Contents

ONE

On Bacon, Hobbes, and Newton, and the Selfishness of Writing Well

The Invention of Clarity

In the European early modern period (c. 1500–1750), everything was changing. The period saw the Protestant Reformation, the introduction of representative democracy, the secularization of political power, and the origins of the sovereign nation-state. It saw globalization of trade in goods and ideas, but also the subjugation of much of the world under European colonization.

Science was transforming itself right alongside religion, politics, and global economies. European curiosity cabinets (figure 1.1) were bulging with specimens from overseas exploration and trade: stones, creatures, and artifacts begging to be explained by new ideas in natural science and anthropology. Chemistry took its first steps away from alchemy and toward rational discovery. Astronomy and physics were revolutionized by painstaking observations and new instruments. Finally, the invention of the calculus gave mathematics its key place at the center of all the sciences.

But while the *content* of human knowledge was exploding, another, more important change was taking place. The development of modern scientific methods, professional scientists, scientific societies, and (in case you were wondering about the point of this historical excursion) modern-style scientific writing changed the way people acquired and communicated knowledge. In a sense, this was when scientists learned to write—or, more particularly, to write with the explicit goal of making their ideas available to a broad scientific community.

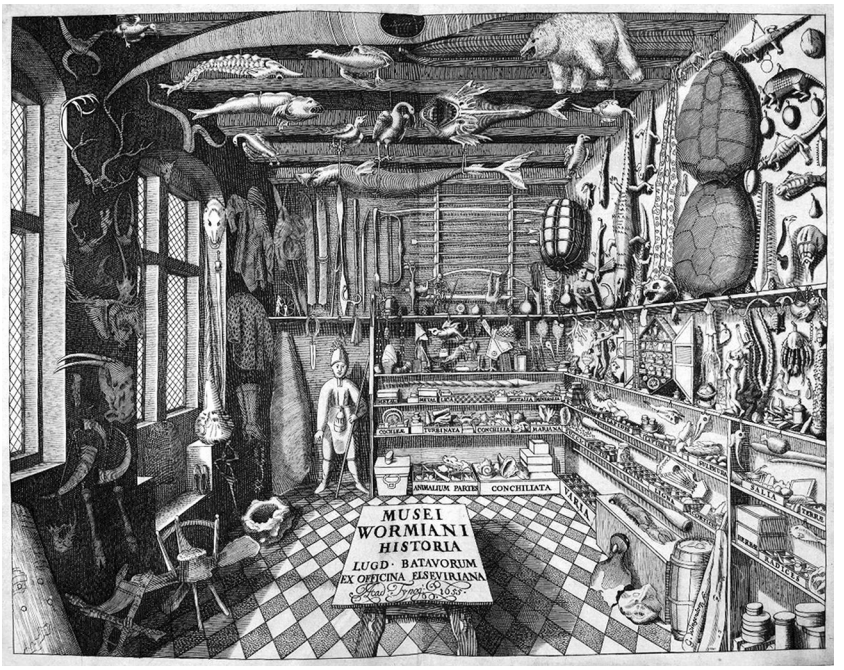

Figure 1.1. Frontispiece to Ole Worm's (1655) *Museum Wormianum*, a catalog of his curiosity cabinet.

This was a big change. Medieval "scientists" (alchemists, for instance) generally thought of themselves as solitary workers who would penetrate nature's secrets for their own gain. Thus, if they wrote their findings down at all, it was to claim priority or to make notes for their own use—and what they wrote was deliberately obscure or even written in code to protect their secrets from their rivals. One of the first proponents of change was Francis Bacon, who criticized this secrecy and argued instead in his 1609 essay *De Sapientia Veterum* that "perfection of the sciences is to be looked for not from the swiftness or ability of any one inquirer, but from a succession." In a novel, *New Atlantis* (1627), Bacon described a fictitious research-institute-cum-scientific-society he called "Salomon's House"—which he clearly intended as a proposal for how science should work. In Salomon's House, research progressed because scientists communicated and collaborated with one another. (Bacon may well have been inspired by Islamic science of the eighth and ninth centuries, which had

flourished, collaboratively, under the Abbasid caliphs Harun al-Rashid and Abu al-Mamun [Lyons 2009].)

Bacon's concept of Salomon's House inspired the creation of the Royal Society of London in 1660. Its founders extended his ideas about communication among collaborating scientists to communication with a broad scientific community and even with the curious public. One of those founders was Robert Boyle, who essentially invented a new form of writing: the scientific report, which described the methods and results of an experiment (Pérez-Ramos 1996). Another was Thomas Hobbes, who wrote in the preface to his 1655 work *De Corpore*, "I distinguish the most common notions by accurate definition, for the avoiding of confusion and obscurity"—a goal that seems routine today, but would have been outrageously unconventional in Hobbes's time. The founding of the Society brought with it the first modern scientific journal, *Philosophical Transactions of the Royal Society*, which printed scientific reports of the kind pioneered by Boyle, written in the clear language advocated by Hobbes. Just a dozen years later, Thomas Sprat described the organization's rhetorical philosophy as

> a constant resolution, to reject all the amplifications, digressions, and swellings of style . . . a close, naked, natural way of speaking; positive expressions, clear sense, a native easiness: bringing all things as near the mathematical plainness, as they can. (Sprat 1667, 113).[1]

All this may seem obvious from our modern vantage point, but the transition from medieval secrecy through Bacon and Hobbes to the "clear sense [and] native easiness" of Sprat's Royal Society was revolutionary. Without this tectonic shift in how science was reported, modern science couldn't be done. The inventions of the calculus, the telescope, the microscope, and the inductive method (all between 1590 and 1630) were certainly important, but they're all outweighed in importance by the idea of describing one's scientific thinking clearly, for all to read.

Of course, no revolution lacks holdouts, and the revolution in scientific communication had a curious one: the famously cranky Isaac

[1] This mention of "mathematical" plainness may be a shout-out to Euclid, whose *Elements* are admirably lucid. However, clarity and openness were not necessarily the rule among ancient Greek thinkers. Pythagorus, for example, bound his followers to secrecy, and his followers may have killed the philosopher Hippasus for divulging his discovery of the irrational numbers.

Newton, for whom publication remained largely about ensuring credit for his work. For example, he drafted his *On Analysis by Infinite Series* in 1669 in response to Nicholas Mercator's *Logorithmotechnia*, which Newton worried would undermine his claim of first discovery for some key insights underlying the calculus. Newton allowed only limited circulation of the manuscript within the Royal Society, and only agreed to open publication in 1711. More famously, he deliberately made his masterwork *Principia Mathematica*—and especially its third volume, *De mundi systemate*—difficult to read. Newton had originally written *De mundi systemate* in plain language to be accessible to readers (Westfall 1980, 459), but changed his mind and rewrote it as series of propositions, derivations, lemmas, and proofs comprehensible only to accomplished mathematicians. He left little doubt of his intent, telling his friend William Derham that "in order to avoid being baited by little smatterers in mathematics, he [Newton] designedly made his *Principia* abstruse" (Derham 1733). That is, Newton wrote to impede communication with other scientists, not to facilitate it! Of course, by then Newton was a superstar, and readers were likely to put in whatever effort was needed to penetrate the fog. Those readers could spare the effort, too, as the flow of published works competing for scientists' attention was still little more than a trickle. This, too, would change.

Clarity and "Telepathy" in the Modern Era

Bacon, Hobbes, Sprat, and others of their time were taking the first steps toward what became, by the twentieth century, a consensus that the goal of most writing is clear communication. The best-known reflection of this is probably Strunk and White's *The Elements of Style*, first published in 1920. White described Strunk's opinion that the typical reader was "floundering in a swamp" and that it was "the duty of anyone trying to write English to drain this swamp quickly and get [the reader] up on dry ground, or at least throw [down] a rope" (Strunk and White 1972, xii). However forceful Strunk's pleading, though, the argument for clarity has its purest expression in Stephen King's *On Writing: A Memoir of the Craft*. King's chapter "What Writing Is" opens with the simple declaration: "Telepathy, of course" (King 2000, 95).

The word "telepathy" may seem chosen for humor, but in scientific writing your goal should always be communication so crystal-clear that it feels to the reader like direct transmission to their brain from yours. You're writing because you have some information to convey, and your goal should be for the reader to receive that information without even being aware of the process. As Nathaniel Hawthorne put it, "The greatest possible merit of style is . . . to make the words absolutely disappear into the thought" (letter to E. A. Duyckinck, 27 Apr. 1851, quoted in Van Doren [1949], 267). If the reader pauses to question your word choice or needs to squint to distinguish between two lines on a graph, then you've joined a battle you don't want to be in: what you're trying to say is fighting for the reader's attention with the way you're saying it.

At this point, you might be a little skeptical. After all, it's a popular belief that people who use big words and complicated sentences seem more intelligent. Most research, though, finds the opposite: people ascribe higher intelligence to writers who (and higher quality to texts that) use smaller words and simpler sentences (e.g., Oppenheimer 2006). But even if the popular belief held and difficult prose did make you seem smarter, this would only help if people actually read it. This brings me to my next point.

The Selfishness of Writing Well

Achieving telepathic writing is hard work (chapter 2). I've spent many hundreds of hours crafting pieces of writing that I hoped might achieve crystal clarity, and in this book I'll urge you to do the same. Those were hundreds of hours I could have spent doing more experiments, or drinking beer with friends, or even just walking along the water's edge skipping stones. So why invest the time and effort in writing well?

It might seem that working to make your writing clear is an act of generosity toward the reader—the impression left by Strunk's metaphor of throwing the reader a rescue line. Or it might seem an act of generosity toward the progress of science. This was the argument made by Bacon, Sprat, and others in the 1600s; in this view, Newton was selfish in withholding his written work and writing for opacity.

There's no question that writing well serves both the reader and the progress of science. But the evolution of science and its spectacular growth since Newton's time have changed the incentives for writing well. In the 1680s, Newton had the luxury of writing a difficult book and knowing that every mathematician, physicist, and astronomer who mattered would invest the time needed to grapple with his text. There just weren't many works of similar importance competing for their attention. But in our modern era, the deluge of published scientific work becomes greater every year. Just for the year 2020, for example, a Scopus™ search returns more than 200,000 records for "cancer," nearly 38,000 for "pollutant," and 24,000 for "graphene." By comparison, the mere 7,000 records for "superconductor OR superconducting" seem almost manageable—but even if just 10 percent of the superconductor literature were relevant to your own work, keeping up with it would mean reading two papers every single day of the year. That *might* be possible for a while, but these numbers omit papers in journals not indexed by Scopus, preprints, technical reports, books, book chapters, theses, grant proposals, or any of the other forms of scientific writing that form teetering piles in scientists' offices around the globe.

As a scientific writer, then, you're competing for attention with an incredible array of material your reader might prefer to your own. But your career and reputation depend on having *your* work read. Hiring, promotion, and tenure committees and granting councils devour citation data for your publications. Grad-school admissions committees look for evidence of writing skill, and the best prospective graduate students search for supervisors by reading the literature to find someone whose ideas excite them. Journal editors and reviewers groaning under the weight of submissions can't be depended on to see the jewel hidden in a manuscript that's difficult to read. Readers have a lot to choose from, and if your paper isn't clear they'll turn to another. When they do, it's you as the writer who suffers most.

You can't make your reader like your science simply by writing better—but you *can* make it easier for them to see why they should like it, or at least why they should read and cite it. The biggest winner when you put in the effort to make your writing clear isn't your reader, and isn't the progress of science: it's you. This is a victory you can shoot for, partly because there's so much bad writing out there for you to outshine (glass half-

empty) and partly because you can learn to write better and better (glass half-full). Newton clung to a world in which the selfish act was to write opaquely, but in the modern world, scientists can do themselves no bigger favor than writing well.

The Transferability of Writing Skill

This book aims to help you improve your scientific writing. But what if your career takes you away from academia and you never need to write a scientific paper again? Will the effort you put into improving your scientific writing be wasted?

In a word, no. Although I decorated my argument for the selfishness of writing well with details from the world of *scientific* writing, every bit of that argument holds for writing in other forms and other careers. Those who move away from scientific research may no longer write scientific papers, but they will almost always write something else. Perhaps they'll complete a geology degree but then work in industry or government and write progress and technical reports. Perhaps after earning a mathematics degree a student will go to law school and draft case summaries, legal opinions, or even legislation. Perhaps a biologist will end up writing instruction manuals, sales brochures, or—who knows?—children's fiction, popular histories, erotica, or even a book about writing. While details vary, the basic tools you need to write well are remarkably transferable across fields. And the payoff to the work you put into improving your writing can be even broader, because doing so inevitably sharpens your logical thinking skills—and everyone uses *those* skills their entire lives.

Chapter Summary

- The most important goal for scientific writers is to write clearly.
- Clear writing benefits the progress of science, the reader, and, most of all, the writer.
- Writing that isn't clear risks being unpublished, unread, or uncited.
- Writing skills learned to improve scientific writing are transferable to almost any career.

Exercises

1. Choose two keywords that broadly define your scientific area of interest (e.g., "sedimentary geology" and "Cretaceous," or "nanoparticle" and "drug delivery").
   a. Execute a literature search, using Google Scholar, Web of Science™, or Scopus™. How many papers does your search find, for the most recent complete year? How many for the last ten years?
   b. How do the results in (a) compare with the number of papers you might be able to read carefully in a year? The number you might be able to skim?
2. List three ways in which you'd like to improve your own practice of scientific writing. These could involve the content or style of your writing or your process or behavior as a writer. Now list three things that satisfy you about your writing ability. Everyone has writing skills and can point to accomplishments, even if some of them are small!

Index

Page numbers in italics refer to figures.