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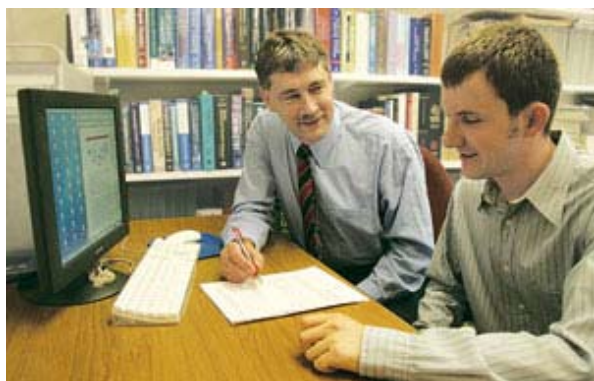
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Tips For Writing A Journal Article

Get organized, revise, and ask for help when you need it

Rachel Petkewich

WRITING IS JUST for English majors, right? Not so, say chemists and engineers, who write theses and dissertations, journal articles, research grant proposals, letters of recommendation, employee reviews, internal reports, and patent applications, not to mention conference abstracts, book chapters, and award nominations.



Andrea Eis

Write On Dembinski (left) discusses manuscript edits with graduate student Adam Sniady at Oakland University.

Written communication can account for much of a researcher's job. In the "publish or perish" culture of science, strong writing skills are essential for progress.

"While we may be technology-centric in our job performance, if we can't convey our ideas, proposals, and conclusions in an effective manner to other people, we have failed," says Jay R. Carnes, a chemical engineer at [Los Alamos National Laboratory](#). "Good writing is hard work, and it takes time for review, reflection, and rewriting to compose a technical argument that can be understood by someone less knowledgeable in the topic area than the author," he adds.

C&EN surveyed dozens of scientists and engineers around the world in academia, industry, and government about how they write a journal manuscript. We'll share some common themes and specific tips with you.

Putting together a manuscript is a passion for some researchers and a personal hell for others. Whichever it is for you, it's clear that scientists value a well-written paper and agree that writing manuscripts is ultimately a collaborative process involving a number of people and a lot of time.

Many chemists and engineers learn journal article writing do's and don'ts by example from graduate or postdoctoral advisers. That is, the students examine published articles, write drafts, discuss edits, and revise multiple times. Professors admit that a manuscript could be completed much faster if they wrote it themselves, but the exercise would lose its educational value.

Chemists and engineers—regardless of specialty or professional setting—describe two main scenarios for assembling a manuscript: The first author drafts it, and coauthors comment; or the first author weaves together pieces written by the coauthors.

The first author is usually the person who contributes significantly to the research and assembles the manuscript. In academic settings, the first author generally is a graduate student or postdoc. In industrial or government settings, the first author may be :

principal investigator (PI), staff research associate, or postdoc. Sometimes the first author and the corresponding author are the same person. The corresponding author in most cases is the PI, who probably holds the grant and oversees the work from idea through preparation of the manuscript.

Most authors say the first author's initial step in putting together the manuscript is finalizing the figures and data tables, which provide the evidence for the paper's conclusions and should guide the prose.

The next step involves drafting the text. Some authors create a detailed outline before settling down to compose sentences. Some authors jot a few notes, and a few authors dive right into the draft, first composing the title and proceeding in order to the conclusion. Most scientists finish the experimental section before they tackle—in varying order—the introduction, discussion, conclusion, and abstract.

What has probably changed most distinctly over time is the medium that authors use to write. Today, scientists and engineers create and edit manuscript text, figures, tables, and schemes all on computers. Even chemists who remember composing with pen and paper, typing final copies with duplicates made with carbon paper, and sketching figures by hand have adapted to e-mailing coauthors documents highlighted with electronic edits. A number of authors, however, still print a hard copy and mark edits with a red pen.

A few experimentalists have moved beyond word processing programs like Word and are investigating writing with wikis and other Web innovations. Derived from the Hawaiian word for "quick," a wiki is a collaborative website with content that can be directly edited by people with access. [Jean-Claude Bradley](#), an organic chemist at Drexel University, and [Henry S. Rzepa](#), a computational chemist at Imperial College London, both use wikis.

Bradley explains that his students record their experimental procedures and upload results to the group's public wiki instead of using conventional lab notebooks. Group members post discussion points online, and Bradley writes a manuscript in the wiki. He hopes that journals will accept the open format, citing transparency as a benefit. "Any statements I make can be traced back to the raw experimental data," he says.



Courtesy of Vicki Grassian

Collaboration Grassian (from left) revises figures for a manuscript with Yong Liu and Alexander Laskin who are at Pacific Northwest National Laboratory.

Rzepa says his students have tried other collaborative software such as Google Docs & Spreadsheets, but so far they favor the wiki format. He is also exploring innovative concepts for sharing scientific data and ideas now largely conveyed by journal articles. The concepts emphasize imagery and incorporate pioneering Web tools that may not change the writing process but could enhance sharing of a final product, he says.

Whether choosing electrons or ink, chemists and engineers provide the following suggestions (in no particular order) for writing excellent manuscripts:

Tip 1. Conduct thorough literature searches and cite precedents. "Good literature searching allows you to provide a cogent paper that is well-thought-out and well-organized, and it also keeps you from embarrassing yourself," says analytical chemist W Jeffrey Hurst at the Hershey Co. For example, it behooves you to discover earlier rather than later "that what you thought was seminal work has been reported on 12 times" already, he says.

Tip 2. Read scientific literature for content and style. Study lots of articles for technical material, but keep an eye out for particularly clear writing styles and incorporate them into your work, says catalysis chemist [Gregory C. Fu](#) at Massachusetts Institute of Technology. Crystallographer [Anthony L. Spek](#) at Utrecht University, in the Netherlands, also suggests reading well-written papers in the specific journals you want to publish in.

Tip 3. Clarify authorship carefully. Sometimes the authorship is straightforward; sometimes it's not. Authorship on journal articles can become an ethical issue, and in certain cases, disputes have cost scientists their jobs and reputations. "Be

meticulous and make sure that authorship is correct," recommends Sean B. Seymore, a professor of patent law at Northwestern University who holds a doctorate in chemistry and has written about authorship abuse (<http://law.richmond.edu/jolt/v12i3/article11.pdf>).

Tip 4. Get organized now. Most authors develop a plan for organizing a paper sometime near the end of completing the lab work. Some researchers pull out the original research grant proposal, scribble the main points on a whiteboard, or take a stab at an abstract.

Other authors use writing as a tool to guide their research. Chemist [George M. Whitesides](#) at Harvard University advocates early outlining so strongly that he wrote a paper about it (*Adv. Mater.* **2004**, *16*, 1375).

A former Whitesides postdoc, Teri W. Odom, adopted the process for her materials research group at Northwestern University. "The principle of the Whitesides' paper-writing process—that outlines and drafts should be constructed in the course of solving a problem rather than after all the data have been analyzed—has been useful."

She says her group will often go through about eight outlines before drafting the manuscript. As an exercise, Odom also requires students to complete a fully referenced paragraph written in the *Nature* format (www.nature.com/nature/authors/gta/Letter_bold_para.doc).

Tip 5. Allow months for revision. Cornell University chemistry professor [Roald Hoffmann](#), a Nobel Laureate, goes through many drafts of a manuscript with his students. "A typical number is 23," he says.

Tip 6. Know your audience. Nonspecialists will read your journal article. Hoffmann advises scientists to "write the manuscript for an intelligent graduate student, not a professor."

When writing up interdisciplinary work, take nothing for granted and explain everything, says University of Iowa physical chemist [Vicki H. Grassian](#), who works on environment-related surface science and nanotechnology. For example, she has had reviewers repeatedly question particular calculations for atmospheric reactions that have been "routinely done in heterogeneous catalysis for more than 50 years," she says.

Tip 7. Tell clear and concise stories. Many researchers refer to journal articles as the "stories" of their research. No one likes long-winded, disorganized, tangential, and confusing story. Chemists and engineers suggest focusing on critical content and succinct sentences. "Create no mysteries—those that nature provides are sufficient," Hoffmann says.

Tip 8. Seek help with grammar and language. "One often hears that English has become the de facto language of science," says [Patrick H. Vaccaro](#), a physical chemist at Yale University. "As a reviewer for several journals, it often seems more appropriate to state that 'bad English' has become the lingua franca of modern science." Vaccaro and other professors direct both native and nonnative English speakers with poor basic writing and grammar skills to university writing centers and language classes.

Tip 9. Learn from the best. Graduate and postdoctoral advisers are just two sources of writing advice. "Don't be afraid to ask other researchers who have been successful in achieving top-tier publications and funding or who are known as good writers to review your material," says chemical engineer [Thomas H. Epps III](#) at the University of Delaware.

Tip 10. Find several readers. Journal articles contain a few big concepts and many small details that an author could miss. [Gabriela C. Weaver](#), a chemical education researcher at Purdue University, pairs up her graduate students as "writing buddies." They read each other's work before she provides comments. Utrecht University's Spek sends his manuscripts to colleagues who are not coauthors so they can comment on them before he submits them to journals.

Because mistyping a number can cast doubt on the rest of the results, organic chemist [Roman Dembinski](#) at Oakland University in Rochester, Mich., has every member of his group proofread each manuscript—whether they are authors on it or not. Chemist Thomas Higgins of Chicago's Harold Washington College points out that "colleagues in the humanities make good proofreaders."

Tip 11. Write often. Chemists say putting down just one paragraph of observations each day can help improve writing. "Get as much experience writing as you absolutely can," says Cynthia S. Dowd, who recently joined the chemistry faculty at George Washington University. "Some PIs don't 'allow' you to write, but take a stab at writing the experimental section, introduction, results, and discussion anyway."

Tip 12. Try different genres. Writing for the layman about nonscience topics can be a fun and helpful way to improve your

writing. For example, [Michelle Franci](#), a theoretical chemist at Bryn Mawr College, in Pennsylvania, has published essays on topics ranging from parenting to music. Hoffmann has published so many scientific and literary works, among them poems and plays, that he now describes himself as a "theoretical chemist and a writer."

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