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# Benjamin Franklin

## *Chasing the Wind*

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IT IS TYPICAL of the history of meteorology that the modern study of storms should begin with the description of a spoiled astronomical event.

The study of weather has always been measured, invariably to its detriment, by the standards of astronomy, its older and more respected sister science. Through thousands of years of kingdoms advised by astronomers, there was never a Meteorologist Royal. Knowledge of the heavens was far advanced by the time the investigation of weather was deemed worthy of a serious man's preoccupation. In the middle of the eighteenth century, astronomy was preeminent and meteorology was hardly a science at all. Some things were respectably knowable about the physical world and some were not.

Two hundred fifty years ago, astronomers could predict the occasions of lunar eclipses precisely as to date and time of day, and they could explain their cause and effects: that the moon's orbit passes periodically out of the brightness of the sun's light and into the darkness of the celestial shadow cast by Earth. By such divinely predictable events the clockwork universe was affirmed. About the intervening weather, on the other hand, that a storm might blow up and obscure an eclipse—whether, when, where, or why—no one had any idea about such unaccountable acts of God.

In the autumn of 1743, as the moon approached Earth's shadow, Benjamin Franklin, a 37-year-old printer and newspaper publisher in the American colony of Pennsylvania, was making plans to witness the eclipse from his home in Philadelphia. A busy and prosperous man, he was nonetheless an eager observer of such phenomena. This eclipse would begin about 8:30 P.M. on October 21, a Friday night. But as Franklin recalled a few years later in a letter to his friend Jared Eliot, "before night a storm blew up at northeast, and continued violent all night and all the next day; the sky thick-clouded, dark and rainy, so that neither moon nor stars could be seen."

Obscured as it was, the timing of the eclipse illuminated for the perceptive Franklin something entirely unexpected about the violent storm, its whereabouts, and its movement that night. As he wrote to Eliot:

> The storm did great damage all along the coast, for we had accounts of it in the newspapers from Boston, Newport, New York, Maryland and Virginia; but what surprised me was, to find in the Boston newspapers, an account of the observation of that eclipse made there; for I thought as the storm came from the northeast, it must have begun sooner at Boston than with us, and consequently have prevented such an observation. I wrote my brother (in Boston) about it, and he informed me that the eclipse was over there an hour before the storm began.

From this information, a scrap of detail that might have gone unnoticed in the hands of a less vitally interested observer, grew an idea that would be central to meteorology, especially to weather forecasting. Storms have characteristic structures and preferred directions of travel. Franklin formed a generalization about the movement of what he continued to describe to Eliot as "storms from the northeast" that could blow violently, sometimes for three or four days. Franklin wrote: "Of these I have had a very singular opinion for some years, viz: that, though the course of the wind is from northeast to southwest, yet the course of the storm is from southwest to northeast; the air is in violent motion in Virginia before it moves in Connecticut, and in Connecticut before it moves at Cape Sable, etc." More than 150 years later, in 1899, the Harvard scholar William Morris Davis, writing in the *Journal of the Franklin Institute,* would look back on this suggestion as a defining moment, observing that "with this began the science of weather prediction." In Franklin's day, however, weather prediction was beyond the realm of science.

As a practical matter, the storm traveled faster than could words of warning in the eighteenth century, although clearly not as fast as Franklin's estimate of 100 miles an hour. The great man was not so great with numbers. In any case, obstacles to scientific weather prediction were more deeply rooted in both the Old World and the New. Future weather was treated like the future of anything else, part of the occult prognostications of astrologers, especially in Europe, where their profitably published almanacs offered artfully worded weather predictions for the entire year. In the colonies, Franklin himself enjoyed a handsome income for 25 years as publisher of *Poor Richard's Almanack*, although his prognostications of weather always came with characteristic humor and wit. Praising Franklin's contributions to meteorology, the pioneering American weather scientist Cleveland Abbe took a close look at the Franklin almanacs in 1906 and found no astrology in them. In a presentation to the American Philosophical Society of Philadelphia, Abbe said, "Now while it is true that in these he published conjectures as to the weather during the respective years, yet we are not to think of Franklin as a planetary meteorologist, for the fact is that in every one of these issues he disclaims all knowledge of the weather or astrology and pokes fun at his own predictions as utterly absurd and useless."

Explanations for the causes of weather remained a traditional part of church doctrine, as it had through the Middle Ages. Since its rediscovery in the twelfth century, Aristotle's *Meteorologica* had been installed as Christian dogma, and his conjectures about the organismic exhalations of Earth satisfied nearly 700 years of theological meteorology. (As a meteorologist, Aristotle was a pretty good philosopher. Not even the loyal pupil Theophrastus could accept his mentor's bald assertion that the wind was not moving air.) In the American colonies, the Puritan clergy yielded to no "secondary natural causes" the power and word of the Almighty in the fierce tempests of the New World, even under the most terrible circumstances.

On August 31, 1735, in New London, Connecticut, a great storm rose overhead just as the Reverend Eliphalet Adams was beginning his afternoon service. A bolt of lightning, "the fire of God," shot down upon his church. Timbers crashed down among the congregation. Smoke and dust filled the air. So fierce was the thunderclap that it left their ears ringing. Everywhere in the wrecked room were wounded of his flock, burned and broken. Pitiful shrieks of shock and agony rang out. At his feet, at the very horn of his altar, a young man, Edwin Burch, lay dying.

The following Sabbath, those of the congregation who were not too seriously injured came back to the temporarily patched meetinghouse to hear about the god who strikes down the faithful at prayer. A proud Adams, with a view to posterity, saw to the printing of his sermon "God Sometimes Answers His People by Terrible Things in Righteousness. A Discourse Occasioned by that Awful Thunderclap which Struck the Meeting-house in N. London, August 31st, 1735." Adams saw God's righteous hand in the sheer power of the event and his merciful hand in the fact that the calamity was not worse: "We might have died by scores and by hundreds, yea, the whole congregation might have been dispatched at once into eternity."

For the disaster, and for the death of Edwin Burch, the Puritan faithful had only their unworthy selves to blame. Adams sermonized:

> There is no blemish or defect in any thing which God doth, nothing of which we should dare to say, that it ought to have been otherwise; there are faults enough and enough in us to justify the Lord in his most severe dispensations towards us; we must hold our peace and not open our mouths to complain, nor suffer an unease or grudging thought to stir in our hearts, how heavy so ever the strokes be, or how much so ever we are made to smart thereby, we must still ascribe righteousness to our maker and our judge.

Just 10 years later, in nearby Philadelphia, Benjamin Franklin would begin a series of investigations into the nature of electricity, work that made him famous. Before long, in 1749, he was entering into his notebook certain conjectures about its similarities to lightning: "The electric fluid is attracted by points; we do not know whether this property is in lightning; but since they agree in all the particulars wherein we can already compare them, is it not probable that they agree likewise in this? Let the experiment be made." In June, 1752, he performed his famous kite experiment, causing an electrostatic spark between a knuckle and a key hanging from the twine. This and other experiments of his design soon established lightning as an electrical phenomenon in the atmosphere. The discovery would lead to the installation of insulated and grounded iron "points," or lightning rods, that carried the fire of God harmlessly down the sides of vulnerable church steeples across the land.

Benjamin Franklin's seven years of research into the nature of electricity, his most intensely focused period of scientific activity, earned him an international reputation as a scientist. In later years, he stopped practicing science only in the sense that in leading the American colonies through revolution and into nationhood, he lost his time to pursue it. All his life, he remained one of the most observant students of nature. Nothing interesting about the weather, or about much of anything else, seems ever to have escaped his curiosity. He thought and wrote about weather for 60 years. In 1726, on a return voyage from London to Philadelphia, entries in his journal included routine weather observations and the appearance of an unusual "lunar rainbow." In 1786, he was offering long-range forecasts to members of his family.

In the spring of 1755, he and a group of friends who were riding on the Maryland country estate of Colonel Benjamin Tasker watched a whirlwind approaching, growing as it came toward them up a hill. Franklin described this adventure in a letter in August to a friend, Peter Collinson.

> The rest of the company stood looking after it; but my curiousity being stronger, I followed it, riding close by its side, and observed its licking up in its progress all the dust that was under its smaller part. As it is a common opinion that a shot, fired through a water-spout will break it, I tried to break this little whirlwind by striking my whip frequently through it, but without any effect. Soon after, it quitted the road and took into the woods, growing every moment larger and stronger, raising instead of dust the old dry leaves with which the ground was thick covered, and making a great noise with them and the branches of the trees, bending some tall trees round in a circle swiftly and very surprisingly, though the progressive motion of the whirl was not so swift but that a man on foot might have kept pace with it; but the circular motion was amazingly rapid. By the leaves it was now filled with I could plainly perceive that the current of air they were driven by moved upwards in a spiral line; and when I saw the trunks and bodies of large trees enveloped in the passing whirl, which continued entire after it had left them, I no longer wondered that my whip had no effect on it in its smaller state.

Franklin rejoined the company, and as the group traveled on for nearly three miles, he watched the leaves taken up by the whirlwind continue to fall from the sky. He wrote Collinson: "Upon my asking Colonel Tasker if such whirlwinds were common in Maryland, he answered pleasantly: 'No, not at all common; but we got this on purpose to treat Mr. Franklin.' And a very high treat it was too."

Accounts of whirlwinds, tornadoes, and waterspouts appear in the chronicles of the ancient world, although nowhere were they as common as in North America, where, since the founding of the colonies, they had been subjects of speculation. In the middle of the eighteenth century, Franklin was in the thick of it, providing an early description of the process of convection. In a letter written in 1753, he proposed two sets of conditions for such winds:

> 1. That the lower region of air is often more heated, and so more rarified, than the upper; consequently, specifically lighter. The coldness of the upper region is manifested by the hail, which sometimes falls from it in a hot day. 2. That heated air may be very moist, and yet the mois-

> ture so equally diffused and rarified, as not to be visible till colder air mixes with it, when it condenses and becomes visible. Thus our breath, invisible in summer, becomes visible in winter.

Although he was always a close observer, Franklin was still a natural philosopher at heart, and he was not inclined to clutter his conjectures with a lot of data or mathematics. He knew good science when he saw it, and he knew when his own theorizing wandered beyond observed facts into "the wilds of fancy." But the man who completed only two years of formal education never lost his disdain for mathematics, the *lingua franca* of modern meteorology. In his letter describing his thinking about whirlwinds, he concluded, "If my hypothesis is not the truth itself it is least as naked: For I have not, with some of our learned moderns, disguised my nonsense in Greek, clothed it in algebra, or adorned it with fluxions. You have it in *puris naturalibus*."

Franklin also found himself attracted to questions of climate, the longer-term state of weather, a subject which had bedeviled the colonists and their European sponsors since the founding of the settlements in the sixteenth century. Without a grasp of the general circulation of the atmosphere, the west-to-east flow in the middle latitudes, nothing was known of the more extreme continental character of the New World's climate. Basking in their moderate oceanic climes, warmed by the Gulf Stream, Europeans were confounded by the patterns of seasonal weather in the colonies. By Franklin's day, however, a general warming trend was noticeable, and in 1763, he met with a group of colonial scholars to discuss the changing climate. Franklin agreed with others that deforestation was likely the cause, that "cleared land absorbs more heat and melts snow quicker," although he argued that many more years of observations would be necessary to make the case.

Other investigations by Franklin at this time led to important advances in the understanding of the Gulf Stream, the "river" of warm water that travels from the tropics far north along the American coast and across the North Atlantic. As deputy postmaster general of the colonies, Franklin heard complaints that English postal vessels traveling from Falmouth to New York consistently took several more days crossing the Atlantic than merchant vessels making the longer voyage from London to Rhode Island. A Franklin acquaintance, Tim Folger, a Nantucket whaler, had a ready explanation. He sketched out the Gulf Stream, and Franklin had it engraved and published on a map that drew wide attention to the important navigational feature from everyone except the captains of British packets, who were not about to take any advice from American fishermen in that day and age. This work led Franklin to take regular readings of sea-surface temperatures on his voyages across the Atlantic, marking the first use of the thermometer as a navigational device.

In his late 70s, while serving as ambassador to France and living near Paris, Franklin noticed a peculiar lack of intensity to the sunlight in the summer of 1783 and drew a connection between it and the severity of the following winter across Europe. He described his thinking in a memoir published by the Manchester Society: "During several of the summer months of the year 1783," he wrote, "when the effects of the sun's rays to heat the earth in these northern regions should have been the greatest, there existed a constant fog over all Europe, and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water." This coolness caused the earth to absorb less heat, he reasoned. "Hence the surface was early frozen. Hence the first snows remained on it unmelted, and received continual additions. Hence perhaps the winter of 1783–4, was more severe than any that happened for many years."

"The cause of this universal fog is not yet ascertained," he wrote. Perhaps it was the burned-out debris of a comet or asteroid, he supposed, or more particularly, "the vast quantity of smoke, long continuing to issue during the summer" from volcanoes near Iceland.

"It seems however worth the inquiry, whether other hard winters, recorded in history, were preceded by similar permanent and widely extended summer fogs," Franklin wrote. "Because, if found to be so, men might from such fogs conjecture the probability of a succeeding hard winter . . . and take such measures as are possible and practicable, to secure themselves and effects from the mischiefs that attend the last."

Following Franklin's line of thought, modern earth and weather scientists, searching climate evidence and historical records, have indeed found a pattern of atmospheric cooling lasting up to two years after the eruptions of large volcanoes.

Benjamin Franklin died on April 17, 1790, at his home in Philadelphia at the age of 84. In 1906, in Philadelphia, the American Philosophical Society, a learned group which Franklin founded in 1743, celebrated the bicentennial of his birth. One of the nation's most astute scientists, Cleveland Abbe, himself a pioneer of American weather forecasting, took the occasion to describe Franklin's contribution to meteorology. "To the laurel that crowns him," Abbe added another leaf: "as the pioneer of the rational long-range forecasters, and of the physical meteorologists who will, undoubtedly, in the future develop this difficult subject."