How much is my paper worth?

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ABSTRACT **For scientific research to have an impact, its findings need to be communicated. Usually, such communications take the form of published papers in a journal. Given that most papers are rarely cited, yet consume a great deal of a scientist's time, treasure, and talent, the value of scientific publication as an enterprise merits consideration. What is a paper really worth? In this Perspective, I consider three potential values: career, science, and society.**

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Like the proverbial tree falling in an unpeopled forest, data that aren't published don't make a sound. Whether unpublished results can even be said to exist is a question for philosophers, but certainly such results, tucked away in a filing cabinet or hard drive, have little impact beyond the few people involved in their creation. Whereas this observation may seem obvious and unworthy of comment, it is equally true that much of what *is* published also barely exists, if citations are held as signs of life. Many published papers sink straight to the bottom of the reference pond, unnoticed but for a transient ripple, leaving no mark. The exact figures have been much debated and may be changing over time, but a significant percentage of scientific papers (recent estimates vary from 10 to 30%, depending on the discipline) is never cited at all (Remler, 2014). Of those that are cited, the median number of citations is four, and the mode is zero (Weingart, 2012). It is a sobering thought that so many science publications are rarely or never cited. How much was invested in time, effort, and money; in the creation of these little-noted publications; and to what end were they constructed? It might be argued that even uncited papers have an intrinsic value as potential historical artifacts in that some future scientist may, like the prospector who sluices a gold fleck from a muddy stream, extract a hidden nugget from the rubble of historical literature, but such rediscovered works are rare. Also, one could posit that there is an inherent training value for the participants in research that is independent of publication or citation, but this argument merely kicks the can down the road, as, at some point, this training has to lead to recognized discoveries if it is to have lasting value to society.

When funding is tight, it is easy to forget that scientific discoveries, made public, are the ends for which funding is the means, and not the other way around. When it is over, your career as a researcher will be judged in large part by your published discoveries, not by your funding record, but in the here and now, money matters if you are to have a career at all. As most work of this kind is underwritten by taxpayer- or donor-funded grants, and such funding has stagnated even as the scientific enterprise has grown, these days it seems as though the only way for one scientist to get a grant is to drive another one out of the funding tree. According to the adage that the best predictor of future success is past success, one strategy has been to emphasize such past successes in the hopes that this will convince reviewers that you have what it takes to merit support. In many cases, it comes down to showcasing what you've done already and how those achievements will inform what you now propose to do. In the end, even if you write with the grace of an angel and the conviction of a zealot, your present application will be judged in light of your past publications. In this straightforward sense, your papers are worth quite a lot, as your continued employment depends on their existence, their quality, and, sad to say, perhaps also their quantity.

Regarding the quality of publications, I have yet to encounter a substitute for human judgment. Competing metrics abound—H indices, impact factors, CiteScore, Eigenfactors, Cited Half-Life, etc.—that seek to capture the importance of a given paper or journal, though all have been found wanting. While there is a growing rebellion against the tyranny of such metrics, and powerful arguments have been made for their abandonment (Eisen, 2012; Schekman, 2013), both grant review study sections and tenure committees remain, in my experience, stubbornly resistant to change and are still heavily influenced by publication in high impact-factor journals, however defined (Tregoning, 2018). To date, the most vocal advocates for a "repeal and replace" publication strategy have been highly prominent scientists who can easily afford the luxury of protest, whereas rank-and-file faculty members may feel they have too much at stake to attempt to challenge the high priests of the

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biomedical enterprise. For these people, a religion that requires one to sacrifice at the altar of the big-three journals remains, for all its strange rituals and unanswered prayers, a surer route to funding heaven than any other faith.

Whatever your views of the desirability of appearing in a top-tier journal, there are certain practical calculations that come into play when contemplating publication. As detailed by Salinas and Munch (2015), there is a trade-off to be considered: the higher impact the journal, the longer the likely interval between submission and publication. During that time, you might be scooped, but that is not the only risk. Typically, you learn little during the revision process, and it can be difficult to maintain morale and suppress the desire to turn to new frontiers when your staff is reduced to replowing old ground to satisfy the umpteenth control demanded by Reviewer #3. However, as the correspondence between impact and time-to-publication appears to break down for low- to mid-impact journals, there may be little risk in shooting for the moon as opposed to the stars. That is to say, you have little to lose for trying to publish in a mid-tier versus a low-tier journal. Finally, it is wise to remember that there is only a weak correlation between the number you actually care about—the impact of your paper—and the overall impact factor of the journal in which it appears (Sutherland *et al.*, 2011). Therefore, although appearing in a high-profile journal might lend a pleasant glow to your CV (and, depending where you live, possibly a financial bounty from your institution [Abritis and McCook, 2017]), this effect can quickly fade if the work is not judged by your peers as truly impactful.

What, then, is your paper worth? In the long run, its chief value is what the world makes of it; that is, a discovery of importance, whether delivered to the public with a blare of sirens in a top-tier journal or with a quiet plop in an obscure blog, will in time enter the wider scientific world as a supporting strut for an existing paradigm or a building block for a new one. If it's important enough, it will lead somewhere; it will change what others think and do. That is the sort of accomplishment you'll be remembered by, not the amount of grant dollars you brought to your institution. But, in the here and now, good work, published in a good journal, has for most of us real economic value and career implications that are hard to ignore. My advice: if you've got something hot, go for it, and submit your work to the most impactful journal you can, but recognize that history will be the ultimate judge. Remember that the results you read in a glamor journal might seem incredible because they are, in fact, not credible, and that history has shown that some of the most important and ultimately highest impact work is published in more prosaic venues. To cite just two well-known examples, the origins of the proteasome/ubiquitin story, which ultimately led to a Nobel Prize, were first delivered to the world in the form of a modest two-figure paper in a quotidian journal (Ciechanover *et al.*, 1978) and the first CRISPR paper was published in specialty journal (Jansen *et al.*, 2002). Despite a legion of similar ashes-to-glory stories, each generation of scientists appears to need to learn the lesson anew: the ultimate value of a publication is not closely tied to the impact factor of the journal in which it appears. To the extent that scientists devote undue effort bowing to the false idol of journal impact, science and the society it serves are poorer for it.

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