claimed, "Dread of stagnating waters sh[oul]d be taught at School, as the Source of the greatest natural evils." This led him to return to ideas about racial immunity. In 1794, Rush claimed, rather than being relatively exempt, Black Philadelphians had been "very subject" to yellow fever "chiefly because they lived in the Skirts of the town" where he had observed filthy gutters and stagnant water. He returned to this entry again in 1799 to note that it undermined the ideas of racial immunity underpinning Colin Chisholm's 1799 account of 1793 and 1794's "Bullam" fever as contagious and imported.[38]

Later that year when Rush claimed the 1794 disease had become contagious, he sought to track the ways in which weather shaped its progress. "The Constitution of the Air was," he claimed, "my polar Star, or Compass in all my distance of this Season." Following it, however, was challenging. It was "hard to tell" what "state of the air or of the disease" created or spread contagion. Rush's weather notes reflected this uncertainty. "Cool days" on the 21st – 23rd of

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[37] Rush, *An Account of the Bilious Remitting Yellow Fever, as It Appeared in the City of Philadelphia, in the Year 1793*, 147–49; 162; 167–68; Rush, "An Account of Epidemic Diseases Began August 1 1793 with Some Chronic Diseases Added," fols. 143r; 150r; 153r; 155r.

[38] Benjamin Rush, "An Account of the Epidemic Diseases of Philadelphia Begun August 19th 1794" (n.d.), fols. 25r; 30r–34r, Yi2/7263 #4, Vol. 90, LCP; Rush identified the specific pages with which he disagreed. Colin Chisholm, *An Essay on the Malignant Pestilential Fever Introduced into the West Indian Islands from Boullam, on the Coast of Guinea, as It Appeared in 1793 and 1794* (Philadelphia: Thomas Dobson, 1799), 220–21; On the connections between West Africa and transatlantic yellow fever outbreaks, see Billy G. Smith, *Ship of Death: A Voyage That Changed the Atlantic World* (New Haven: Yale University Press, 2013).

September saw the disease "much encreased" because "the miasma [was] concentrated but not precipitated." On September 30th, there was "a sudden change from heat to cool in the air" but no comment on disease. Cold, rain, and wind on the 1st of October saw a dramatic decrease in calls. Despite this, Rush claimed, "Not to acknowledge the Weather in diseases, is as absurd, as not to acknowledge a providence in human affairs" in his section titled "Errors and Falsehoods of Physicians."[39]

After claiming that the state of the atmosphere had been his lodestar in 1794, subsequent years offered little sense of bearings. Entries from 1796 to 1798 ran together, often out of chronological order. Notes on disease came at the end of paragraphs of staccato meteorological reports without an explanation for how they were related. He pasted in newspaper clippings and transcribed reports from Charleston, New York, and Albany. He noted natural phenomena, including an explosion in the mosquito population, the absence of birds, the destruction of pasture, the production of undersized peaches, cherry blossoms arriving 2-3 weeks earlier than expected, and "meteors seen in many places." There were assertions of direct causation—"Rain and cool weather about the middle of July [1798] checked the fever"—but a willingness to speculate about "a <u>secret</u> influence of the weather." He pasted in newspaper clippings on 101º heat in Wilmington, Delaware that was "beyond what the observer had ever known before by observation" and efforts to cleanse Philadelphia's gutters. His final entries on weather came on the 23rd and 26th of August 1798. On the first, he noted, "The weather became <u>cool</u>," but this change either did little or worsened the disease. On the 26th, he wrote "Deep and universal

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[39] Rush, "An Account of the Epidemic Diseases of Philadelphia Begun August 19th 1794," fols. 54–55; 62r; 69v; 74r; 81r; 83r; 93r.

distress as in 1793 pervades."[40] He was certain weather mattered but how it did so appeared more uncertain than ever.

The December 1797 report from Rush and his Philadelphia Academy of Medicine, a group of physicians formed after Rush's split with the College of Physicians of Philadelphia conveyed anxious uncertainty. Yellow fever, they wrote, "is a modern appearance in our country." It emerged from "certain revolutions in the atmosphere as yet observed only but not accounted for by Physicians." Climate mattered—yellow fever was "the bilious remitting fever of warm climates excited to a higher degree of malignity" and "heavy rains and frosts" destroyed it—but climate and weather did not offer a complete explanation since even purportedly hot climates like those of the West Indies could be healthy. Ultimately, the Academy argued a "habit of cleanliness" would enable Philadelphia to remain healthy, even amidst atmospheric revolutions.[41]

Even their opponents in the intense and vigorous debate on the nature, origin, and spread of yellow fever in Philadelphia seemed to agree on the virtues of hygiene. The College of Physicians warned Philadelphians to avoid prolonged exposure to the sun and "to accommodate dress to the weather." From 1793 to 1797 they consistently recommended vigorous washing of the streets and gutters along with other efforts like putting quicklime into privies. When the College argued that yellow fever was not the product of local conditions, they maintained that there were "Fevers that occur in this Climate from Domestic Causes." William Currie, who opposed Rush's account of yellow fever in print, presented a paper before the College of Physicians in May 1796 on the relationship between weather and disease in Philadelphia and

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[40] Rush, fols. 156r–157v; 159r–161v; 163r; 174v–175v; 179r.

[41] Benjamin Rush and Associates Physicians of Philadelphia, "Report to the Governor...on the Nature and Origin of the Late Contagious Disease" (December 1797), 1–3; 11; 13–14, Benjamin Rush Papers, MSS 2/0096-01, HML.

maintained the importance of a connection between weather and disease up to 1817 when warned the College of Physicians that they had fallen into a state of “lifeless apathy” because they abandoned efforts to investigate “the diseases and remedies which are peculiar to our Country by observing the effects of different Seasons, Climates and Situations upon the human body.”[42] Even those arguing that Philadelphia’s climate and landscape did not produce yellow fever nonetheless maintained that efforts to treat contagious disease needed to consider atmospheric and meteorological conditions. This invited possibilities for how best to do so.

Vast Ambitions: Managing Atmosphere and Climate in Philadelphia and Beyond

There were many contemporary claims about the purifying effects of water at the same time as Latrobe’s proposal. A widely circulated proposal to the naturalist and physician Dr. Benjamin Smith Barton to prevent yellow fever in Philadelphia through the creation of a gravity-fed waterworks offered a similar account for the atmospheric origins of the disease. In it, J. Sullivan lamented to Barton, “Your atmosphere is not agitated by the sea-breezes which we complain of in Boston.” As a result, the summer heat and the oven-like temperatures generated by sun-baked brick walls “renders the air, in a degree, unfit for respiration.”[43] For Sullivan, yellow fever emerged from the combination of heat and stillness that could occur even in temperate climates. The presence of flowing water could help to alter these conditions.

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[42] Simon Finger, *The Contagious City: The Politics of Public Health in Early Philadelphia* (Ithaca: Cornell University Press, 2012), 120–34; Thomas A. Apel, *Feverish Bodies, Enlightened Minds: Science and the Yellow Fever Controversy in the Early American Republic* (Stanford, California: Stanford University Press, 2016); “John Redman to Thomas Mifflin” (August 18, 1797), Manuscript Archives of The College of Physicians of Philadelphia, 1787-1847, CPP 1, pg. 331, HML; “Memorial of the College of Physicians of Philadelphia to the Senate and House of Representatives of Pennsylvania” (December 1797), CPP 1, pg. 373-377, HML; “College of Physicians, Special Meeting Minutes, 25 August 1793 - 5 December 1797,” 209; 213; 223, CPP 1, pgs. 209-230, HML; “Papers Read Before the College of Physicians” (June 1796), CPP 1, pg. 301, HML; “William Currie to the College of Physicians” (November 2, 1802), CPP 1, pgs. 418-420, HML; “William Currie to the College of Physicians” (July 1, 1817), CPP 1, pg. 483-484, HML.

[43] J. Sullivan, “A Letter, to Dr. Benjamin Smith Barton, on Supplying the City of Philadelphia with Water.,” *The Weekly Magazine*, June 30, 1798.

Latrobe's proposal drew heavily and in detail on Erasmus Darwin's *The Botanic Garden* (1791), which had just been printed for North American audiences in March 1798. Darwin's enthusiastic embrace of the transformative power of steam anticipated both the tone and specifics in Latrobe's proposal. In the passage of the poem Latrobe cited in his journal, Darwin referenced his essay in *Philosophical Transactions* on the "fountain of Hiero" in which rapidly depressurized air led to water vapor falling "down in a shower of snow."[44] Drawing on this phenomenon, he suggested that changes in pressure and the "devaporation" of water vapor could produce cold. Naturally occurring examples showed that this could take place over a large area.[45]

At that larger scale, Darwin suggested that this enabled climate control. "It seems possible," he wrote, "to devaporate a great province" creating a large vacuum and drawing in wind. And "if it should ever be in the power of human ingenuity to govern the course of the winds," he imagined, "which probably depends on some very small causes," then people could create a new climate in any area by attracting winds from nearby regions with the desirable combinations of temperature and humidity. Darwin asked readers to "suppose this to happen to the north of our climate" in Scotland and to imagine the consequences of warming southwest

[44] Edward C. Carter II, ed., *The Virginia Journals of Benjamin Henry Latrobe, 1795-1798*, vol. 2 (New Haven: Yale University Press for the Maryland Historical Society, 1977), 433–36; Erasmus Darwin, *The Botanic Garden: A Poem in Two Parts*, First American Edition (New York: T. & J. Swords, 1798); Erasmus Darwin, "Frigorific Experiments on the Mechanical Expansion of Air, Explaining the Cause of the Great Degree of Cold on the Summits of High Mountains, the Sudden Condensation of Aerial Vapour, and of the Perpetual Mutability of Atmospheric Heat," *Philosophical Transactions of the Royal Society* 78 (December 31, 1788): 46–47; "Descriptio Fontis Hieronis in Metallifodinis Chemnicensibus in Hungaria, Anno 1756 Extructi; Auctore Wolfe, M.D. Communicated by Mr. Henry Baker, F.R.S.," *Philosophical Transactions of the Royal Society* 52 (1761): 46–47 Darwin's summary largely followed the discussion of the phenomenon in the original.

[45] Darwin, "Frigorific Experiments on the Mechanical Expansion of Air, Explaining the Cause of the Great Degree of Cold on the Summits of High Mountains, the Sudden Condensation of Aerial Vapour, and of the Perpetual Mutability of Atmospheric Heat," 50–51.

winds, writing that "the discovery would thence be of greater utility than any that has yet occurred in the annals of mankind."[46]

The wide-ranging writer Noah Webster's universal history of epidemic diseases concluded with a similar idea but stopped short of Darwin's climatic ambitions. In these books, he attempted to unite discussions of weather, volcanic eruptions, meteors, and outbreaks of seemingly distinct epidemic diseases like yellow fever and plague together to identify moments of "general, or universal epidemics" that "pervade whole quarters of the earth, or the whole globe." Volcanoes, climate, weather, and comets were all connected and thus the appearance of any one notable event anyplace might signal something larger.[47]

Although climate and disease were the result of forces stretching beyond the planet, Webster maintained it was possible to mitigate their effects. Both climate, which he understood as the typical meteorological conditions in a particular area, and specific weather events contributed to outbreaks of epidemic disease, but they did so through specific, localized mechanisms. Seasonal weather shifts, alongside "the action of electricity, the main operative agent in the earth and atmosphere," produced epidemics by effecting "some essential alteration in the primary qualities of air and water." Webster argued that even "tropical climates" did not generate contagious yellow fever during "ordinary" seasons and instead required either a shift to "unfavourable" seasons or the influx of troops from northern latitudes to do so. In "cool northerly countries" like England, yellow fever "probably cannot exist in the climate," at least so long as the "*ordinary* state of the elements and the *ordinary* temperature of the summer remained

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[46] Darwin, 51–52; In his ambitions to moderate cold, Darwin shared the concerns, if not quite the same causal explanations, of many of his contemporaries. See Anya Zilberstein, *A Temperate Empire: Making Climate Change in Early America* (Oxford: Oxford University Press, 2016).

[47] Noah Webster, *A Brief History of Epidemic and Pestilential Diseases*, vol. 2 (London: Printed for G. G. and J. Robinson, by G. Woodfall, 1800), 15; 26; 69; 93; 347; Noah Webster, *A Brief History of Epidemic and Pestilential Diseases*, vol. 1 (Hartford: Hudson & Goodwin, 1799), 240–42.

constant." Climate, however, could become disordered. Specific weather events contributed to disease through the production of "noxious exhalations," which "diminish the stimulant power of the atmosphere" by "an undue proportion of hydrogene, or with any species of acid which is hostile to the lungs." In the case of yellow fever, this required "a period of heat rising, for a considerable time, to 85 degrees [Fahrenheit] or higher."[48]

Webster's belief in the largely healthy qualities of "ordinary" conditions, particularly in temperate and cool climates informed his approach to preventing and mitigating epidemic diseases. "People in cities rely too much on cleansing their streets to preserve public health" because they did not understand that "noxious exhalations" were the result of altered atmospheric chemistry. Streets should still be cleaned, but "the only effectual remedy" for epidemic diseases like yellow fever was "fresh running water." Water "removes the cause of noxious vapours" by cleaning streets and "by cooling the sultry air of a city prevents debility." Most impressively, water "extricates a considerable quantity of new and wholesome air from its own substance." Although Webster warned, "our climate we cannot change," he nonetheless argued that running water could cool temperatures, cleanse the streets, and produce healthy air to mitigate dangerous climate disorders.[49] People might not be able to control the climate, but they could manage the atmosphere.

Efforts to manage climate or atmosphere continued to appear in promotional materials for waterworks as well. In 1805, the English engineer Ralph Dodd authored a book as promotional material for the South London Waterworks Company that promised his steam-powered works could bring cleansing rain to prevent disease in London and cooling air to protect the imperial outpost at Gibraltar from yellow fever. Dodd, like Latrobe, cited efforts to cool and cleanse air in

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[48] Webster, *Brief History*, 1:240–42; Webster, *Brief History*, 2:110–12; 347; 355–57.
[49] Webster, *Brief History*, 2:357–59; 383; 396.

deep mines in support of his claims.[50] In 1819, Philadelphia's Watering Committee, a jointly appointed group from Philadelphia's City Councils responsible for the city's water supply since 1797, paraliptically noted that they would "forbear to display the advantages which would be derived in extreme hot weather, from a constant flow of water in our streets, and the playing of fountains in our public walks, creating an elasticity in the air so necessary to health." Even as the city's Watering Committee abandoned the technology at the core of Latrobe's initial proposal, they maintained that the city's water system could alter the atmosphere.[51]

The principles that animated these early projects continued to generate new schemes for urban cooling infrastructure, even as the type of infrastructure changed. The Florida physician and inventor John Gorrie, who has come to serve as a foundational if failed figure in the history of air conditioning and artificial cooling for his successful invention of a machine capable of making artificial ice, drew on them in his 1842 plan to ensure that southern cities would not exceed 75º.[52] Gorrie investigated the same questions about temperature, pressure, and evaporation that Erasmus Darwin and Latrobe had, but he distinguished between efforts to cool via evaporation and via the compression and expansion of gasses. Evaporation, Gorrie claimed, "is the first and most obvious source of artificial refrigeration," but it could not successfully cool an entire city with an atmosphere that was already fully saturated with moisture. A city that had

[50] Ralph Dodd, *Observations on Water with a Recommendation of a More Convenient and Extensive Supply of Thames Water to the Metropolis, And Its Vicinity; As the Best Means to Counteract Pestilence of Pernicious Vapours.* (London: George Cooke, 1805), 94; 99–100.
[51] *An Additional Report, on Water Power, by the Watering Committee: With Communications on the Subject from Messrs. Ariel Cooley, Lewis Wernwag, Thomas Oakes, William Briggs, and William Lehman. And Other Documents* (Philadelphia: William Fry, 1819), 5.
[52] Salvatore Basile, *Cool: How Air Conditioning Changed Everything* (New York: Fordham University Press, 2014), 34–39; For a more skeptical account of Gorrie's place in histories of artificial cooling, see Stefan Höhne, "Cities of Cool Comfort: Cryogenic Urbanization and the Rise of Wellbeing Regimes in the Twentieth Century," in *Urban Infrastructure: Historical and Social Dimensions of an Interconnected World*, ed. Joseph Heathcott, Jonathan M. Soffer, and Rae Zimmerman, History of the Urban Environment (Pittsburgh, PA: University of Pittsburgh Press, 2022), 60–63.

fully adopted Latrobe's plan and was "numerously supplied with *jets d'eau*" would only alter "its medium temperature very slightly, if at all." Instead, Gorrie called for the creation of stations in the suburbs where steam, water, or wind power would create "reservoirs" of compressed air that would be distributed "through conduits, like water or gas, so that it may be distributed to, and set free in the houses, and even in the streets and squares of the city." Despite looking to compressed air rather than jets of water, Gorrie drew on the same example of artificial snow in a deep mine as Darwin and Latrobe: "Hero's fountain, used in one of the mines of Hungary" demonstrated that pressure release generated cold because it caused any moisture in the de-pressurized air "to appear, even in summer, as a shower of snow."[53]

Gorrie framed the need for his plan in explicitly and enthusiastically racist terms. The "white race," he claimed suffered "indisposition to, and indeed, incapacity for, continuous muscular exertion … during the existence of tropical heat." Beyond these purported impediments to productive labor, "Solar heat" was uniquely dangerous to the "Caucasian race" causing "all the functions become deranged" and producing "malarious diseases" and yellow fever. These dangers led the white residents of southern cities to flee during the summer months, leaving only "other races of the human family, who are endowed with the faculty of resisting solar heat with impunity, [but] have not the intelligence requisite to enable them to compete successfully in the arts with the natives of more temperate climates." Successfully cooling southern cities would lead to an economic boom, he claimed, "beyond all that the world has before witnessed" by

[53] John Gorrie, "Refrigeration and Ventilation of Cities," *Southern Quarterly Review* 1, no. 2 (April 1842): 421–22; 426–27.

enabling newly invigorated white city-dwellers to develop manufacturing capacity to locally process agricultural goods produced by enslaved people.[54]

Conclusions

In their 1797 report, Rush and the Academy argued that, in addition to its other benefits, their claim that yellow fever was a disease of domestic, environmental origin was necessary to provide hope. If yellow fever was imported, they warned, "we are led in despair to consider the disease as removed beyond the prevention of human power or wisdom." Constant commercial interactions with the West Indies meant that "utmost possible vigilance of health officers" could not prevent a contagious and imported disease from entering the city and devastating its residents. To see the disease as a product of atmospheric alterations brought about when hot weather met putrescent matter, in contrast, enabled action that would protect and advance "the value of property, the increase of commerce, and the general prosperity of our city" while preserving "the lives and happiness not only of the present inhabitants of Philadelphia, but of millions yet unborn in every part of the Globe."[55] Even if the exact relationships between climate, weather, atmospheric chemistry and yellow fever were uncertain, operating from the assumption that there was *some* connection enabled actions to continue present forms of political and economic organization without metabolizing regular cycles of mass death.[56] The atmospheric engineering projects that followed attempted to realize hope as urban infrastructure.

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[54] Gorrie, 414–15; 443–44; On racist myths about climate and bodily fitness, see Johnston, *The Nature of Slavery: Environment and Plantation Labor in the Anglo-Atlantic World* Gorrie's attempt to enter into these discourses was unique. He drew upon similar rhetoric to pro-slavery advocates about climate and the capacity to labor but used it to call for climate alteration (while continuing to support slavery). On these debates just prior to the Civil War, see pgs. 156-186.

[55] Benjamin Rush and Associates Physicians of Philadelphia, "Report to the Governor," 13–14.

[56] This stands in stark contrast to the embrace of these cycles described in Kathryn Olivarius, *Necropolis: Disease, Power, and Capitalism in the Cotton Kingdom* (Cambridge, MA: The Belknap Press of Harvard University Press, 2022), esp. 154-194.

At our present moment, technologies promising control over the atmosphere have yet again been branded as tools of hope and necessity by "Promethean" techno-optimists and environmentalists reluctantly admitting that all else seems to have failed. Even as some climatologists have warned against counting negative emissions before any carbon has been sequestered, others in environmental policy have instead argued that we need a new ethics of "gambling" to determine how best to implement technologies whose cost and effectiveness is uncertain but that we must hope will work.[57] The scale of our present Earth System crisis is indeed new and unprecedented, but concerns about climate and technical schemes to control it are not. My own anxiety in narrating this history is that it offers no solutions; my ambition is that moving beyond these frameworks and conversations might allow others to find some.

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[57] Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven: Yale University Press, 2013), 107–37; Bill McKibben, "The Enormous Risk of Atmospheric Hacking," *The New Yorker*, February 17, 2021, https://www.newyorker.com/news/annals-of-a-warming-planet/the-enormous-risk-of-atmospheric-hacking; Bill McKibben, "Dimming the Sun to Cool the Planet Is a Desperate Idea, Yet We're Inching Toward It," *The New Yorker*, November 22, 2022, https://www.newyorker.com/news/annals-of-a-warming-planet/dimming-the-sun-to-cool-the-planet-is-a-desperate-idea-yet-were-inching-toward-it; Elizabeth Kolbert, "Can Carbon Dioxide Removal Save the World?," *The New Yorker*, November 13, 2017, https://www.newyorker.com/magazine/2017/11/20/can-carbon-dioxide-removal-save-the-world; Elizabeth Kolbert, *Under a White Sky: The Nature of the Future* (New York: Crown, 2021); Kevin Anderson and Glen Peters, "The Trouble with Negative Emissions," *Science* 354, no. 6309 (October 14, 2016): 182–83, https://doi.org/10.1126/science.aah4567; Daniele Fulvi and Josh Wodak, "Gambling on Unknown Unknowns: Risk Ethics for a Climate Change Technofix," *The Anthropocene Review*, October 12, 2023, 20530196231204324, https://doi.org/10.1177/20530196231204324.