1. **[Communiqué Blog](https://toxchange.toxicology.org/p/bl/et/blogid=9)**

The Scientific Paper: Not Dead Yet

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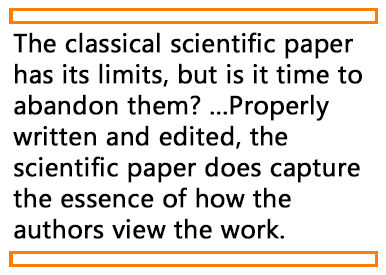


I recently read an article in *The Atlantic* entitled “The Scientific Paper is Obsolete” by James Somers. The premise is intriguing. The author argues that the use of ink on paper (i.e., the PDF) represents a static form of scientific communication and that it fails miserably in describing the science it claims to describe. The article has a demonstrably mathematical slant. All of the examples come from math and computer science. At first, it was hard to see the connection to our biologically-based research in toxicology. However, the more I thought about it the more I came to recognize the similarities between the problems he presented and the problems we face in toxicology.

The author describes the development of Mathematica, the program used for technical computing and many scientific applications. He explains the limits of older systems to describe and report research and hails the computational essay that the Mathematica notebook allows. All of the processes and results are laid bare for the reader. There is no selective reporting of the results, and the information used to solve the problem is readily available.

For a person who is not especially good at math, I find it impossible to ignore its importance in all aspects of life. A coincidental encounter with the tomb of Henri Poincaré during a stroll in the Montparnasse Cemetery provided an unexpected link to this essay. The Poincaré conjecture, one of the major problems in math, was solved by Grigori Perelman in 2002–2003. Notably, the proofs were loaded on the physics preprint server airXiv, the inspiration for bioRxiv, which has been [discussed in the pages of *Toxicological Sciences*](https://academic.oup.com/toxsci/article/155/2/300/2957144). Perelman’s solution was widely hailed as a breakthrough in science and serves as an inspiration for those seeking truth in the absence of accolades (the genius notably refused the Field’s Medal and the Clay Mathematical Institute’s Millennium Prize). This reminds me to go back to Donal O’Shea’s book *The Poincaré Conjecture: In Search of the Shape of the Universe*, which sits on my nightstand, sadly unfinished.

The apparently esoteric problems Somers described in *The Atlantic* piece may not be so removed from our problems in biology. The author describes the utility of Mathematica notebooks that are akin to submitting your actual lab notebooks and videos of you doing the experiments to a journal. Think about how much easier it would be to replicate studies with such information. More recently, resources based on the Jupyter platform give computer programmers a way to produce these computer notebooks for any computer language. As the sub-discipline of computational toxicology grows, I hope that it will fully embrace the ethos of Jupyter and Mathematica. Indeed, computational toxicologists may be the ones to shepherd the rest of the toxicologists into the future.

Circling back to Somers’ premise is that the use of the PDF is stifling to science (with his mathematical focus). The PDF cannot capture the entire essence of how the work was conducted. In this respect, I fully agree. The classical scientific paper has its limits, but is it time to abandon them? Here, I respectfully disagree. Properly written and edited, the scientific paper does capture the essence of how the authors view the work. With our increasingly complex datasets, the scientific paper has become more like an executive summary of the body of work. I don’t think this is a problem. The scientific paper sets up the problem, explains the hypothesis, and then provides evidence for or against said hypothesis. These papers are the currency for most of modern science and will continue to be for decades.

Even though the scientific paper in its PDF form is the accepted form of scientific transmission, it cannot be expected to be all things to all readers. The scientific paper must be supplemented with other supporting information to provide the components of the computational essay. Github, Figshare, and the Dryad Digital Repository provide means of reporting the details that don’t fit (literally or figuratively) in the scientific paper and do so in a much more effective manner than supplementary files. Provide detailed laboratory protocols for your studies, not just the sanitized methods section. Show the raw data in a data repository. Post your code on Github. Toxicologists must start utilizing these resources, or it may not just be our scientific papers that face obsolescence.

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