

Sixty Years of *Pharmacological Reviews*: Has The Role of Review Articles in Biomedical Sciences Changed and, If So, How Does This Affect *Pharmacological Reviews*?

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I. Introduction

Pharmacological Reviews has been publishing high-quality review articles since 1949. Over those 60, years the pharmacological sciences have changed dramatically; accompanying this change in the science has been the development and use of information technologies. These changes have undoubtedly led to transformations in the users, purposes, and accessibility of review articles. Insights into these changes should inform decision making by authors of review articles and the editorial policies of journals that publish them.

II. The Traditional Role of Review Journals

Why did review journals like *Pharmacological Reviews* develop? A reasonable hypothesis would be that in the era before simple electronic literature searches, the most readily accessible source of information that compiled published literature in a specific topic or field were “definitive reviews,” such as those published by this journal. In 1949, the number of journals that published scientific research was substantially less than it is today. On the other hand, identifying and accessing these articles was considerably more challenging for scientists and for the public than it is today. *Index Medicus* provided a compendium of published articles. However, it was not universally accessible. Furthermore, listings in

Index Medicus were monthly and annual, rather than cumulative, and used a limited number of search terms for scientific topics. As a result, identifying the literature relevant to a research question was challenging and time-consuming. In such an environment, review articles provided a forum for recapitulation of the findings in a field and a comprehensive repository for references in the area of interest. This is reflected in the style, length, and references cited in early *Pharmacological Reviews* articles. In 1950, articles in the journal typically cited 150 to more than 500 publications, despite the limited number of journals and publications in that era (Table 1). As citable references increased, so did the length of articles and the number of citations (Table 1). By 1975, articles cited up to 700 references.

Those reference lists, which took enormous effort to compile, provided a valuable resource to scientists, particularly to those new to the reviewed field. It is noteworthy that this approach to review article construction has largely remained intact up to the present. Although the number of references in contemporary articles in *Pharmacological Reviews* varies widely, the number typically ranges from 200 to 500. The number of articles cited in these reviews has remained relatively stable, despite the enormous increase in the universe of articles published and the much easier electronic means with which to access cited articles. This probably reflects a more selective use of references by authors of reviews. Alternatively, this stability in cited references might reflect the development of reviews in more focused topic

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TABLE 1
Representative article lengths and references cited in Pharmacological Reviews 1950 and 1975

The number of citations was determined using ISI Web of Knowledge.

First Author	Topic	No. of References	Article Length pages	No. of Citations
<i>Pharmacological Reviews</i> 1950 Volume 2 Number 1				
Molitor and Graessle, 1950	Antibiotics	360	60	30
Moe and Freyburger, 1950	Ganglionic blocking agents	258	35	1
Hunt and Kuffler, 1950	Neuromuscular junction	171	25	0
Butler, 1950	General anesthesia	154	40	90
Pitts and Sartorius, 1950	Diuretics	504	66	3
<i>Pharmacological Reviews</i> 1975 Volume 27 Numbers 1 and 2				
Schwartz et al., 1975	Sodium-potassium ATPase	729	132	729
Gulberg and Marsden, 1975	Catechol-O-methyl transferase	442	72	442
Spaziani, 1975	Accessory reproductive organs	566	77	84

areas; such reviews would focus on a smaller segment of a broader scientific field surveyed by the previous generation of more all-encompassing reviews.

III. How Has Improved Access to the Scientific Literature Affected the Importance of Review Journals? Do They Remain Relevant?

In contrast to the conditions in 1949, today every scientist and much of the public have ready access to and the capability to perform comprehensive electronic literature searches. These searches can be customized, reviewed, and refined using iterative approaches that allow identification of published works of interest and specific needs or questions to be addressed. Thus, a comprehensive list of works cited in a review article, even in electronic format with direct links to cited articles, is much less important as a resource than it was in 1949. In fact, this aspect of a review article may have less utility today than electronic bibliographic resources such as PubMed or Google Scholar. This is due to the superior abilities of these electronic resources to identify specific articles based on the use of multiple search terms. Thus a major role of the traditional review article (i.e., as a compendium of all known knowledge in a field) is no longer as important in the current scientific environment.

The other major feature of "traditional" reviews has been their encyclopedic nature, a characteristic widely associated with *Pharmacological Review* articles. How well has that form of communication stood the test of time? In some respects, the answer has to be "remarkably well." Publications that are dedicated to review

articles, including *Pharmacological Reviews*, remain highly cited in the biomedical literature (Tables 1 and 2, Fig. 1). Beyond traditional measures of "impact," electronic access provides new metrics for assessing review article utilization. Electronic access also permits a more immediate measure of interest in an article or topic. Our reviews, including newly published ones, are still widely used, even by those newer standards. For example, an article on "The Role of Incretins in Glucose Homeostasis and Diabetes Treatment" published in December 2008 (Kim and Egan, 2008) was accessed 808 times in January 2009 and had the second highest access count among *Pharmacological Reviews* articles that month. For *Pharmacological Reviews*, these "e-data" support the hypothesis that reviews are widely used as reference material beyond the impact measurable by their citation numbers (Table 2). It is noteworthy that electronic access of full articles far exceeds the number of citations for the same articles. Such on-line access suggests a much broader readership for our articles than is simply reflected by citation rates.

However, closer examination of impact factors and electronic access rates suggest shortcomings in applying these approaches to assess the "worth" of traditional reviews. Most scientists would agree that the principal purpose of any biomedical scientific communication is to transmit information important either 1) in the generation of new knowledge (i.e., in facilitating other scientists/readers to put their own work in perspective or to stimulate new studies) or 2) as a stimulus to clinical application of that knowledge. In this context, how well do parameters such as impact factors or electronic "hits"

TABLE 2
Electronic access and citation rates for articles from Pharmacological Reviews

Articles were chosen for illustrative purposes and were not systematically identified. The number of citations was determined using ISI Web of Knowledge. Citations per year were determined by dividing the number of citations by the number of days since publication divided by 365. Note that the electronic access numbers are for full texts of the articles during January 2009 only.

Article	Topic	Electronic Accesses January 2009	Citations Since Publication	Citations per Year Since Publication	Electronic Accesses per Annual Citation
Andersson, 2001	Penile erection	1310	197	26.5	49.4
Kreek et al., 2005	Cocaine	498	68	17.3	28.8
Dingledine et al., 1999	Glutamate receptor	746	1620	163	4.6
Moghim et al., 2001	Nanoparticles	381	494	64.3	5.9
Hawkins and Davis, 2005	Blood-brain barrier	417	146	39.7	10.5

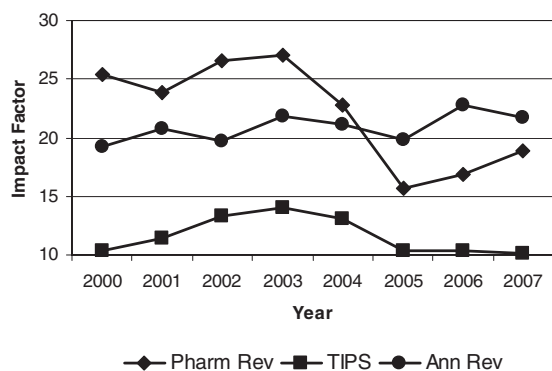


FIG. 1. Impact factors for *Pharmacological Reviews* (*Pharm Rev*), *Annual Review of Pharmacology and Toxicology* (*Ann Rev*), and *Trends in Pharmacological Sciences* (*TIPS*). The impact factor reflects citations from the reporting year of those articles published in the preceding 2 years. For example, the 2008 impact factor for a journal is the average number of citations for articles published in that journal in 2006 and 2007.

hold up as indices for assessing the importance of review articles? We would suggest that both of these indices may overestimate the impact of review articles. With regard to the high internet access rates that *Pharmacological Reviews* articles enjoy, in some cases the disproportionate number of electronic viewings may represent curious inquiries by nonscientists for certain topics such as “penile erection” and “cocaine.” This concept is supported by disproportionate numbers of electronic accessions (compared with the number of citations) for some articles (Table 2). “Pharmacology of Penile Erection” (Andersson, 2001) has remained the most accessed *Pharmacological Reviews* article for the past several years (accessed over 1300 times in January 2009 alone). However, more than 90% of electronic viewings for this article were of the HTML full text version rather than the PDF, whereas for most articles, the number is closer to 50%. In contrast, although the article on “The Glutamate Receptor Ion Channels” (Dingledine et al., 1999) had only half the number of electronic accesses, it has been cited almost 10 times more often than Dr. Andersson’s review. This analysis suggests that some articles that might be viewed as “high impact” based on electronic access are being used in a more cursory and perhaps less-than-“academic” manner (and as a result, are less likely to affect new knowledge generation or clinical application). Without completely dismissing the utility of publishing review articles for these other uses, such usage has not been traditionally viewed as the principal purpose for their publication.

What about the use of impact factors as the “gold standard” for assessing the “worth” of a review article in changing scientific thought/direction? Even here, we would suggest that the remarkably high impact factors scored by *Pharmacological Reviews* and other related journals may also not readily translate to “high impact”—at least as we have defined it—with regard to influencing scientific thought/direction. In a nonsystem-

atic survey, we found that review articles were frequently cited in the *Introduction* or in the introductory paragraph of the *Discussion* section of an article. Furthermore, references to reviews were most often used to support general statements about the field of an original article and to provide a resource for interested readers. Thus, the centrality of standard reviews to the works that cite them (or the impact of those reviews in stimulating the design and/or execution of studies described in those articles) can be questioned.

Beyond such quantitative measures of usage and utility, there is a growing sense that encyclopedic review articles and the journals that publish them are becoming less important as resources for learning. Reviews have traditionally provided a means by which scientists could become conversant with a particular area of biomedical science. However, it is questionable whether reading 50 or more pages of dense journal text meets the learning needs and styles of the contemporary scientist. Shorter, more focused reviews may be of higher utility. Consistent with this, many respected venues for original research articles, including *The Journal of Biological Chemistry*, *Molecular Pharmacology*, and *The Journal of Clinical Investigation*, as well as the journals of the American Heart Association (among many others), now publish extended perspectives and “minireviews” in areas perceived to be of high current interest. These reviews typically allow readers to familiarize themselves with a much more circumscribed research area than those covered in more traditional reviews. Furthermore, in the best examples of this type, such reviews provide readers with a succinct understanding of the field’s significance and potential future directions. The impact of such perspectives and minireviews has generally been positive (at least as judged by impact factor trends for many of the specialty journals). However, the ultimate “value,” as judged by how effectively the articles “move” scientific thinking, remains to be established.

Thus, despite some measures demonstrating the persistent utility and impact of review articles, such as those that published in *Pharmacological Reviews*, one might reasonably question whether encyclopedic reviews and review journals, like ours, remain relevant to 21st-century scientists.

IV. Is There a Future for Review Journals? If So, What Should They Look Like?

We believe that review formats will continue to be important forms of scientific communication, despite their shortcomings and despite the dramatic changes in how and why scientists access information. However, our sense is that it is important to have a clear perspective on what scientists require when they read reviews and for editors to use such information to optimally shape editorial policy. We suggest that there are several important functions that review articles could subserve

and that may have significant impact on reshaping the format of review journals like ours.

A. *Reviews Should Be Authoritative (and Choices of Cited References Should Generally Be More Selective)*

As noted above, the importance of reviews as compendia of cited literature is likely to be the vestige of a bygone era in scientific publications. What remains as critical for review articles in the current era is the ongoing need for experts to be able to filter information, to sift out lower quality studies and emphasize important articles and to make conclusions (or as close to conclusions as possible, depending on the clarity of the available literature) with which to guide scientific thought. The implications of implementing this mandate are several. First, this approach would require stringent criteria for authorship of a review article; implementation of such a policy would probably limit the roles of scientists who are new to a field (or to science) in a review's development and preparation. Second, this approach would suggest that selectivity (versus encyclopedic comprehensiveness) in citing references should be the hallmark for most modern reviews. Only when a review provides a summary of all data on a specific point (e.g., to illustrate discrepant experimental results) would comprehensiveness be an asset.

B. *Reviews Should Be Readable*

One of the biggest attractions of minireviews and perspectives is their "readability." At their best, these communications focus on specific questions, put the current state of literature into perspective, and provide succinct conclusions. We would suggest that even for longer reviews, a similar format should be increasingly adopted. Reviews should be organized to answer discreet questions in a field and should generally not attempt to go from "A to Z."

C. *Review Journals Should Accommodate a Range of Formats*

Given the varying needs of the readers and the varying states of clarity in scientific fields of interest, review journals need to be much more flexible in accepting a range of article formats. This would include publishing short perspectives, opinion pieces, and minireviews, while continuing to reserve a place for the "definitive" review. Offering a range of formats might also help in

improving the "pipeline" for developing reviews. In the current environment, many key opinion leaders may see the development of an "encyclopedic review" as an overly challenging task. Offering a range of (shorter) formats might alleviate this challenge.

V. Closing Thoughts

During our term as Editors for *Pharmacological Reviews*, we have tried to understand the new dynamics of the biomedical review article and to allow the journal's evolution to meet these trends. With the assistance of the Associate Editors, we have worked to identify topics that we thought were of high current interest, and we encouraged the development of shorter, more focused reviews prepared with more aggressive time lines. It is noteworthy that we have asked authors of reviews to be more integrative and synthetic in their approach and to be more forward looking, as opposed to being exclusively retrospective. At the same time, we have acknowledged the value of the more encyclopedic review as a repository for the work in a field and have encouraged such reviews in some areas. Whether these efforts have been either meritorious or successful we leave to the pharmacology community to decide.

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