Chapter 1
Getting Started

If you are thinking about writing a science paper for peer review and publication, what should be your first steps? Ideally, you have thought about the possibility of writing and publishing early in your research project because some early planning can help you avoid problems later. But first, you should ask yourself about your motivations for writing a science paper.

1.1 Why Write and Publish a Paper?

Writing a paper and getting it published in a peer-reviewed journal is hard work, even after the hard work that led to the publishable results. So why do people do it? What motivates authors to go through the writing process, and then the peer review process, in order to publish their work? There are two kinds of motivations, *altruism* and *self-interest*, and most authors have some combination of the two.

Altruism

Peer-reviewed science publications are the predominant method today for disseminating and archiving scientific advances (books, conference presentations, and university teaching are other common ways). Science grows and advances through a communal collection of knowledge that is constantly being challenged, revised, and expanded.[1,2] Most scientists (and I include engineering in the broadest sense of science) have a strong desire to contribute to the advancement of their field, which is often their primary reason for becoming a scientist. Publication is usually the most straightforward way to make such a contribution, and it is thus highly motivating (and satisfying) to most scientists.

Self-Interest

Publishing can also bring tangible benefits to an author, thus providing a self-interested motivation for writing and publishing a paper. Publishing may be required for career advancement and is frequently accompanied by direct or indirect monetary rewards. The familiar "publish or perish" paradigm in academia adds a proverbial stick to the carrot of career advancement. But even without these obvious professional motivations, almost all human beings crave recognition for their efforts. I know that I am highly motivated by the reward of peer recognition;

I am gratified to see my worked used and referenced, and I take pride in publishing in journals that I respect and admire.

Balancing Altruism and Self-Interest

Let me be clear that I do not view self-interested motivations as inherently bad or even fundamentally worse than altruistic motivations. Any properly regulated and well-functioning "marketplace" (to borrow economic parlance) aligns self-interested and selfless motivations as much as possible. I suspect that every author has some combination of these two classes of motivation. The problem comes when altruism and self-interest are not balanced. In particular, if self-interest becomes so strong as to become selfish and swamp the altruistic goal of scientific advancement, the entire scientific enterprise can suffer.

In the academic world, as in the economic world, systems that promote greater disparity in "wealth" contribute to unbalanced selfishness. A winner-take-all tournament, where only the scientists with the top-rated papers published in the top-rated journals have a chance of getting jobs, tenure, grants, and students, will skew motivations towards self-interest. In the business world, rewarding and recognizing only monetary gain for one's employer can have the same effect. (Some universities are actively applying both pressures to their professors.) The result can be a continuum of sins: lack of motivation for replication experiments,[3] bias against the null result, increased prevalence of faddish and safe science over creative exploration, unnecessary feuds over priority, preference for competition over collaboration,[4] lack of transparency and full disclosure, conflicts of interest, double publication, plagiarism, and outright fraud. (Many of these subjects will be discussed in the following chapters.)

With the exception of outright fraud (at least, to my knowledge), the *Journal of Micro/Nanolithography, MEMS, and MOEMS* (JM^3) has seen all of these sins in manuscripts submitted for publication during my tenure as editor-in-chief. I have no idea if any of these imbalances are trending up or down today. I do know that the best way to combat imbalanced self-interest is to find ways to constantly remind yourself of why you became a scientist or engineer in the first place: to make a positive difference in the world. (Am I being too bold or naïve to make this assumption about each of you? I do not think so.) If you keep your altruistic motivations always close and never compromised, the personal benefits can come along (self-interest "and" altruism, rather than "or").

1.2 The Literature Search

A new research project almost always begins with a literature search—or at least it should. The goal of the search is to evaluate the state of our communal knowledge on a topic before embarking on a quest of adding to that knowledge. Because science is about either confirming or refuting existing knowledge or developing new knowledge, a thorough understanding of the current state of communal knowledge is essential. Additionally, this literature search will form a

foundation for the five goals of citations (see Chapter 5). Note that a literature search is not about *finding* relevant papers, it is about *reading* relevant papers.

Unfortunately, literature searches are rarely done as well as they should be. Here are a few hints to improve literature searches:

- Do the literature search before performing the research, and certainly before writing the paper.
- The next most promising papers to read are often those referenced in the relevant papers you have already found.
- Look in fields outside your discipline (this often means looking for different search keywords, which one recursively discovers when reading the literature outside of one's discipline).
- While your memory of which previous papers are worth citing is a good start, no one ever knows the full scope of the literature in even the smallest of niche fields. Do not rely on your memory alone.
- When finishing up the manuscript, look for recent publications on the subject. Often, other researchers are working on similar topics and may have published papers that should be read to ensure that your manuscript captures the latest communal knowledge in the field.

Starting a literature search always leads to a difficult question: How do you know when to stop? There will always be important papers that you never find. This is the nature of modern science. Knowing when to quit (or pause) the literature search and begin the new work is a matter of judgment and experience.

1.3 Plan and Execute Research with Publication in Mind

Most projects begin with the intention of writing a paper as an output of the work, or at least with the thought that this could be a possibility. If so, the research should be planned and executed with publication in mind. As discussed throughout this book (especially in Chapter 2), one of the critical requirements of a science paper is to document the work in sufficient detail so that the reader can follow the reasoning presented and validate the conclusions drawn. Furthermore, the authors of a published paper must be willing to defend the work against criticism, and so they should have available for later review the raw data used and significant detail about the experimental procedure.

First and foremost, these goals require good laboratory record keeping. Classically, it is the "lab notebook" that has served this purpose, though today it is often a virtual notebook of (ideally) well-organized digital files. Knowing what you might need from these records for paper writing can help your record keeping. For example, if you review the requirements for what is needed in a method section of a paper (see Chapter 2), you will know what record keeping is required to make the process of writing the methods section easier.

Raw data are often manipulated, reformatted, filtered, summarized, and graphed before being presented in a publication. It is almost always a requirement that the data be archived at each of these various stages. You do not want to be in a position of publishing a graph where the "picture" of the graph is the only thing that remains of the original data.

1.4 Conclusions

Experienced authors have a clear idea of what is required to write a good science paper, and so they plan and execute a research project with the requirements of publication in mind. For those with less experience, I recommend reading this book (especially Chapters 2, 7, and 12) at the beginning of a research project to make sure you can meet the most important requirements of writing and publishing your work.

References

[1] R. K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations*, University of Chicago Press, Chicago, IL (1973).
[2] T. S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed., University of Chicago Press, Chicago, IL (1996).
[3] Editorial, "Go forth and replicate!", *Nature* **536**, 373 (2016).
[4] F. C. Fang and A. Casadevall, "Competitive Science: Is Competition Ruining Science?", *Infection and Immunity* **83**(4), 1229 (2015).