THE COLLABORATIVE REFERENCE LIBRARY

A suite of tools can help researchers to manage citations for grants and papers — and share those references with colleagues. **By Jeffrey M. Perkel**

For such utilitarian tools, reference management software can inspire strong reactions. Physician Ben Goldacre, for instance, has tweeted at least five times about Paperpile, a subscription-based reference manager that integrates tightly with Google Docs, calling it "amazing", "fantastic, best ever", and "unbeLIEVably good". Goldacre, who is also director of the DataLab at the Centre for Evidence-Based Medicine at the University of Oxford, UK, explains: "Paperpile is the first time I've used a reference manager where it didn't make me want to punch myself in the face on a regular basis out of sheer rage. It's just glorious and perfect."

That's because it dovetails nicely with his team's workflow. Reference-management tools, also called citation managers, perform a handful of related functions: searching the literature; storing and organizing PDFs of papers and supplementary materials; generating bibliographies; and fostering collaboration. There are dozens of options, including End-Note, Mendeley Reference Manager, ReadCube Papers, RefWorks, Sciwheel and Zotero. (Read-Cube Papers is supported by Digital Science — part of Holtzbrinck, the majority shareholder in *Nature*'s publisher, Springer Nature.)

For Goldacre, Paperpile's seamless compatibility with Google Docs, which the team uses for collaborative writing, is what tipped the scales towards its use. For PhD student Emily Wissel, who studies how the microbiome affects pregnancy, it was Zotero's status as a freely available, open-source project that led her to favour it over other software.

When Wissel took the preliminary examinations required by her department at Emory University in Atlanta, Georgia, to advance in her doctoral programme, she struggled with the citations. She had been using Google Scholar, which can output references in only a small number of styles. But for her exam, she needed a format that Google Scholar didn't support, and she had no time to learn to use a new piece of software that did. So she turned to an online bibliography generator, and "used as few citations as possible to save myself some pain", she says. Weeks later, on the advice of a university librarian, she was using Zotero to insert citations in an online magazine when she was moved to tweet: "HOW AM I JUST USING A CITATION MANAGER FOR THE FIRST TIME??"

Reference features

Michael Francavilla, a paediatric radiologist at the Children's Hospital of Philadelphia, Pennsylvania, uses his reference manager as an electronic brain — a place where he can store what he's learnt about the conditions he

treats, as well as informative graphics that he can share with patients and trainees. "Having a reference manager versus not having a reference manager is just a sea change," he says.

Francavilla catalogued some basic criteria for choosing a reference manager in a 2018 review (M. L. Francavilla *Pediatr. Radiol.* **48**, 1393–1398; 2018). The variables considered include cost, cloud-storage limits, operating-system compatibility and support for annotating PDFs (for a list of various reference managers and their features, see Supplementary table at go.nature.com/2d7athc).

Reference managers are typically desktop applications with an associated web interface that allows researchers to remotely access their own user 'libraries' — curated lists of references and associated PDFs — as well as browser plug-ins that make it easy to import references from a journal web page or other online source. Some (including Paperpile, RefWorks and Sciwheel) are exclusively web-based, meaning there is no installation or cloud syncing required, and most provide mobile apps that allow users to read and add references from their smartphones or tablets.

Juliana Soares Lima, a reference librarian at the Federal University of Ceará in Brazil, is a Mendeley Advisor — a volunteer regional ambassador for Mendeley's reference-management software. She uses Mendeley's mobile app, and found that the convenience of saving references that she found on Twitter helped with her doctoral dissertation. (Other reference managers also have this option.) "It facilitated the tracking of updated, recently published and curated scientific literature," she says.

With most reference managers, users can organize their libraries with folders and tags, and search for articles by author name, keyword, text and notes. Built-in PDF viewers enable them to read and annotate documents, to highlight key passages and take notes. External search functions let them import articles — for instance, from PubMed or Google Scholar, or in Mendeley's case, from a custom catalogue of more than 100 million papers. ReadCube Papers offers an 'enhanced PDF' experience, which fleshes out the PDF with supplementary material and hyperlinks.

Recommended reading

Some reference-management tools recommend articles of interest on the basis of what's already in the user's library. Sciwheel flags articles in searches that have been recommended by a rating service called Faculty Opinions, and can also suggest articles based on the text the author is writing. RefWorks integrates with a recommendation tool called Leganto that enables users to import their compiled reading lists directly into their RefWorks library. And Zotero includes plug-ins that find PDFs using the Open Access database Unpaywall,

and that flag retracted articles, thanks to a partnership with the Retraction Watch blog. ReadCube can also flag retracted articles. And RefWorks is adding integration with Unpaywall, says Shalhevet Bar-Asher, product manager at the Ex Libris Group, based in Jerusalem, Israel, which develops RefWorks.

Reference managers are mainly organizational tools. But for many users, their truly must-have features have nothing to do with organization.

Integration with word-processing software, for instance, allows authors to find and insert citations into documents as they write, and to build and reformat bibliographies in any of thousands of journal styles with just

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a click of the mouse. In the absence of such tools, even minor revisions can throw manuscripts into disarray, to say nothing of reformatting an article for a different journal. "It can really be quite a nightmare," says Yahaya Gavamukulya, a biochemist at Busitema University in Mbale, Uganda.

EndNote has offered a Microsoft Word plug-in since 1993, says Gillian Neff, product manager for Endnote Desktop at Clarivate in Philadelphia, Pennsylvania; many other tools have since followed suit. Paperpile, Sciwheel, Zotero, ReadCube Papers and RefWorks all support Google Docs; the latter two also support Microsoft's web-based version of Word, as does Mendeley Reference Manager. Sciwheel is currently developing this feature.

Also increasingly essential, says Barbara Rochen Renner, a librarian at the University of North Carolina at Chapel Hill, is support for team-based workflows. "I'd definitely urge a researcher to think about how well a particular product facilitates collaboration of the type they do, anticipate doing, or would like to do."

Reference managers typically allow researchers to share all or part of their library with colleagues, which they can use when writing manuscripts as a team or as a shared knowledge base. As of May this year, Zotero users have created some two million public and private groups, according to Sean Takats at the University of Luxembourg, who has led Zotero development since 2006. Sharing attachments, such as PDFs, is usually reserved for private teams, which can range in size from 25 in Mendeley to 150 for Sciwheel; groups in Paperpile, RefWorks and Zotero can be of any size.

Beyond library sharing, Sciwheel includes features for shared projects and papers, as well as manuscript version control, says Tiago Barros, the company's managing director. And ReadCube Papers and EndNote are developing

features to allow for threaded discussions in the reference library, according to company representatives. Because of the coronavirus pandemic, "Right now everyone needs to be able to collaborate on their research efforts, and we need to be able to do that when we're not sitting right next to each other," Neff says.

Fit for purpose

How much weight users assign to each feature varies. In 2018, Renner co-authored a study illustrating how different users require different functions from a reference manager (L. Murphree *et al. Med. Ref. Serv. Q.* **37**, 219–233; 2018). Whereas medical doctors might value mobile access and the ability to access their reference library after they leave the institution, for instance, wet-laboratory researchers tend to prioritize collaborative writing, recommendations and use of the program offline.

For Gavamukulya, the choice of reference manager came down to cost. While writing his master's thesis, he test-drove EndNote, but opted for Mendeley because it could do what he needed and was free to use. "The key thing is its integration with different word processors and ease of importation of references from online sources," he says. (Gavamukulya is a Mendeley Advisor, too.)

Francavilla uses Sciwheel, the reference manager his department adopted. That decision was based both on price and practicality: because Sciwheel is a web-based tool, team members could use it anywhere, no installation required. But to others he recommends Mendeley, which is free like Zotero, but offers 2 gigabytes of online storage. (Zotero caps attachments at 300 megabytes; users can purchase extra storage starting at US$20 per year.)

Those researchers who just want to create bibliographies have other options. These include BibTeX for documents created using the LaTeX manuscript-preparation system, and Manubot, a GitHub-based authoring tool for documents written using the formatting language Markdown.

There are also online bibliography generators. ZoteroBib, for instance, is a free web tool that allows users to create and format a bibliography in any of nearly 10,000 styles, then copy the result to the clipboard or publish it online.

In choosing a reference-management tool, consider your workflow, and that of your collaborators. Think about usability, customer support and the ease of migration from one reference manager to another. And, Renner advises, consult your librarian. "If you're a novice to these [tools] and aren't a go-it-alone-type person, you're going to want to know about support, and you're going to want to know what's free. You may want to know what most labs here are using."

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