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350 Years of Scientific Journals

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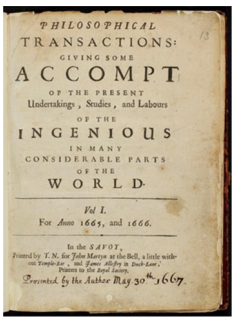
PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.
Vol. I.
For Anno 1665, and 1666.
In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane, Printers to the Royal Society.
Presented by the Author May 30th. 1667.

Title page of the first issue of the Philosophical Transactions, March 1665 (image from Wikimedia Commons).

350 Years of Scientific Journals

In March of 1665, a seemingly small thing happened: the first scientific journal was published. For the next 350 years this new communication forum went through fits and starts, changed its form and language, and eventually flourished into the premier mechanism for documenting and propagating our communal collection of scientific knowledge. Today, almost all advances in science, major as well as minor, find their way onto the pages of a scientific journal. But in 1665 this was certainly not the case.

From the beginning of the scientific revolution in the 16th and 17th centuries, scientific discoveries were mostly communicated in two basic forms: self-published books and pamphlets, and personal letters (usually to other scientists). Books were often of the *magnum opus* style, a collection of one's life's work. Letters were used to spread more timely results and to claim priority for them. As the practice of science spread and communities of scientists grew, letters took on a more communal form and were often shared, copied, and forwarded to many like-minded scientists, forming what are now called "hidden colleges," the forerunners of today's professional societies.[1]

Inspired by Francis Bacon, the Royal Society was formed in London in 1660 with the goal of promoting "Physico-Mathematical Experimental Learning."[2] The original 40 members were a collection of university professors, medical doctors, and enthusiastic amateurs who met a few times a month to hear lectures and discuss "natural philosophy," as science was called in those days. Occasionally, those who could not attend these meetings would send letters to be read at the meeting by a member of the society.

The job of reading these letters often fell to Henry Oldenburg, the first secretary of the society. Through his many connections to scientists throughout England and the continent, Oldenburg frequently served as a clearing house for these scientific letters, copying and passing them on. Now as secretary of the Royal Society this role became more formalized. In March 1665, Oldenburg published (as a private, authorized venture) a printed version of the papers and letters read at the Royal Society meetings, and thus was born the *Philosophical Transactions*, a monthly periodical "giving some [account] of the present undertakings, studies, and labours of the ingenious in many considerable parts of the world."

The first volume, 16 pages long, had 10 short articles on topics such as the making of optical glass, whale watching in the Bermudas, and the performance of a pendulum watch at sea. By all accounts this first scientific journal was a success, and the *Philosophical Transactions of the Royal Society* is still being published today. The first decades of its publication saw many memorable papers, including Isaac Newton's first publication, on his prism experiments of 1666.[3] Newton's experience, however, highlights the tentativeness of this new medium for scientific publication in the 17th century. After numerous scientists published letters challenging Newton's new optical theory, Newton grudgingly responded but never again published a new scientific result in a journal. Instead, he fell back on the book as the preferred medium for expressing his ideas, publishing his masterworks the *Principia* in 1687 and *Opticks* in 1704.

The success of the *Philosophical Transactions* inspired the birth of many other journals, most of which experienced significantly less longevity. But the road from the first journal to today's modern scientific publication was a long one, with many changes and innovations along the way. A look at the evolution of the scientific publication informs not only our understanding of the nature of communication over this time period, but the evolution of scientific thought and philosophy as well.

Today there are about 30,000 peer-reviewed journals publishing more than 2 million articles a year (with these numbers doubling about every 20 years).[4] The modern form of the scientific article, one that we all would recognize from the pages of JM^3 and almost all other peer-reviewed science journals, became ubiquitous only in the last 50 years or so. To see and understand the changes in scientific writing over the last 350 years, we can examine some of the important features that distinguish a scientific article.

1 Specialization

The first science journals had broad scopes, as almost all scientists were generalists. The growth of science led to specialization, and this specialization was reflected in the nature of scientific journals. By the end of the 18th century, many journals were increasingly devoted to more specialized topics,[1] a trend which accelerated with the development of university science departments during the middle of the 19th century. The common complaint that it is impossible to read every published paper of interest has existed for most of the 350-year history of scientific journals. Thus, while general scientific

periodicals still remain (think *Nature* and *Science*), today almost all science journals are highly specialized (as, of course, JM^3 is), devoted to a narrow and highly specialized readership of subject matter experts.

2 Language

Early science articles took the form of letters, usually written in the first person. In these early days, science was often of the Baconian style, a collection of empirical observations with little if any interpretation or theorizing. The articles often took pains to establish the credibility of the eye-witness account and thus were written in a descriptive and chronological style.[5,6] The language was often flowery and literary, full of complicated clauses and long sentences. It was more qualitative than quantitative.

As our philosophy of science matured, publications began to remove the personal from the narrative. Today, we expect scientific results to be reproducible and not dependent on the scientist performing the work. The passive voice is used to remove first-person pronouns, and accounts are rarely presented in chronological order. The personal voice of the scientist has been replaced by the impersonal voice of science expressed through the words of the scientist.

Early on there was little technical vocabulary, and scientific literature was readable by any educated person. The growth of science led to specialization, which led to the invention of specialized vocabulary. Today, scientific language is characterized by simple sentence structures (with few if any embedded clauses) and simple verbs, but with very complicated noun phrases full of technical terms only understood by similarly informed readers. Abbreviations and acronyms abound.

The increased use of hedging language is also indicative of philosophical changes in our view of science. Instead of knowledge as the discovery of past wisdom through the study of existing texts, we now think of all knowledge as tentative, subject to revision in light of new data or discoveries. Thus, today's scientific article is likely to be peppered with hedging phrases carefully constructed to convey the author's sense of confidence in the results and their interpretation: *seems obvious, may suggest, is likely a result of, were found to vary, may be significant*, etc. This style of presentation can also blunt the impact of criticisms from a future work that presents contradictory findings.

3 Structure and Organization

The first scientific articles took the forms of letters, including the formal structures of greetings and signatures. Over time these formalities were dropped but often the articles still read like letters. By the end of the 17th century articles usually had titles, but few included section headings. In the 18th and 19th centuries, science became less about reporting observations and more about providing interpretations of observations and experimental data. Thus, the scientific article became a presentation of argument. Rhetorical forms of introduction, body, and conclusion became more common. Headings began to appear in the 18th century, becoming more common than not by the 19th century.[5] But it wasn't until the second half of the 20th century that the common IMRaD structure[7] became ubiquitous, and all papers began to have uniformly formatted titles, author lists, abstracts, headings, and references.

4 Figures, Tables, and Equations

Today's science articles are loaded with data, which are almost always presented in the form of tables and graphs. This has not always been the case. Early papers were more qualitative than quantitative, and the small amount of data presented was often integrated directly into the text. Printing technology made the production of figures expensive until recently. In the 17th and 18th centuries, most figures were drawings of the things being observed or the apparatus used in experiments. Many of the common types of graphs of data we take for granted today were not invented until the early 19th century.[8,9] By the early 20th century, most papers still did not contain a single figure.[5] Of course, today almost every scientific paper contains figures.

Likewise, equations were rare in the first 200 years of the history of the scientific journal. Even in 1900 the vast majority of journal articles did not contain equations separated from the text. Like many innovations, the use of numbered equations did not become common in scientific journals until the second half of the 20th century.[5]

5 Citations

Citations to other publications were rare in the 17th century. By the 18th century they were more common, with about half of all papers having citations either embedded in the text or as footnotes.[5] The use of citations grew slowly, and their format was far from uniform. As late as the beginning of the 20th century, only about ¾ of scientific articles included citations, still mostly found as footnotes.[5] But by the second half of the 20th century, virtually every journal article included references, almost always found as a list at the end of the article. The number of citations per article grew as the purposes of the citation expanded.[10]

6 Authorship

In early scientific publications, the roles of authors and editors were not entirely clear. Letters sent to the editor, or to someone who passed it on to the editor, were sometimes published verbatim, but sometimes treated as news reports written at least partly by the editor or letter recipient. Reprinting previously published works, sometimes in translation, was common in the 17th and 18th centuries without much regard for "permission." But even 350 years ago, scientists were preoccupied with receiving credit and priority. By the 19th century the modern role of author as claiming credit and taking responsibility for the content of a published work was well established. Multi-authored papers did not become the norm until the second half of the 20th century.

7 Peer Review

Like so many aspects of the scientific journal that we take for granted today, the practice of peer review is relatively modern. For example, there were no reviewers for the *Philosophical Transactions* until 1752, when a committee of five Royal Society members began selecting articles for publication.[11] This change was no doubt due to criticisms over the quality of the articles that were sometimes being published, including

the discovery of a merman in Virginia[12] and a demonstration of human-powered flight.[13] Reviews were almost wholly performed by journal editors through most of the 19th century, and the modern "peer review" process became common only after World War II.

As the above discussion shows, the scientific article as a means of communicating and preserving scientific knowledge has gone through tremendous change and innovation during its 350-year history. This history of change, combined with our natural desire for constant improvement, means that the scientific article will likely continue to evolve. I hope that JM^3 will contribute not only to the science and technology that is so important to our community, but also to progress in the art of science writing as well.

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