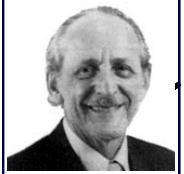
Essays of an Information Scientist, Vol:5, p.703,1981-82 Current Contents, #40, p.5-12,
October 4, 1982



Current Comments

Benjamin Franklin—Philadelphia's Scientist *Extraordinaire*

Number 40 October 4, 1982

Earlier this year I invited *Current Contents*® (*CC*®) readers to visit Philadelphia as we celebrate its 300th birthday.[1] Philadelphia offers its residents and visitors a wide array of scientific attractions. Its universities, museums, libraries, foundations, and institutes have made Philadelphia one of the top research centers in the world. In fact, Philadelphia ranks among the world's top ten cities in the number of local scientists publishing articles and books.[2]

Philadelphia owes much of its current scientific prestige to an eighteenth-century printer who had only two years of formal education—Benjamin Franklin. Most of us know Franklin as a rebel, statesman, inventor, businessman, philanthropist, and author. And his famous kite-flying experiment with lightning is a part of America's national folklore. But this was just one of his many scientific achievements. Now I'd like to briefly describe Franklin's contributions to science and, equally important, to the international communication of scientific information.

Carl Van Doren gave an entertaining account of Franklin's early life in his exhaustive biography,[3] which won the Pulitzer prize. Franklin was born in Boston in 1706 to a crowded household. His family eventually included 14 brothers, sisters, half brothers, and half sisters. His father, Josiah, took him out of school when he was ten years old to work in the family's candle-making business. Two years later, he was apprenticed to his brother James, a printer. While learning his new trade, he taught himself arithmetic, navigation, grammar, and logic, and read whatever books he could buy or borrow. Franklin absorbed knowledge like a sponge. When he was 16, he started a series of satirical pieces written under the pseudonym Silence Dogood. These appeared in his brother's newspaper, the *New England Courant*.[3] (p. 21)

The apprenticeship became uncomfortable and confining to Franklin's precocious mind. He took the first opportunity to escape the remaining four years of his contract. James persuaded all the printers in Boston not to hire his upstart younger brother. In later years, he regretted running out on James, and considered it one of his first "errata."[3] (p. 32)

But the course of his later life proved that Franklin would make few mistakes in the future. He arrived in Philadelphia in 1723, a poor and friendless 17-year-old runaway apprentice. Five years later, he was master of his own printing shop. In 1729, Franklin became publisher of his own newspaper, the *Pennsylvania Gazette*. The following year, he was appointed official printer for Pennsylvania, and later for Delaware, New Jersey, and Maryland. In 1733, he issued the first volume of his *Poor Richard's Almanac*, which contains homespun wisdom that is still popular today.

municated, die with the discoverers, and are lost to mankind; it is, to remedy this inconvenience for the future, proposed that one society be formed of...ingenious men residing in the several colonies, to be called *The American Philosophical Society*, who are to maintain a constant correspondence."[7] (Vol. 2, p. 229)

Franklin's clear intention was to establish the first institution through which colonial scientists could communicate by correspondence. He planned to issue quarterly abstracts of useful correspondence which would be sent without charge through the mail—remember that Franklin was postmaster.[3] (p. 139) But the proposed network of scientific communications wasn't limited to the colonies. Franklin included the Royal Society of London and the Dublin Society on his mailing list. In fact, the American Philosophical Society was patterned after the Royal Society.[8] (p. 4)

Unfortunately, the members lost enthusiasm after only a few meetings, and the society lapsed in 1745.[9] At the time, American scientists did little original research. Instead, they acted as fieldworkers for European scientists, collecting specimens of biological species and genera indigenous to the colonies. These were sent to Collinson, Carl Linnaeus in Sweden, and John Gronovius in Holland for analysis and classification.[10] Perhaps American scientists felt little need to communicate their findings among themselves. Or, as Franklin suggested, they may simply have been "very idle gentlemen."[7] (Vol. 2, p. 289)

But Franklin had little time available to resuscitate the American Philosophical Society. In 1746, Collinson donated to the Library Company a simple glass tube with instructions on how to use it. By rubbing it with silk, enough static electricity was generated to give off sparks.[3] (p. 156) Franklin's return letter to Collinson, dated March 28, 1747, reveals the exciting effect this donation had on him: "For my own part, I never was before engaged in any study that so totally engrossed my attention and my time as this has lately done; for what with making experiments when I can be alone, and repeating them to my friends and acquaintance...I have, during some months past, had little leisure for any thing else."[7] (Vol. 2, p. 302) Collinson's gift set in motion a series of original experiments in electricity that won Franklin international fame and admiration.

When Franklin began his experiments in 1747, European scientists believed there were two kinds of electrical "fluid." Rubbing glass with silk created "vitreous" electricity. "Resinous" electricity was generated by rubbing resin with wool or fur.[3] (p. 156) In a letter to Collinson, Franklin formulated a "single-fluid" theory of electricity. He stated that all bodies contain electricity—they have no charge because they are in equilibrium. When they are charged, electricity is not *created*. Rather, it is *separated*—the body has either an excess of electricity or a deficiency. Franklin defined a new terminology to explain his theory. Uncharged bodies are "neutral," excessively charged bodies are "positive" or "plus," and deficiently charged bodies are "negative" or "minus."[11,12] Franklin introduced other technical terms as well, such as armature, battery, condenser, conductor, electrician, and electric shock,[13] according to I. Bernard Cohen, Harvard University. Cohen is a well-known scholar of Franklin's scientific achievements.

Franklin also was the first to propose the conservation of electrical charge. That is, when the electrical equilibrium of a neutral body is disturbed, the plus and minus charges generated are in exactly equal amounts. Franklin made this municated, die with the discoverers, and are lost to mankind; it is, to remedy this inconvenience for the future, proposed that one society be formed of...ingenious men residing in the several colonies, to be called *The American Philosophical Society*, who are to maintain a constant correspondence."[7] (Vol. 2, p. 229)

Franklin's clear intention was to establish the first institution through which colonial scientists could communicate by correspondence. He planned to issue quarterly abstracts of useful correspondence which would be sent without charge through the mail—remember that Franklin was postmaster.[3] (p. 139) But the proposed network of scientific communications wasn't limited to the colonies. Franklin included the Royal Society of London and the Dublin Society on his mailing list. In fact, the American Philosophical Society was patterned after the Royal Society.[8] (p. 4)

Unfortunately, the members lost enthusiasm after only a few meetings, and the society lapsed in 1745.[9] At the time, American scientists did little original research. Instead, they acted as fieldworkers for European scientists, collecting specimens of biological species and genera indigenous to the colonies. These were sent to Collinson, Carl Linnaeus in Sweden, and John Gronovius in Holland for analysis and classification.[10] Perhaps American scientists felt little need to communicate their findings among themselves. Or, as Franklin suggested, they may simply have been "very idle gentlemen."[7] (Vol. 2, p. 289)

But Franklin had little time available to resuscitate the American Philosophical Society. In 1746, Collinson donated to the Library Company a simple glass tube with instructions on how to use it. By rubbing it with silk, enough static electricity was generated to give off sparks.[3] (p. 156) Franklin's return letter to Collinson, dated March 28, 1747, reveals the exciting effect this donation had on him: "For my own part, I never was before engaged in any study that so totally engrossed my attention and my time as this has lately done; for what with making experiments when I can be alone, and repeating them to my friends and acquaintance...I have, during some months past, had little leisure for any thing else."[7] (Vol. 2, p. 302) Collinson's gift set in motion a series of original experiments in electricity that won Franklin international fame and admiration.

When Franklin began his experiments in 1747, European scientists believed there were two kinds of electrical "fluid." Rubbing glass with silk created "vitreous" electricity. "Resinous" electricity was generated by rubbing resin with wool or fur.[3] (p. 156) In a letter to Collinson, Franklin formulated a "single-fluid" theory of electricity. He stated that all bodies contain electricity—they have no charge because they are in equilibrium. When they are charged, electricity is not *created*. Rather, it is *separated*—the body has either an excess of electricity or a deficiency. Franklin defined a new terminology to explain his theory. Uncharged bodies are "neutral," excessively charged bodies are "positive" or "plus," and deficiently charged bodies are "negative" or "minus."[11,12] Franklin introduced other technical terms as well, such as armature, battery, condenser, conductor, electrician, and electric shock,[13] according to I. Bernard Cohen, Harvard University. Cohen is a well-known scholar of Franklin's scientific achievements.

Franklin also was the first to propose the conservation of electrical charge. That is, when the electrical equilibrium of a neutral body is disturbed, the plus and minus charges generated are in exactly equal amounts. Franklin made this

Franklin's lightning rod also created a political controversy involving George III, king of England. In 1772, the Royal Society commissioned Franklin and several other scientists to recommend a way of protecting gunpowder storehouses from lightning. Not surprisingly, they recommended pointed lightning rods. As a result, they were erected on British gunpowder magazines, Kew Palace, and other government buildings. But when the American Revolution broke out, George III insisted that the rebel Franklin's pointed rods be replaced with blunted rods, as recommended by Benjamin Wilson, a British electrician. Sir John Pringle, president of the Royal Society and court physician, disagreed with the king's decision—he lost both his posts because of it.[3] (p. 430)

Although Franklin attained worldwide notoriety for his electrical experiments, he made other fundamental contributions to science. As early as 1729, Franklin investigated the relation between color and heat absorption. He arranged different colored squares of cloth on snow on a sunny day and measured how far each sank. The darkest ones sank deepest while the lightest ones sank little, if at all. He also found that dark objects conducted heat more efficiently. Like all of Franklin's experiments, this one had a practical application. He suggested that soldiers and sailors in equatorial regions wear white uniforms to stay cooler; that white hats be worn to avoid sunstroke; and that the outside walls of rooms used to store fruit be painted black to retain heat against nighttime frosts.[15]

In 1743, Franklin made an important meteorological observation about storms while trying to observe a lunar eclipse in Philadelphia. The eclipse was obscured by a northeast storm at nine o'clock that evening. Assuming that the storm would have passed over Boston hours earlier, since Boston lies northeast of Philadelphia, he was surprised to hear that Bostonians viewed the eclipse until a cloud cover appeared at eleven o'clock—hours *later* than in Philadelphia. Franklin checked newspaper accounts of the eclipse's visibility in other colonies and found the storm's beginning always was reported later the farther northeast the colony.[3] (p. 174)

Franklin used an insightful analogy to explain the weather pattern of northeast storms: "Suppose the air in a chamber at rest, no current through the room till you make a fire in the chimney. Immediately the air in the chimney, being rarefied by the fire, rises; the air next the chimney flows in to supply its place, moving toward the chimney; and, in consequence, the rest of the air successively, quite back to the door. Thus to produce our north-east storms I suppose some great heat and rarefication of the air in or about the Gulph of Mexico; the air thence rising has its place supplied by the next more northern, cooler, and therefore denser and heavier, air; that, being in motion, is followed by the next more northern air, etc., etc., in a successive current."[7] (Vol. 4, p. 17) Thus, Franklin was the first to observe atmospheric heat convection.[13]

Franklin also pioneered the diagnosis of lead poisoning. He was interested in the problem as early as 1745, when he published Thomas Cadwalader's *An Essay on the West Indian Dry Gripes.*[16] The dry gripes or "bellyache" is a symptom of lead poisoning. In later correspondence, Franklin recounted cases in which people ingested lead from rainwater collected from leaded roofs, for example, or cases in which printers were poisoned by handling lead types.[16] He believed lead poisoning was the result "of a metallic cause only."[3] (p. 423) Franklin also wrote on several other medical topics—inoculation, infant mortality, deafness, gout, blood heat, infection from corpses, and so on.[13] He

Franklin's lightning rod also created a political controversy involving George III, king of England. In 1772, the Royal Society commissioned Franklin and several other scientists to recommend a way of protecting gunpowder storehouses from lightning. Not surprisingly, they recommended pointed lightning rods. As a result, they were erected on British gunpowder magazines, Kew Palace, and other government buildings. But when the American Revolution broke out, George III insisted that the rebel Franklin's pointed rods be replaced with blunted rods, as recommended by Benjamin Wilson, a British electrician. Sir John Pringle, president of the Royal Society and court physician, disagreed with the king's decision—he lost both his posts because of it.[3] (p. 430)

Although Franklin attained worldwide notoriety for his electrical experiments, he made other fundamental contributions to science. As early as 1729, Franklin investigated the relation between color and heat absorption. He arranged different colored squares of cloth on snow on a sunny day and measured how far each sank. The darkest ones sank deepest while the lightest ones sank little, if at all. He also found that dark objects conducted heat more efficiently. Like all of Franklin's experiments, this one had a practical application. He suggested that soldiers and sailors in equatorial regions wear white uniforms to stay cooler; that white hats be worn to avoid sunstroke; and that the outside walls of rooms used to store fruit be painted black to retain heat against nighttime frosts.[15]

In 1743, Franklin made an important meteorological observation about storms while trying to observe a lunar eclipse in Philadelphia. The eclipse was obscured by a northeast storm at nine o'clock that evening. Assuming that the storm would have passed over Boston hours earlier, since Boston lies northeast of Philadelphia, he was surprised to hear that Bostonians viewed the eclipse until a cloud cover appeared at eleven o'clock—hours *later* than in Philadelphia. Franklin checked newspaper accounts of the eclipse's visibility in other colonies and found the storm's beginning always was reported later the farther northeast the colony.[3] (p. 174)

Franklin used an insightful analogy to explain the weather pattern of northeast storms: "Suppose the air in a chamber at rest, no current through the room till you make a fire in the chimney. Immediately the air in the chimney, being rarefied by the fire, rises; the air next the chimney flows in to supply its place, moving toward the chimney; and, in consequence, the rest of the air successively, quite back to the door. Thus to produce our north-east storms I suppose some great heat and rarefication of the air in or about the Gulph of Mexico; the air thence rising has its place supplied by the next more northern, cooler, and therefore denser and heavier, air; that, being in motion, is followed by the next more northern air, etc., etc., in a successive current."[7] (Vol. 4, p. 17) Thus, Franklin was the first to observe atmospheric heat convection.[13]

Franklin also pioneered the diagnosis of lead poisoning. He was interested in the problem as early as 1745, when he published Thomas Cadwalader's *An Essay on the West Indian Dry Gripes*.[16] The dry gripes or "bellyache" is a symptom of lead poisoning. In later correspondence, Franklin recounted cases in which people ingested lead from rainwater collected from leaded roofs, for example, or cases in which printers were poisoned by handling lead types.[16] He believed lead poisoning was the result "of a metallic cause only."[3] (p. 423) Franklin also wrote on several other medical topics—inoculation, infant mortality, deafness, gout, blood heat, infection from corpses, and so on.[13] He made life easier. For example, he designed a rocking chair that fanned the sitter while he or she rocked. Another chair converted into a stepladder for access to books on tall library shelves. A different device Franklin invented, called the "long arm," could be used for the same purpose. It is still used today, but mainly in grocery stores instead of libraries. Franklin also designed a stove that produced more heat and less smoke, called the Pennsylvania Fireplace or Franklin Stove.[22] And I've already mentioned the flexible catheter and bifocal glasses he invented. Interestingly, Franklin never patented any of his inventions. He believed, "We should be glad of an opportunity to serve others by an invention of ours, and this we should do freely and generously."[4] (p. 192)

Visitors to Philadelphia can see several of Franklin's inventions on display at the Franklin Court Museum. The museum was built under the plot of land where Franklin's house once stood. Although nobody knows what this house looked like, a metal frame was erected to show its approximate dimensions. This unique "ghost house" was designed by the architects Venturi, Rauch and Scott Brown, who also designed ISI®'s new headquarters in University City Science Center.

It is astonishing to think that Franklin achieved so much during an active scientific career that spanned only six years. Remember that he began his first electrical experiments in 1747 and communicated his last kite experiment to the Royal Society in 1752. Before 1747, he was involved in establishing his printing business and improving the quality of life of his fellow Philadelphians. After 1752, Franklin was busy in England as spokesman for colonial interests and in France as procurer of arms and supplies for the American Revolution. Incidentally, during his years in London, Franklin lived in a house on Craven Street. The house still stands, and is being used today as offices of the Science Policy Foundation. I often speak with the director of the foundation, my old friend Maurice Goldsmith. It's somewhat eerie to know that he's calling from what used to be Franklin's study.

Franklin's six short years in active research earned him an immortal place in the history of science. Robert A. Millikan, who won the Nobel prize for his work in electricity, considered Franklin to be the fifth most-influential scientist after Copernicus, Galileo, Newton, and Huygens. He placed Franklin ahead of Faraday, Darwin, Pasteur, Gauss, and several others.[11] How he managed to rank these geniuses without citation analysis, I'll never understand.

Yet Franklin's impact is not limited to the past. The institutions he established are a very active legacy. The Library Company today is a valuable resource for scholars of American history and culture. Pennsylvania Hospital, co-founded by Franklin and Dr. Thomas Bond in 1751, remains an important center of patient care and medical research. The University of Pennsylvania, founded by Franklin in 1749 as the Academy of Philadelphia, is a leading educational and research institution. The American Philosophical Society has invaluable collections of Frankliniana, North American Indian linguistics and archaeology, genetics, quantum physics, and early American science. In fact, a number of academies and societies developed out of the American Philosophical Society—the College of Physicians and the Academy of Natural Sciences, for example.[9]

Franklin combined the best qualities of the experimental and theoretical scientist. He possessed a lively curiosity, pursuing an idea or observation to its logical end. His intellect was clear and penetrating, recognizing orderly principles under a jumble of facts. Franklin made life easier. For example, he designed a rocking chair that fanned the sitter while he or she rocked. Another chair converted into a stepladder for access to books on tall library shelves. A different device Franklin invented, called the "long arm," could be used for the same purpose. It is still used today, but mainly in grocery stores instead of libraries. Franklin also designed a stove that produced more heat and less smoke, called the Pennsylvania Fireplace or Franklin Stove.[22] And I've already mentioned the flexible catheter and bifocal glasses he invented. Interestingly, Franklin never patented any of his inventions. He believed, "We should be glad of an opportunity to serve others by an invention of ours, and this we should do freely and generously."[4] (p. 192)

Visitors to Philadelphia can see several of Franklin's inventions on display at the Franklin Court Museum. The museum was built under the plot of land where Franklin's house once stood. Although nobody knows what this house looked like, a metal frame was erected to show its approximate dimensions. This unique "ghost house" was designed by the architects Venturi, Rauch and Scott Brown, who also designed ISI®'s new headquarters in University City Science Center.

It is astonishing to think that Franklin achieved so much during an active scientific career that spanned only six years. Remember that he began his first electrical experiments in 1747 and communicated his last kite experiment to the Royal Society in 1752. Before 1747, he was involved in establishing his printing business and improving the quality of life of his fellow Philadelphians. After 1752, Franklin was busy in England as spokesman for colonial interests and in France as procurer of arms and supplies for the American Revolution. Incidentally, during his years in London, Franklin lived in a house on Craven Street. The house still stands, and is being used today as offices of the Science Policy Foundation. I often speak with the director of the foundation, my old friend Maurice Goldsmith. It's somewhat eerie to know that he's calling from what used to be Franklin's study.

Franklin's six short years in active research earned him an immortal place in the history of science. Robert A. Millikan, who won the Nobel prize for his work in electricity, considered Franklin to be the fifth most-influential scientist after Copernicus, Galileo, Newton, and Huygens. He placed Franklin ahead of Faraday, Darwin, Pasteur, Gauss, and several others.[11] How he managed to rank these geniuses without citation analysis, I'll never understand.

Yet Franklin's impact is not limited to the past. The institutions he established are a very active legacy. The Library Company today is a valuable resource for scholars of American history and culture. Pennsylvania Hospital, co-founded by Franklin and Dr. Thomas Bond in 1751, remains an important center of patient care and medical research. The University of Pennsylvania, founded by Franklin in 1749 as the Academy of Philadelphia, is a leading educational and research institution. The American Philosophical Society has invaluable collections of Frankliniana, North American Indian linguistics and archaeology, genetics, quantum physics, and early American science. In fact, a number of academies and societies developed out of the American Philosophical Society—the College of Physicians and the Academy of Natural Sciences, for example.[9]

Franklin combined the best qualities of the experimental and theoretical scientist. He possessed a lively curiosity, pursuing an idea or observation to its logical end. His intellect was clear and penetrating, recognizing orderly principles under a jumble of facts. Franklin also was resourceful, improving available methods or inventing others when none existed. And last but not least, his writing style was clear and direct. Franklin's communications to the Royal Society were so concise that they were read in full to the members. Usually, only summaries were presented, but Franklin's terse letters defied abridgment. Franklin's example of the eighteenth-century philosopher still serves as an ideal to be imitated by twentieth-century scientists.

* * * * *

My thanks to Alfred Welljams-Dorof for his help in the preparation of this essay.

REFERENCES

1. **Garfield E.** You're invited to historic Philadelphia for the tercentennial. *Current Contents* (1):5-13, 4 January 1982.
2. **Institute for Scientific Information.** *Current bibliographic directory of the arts & sciences. 1981 annual.* Philadelphia: ISI, 1982. 2 vols.
3. **Van Doren C.** *Benjamin Franklin.* New York: Viking Press, 1938. 845 p.
4. **Labaree L W, Ketcham R L, Boatfield H C & Fineman H H,** eds. *The autobiography of Benjamin Franklin.* New Haven, CT: Yale University Press, 1964. 351 p.
5. **Wolf E.** *"At the instance of Benjamin Franklin."* Philadelphia: Library Company of Philadelphia, 1976. 55 p.
6. **Conklin E G.** A brief history of the American Philosophical Society. *Amer. Phil. Soc. Year Book* 1966:37-63, 1967.
7. **Smyth A H,** ed. *The writings of Benjamin Franklin.* New York: Macmillan, 1907. Vols. 2-4.
8. **Smith M D.** *Oak from an acorn.* Wilmington, DE: Scholarly Resources, 1976. 291 p.
9. **Bell W J, Jr.** The American Philosophical Society and medicine. *Bull. Hist. Med.* 40:112-23, 1966.
10. **Hindle B.** Science and the American Revolution. *J. Gen. Educ.* 28:223-36, 1976.
11. **Millikan R A.** Benjamin Franklin as a scientist. *J. Franklin Inst.* 232:407-23, 1941.
12. **Devons S.** Benjamin Franklin as experimental philosopher. *Amer. J. Phys.* 45:1148-53, 1977.
13. **Cohen I B.** Franklin, Benjamin. (Gillispie C C, ed.) *Dictionary of scientific biography.* New York: Scribner's Sons, 1972. Vol. 5. p. 129-39.
14. **Dvoichenko-Markoff E.** Benjamin Franklin, the American Philosophical Society, and the Russian Academy of Science. *Proc. Amer. Phil. Soc.* 91:250-7, 1947.
15. **Cohen I B.** Franklin's experiments on heat absorption as a function of color. (Hindle B, ed.) *Early American science.* New York: Science History Publications, 1976. p. 16-9.
16. Ben Franklin on lead poisoning. *Sat. Evening Post* 252:70-1; 82, 1980.
17. **Zirkle C.** Benjamin Franklin, Thomas Malthus and the United States Census. (Hindle B, ed.) *Early American science.* New York: Science History Publications, 1976. p. 38-42.
18. **Otto R A.** Poor Richard's population biology. *Bioscience* 29:242-3, 1979.
19. **Richardson P L.** Benjamin Franklin and Timothy Folger's first printed chart of the Gulf Stream. *Science* 207:643-5, 1980.
20. **Schmitt F P.** Benjamin Franklin and the Gulph Stream. *Oceans* 11(3):5-6, 1978.
21. **Lingelbach W E.** B. Franklin and the scientific societies. *J. Franklin Inst.* 261:9-31, 1956.
22. **Cohen I B.** *Franklin and Newton.* Philadelphia: American Philosophical Society, 1956. p. 29.