ELOQUENT SCIENCE



A practical guide to becoming a better

Writer, Speaker & Atmospheric Scientist

DAVID M. SCHULTZ

AMERICAN METEOROLOGICAL SOCIETY

ELOQUENT SCIENCE

A Practical Guide to Becoming a Better Writer, Speaker, and Atmospheric Scientist

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American Meteorological Society

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CONTENTS

PREFACE

Mary Grace Soccio. My writing could not please this kindhearted woman, no matter how hard I tried.

Although Gifted and Talented seventh-grade math posed no problem for me, the same was not true for Mrs. Soccio's English class. I was frustrated that my first assignment only netted me a C. I worked harder, making revision after revision, a concept I had never really put much faith in before. At last, I produced an essay that seemed the apex of what I was capable of writing. Although the topic of that essay is now lost to my memory, the grade I received was not: a B–.

"The best I could do was a B–?" The realization sank in that maybe I was not such a good writer.

In those days, my youthful hubris did not understand about *capacity building*. In other words, being challenged would result in my intellectual growth—an academic restatement of Nietzsche's "What does not destroy me, makes me stronger." Consequently, I asked to be withdrawn from Gifted and Talented English in the eighth grade.

Another capacity-building experience happened when I was a postdoctoral research fellow. In writing the journal article that resulted from my Ph.D. thesis, one of my coadvisors, Dan Keyser, and I discussed revisions by phone while he lived in upstate New York and I in Oklahoma. My schooling was severe: fifteen one-hour-long phone calls where we would go through the draft together—one section at a time, sentence by sentence. Not all of Dan's lessons I embraced immediately, however. Sometimes we were frustrated by each others' stubbornness: me by his insistence to do things his way and he by my resistance to learning. Finally, something snapped inside and clarity came: I understood what he was trying to tell me about transition, coherence, and precision, and it made complete sense. Subsequent revisions went much more smoothly, and the manuscript made it easily through the review process and

was published. Wherever that revelation came from, *Eloquent Science* would not have happened without that moment.

Throughout my career, mentoring by Dan, my other advisors, and my colleagues was essential to my development as a scientist and a writer. Unfortunately, not everyone has the benefit of such mentoring. The good news is that being a better writer, whether a student or a scientist with years of experience, does not require a revelation, merely an open mind. As I hope to convince you in this book, the essential skills can be taught. Moreover, it's not just the young dogs who can be taught new tricks. Everyone, no matter how experienced, can learn new skills to improve their writing.

Eloquent Science is an outgrowth of a scientific communication workshop I developed for the National Science Foundation–funded Research Experiences for Undergraduates program that the Oklahoma Weather Center (and its members the National Severe Storms Laboratory, the University of Oklahoma, the Cooperative Institute for Mesoscale Meteorological Studies, and Center for the Analysis and Prediction of Storms) hosted from 1998 to 2005, and has continued from 2007 to this writing. After seeing that we were not educating our students about how to write a scientific paper and make a scientific presentation, I created and led this workshop during 2000–2005. The workshop began as a collection of thoughts on a Web site, turned into an afternoon lecture, and became an eight-hour interactive workshop where students learned to critique their own and their peers' writing. I argued that these undergraduates would be my future colleagues, and I would likely be reviewing their papers and attending their seminars. Besides my desire to see them create excellent scientific work and present it effectively, I realized that if I could influence them not to write a bad paper or make a bad presentation in the future, I could be saving myself some subsequent heartaches.

As I developed the workshop from year to year, the organic approach took its toll. My slides, with new insertions each year, were characterized at best as verbose lecture notes rather than a clear and effective presentation. Also inadequate was the poorly organized collection of articles and handouts serving as a reference guide. Neither were even adequate examples of the instruction I was trying to give. The idea for turning the lectures into a book struck in summer 2005 while at a conference, frustrated by the pathetic presentations I was enduring. A book would solve both my problems, I thought. It would create a more effective vehicle to deliver the information on paper and free me to focus on improving the style of the presentations. An added benefit, I wishfully dreamt, might be to distribute this book to other atmospheric scientists to ease the kind of pain I experienced at that conference.

Writing a book about communicating effectively to a scientific audience is like speaking to an audience at a classical music concert about how to play a violin as a virtuoso would. Although some in the audience will learn quite

a bit and benefit immediately, more experienced violinists need only specific advice to improve. Moreover, future performances by the speaker will be intensively scrutinized. As with that speaker, I fear that my words will come back to haunt me in the future. (I can already hear readers raising questions about my previous publications!) In my defense, few writers alive today believe that their previous work is impervious to revisions. And we should not expect perfection, either. In fact, many examples in *Eloquent Science* derive from my own writings and presentations: not only the best examples, but the imperfect, as well. For my future writing efforts, I can only plead forgiveness for a limited brain capacity to store and recall the abundant information contained within this book.

If you have any comments about the material in this book, I would appreciate hearing from you: eloquentscience@gmail.com.

ACKNOWLEDGMENTS

I am grateful to many people for their help in teaching me how to write. My parents supported me in my early development, bought me my first typewriter for college, and assisted me while I earned my Ph.D. My M.S. thesis advisor Cliff Mass is another who deserves praise. My 315-page M.S. thesis, although an unwieldy compilation of nearly everything I learned about occluding cyclones, was my first major lesson in managing a book-length manuscript. The result is that I improved somewhat with my Ph.D. dissertation, constraining the length to 198 pages. My Ph.D. advisors Lance Bosart and Dan Keyser were responsible for helping me further hone my writing and speaking skills. Lance and Dan would reign over rehearsals for presentations we students would give at national conferences, until we got it right. Dan was of particular help in the many hours he spent with me on the phone between Norman and Albany as we finalized the manuscript that arose from that Ph.D. dissertation. The writing process that Dan opened my eyes to was a turning point in my educational experience. Finally, in my National Research Council postdoctoral fellowship at the NOAA/National Severe Storms Laboratory, Chuck Doswell poked, prodded, and peeved me into further refining my writing style or defending why I chose to be different. The process of the two of us writing the *Guide for Authors, Reviewers, and Editors* for the *Electronic Journal of Severe Storms Meteorology*, which we helped cofound with other meteorologists, influenced several aspects of this book, as did the material from his Web pages. Furthermore, his extensive critiques of several chapters have made that material immensely stronger.

Because *Eloquent Science* is derived from the Research Experiences for Undergraduates program in Oklahoma, Director Daphne LaDue made the foundations of this book possible. Her insight into and support of undergraduate education and good communication skills makes her an extraordinary

resource for our community. Stephan Nelson at the National Science Foundation provided the financial support to the program. Most importantly, I value the dozens of students who have endured the years I grew the workshop and provided feedback to improve the workshop. Much of the book was also test-driven in my Communication Skills for Scientists class at the University of Helsinki and at numerous workshops and conferences in North America and Europe. I appreciate those students' contributions to the material in this book, as well.

Colleagues that I have worked with have cajoled me to improve my scientific communication skills, and I thank them, especially Jim Steenburgh, Paul Roebber, John Knox, George Bryan and Fred Sanders. Some of the ideas about publishing papers (Section 2.1) and the review process come from C. David Whiteman. Some aspects of overcoming writer's block in Chapter 5 come from a writing workshop led by Norman author Darlene Graham and sponsored by the Norman Arts Council. Andy White has lectured in my classes previously about the principles of graph construction—some of his ideas were used in this book. Mary Golden, the chief editorial assistant extraordinaire of *Monthly Weather Review*, has been a great supporter of this book and teaching communication skills for English as a Second Language scientists. She provided numerous suggestions for the book, as well as extensive editorial support. I have been very proud of my association with *Monthly Weather Review*, which maintains rapid times for manuscript decisions (the best in the American Meteorological Society, as of this writing) without sacrificing high standards. David Jorgensen set the bar high and has served as a tremendous inspiration to me during his role as one of the chief editors. If I have inadvertently borrowed the thoughts of any of these people without attribution in this book, it is because I have integrated their lessons so well that I have lost the ability to distinguish their original ideas from my own.

Some people suggested specific material for the book. Paul Roebber offered "An Incoherent Truth" as the title of the book (which was later used for the Introduction, instead). Tracey Holloway suggested the Ask the Experts columns and the expression "manuscript-on-the-wall poster," and Peter Grünberg described to me his story of his Nobel Prize–winning discovery (page 249). Mary Golden interviewed and surveyed authors for the ESL chapter; I thank those individuals for their time and contributions: George Bryan, Huaqing Cai, Jielun Sun, Junhong Wang, and Yafei Wang.

Content for the book was graciously provided by Jelena Andrić, Svetlana Bachmann, Howie Bluestein, Lance Bosart, Chris Davis, Charles Doswell, Dale Durran, Kerry Emanuel, Robert Fovell, Alistair Fraser, Michael Friedman, Robert Marc Friedman, William Gallus, Mary Golden, Eve Gruntfest, Sabine Göke, Tom Hamill, Yvette Hancock, Vesa Hasu, Ken Heideman, Pamela

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I am honored that the American Meteorological Society gave this book their stamp of approval. I thank my editor Sarah Jane Shangraw for her efforts to allow my vision for this book to blossom with few compromises. I also thank Ken Heideman and Keith Seitter for their management and approval. The book was expertly copy edited by Ellen Goldstein. In addition to the editorial comments of Sarah Jane, Ken, and Ellen, the following AMS staff members also provided their input into the book through their content or comments: Beth Dayton, Mark Fernau, Michael Friedman, Lindsy Gamble, Jocelyn Humelsine, Stephanie Kenitzer, Jessica LaPointe, and Brian Papa.

My wife Yvette Hancock deserves recognition, as well. Her perspective from the theoretical physics community has brought a welcome breadth to the book, and our discussions on communicating science have opened my eyes to other approaches. I appreciate the time she gave from our relationship so that I could write this book.

Eloquent Science was largely written during my time at the University of Helsinki and Finnish Meteorological Institute starting in November 2006. I appreciate their patience with me during the writing process. I also thank the NOAA/National Severe Storms Laboratory and Cooperative Institute for Mesoscale Meteorology at the University of Oklahoma for their prior support (1996–2006) and Vaisala Oyj for their current support.

Finally, I thank Mrs. Mary Grace Soccio, who died while I was writing this book. I had the privilege to write to her a few years ago, letting her know of

my journey since leaving seventh grade to becoming a better writer, including writing this book. Although I did not understand it in seventh grade, what she was teaching me was the value of repeated revision. I can assure her, as can my colleagues with whom I have written manuscripts, that I have learned that lesson.

—David M. Schultz
Helsinki, Finland
24 March 2009

FOREWORD

Professor Kerry Emanuel, MIT

Good communication is the lifeblood of science. Much of the thrill of discovery is wrapped up in the anticipation of sharing one's findings, and in this current age of highly collaborative science, discovery itself often involves intricate communication between colleagues. Among the most beautifully written documents in world history are scientific treatises, yet this history is littered with the refuse of virtually unreadable papers, some of which mask important discoveries now credited to other scientists who better knew how to present their findings.

In spite of the critical importance of communication to the scientific enterprise, few graduate students receive formal training in scientific communication. Almost all effort is devoted to developing the art of doing research; students are expected to pick up speaking and writing on their own. In a very real sense, students receive an excellent education in how to write bad papers and give boring presentations, simply because, in the course of their work, they must read dozens of papers many or most of which are badly written, and listen to poorly conceived and delivered talks. By this means, bad scientific writing and speaking perpetuate themselves.

Professional societies often contribute to the problem. The major one I belong to strongly encourages the use of the passive voice, and forbids the use of the active in abstracts. The idea, one supposes, is to convey an air of dispassionate professionalism . . . that dry sense of calculating logic so valued in Victorian doctors and Mr. Spock. We must never insert ourselves into our writing or speaking, lest we be suspected of having any passion for our work. This recipe for dull writing is honored in the breach by the best science writers—scientists like Richard Feynman and Carl Sagan, whose popular books and papers are eagerly read by a science-starved public, sometimes to the tut-tutting disapproval of their fellow scientists, steeped as they are in a culture of bland, dry, and passionless science writing.

Kerry Emanuel is a professor in the Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology. He has written three books: Atmospheric Convection *(1994),* Divine Wind: The History and Science of Hurricanes *(2005), and* What We Know About Climate Change *(2007).*

Some enterprising graduate programs hire communications experts to coach their students in the arts of written and oral communication. While admirable, such efforts can be compromised by a lack of scientific training of the communications professionals, who may have degrees in literature or the arts, and may not understand the need for precision or the use of even rudimentary scientific terminology. Worse, their backgrounds in the humanities may have inculcated in them an active hostility to science, of the kind so well described by C. P. Snow in his "Two Cultures" lecture a half century ago. More than once have I seen such professionals turn moderately good student science essays into rubbish.

The challenge does not only rest with our writing and speaking skills. Even mature scientists well versed in the art of communication can have serious difficulties working with journalists, few of whom have a background in science. It is here, especially, that the clash of Snow's two cultures produces the most disturbing results. The scientist imagines that the reader/viewer shares his enthusiasm for nature, while the journalist assumes that his audience, like him, is bored by science and interested only in personal conflict, misconduct, and politics. Such orthogonal motives do not make for stellar journalism, and scientists are often caught off guard and may come across as wishy-washy, defensive, and/or petty, while the message they wanted to convey has been warped or omitted altogether.

Into this lamentable morass steps David Schultz, a working research scientist and editor of several professional journals, with a keen interest in scientific communication. Here before you is the complete guide to writing a good scientific paper, from the creation of an outline right through to the formalities of submission, review, and proofing. Just as important, Schultz provides invaluable guidance to the preparation and delivery of a scientific talk or poster, including techniques for soliciting and fielding questions, and fostering lively discussion. Finally, Schultz offers tips on the teaching of science, and on how to communicate effectively with the public and the media, avoiding those pitfalls that many have learned the hard way, often at a price to their careers. This book is also laced with advice from a wide spectrum of professional scientists, on subjects ranging from the use of scientific terminology to how to present at a conference. Although aimed specifically at atmospheric scientists, many of the important lessons you will find here are applicable throughout the sciences. So read on, and prepare to absorb what may prove the most valuable advice you will receive as a scientist.

HOW TO USE THIS BOOK

Eloquent Science is written so that students, early career scientists, and senior scientists can improve their communication skills. The book addresses the principal means by which we scientists communicate formally—we participate in the publication process by writing and reviewing scientific papers, and we attend conferences. In Part I, the focus is on writing a scientific document for a class project, conference extended abstract, thesis, or article in a scholarly journal. For brevity, I have not covered all the different types of documents that we might be called upon to write in our career, although the lessons herewithin are clearly relevant to them as well. Part II sheds light on the peer-review process and provides advice on how to participate as a reviewer and an author. Part III focuses on oral and poster presentations at conferences, although your hour-long seminars and speeches to lay audiences will also benefit from this material. Part IV discusses how to communicate outside of the scientific world, either to the public, particularly through the lens of the media, or in a professional setting. This part also contains the last chapter, which closes the book with suggestions on how to improve your skills. Two appendices help readers properly employ select punctuation and scientific terms. Each of the 31 chapters can be read largely independent of each other, so there is no need to read the book sequentially. Experienced scientific (and nonlinear) readers are unlikely to do so anyway.

This book contains four other features you may find useful:

- **Sidebars** highlight important information or discuss tangential topics.
- **Ask the Experts** include contributions from friends and colleagues to provide more than just my perspective.
- **Notes** provide specific citations and elaborate on items discussed in the text.

- **For Further Reading** is an annotated list of sources of additional information culled from my many hours of research and featuring the best material of which I am aware outside of this book.

The figures, tables, and examples in *Eloquent Science* were derived from one of four sources. First, some of the examples come from American Meteorological Society (AMS) publications. Wherever possible, I tried to get the author's permission for these examples. Second, a few examples come from the public domain. Third, I created some of the other examples specifically for this book to illustrate certain points. Fourth, many examples come from my own writings or those of my coauthors. In some cases, the text or figure was revised to correct bad practices; in other cases, the bad practices were left in to illustrate a point. Although using my own material limits the breadth of the book and prohibits showcasing many other talented writers, it does mean that I can pick more effective material and be uncompromisingly critical of it.

HOW THIS BOOK COMPARES TO OTHERS

Although numerous books on communication skills for scientists have been written, *Eloquent Science* both distinguishes itself from and complements the others. With such a large topic, no single book can address all the issues in a manner appealing to everyone. My approach, therefore, is a practical one. I discuss what I see as the most relevant, topical, and important issues, which clearly may be different from others' opinions. More specifically, other books have not presented, or have done so only cursorily, certain topics that I wanted to emphasize, such as editing your writing, writing reviews for scientific journals, attending conferences, and presenting posters. In addition, because some aspects of formal communication are discipline specific, I draw nearly all of the examples from atmospheric science, even including a chapter on writing for the atmospheric sciences (Chapter 18).

DEFINITIONS

I use a few terms throughout this book that would be best to define here. A *document* refers generically to any number of types of writings that a scientist may produce: thesis, journal article, conference extended abstract, technical memo, etc. A *manuscript* is any unpublished document, whether completed or in draft form. An *article* is a published document in a scientific peer-reviewed journal. A *paper* is a document aimed at a scientific peer-reviewed journal, whether published as an article or not.

CAVEATS

The material in this book is a collection of good-use practices and tips that I have read, researched, or learned for myself. Many ways exist to write a journal article or make a presentation. Not every technique will work for every person or in every circumstance. Some people can deliver humor in their presentations flawlessly. Others should not even try.

Some readers might dispute my recommendations. I have tried to indicate topics where reasonable people can disagree. I would rather make a recommendation and let the reader make a conscious decision to disregard my advice than never to have considered the issue in the first place. Proceeding along the wrong path because "that's the way I was taught" is never an acceptable excuse.

INTRODUCTION: AN INCOHERENT TRUTH

> Too frequently, published papers contain fundamental errors. The presentation in many papers is careless. Some papers abound in unsupported claims stated as facts.

Was this an attack on global warming research by a climate skeptic? No. This quote comes from one of our own. Dr. Ronald Errico, then at the National Center for Atmospheric Research, published an essay in the *Bulletin of the American Meteorological Society* in 2000 that questioned whether we research scientists were being held accountable for our science. He continued, "the unnamed papers . . . are not obscure articles. . . . Both editors and authors have told me that some of these articles have sailed through the review process."

My own experience is similar to Dr. Errico's. Whether I am serving as a voracious reader of the scientific literature, as a reviewer for manuscripts submitted to scientific journals, or as an editor for one of four scientific journals, many papers I read lack sound scientific knowledge, properly constructed arguments, and basic language skills. As an editor, I rely on reviewers to provide recommendations about whether manuscripts should be published or not. Sometimes reviewers provide inadequate criticism of low-quality papers. If editors choose reviewers poorly or make hasty decisions, substandard manuscripts can slip through the review process and be published, officially blessed as The Scientific Truth.

The scourge of shoddy papers has also disturbed the respected fluid dynamicist, founder, and long-time editor of the *Journal of Fluid Mechanics*, G. K. Batchelor. On the 25th anniversary of the founding of his journal in 1981, he wrote a 25-page essay entitled "Preoccupations of a journal editor" in which he indicted such papers:

> Papers of poor quality do more than waste printing and publishing resources; they mislead and confuse inexperienced readers, they waste and distract the attention of experienced scientists, and by their existence they lead future authors to be content with second-rate work.

I once saw a professor, someone for whom English is a second language, misspell a word in his presentation: *litterature*. I smiled to myself because he could not have known how often he was correct. Students may be shocked to learn that the quality of many published papers is less than ideal. The literature, or should I say *litter-ature*, does not meet even mediocre standards sometimes.

And the trend is getting worse. Geerts (1999) showed that the clarity of papers in 22 atmospheric science journals was either holding steady or declining. The reasons were the increasing number of words and figures, the increasing length and complexity of the abstract, and the increasing length of the conclusion section owing in part to tangential discussion topics. And these are the papers that survive peer review and get published. Most certainly an inconvenient—and an incoherent—truth!

Fortunately, most of the worst ones get rejected. Indeed, in 2006, the eight scientific journals published by the American Meteorological Society (AMS) rejected 685 manuscripts out of 2353 submissions, or 29%. Rejection rates for individual journals have been relatively constant over time and do not show much spread from this mean, ranging from 19% to 39%. These rejection rates are consistent with the rates from 46 atmospheric science journals, which range from 2% to 68% with a mean of 37%. Thus, more than a third of manuscripts submitted for publication were written by authors who have not demonstrated an ability to communicate effectively or perform high-quality science.

A CAREER COMMUNICATING

Why do we spend so much effort writing articles? Why do we pay as much as $2000 to attend scientific conferences around the world? We do this to communicate our ideas to, and learn from, others about the way nature works. Writing forces us to clarify our own thinking, leading to a much improved understanding. Conferences provide an opportunity for us to get direct feedback on our research and inform others of our results. Publications and conference presentations show funding agencies that their money was well spent, ensuring that they receive credit for their financial commitment. Science could not progress without communication. One of the most veracious statements I have heard is that *we write for our audience, not for ourselves*. This eight-word mantra reminds us *why* we communicate and the importance of doing it well.

There are no boundaries, no walls, between the doing of science and the communication of it; communicating is the doing of science. —Scott L. Montgomery (2003, p. 1)

Being a successful scientist means being an effective communicator. This may come as a surprise to those scientists with relatively low scores on the verbal components of standardized tests—the very same people who dread public speaking, who just want to be left alone in their offices to do their science. Suppose you had discovered the cure for cancer, but never communicated it to others before you died. Your discovery would be wasted, waiting for someone else to discover it again, perhaps not for decades. That is why senior scientists often write biographies or textbooks, summarizing their lifelong results and preserving their legacy for future generations of scientists to build upon. How unfulfilled the uncommunicated life must be!

Even those in nontraditional career paths need to write and speak well. Students may believe that, if they are not choosing teaching or research careers like their professors, they do not need communication skills. This is simply not true. As one example, forecasters need to convince their coworkers that their forecast scenario is the most probable one, and then they need to communicate their forecasts and warnings clearly to their customers or the public—people whose livelihoods, if not their lives, may depend on understanding the warning. A study conducted by the College Board's National Commission on Writing found that writing is part of the job of two-thirds of salaried employees in large U.S. companies, and writing is taken into consideration during hiring and promotions at half of those companies. Communication skills are not only needed in the workforce, but are in demand.

SCIENCE IS FUN

Scientists have one of the most exciting occupations I know. In general, we love our jobs. We get to learn new things every day, explore our own research interests, talk with other like-minded people, see our friends at conferences in exotic locations, and share the thrill of discovering the natural world with students. Yet, as I have shown in this introduction, scientists waste valuable and potentially enjoyable time by writing reviews rejecting poorly written papers and sitting through insipid conference presentations.

> Ah, there's nothing more exciting than science. You get all the fun of: sitting still, being quiet, writing down numbers, paying attention. Science has it all.
> —*Principal Seymour Skinner*, The Simpsons

How did we lose the fun? I believe part of the answer is that we are taught at an early age that science is impartial. Like Principal Skinner's vision of how science is done, we collect data and we report it, eliminating any evidence that science is done by real individuals. Yet, we scientists like a good mystery story.

The hunt for new knowledge excites us. We may even think something that no one has ever thought before. But, when we write or speak, we fail to convey our enthusiasm and to personalize our science within a proper context. Purging our personalities from our work sterilizes it. We scientists individually need to find our voices, our creativity, and our originality.

Improving our ability to communicate is a lifelong process. I hope this book excites you about your writing and presentations, encouraging you to make them better, interesting, and unique. How many manuscripts must be rejected before we say enough? How many boring presentations must we sit through until we demand better? I look forward to the day when all manuscripts I oversee as editor receive my recommendation to publish and all presentations I attend engage my scientific imagination.

WRITING AND PUBLISHING SCIENTIFIC RESEARCH PAPERS

1

THE PROCESS OF PUBLISHING SCIENTIFIC PAPERS

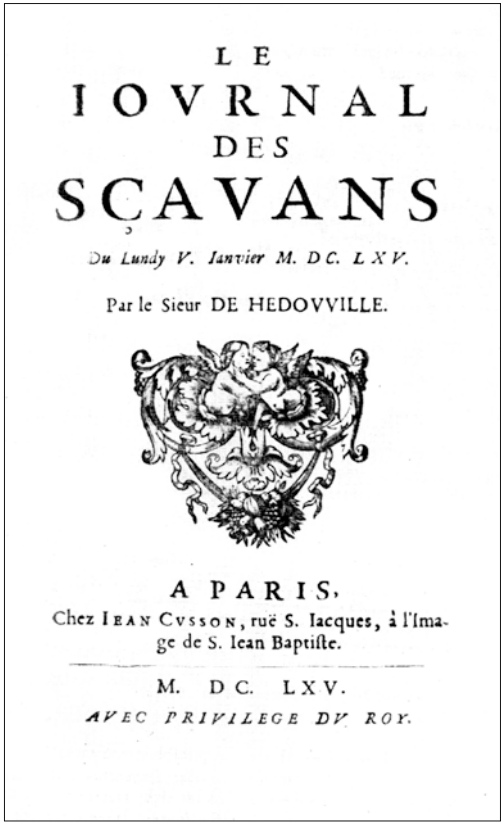
Publishing a scientific paper involves interactions among authors, editors, reviewers, copy and technical editors, and the publisher, with the goal to publish the best-quality research as timely as possible. This chapter describes the publishing process, starting with how to submit a manuscript to a journal, what editors and reviewers do, how manuscripts navigate the peer-review process, and how an accepted manuscript undergoes layout and printing, finally becoming part of the scientific literature.

Scientific journals have been established since 1665 when *Journal des Sçavans* debuted on 5 January, followed by *Philosophical Transactions of the Royal Society of London* two months later (Fig. 1.1). Both are still published today. Despite scientific journals being around for over 300 years, many experienced scientists do not understand the publication process.

This chapter describes this process as it happens at many scientific journals. Although most articles have two or more coauthors, most of the time in this book I refer to a single author, specifically the corresponding author. The *corresponding author* is the person who represents all coauthors by being the one who submits the article to the journal, maintains correspondence with the journal, keeps coauthors informed about the status of the manuscript, and is responsible for revisions. The corresponding author may or may not be the first author listed on the manuscript.

1.1 SUBMISSION

Before the manuscript is written, the author usually has a vision for where it should be published, the *target journal*. Each journal has its own rules for submission. Some journals place few restrictions on submitted manuscripts,



LE
IOVRNAL
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Par le Sieur DE HEDOVVILLE.

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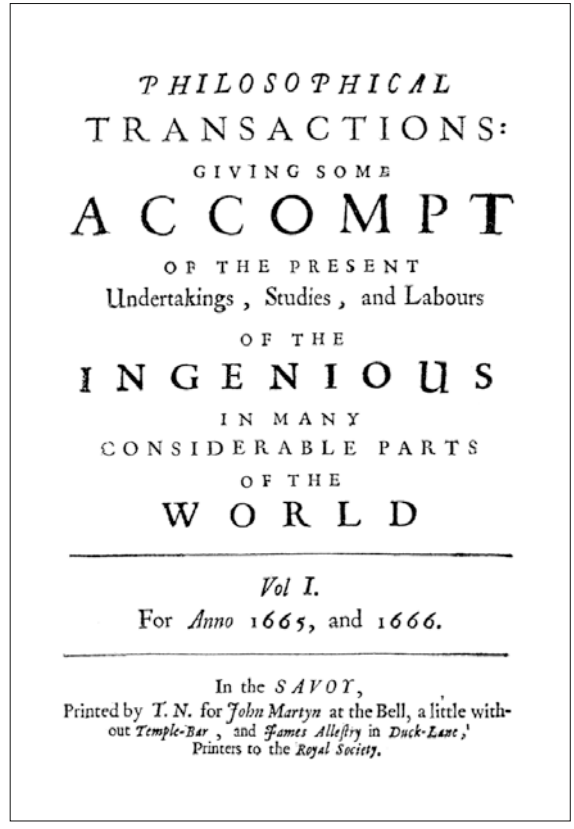

PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD

Vol I.
For Anno 1665, and 1666.

In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane,
Printers to the Royal Society.

Fig. 1.1 The first scientific journals: *Journal des Sçavans* and *Philosophical Transactions of the Royal Society of London.*

as long as they have certain information on the cover page and are set in 12-point font, whereas other journals have strict rules about the format of their submissions.

When the manuscript is completely written and formatted as required by the target journal, the author submits the manuscript to the journal. Even as recently as the first few years of the millennium, the author would send four to six photocopies of the manuscript to the target journal by post, which cost paper resources and money for postage, as well as slowed down the review process. Today, nearly all journals have Web sites where authors can upload digital files. Typically, the manuscript, figures, and a cover letter are uploaded in their native format (e.g., Microsoft Word, LaTeX). Often, a PDF document is created from the uploaded files, and authors are required to approve the rendered PDF. Authors who fail to approve the rendered PDF document can delay the submission process, so pay special attention to the journal's requirements.

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