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EDITORS

A Field Guide for Science Writers

The Official Guide of the National Association of Science Writers

SECOND EDITION

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EDITED BY

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Part One

Learning the Craft

To you students who are aspiring science writers and to science and medical writers just starting out, welcome to science writing boot camp. How I wish I could have attended one! My life changed the day my editor unexpectedly told me that I was the new medical writer at the *Baltimore Sun.* The previous long-time medical writer had left on very short notice, and I was stuffed into a beat that had to be filled; overnight I went from being a generalist to being a specialist in a city that was home to the world-famous Johns Hopkins Medical Institutions, had a large and growing University of Maryland Hospital and School of Medicine, and was a short drive to the National Institutes of Health.

Never having covered medicine or science, I remember desperately trying to learn some of the scientific vocabulary on my way to my first science writers meeting, put on by the American Cancer Society. Once there, I was properly intimidated by the depth of knowledge reporters commanded as they grilled scientists who had made presentations. The best reporters seemed, from the framing of their remarks, to know as much about the subject as the scientists they were questioning. By comparison, I felt so not ready even to be at a cancer conference asking questions and deciding what may be a daily story. I experienced what a staggering challenge it is to get thrown in and have to start from scratch being a medical or science writer.

You may be about to jump in, too. Go ahead. I promise it gets easier as you develop news judgment, background knowledge, and very good sources. You get to know the territory. You come to know from extensive reading, reporting, and networking with well-connected smart sources what is big news and what is worth watching. And before you know it, you're one of those journalists standing up asking pointed, incisive questions. You're going to have a lot of fun!

And so part I of the *Field Guide* is especially for you. The authors, all masterful writers, will drill you in the basics of getting started as a science writer, from finding story ideas and sources to reporting accurately and writing well.

Then at the end of this part, two eloquent writers will take you to the next level, sharing lessons they have learned about how to pursue and write a story that is a standout, notable for its depth of reporting, style, and voice.

Begin by reading extensively, Phil Yam advises in chapter 1. Read science stories in the media and scientific papers written by scientists in journals. If you are a student, you should be able to access PubMed, Lexis Nexis, and other databases through your university. Find out from a librarian how to connect your home computer into the university system. You can access PubMed and many other databases direct through your own Internet connection, but you're more likely to get full-text articles from more journals by routing through your university, which subscribes to the journals. It is crucial for you to build sources, and Phil gives tips for doing that.

Two of the most challenging responsibilities you take on as a science writer are reading journal articles and really understanding statistics. You need to know how to read a scientific paper published in a journal to see if it is worth writing about. To help in making your decision, it's important to understand statistics and know what questions to ask scientists about how their studies were conducted and what the results mean.

In chapter 2, Tom Siegfried explains the importance of peer-reviewed journals and names the most widely read ones. He walks you through how to read a scientific paper critically and assess its worth, and gives commentary on the embargo system about which all science writers must be aware.

Do statistics scare you, leave you feeling ignorant, ashamed, disoriented? You're in the right place. In chapter 3, Lew Cope tells you what questions to ask "to separate the probable truth from the probable trash." He also explains five principles of scientific analysis and defines those oft-used terms *statistical probability* and *statistically significant.* With the information in this chapter, you'll be able to go well beyond asking scientists to explain their findings in English. You'll be equipped to ask challenging questions that test whether the scientific skeleton on which the study was built supports its conclusions.

In chapter 4, some of us who teach science writing at universities share techniques for writing well about science. This is sort of a smorgasbord of tips you can use immediately. "Use transitions. A story has to flow. Leaping from place to place like a waterstrider on a pond will not make your prose easy to follow," Deborah Blum charmingly advises. And in doing so, she sneaks in a great little simile.

With the basics behind us, in chapter 5 Nancy Shute discusses "Taking Your Story to the Next Level." This is a very thought-intensive effort, and once you get an idea for a big story, you begin with extreme measures of reporting. "I like to think of journalism as bricklaying," Nancy writes, "a noble craft, but a craft all the same." She gives four hallmarks of a great story: "a good story idea, meticulous reporting, great characters, and the right perspective." When they are all put together, she writes, "the results can be riveting."

Nancy uses a story by Atul Gawande to depict this riveting result. Gawande, a practicing surgeon who is also one of us, a journalist, narrative writer, and essayist, could just as well be held up as an exemplar for the topic that closes out part I: writing with a voice and style. One quality that resonates from all his stories is honesty.

Style and voice are those qualities, elusive to define and teach, that, I think, makes a story professional and publishable. Your "personality on the page," David Everett calls them. In chapter 6 he gives us a recipe: "Style and voice flow from straightforward elements such as rhythm, punctuation, verb tense, word choice, sentence construction, adjectives and adverbs." The list continues and includes "larger artistic mysteries." It all sounds daunting, but don't worry. By the time you have arrived at this juncture in journalism where you are chiseling your personality on the page, you will know how to use all these tools. And developing your style and your voice will be the most fun of all.

MARY KNUDSON

1

Finding Story Ideas and Sources

PHILIP M. YAM

Philip Yam cut his journalism teeth as a staff writer for the independent *Cornell Daily Sun*, the morning newspaper in Ithaca, New York, while studying physics at Cornell University. A few years after graduating in 1986, he joined *Scientific American* as a copy editor. A year later, he became an articles editor, writing news stories and profiles in addition to editing scientist-authored material and the "Amateur Scientist" column. Then, in September 1996, he became the news editor. Phil was a science writing fellow at the Marine Biological Laboratory in Woods Hole, Massachusetts, and the Knight Foundation boot camp at MIT. The subject of prions provoked his interest enough to write a popular-science book, *The Pathological Protein: Mad Cow, Chronic Wasting, and Other Deadly Prion Diseases* (2003).

As a freelance or a staff journalist, you will face at some point dread and insecurity as you wonder if the story ideas you're about to pitch to an editor are any good. We've all been there. There is no formula for coming up with that novel angle or fresh topic. But certain approaches and strategies can help you hone your nose for science news and root out interesting stories editors will want.

First, scope out publications, both print and Web. If you've contemplated science journalism, then you have probably read the science and technology sections of major newspapers and leafed through the popular-science magazines on the newsstands.

Familiarize yourself with the weeklies, such as *New Scientist* and *Science News*, as well as the news section of *Science*. Gain a greater depth by, for instance, reading review-type articles, such as those that appear in *Scientific American*, *Nature*'s News and Views section, or the News & Commentary section of *Science*.

Check out clearinghouses for press releases, such as Newswise, Eurekalert!, and PRNewswire. They send periodic e-mail alerts and maintain searchable websites. Some require that you have a published body of work before granting you access to certain privileged information (such as the contact numbers of researchers). Others may require that you obtain a letter from an editor. You can also subscribe to mailing lists of media relations offices at universities, medical centers, and other research institutions and sign up for various industry newsletters.

When surfing the Web for science information, don't forget major government websites, such as those of the National Aeronautics and Space Administration, the National Institutes of Health, the National Institutes of Standards and Technology, and the Department of Energy, which manages the national labs. Besides weapons work, the DOE labs—including Los Alamos, Brookhaven, Oak Ridge, and Lawrence Livermore—conduct research in both physical and biological sciences. Other worthwhile online resources include listservs and Web logs, but keep in mind that the ideas there are not vetted as they are in journals. Plus, you have to have the patience to get past the ranting and raving that can obscure good postings. For beginning science journalists, it may be best to follow blogs of well-respected researchers.

You can also try fishing for stories directly from journals. Be warned, though, it takes an experienced eye to mine the vast numbers of papers with impenetrable titles published every month. Would you have guessed that "Lysosomotropic Agents and Cysteine Protease Inhibitors Inhibit Scrapie-Associated Prion Protein Accumulation" refers to certain drugs that could treat mad cow disease? Don't worry; nobody else did, either—until a year later in 2001, after another team reported similar findings and had the benefit of a press release issued by its university.

Despite the potential pitfalls, journal scoping is a way to get to a story no one else is likely to pursue. For the physical sciences, a popular place to look is www.arXiv.org, an online preprint library. There is no current analogue for the biological sciences, but I have found the National Library of Medicine's database of published articles, PubMed (www.ncbi.nlm.nih.gov/entrez/query.fcgi), to be useful. PubMed is a major resource for finding medical journal abstracts and many full-text articles, and I feel more comfortable with an idea if it has generated legitimate papers in top-notch journals by recognizable authors.

If you are a university student, you should be able to access PubMed, Lexis Nexis, and other databases from your home computer by routing through your university library. Schedule a time to sit down with a librarian who can tell you how to link your home computer to these databases through Remote Access to University Libraries (RAUL) or some other system at no charge. The advantage to accessing medical journals through a university library is that the library subscribes to most journals you would want. So if you can't otherwise get more than an abstract, you can more likely get the full text of an article through the university library. Lexis Nexis is a quick way to find out whether a story you want to write has already been written in magazines, newspapers, or scientific newsletters, or to get background information on a subject that interests you.

Following the money can pay off as well, notes Christine Soares, a *Scientific American* editor and former writer and editor for *The Scientist.* As she puts it: "If a funding agency like the National Science Foundation creates a new program, or a national lab announces they've just tripled spending on some particular line of research, it could be a sign that the field has reached some critical mass and is worth looking into. This can mean slogging through the *Federal Register* and/or subscribing to assorted e-mail newsletters (for example, the American Society for Microbiology and the American Institute of Biological Science have 'funding alert' e-mails), but may occasionally pay off in a very early lead on a field that's going to be making news."

Prizes can also be an excellent source. The Nobels, announced in early October, are often the time when basic research takes the spotlight, although they are also often a time capsule of discoveries of a bygone decade. More up-to-date work is honored by the MacArthur Foundation, which focuses particularly on researchers who are young, working in a hot field, and not getting the grants afforded to more easily fundable topics. In part, that is how I came to ask contributing editor Marguerite Holloway to profile two investigators in 2004: Bonnie Bassler, a Princeton University biologist studying quorum-sensing in bacteria (how they decide to act depending on their numbers); and Deborah Jin, a physicist who created a new state of matter with ultra-cold atoms. The Albert Lasker Medical Awards often point the way to future Nobel Prize winners. Lesser known annual awards include the Kyoto Prize and the Lemelson—MIT prizes.

Keeping up with what's going on and learning which kinds of stories are most likely to make it in print, on the Web, or over the air will help you develop news judgment. Having such a background also helps in formulating novel angles and coming up with the day-after analysis that headline news often lacks. (As news editor, I encourage all writers to come up with deeper analyses.) The more you know what's going on, the better you will be at recognizing a good story when it comes along.

That's how I ended up being the first to write about the discovery of the Bose–Einstein condensate for *Scientific American* when I was an articles editor. The Bose–Einstein condensate (BEC for short) develops when a dense gas is trapped and chilled to a few billionths of a degree above absolute zero. Driven by the Heisenberg uncertainty principle—as the velocities of the gas atoms decrease, their positions become more unknown and must overlap—the atoms condense into one giant entity. Since 1925, when Indian physicist Satyendra Bose and Albert Einstein predicted it, physicists wondered if this quantum ice cube could indeed form. Creating the BEC was one of those long-sought goals of scientists that inspired a race among different groups.

In 1994 researchers managed to refine the refrigeration and trapping technology so that atoms could be chilled to where Bose—Einstein condensation is supposed to occur. Physicists began achieving ever lower temperatures—from thousandths to millionths to billionths of a degree above absolute zero. As I collected the various reports about the low-temperature records, I became convinced that someone would soon make the BEC. In May 1995, I got the go-ahead from my news editor to proceed with a story about the race, and I began in late May making phone calls to physicists at the Massachusetts Institute of Technology, the National Institute of Standards and Technology (NIST), and the University of Colorado at Boulder.

My second phone conversation with Eric Cornell of NIST took place on the afternoon of June 5, which turned out to be the day his team first made a BEC out of rubidium atoms. I remember thinking that I must be the only journalist in the world to know of the discovery and could actually break the story in a monthly magazine.

My excitement soon turned to frustration because Cornell and senior researcher Carl Weiman quickly decided that they wanted to publish their article in *Science*. The journal's embargo policy—shake fist now—scared the researchers out of continued talks with me. But I had enough information to write the story; my main worry was that they might retract their finding while our August issue went to press. Fortunately, except for a small detail I got wrong—the number of atoms trapped—things worked out: Our subscribers found out about the BEC in early July, a few days before the discovery made the cover of *Science* and the front page of the *New York Times*.

As is true for any kind of journalism, the best sources are people. If you studied science in college, you can tap old professors, teaching assistants, and even fellow students who have pursued science as a career. Just ask them what is the most interesting thing going on in their field right now.

Meetings are the most efficient way to connect with a lot of sources. The biggest, at least for the diversity of topics offered, is the annual meeting of the American Association for the Advancement of Science (AAAS), held in February. Typically, however, speakers at this meeting do not present a lot of new news, although the sessions can provide significant background information.

Smaller meetings are often a better bet; virtually every field, from anthropology to zoology, has associations or societies that hold meetings that are open to journalists. The American Physical Society (www.aps.org) holds its biggest meeting in March, when condensed-matter physicists gather to discuss the behavior of solids and liquids. About a month later comes the APS meeting covering most of the other branches, especially astrophysics and particle physics. Other subtopical meetings—for acoustics, nuclear, and optical, among others—are scattered around the country and the calendar. The American Chemical Society (www.chemistry.org) holds two national meetings a year, plus several regional meetings.

National meetings of societies are still large—the Society for Neuroscience (apu.sfn.org) November meeting draws around 25,000 researchers—and can easily overload your neural circuitry. The American Heart Association's annual meeting (scientificsessions.americanheart.org), also in November, is where the biggest news in cardiology is made.

To keep things manageable, set up an agenda before you actually get to a big meeting, preferably well before the airplane ride there. Look over the program and abstracts. Then map out which talks you want to attend. The invited talks are easier to grasp: Most of the contributed abstracts are by graduate students presenting their data to their immediate colleagues, and you have to be pretty familiar with the topics to appreciate them. Invited talks, however, can still be daunting. When covering the APS March meeting, I would call the speakers a couple of weeks beforehand and try to set up a meeting over coffee before or after their talks. That way, I had their undivided attention and could get all my questions answered, while also feeding my caffeine addiction. Away from the microphone, most presenters are more casual and accommodating. Don't overlook the organizers of panel talks themselves; they can provide impartial context.

Rather than hooking up with sources at official gatherings, you can request a private audience. Mariette DiChristina, *Scientific American*'s executive editor, recommends taking advantage of your location—especially if you happen to be where editors and other writers aren't. In her words: "A great way to find new news is to spend a day at a local research institution of your choice. You can start by contacting the public information officer and, ideally, you might set up a day or so of interviews. The PIO can help make recommendations about researchers whose work could be newsworthy, or you can make your own suggestions about people you'd like to see. Be clear about your intentions: You're a writer on the hunt for story ideas, which you hope to sell." You can't make any promises, but make it clear that you have every intention of placing a story in a media outlet.

Don't schedule more than one interview per hour, Mariette recommends, and "follow up later with the people you meet—to cultivate the relationship and to keep tabs on work that is progressing."

As in any good interview, pay attention to the details, which can sometimes lead to a better story. That's how *Scientific American*'s senior writer W. Wayt

Gibbs managed to break the story about the growth of new neurons in adult humans in 1998. Wayt had been following up on the research of Elizabeth Gould, a Princeton University biologist who made headlines in March 1998, with news that adult monkeys can grow new neurons. He contacted several researchers, many skeptical of the finding because of concerns about the experimental protocol. Among those whose input Wayt solicited was the Salk Institute's Fred "Rusty" Gage, who informed Wayt about his reservations while also saying that Gould wasn't necessarily wrong—a statement that makes an astute journalist's ears perk up.

In Wayt's words: "I sensed he was holding back and pressed him on the topic. He said that he had preliminary results that were very intriguing but couldn't talk about them yet and suggested I call him back in a few weeks." That tantalized us into killing the story about Gould's work—I had become the magazine's news editor by then—and finding out just what Gage was getting at. "I kept pestering Gage and at last in July he allowed me to come visit his lab at the Salk. We made an agreement that he would tell me all about his research, but I would not publish until he had submitted his paper for publication and gotten it through peer review." Wayt spent hours with Gage going over persuasive evidence more interesting than monkey brains, namely, that adult human brains can sprout new neurons, proving textbook dogma wrong.

To honor our agreement with Gage, we held off running the story for the next issue, and then again for the next. By September 1998, while I was lining up stories for the November news section, Wayt learned that the paper was finally in peer review at *Nature Medicine* and was being fast-tracked. So I decided to slot it as the top story for the November issue, which would appear in early October. As a courtesy, Wayt contacted *Nature Medicine* to inform the editor that we would be breaking the story.

We ended up catching some unfair flak for this—the NASW newsletter *ScienceWriters* chastised us in a story about uncontrolled embargo breaks. But *Nature Medicine* embargoed the story well after we had told them about our plans and had gone to press, so we didn't violate the journal's policy. Moreover, it would have been unfair to allow Wayt's hard work, relentlessness, and attention to detail to go for naught simply to satisfy an anticipated embargo.

My final bit of advice: Find someone with whom you can shoot the breeze—a professor, a scientist, a pundit, a colleague, a friend, a mentor. Exchanging ideas is a great way to keep you alert and to come up with fresh angles and perspectives. Good science journalism is, after all, less about having a science background than it is about having an inquisitive, tenacious mind.

2

Reporting From Science Journals

TOM SIEGFRIED

Tom Siegfried was born in Ohio and migrated to Texas, graduating from Texas Christian University in 1974 with majors in journalism, chemistry, and history. He earned a master's degree from the University of Texas in 1981. He was science editor at the *Dallas Morning News* from 1985 to 2004. He has written two popular science books: *The Bit and the Pendulum* (2000) and *Strange Matters* (2002). His work has been recognized with awards from the American Chemical Society, the American Psychiatric Association, the American Association for the Advancement of Science, and the National Association of Science Writers.

For police reporters, there are crimes. For political writers, elections. Sportswriters have games. And science writers have journals. In fact, there are more journal articles published every year than there are games, elections, and murders in all U.S. cities combined. So science writers must be selective. To select wisely, you'll need to know, first of all, what the major news-providing journals are, and what sorts of science they publish. You'll need to understand the different kinds of journals and different kinds of papers within them. And you'll need to comprehend how to navigate the elaborate web of censorship rules that most journals impose on reporters—a pernicious convenience known as the embargo system.

Once you know all that, you can concentrate on reporting and writing.

The Journal Menu

For science writers, the only journals of interest are those that are *peer-reviewed*, meaning that experts in the field have read the papers, and possibly suggested corrections and revisions, before the journal agreed to publish them. Traditionally, many science writers have focused on reporting from the "Big Four" peer-reviewed journals: *Science*, *Nature*, the *New England Journal of Medicine*, and the *Journal of the American Medical Association.*

Science and *Nature* are major sources of science news, and they should be. They are the premier interdisciplinary journals of the English-speaking world, and therefore ought to be publishing the most important research of the broadest interest to the scientific community. Naturally, such research is most likely to be of interest to the general public as well.

In recent years, the Big Four have been joined by several others as regular sources of science news—particularly the *Proceedings of the National Academy of Sciences*, the biology journal *Cell*, and the neuroscience journal *Neuron.* And the Nature publishing group has flooded the media journal market with a whole roster of specialty journals on such topics as neuroscience, biotechnology, genetics, and materials science. Other important journals for medicine include *Annals of Internal Medicine* and several published by the American Heart Association, such as *Circulation* and *Stroke.* An intriguing newcomer in late 2003 from the Public Library of Science is *PLoS Biology*, an "open-access" journal available free online.

The journals the media turn to most are not, however, the only sources of important scientific research, and for some fields they are not even the best. Depending on the scope of your beat, news will come to you from any number of other journals serving narrower segments of the scientific world.

In the physical sciences, for example, you will want to be familiar with the journals of the American Physical Society, including *Physical Review Letters* (publish.aps.org). The American Chemical Society (pubs.acs.org) also publishes a wide range of journals. For astronomy and astrophysics, you'll want to tune in to the *Astrophysical Journal.* For geology and the earth sciences, start with *Geology* and *Geophysical Research Letters.*

Many of these journals are available via the online service Eurekalert! (www.eurekalert.org), which posts "tip sheets" (restricted to registered journalists) announcing what the journals consider to be the best papers in each upcoming issue. Usually, full tables of contents are also available, as well as full text of the articles. *Nature* has its own press access Web portal. The American Physical Society offers an open Web page that alerts journalists to many upcoming stories (focus.aps.org), plus a restricted access site where reporters can acquire full-text papers.

So far, so good. But keep in mind that news also lurks in journals that don't advertise their existence. When you are reporting on a specific discipline, you should ask experts within that discipline which journals they regard as authoritative. When you identify good journals in a field, it's usually possible to sign up for e-mail alerts with tables of contents.

Another thing to keep in mind is that not all journals exist for the sole purpose of publishing original research. Many are devoted to "review" articles that help researchers keep up with new developments and trends in their fields. Usually, review articles are not a source of news, but they can provide important background for putting new reports in context.

Embargoes

A common feature of many major journals is their insistence on enforcing an *embargo* on release of their news. New papers (or drafts) are typically made available about a week before publication, with the understanding that reporters receiving this embargoed material agree to wait until the actual publication date to report it. Ostensibly this system gives reporters time to work on the story without fear of someone else's reporting it first.

If that were all the embargo system amounted to, it would not be so bad. But such journals usually also impose a gag order on authors of papers awaiting publication. In some cases, the scientists must sign a written agreement not to tell journalists about their work (except when the reporter has agreed not to violate the embargo). Some journals allow scientists to report their findings at scientific meetings, but not to answer journalists' questions about them. On occasion, journals have even prohibited scientists from presenting their work to other scientists at such meetings. You may freely report on what a scientist presents at a meeting you attend, of course, whether the journal likes it or not.

Be aware of how the embargo system operates and be alert to the possibility that someone else will in fact violate it. On major stories, it's a good idea to get your story done well in advance of the embargo date, so it will be ready to run right away if someone else breaks the embargo. Once any publication breaks an embargo, other media will no longer observe it.

Preparing

Thanks to the availability of journal papers in advance of publication, science writers usually have a fair amount of preparation time before applying fingers to keyboards. Take advantage. Don't wait until the last minute. Download the paper as soon as possible, and collect whatever peripheral information is available, such as news releases or commentary articles that accompany the paper.

You'll usually want to acquire additional background information from various sources. Google-search the authors to get some context about their research. Check your own publication's electronic morgue to determine what aspects of this research have already appeared. Do a Nexis search to find out what has been reported elsewhere. Check PubMed or other databases to find the authors' earlier papers and related papers by other scientists. If you're unfamiliar with the new paper's field, a general review article or a basic encyclopedia entry can familiarize you with essential terminology.

And then—and here is the key step in the process—*read the paper.*

Not all science journalists do. Some read the news release, glance at the paper, and then call up the researcher and ask a few questions. Go ahead and take that approach if your goal is mediocrity. If you want to be good, you have to learn how to read a scientific paper critically.

When I read a paper, I usually first scan the abstract and then read the introductory paragraphs to get a sense of the context for the research. I then go to the conclusions section at the end, so I'll know what the authors have to say about the ramifications of their work and what to pay attention to when reading the rest of the paper. Then I'll read the paper through, watching for things that might raise questions about the work (where did the data come from, how statistically significant are the results, any peculiarities about the methodology, presence or absence of control groups, etc.). Then I look at the data tables and graphs, trying to see if I can figure out how the data illustrate the conclusions the authors have stated.

All through this process, it's a good idea to jot down the questions that arise in your mind. The next step is deciding which scientists to pose them to.

Obviously, you need to talk with one of the authors of the paper. Typically, the first author listed is the person who did most of the work (often a graduate student or postdoc); the last named is the senior scientist or head of the lab (who often did none of the work). However, senior authors frequently have the best grasp of the research as a whole and are best able to answer questions and put it in context (and sometimes they actually did do a lot of the work).

Often it's a good idea to talk to more than one of the authors. They may have worked on different aspects of the study, and they may also have quite differing opinions on the meaning and significance of the results.

For most stories from journals, you'll need outside comment from sources not involved in the published paper. But some journalists (especially nonscience journalists) misunderstand this requirement. The point is *not* to find someone who disagrees with the results so that you can say that your story is "balanced." This is an idiotic idea, sometimes imposed by nonscience journalist editors with an archaic notion of "telling both sides" of the story. (This attitude is perhaps advisable when covering politics, or accusations of wrong-doing, but nonsense when applied to science. Otherwise every space story involving satellites would include a comment from the Flat Earth Society.)

In fact, the purpose of outside comment is to provide readers with an intelligent assessment from a knowledgeable specialist who is in a position to understand and appreciate the paper's significance.

It's important to realize, of course, that not all competent scientists would necessarily offer the same assessment of a given paper. You need to be aware, for example, if scientists in a given field are divided into camps with opposing views. In that case, it is perfectly appropriate to seek comment from members of each camp. It is irresponsible, on the other hand, to portray the views of a lone dissenter as equally meritorious to those reflecting an established scientific consensus.

You can find experts to call by checking the acknowledgments and the references at the end of the paper. You can ask the author of the paper to suggest people who are familiar with the work—and in fact, you can ask for names of people in the field who are likely to have a different (even disagreeing) perspective. Good scientists will tell you.

Another good approach, especially if you are in a hurry, is to identify a university or other institution that is prominent in the field. The public information officer there can usually put you in touch with an expert quickly. For a story involving subatomic particles, for instance, you might call Fermilab; for nanotechnology, you could call Caltech. Or you can call the press officer at the relevant scientific society—the American Astronomical Society for an astronomy story, for instance, or the American Geophysical Union for news in the earth sciences.

Checking the Facts

Don't Trust the Blurbs on Tip Sheets

They can be helpful, but they can also be wrong. (Just after writing this sentence, I received a tip sheet correction from *Nature*. Seems that the experiments on cat whiskers reported on the tip sheet were actually performed on rat whiskers.)

Don't Trust News Releases

They can be helpful, but they can also be wrong. Verify release information from the actual paper or the paper's authors (and whatever you do, don't lift quotes from the release). Double-check background information with other reliable sources.

Be Aware of the Pitfalls of the Peer-Review System

Some journals have more rigorous peer review than others, and even the best journals occasionally slip up. A paper once accepted for publication in *Physical Review Letters* purported to show evidence that the universe possessed a preferred direction of space. Now, anybody with an even elementary understanding of the universe knows that space is supposed to be the same in all directions. But here was a paper proclaiming that polarized radio waves preferentially twisted one way rather than another. When a paper expressing a claim of such magnitude gets published in such a prestigious journal, the claim warrants attention—and maybe even a story.

But I was not impressed. The study was based on a reanalysis of old data—observations not originally intended to test the space-direction issue. The statistical significance of the result was borderline. And some of the data that didn't support the conclusion had been thrown out. I decided not to write a daily story.

Some other newspapers did run the story. Within a week or so, though, papers by other physicists began appearing on the Internet, rebutting the *Physical Review Letters* paper's conclusions. The paper was quietly forgotten. It was a nonstory, one of many published papers of no lasting (or even temporary) significance—even though it came wrapped in all the trappings of the real stories that science journalists are supposed to write. The lesson is simple: Just because a paper gets published in a peer-reviewed journal, that doesn't mean it warrants a story.

Ask a Paper's Authors About Previous News Coverage of Their Work

You want to make sure that what you think is new really is, and wasn't widely reported last year after a presentation at a meeting.

Ask About Potential Conflicts of Interest

For example, do any of the researchers have a financial stake in a company that could profit from a study's findings? (But be careful in reporting such conflicts—a financial interest does not automatically invalidate the results of a properly conducted study. You have to judge whether stating the conflict might be misinterpreted as calling the research into question.)

Check Trivial Facts

For example, check a scientist's affiliation and title. Sometimes the title page of a journal article contains mistakes on such matters.

Writing the Story

From the moment you begin considering a story on a journal paper, you should be thinking about the story's opening sentence or paragraph: the all-important *lead* (or *lede*, as it's commonly spelled in our world). What is the key new point? What is the most important, most interesting thing about it? How can you capture all that in a concise, clear, and catchy way?

From then on, it's go with the flow. Support the lead with the facts. Provide a quote that dramatically expresses significance. Work in the background that provides context—both basic information and previous relevant findings. Give details that answer all the questions you can imagine a reader asking. And say what will or will not happen next. Sometimes you also need to tell what the results do *not* mean, as in medical stories where a promising finding does not imply an immediate cure.

But always remember, sometimes the best thing to do is not to write a story at all. Daily stories from journals are a staple of science journalism, but they are far from all that science journalism should be. It's often wiser to wait for scientists to publish more research or for you to do more reporting. Ultimately, you serve your readers best when you write stories that report the work of science with context and perspective.

3

Understanding and Using Statistics

LEWIS COPE

Lewis Cope was a science writer at the *Minneapolis–St. Paul Star Tribune* for 29 years. He is a member of the board of the Council for the Advancement of Science Writing and a former president of the National Association of Science Writers. He is co-author (with the late Victor Cohn of the *Washington Post*) of the second edition of *News & Numbers: A Guide to Reporting Statistical Claims and Controversies in Health and Other Fields* (1989, 2001).

A doctor reports a "promising" new treatment. Is the claim believable, or is it based on biased or other questionable data? An environmentalist says a waste dump causes cancer, but an industrialist indignantly denies this. Who's right?

Meanwhile, experts keep changing their minds about what we should eat to help us stay healthy. Other experts still debate what did in the dinosaurs. Which scientific studies should you believe?

This chapter deals with the use (and sometimes misuse) of statistics. But don't let this S-word panic you. Being a good science writer doesn't require heavy-lifting math. It does require some healthy skepticism, and the ability to ask good questions about various things that can affect research studies and other claims. To separate the probable truth from the probable trash, you need to get answers to these questions:

1. Has a study been done, or is a claim being made on the basis of only limited observations? If a study was done, how was it designed and conducted?
2. What are the numbers? Was the study large enough (did it have enough patients or experiments or whatever) to reach believable conclusions? Are the results *statistically significant*? That phrase simply means that, based on scientific standards, the statistical results are unlikely to be due to chance alone.
3. Are there other possible explanations for the study's conclusions?
4. Could any form of bias have affected the study's conclusions, unintentional or otherwise?
5. Have the findings been checked by other experts? And how do the findings fit with other research knowledge and beliefs?

Principles for Probing Research

To find the answers to these questions, we must understand five principles of scientific analysis:

1. The Certainty of Some Uncertainty

Experts keep changing their minds not only about what we should eat to stay healthy but also about what we should do when we get sick. A growing number of drugs and other treatments have been discredited after new research has raised questions about their effectiveness or safety. Even the shape of the universe (more precisely, how astronomers *think* it's shaped) has changed from one study to another.

To some, these and other flip-flops give science a bad name. But this is just part of the normal scientific process, working as it's supposed to work.

Science looks at the statistical probability of what's true. Conclusions are based on strong evidence, without waiting for an elusive proof positive. The complexities of nature and the research process can add to uncertainty.

But science can afford to move ahead because it is always an evolving story, a continuing journey that allows for mid-course corrections. In fields from medicine to astronomy, from geology to psychology, old conclusions are continuously being retested—and modified (or occasionally abandoned) if necessary.

We need to explain this to our editors and news directors, and to our readers and viewers. Some uncertainty need not impede crucial action if the public understands why *at best* almost all a scientist can say is: "Here's our strong evidence that such-and-such is probably true. Please stay tuned as we work to learn more."

As we move into the details, keep in mind that not all research is equal.

2. Probability, Power, and Large Numbers

Have you heard the one about a new drug tried in mice? "Thirty-three percent were cured, 33 percent died—and the third mouse got away." This old joke reminds us how important numbers are in assessing the worth of a study.

The more patients in a study, the better. The higher the success rate with a new treatment, the better. The more weather observations that meteorologists make, the better they can predict whether it will rain next week. Here's how the numbers affect the statistical *probability* that something is true:

A commonly accepted numerical expression is the *P* (probability) value, determined by a formula that considers the number of patients or events being compared. A *P* value of .05 or less is usually considered statistically significant. It means that there are 5 (or fewer) chances in 100 that the results could be due to chance alone. The lower the *P* value, the lower the odds that chance alone could be responsible.

Put another way: The larger the number of patients (or whatever), the more reliable the *P* value.

There are two related concepts. This first is called *power.* This is the likelihood of finding something if it is there—for example, an increase in cancer cases among workers exposed to a suspect chemical. The greater the number of observations or people studied, the greater the power to find an effect. A new drug's risk of causing a rare but dangerous side effect may not become clear until it has been marketed and then used by many tens of thousands, sometimes even millions, of patients.

The second is called *statistical strength.* If a pollutant appears to be causing a 10 percent increase in illnesses above background levels, it may or may not turn out to be a meaningful association. If the risk is 10 times greater (like the relative risk of lung cancer in cigarette smokers versus nonsmokers), the odds are very strong that something is happening.

Science writers don't have to do the math. They just have to ask researchers: *Show me your numbers.*

Key questions to pose: *Are all your conclusions based on statistically significant findings?* (Be leery if they aren't, and warn your readers or viewers.) *What are the P values—the chances that key findings are due to chance alone? Was your study big enough to find an effect if it was there? Are there other statistical reasons to question your conclusions? Are larger studies now planned?*

But just because findings are statistically significant, and have sufficient power, and so forth, doesn't mean that the findings are necessarily correct, or important. So our list continues.

3. Is There Another Explanation?

Association alone doesn't prove cause and effect. The rooster's crowing doesn't cause the sun to rise. A virus found in patients' bodies may be an innocent bystander, rather than the cause of their illness. A chemical in a town's water supply may not be the cause of illnesses there. Laboratory and other detailed studies are needed to make such cause-and-effect links.

A case history: A few scientists (and many news reports) have speculated about whether childhood immunizations might be triggering many cases of autism. But most experts believe this is coincidence, not causation. The "link" is only that autism tends to start at the same age that children get a lot of their shots, these experts say. The concern now: Some worried parents may delay having their children immunized against measles and other dangerous diseases because of a false fear about autism. In many press reports, the missing numbers are the tolls these childhood diseases took before vaccines were available.

A study's time span can be very important. Climate studies must look at data over many years, so they won't be confused by normal cycles in the weather. A treatment may put a cancer patient into remission, but only time can tell if this provides a cure or even lengthens survival.

Some patients may drop out during the course of a long study. If they leave because they aren't doing well, this may confuse the study's numbers.

Then there's the *healthy worker effect.* A researcher studies workers who have been exposed to a risky chemical and finds that, on average, they are even healthier than the general population. But don't absolve the chemical yet. Workers tend to be relatively healthy—they have to be to get and then keep their jobs.

And expect some normal variations. People are complex. There may be day-to-day biological variations in the same person—even more between populations. Similar studies may have small differences in results, occasionally even marked differences, due to variability or other research limits.

The list could continue, but broad questioning may keep you from going astray. Ask the researcher (and ask yourself as well): *Can you think of any alternate explanations for the study's numbers and conclusions? Did the study last long enough to support its conclusions?*

In science, the term *bias* is used to cover a wide range of failures to consider alternate explanations. But science writers also need to probe the possibility of another type of bias by asking researchers: *Who financed your study?* Many honest researchers are funded by companies with an interest in what's being studied. You should ask about such links, and then tell your readers and viewers about them.

4. The Hierarchy of Studies

For costs and other reasons, not all studies are created equal. As a result, you can put more confidence in some types of studies than in others.

In biomedical research, laboratory and animal studies (even those with many more than three mice) should be viewed with particular caution. But they can provide vital leads for human studies.

Many epidemiological and medical studies are *retrospective*, looking back in time at old records or statistics or memories. This method is often necessary but too often unreliable, because memories fade and records frequently are incomplete. Far better is a *prospective* study that follows a selected population for the long term, sometimes decades.

The "gold standard" for clinical (patient) research is a *double-blind* study, with patients randomly assigned to either a treatment group or a *control* (comparison) group. The patients in the control group typically receive placebos. The blinding (where practical) means that neither the researchers nor the patients know who has been assigned to which group until the study is completed. This keeps expectations and hopes from coloring reported results. Patients are randomly assigned to the two groups so that a researcher won't subconsciously put a patient who's likely to do better into the treatment group.

Less rigorous studies still may be important—sometimes even necessary. But put more faith in more rigorous studies.

Ask researchers in all scientific fields: *Why did you design your study the way that you did? What cautions should people have in viewing your conclusions?* And often: *Is a more definitive study now needed?*

5. The Power of Peer Review

You can give a big plus to studies that appear in *peer-reviewed* journals, which means these studies have passed review by other experts. But this is no guarantee. Reviewers are human. Good stories can also come out of science meetings before they appear in peer-reviewed journals, and even from scientists who are just beginning studies. But these research stories demand more cautious reporting, more checking with other experts.

Ask researchers: *Who disagrees with you? Why? How do your findings and conclusions fit with other scientific studies and knowledge?*

The burden of proof rests with researchers seeking to change scientific dogma. And always, science loves confirming studies. Science writers should look for consensus among the best studies.

In *News & Numbers*, we give this bottom-line advice: "Wise reporters often use words like 'may' and 'evidence indicates,' and seldom use words like 'proof.'" Spell out the degree of uncertainty involved in what you are reporting. Provide appropriate cautions and caveats for added credibility.

Dollars and Averages

Ask about costs. It's fun to write or talk about a futuristic scheme to move some asteroid away from a possible collision course with Earth, but *how much would it cost? Can we afford it?* The public particularly wants to know the price tag for any new medical treatments. Ask, *Will it be so expensive that it's unlikely to see widespread use?* If the researchers don't have cost estimates, that's news, too.

Don't be misled by averages. People can drown in a lake with an average depth of four feet when it's nine feet deep in the middle. The average person in a study exercises three hours a week; not mentioned is that most of the participants don't exercise at all, while a few are zealots. Ask, *What are the numbers behind the average?* A radio report said that "*you'll* live longer" if you exercise and eat a prudent diet. The evidence is only that people will live longer *on average.* "You" only increase your chances of doing so.

Rates and Risks

Avoid rate confusion. The *Washington Post* ran an article with the headline "Airline Accident Rate Is Highest in 13 Years." The story, like many others that misuse the term "rate," reported no rate at all, merely death and crash totals. A correction had to be printed pointing out that the number of accidents per 100,000 departures—the actual rate, the "so many per so many"—had been declining year after year. (The headline would have been technically correct if it had simply said "Airline Accidents Highest in 13 Years." But in this and many other cases, I think that the rate is the fairest way to judge what's really happening.)

Watch risk numbers. Someone cites deaths per ton of some substance released into the air, or deaths per 10,000 people exposed. Someone else cites annual deaths, or a 10-year death total. There are many choices to make something seem better or worse. Make sure you get a full, fair picture.

While you're at it, pay attention to the difference between *relative risk* and *absolute risk.* Relative risk is a measure of the increased risk of developing an illness or disorder. Example: A study concludes that people exposed to a chemical (say a hypothetical Agent Purple) are twice as likely to develop a particular cancer as the people who were not exposed to that chemical. The relative risk is 2.

But in total lives affected, even a large increased risk for a rare illness is not as important as a small increased risk for a common illness. Absolute risk takes this into consideration. It calculates the "number of cases per X thousand population per year." Relative-risk calculations can be important in discovering a threat; absolute-risk calculations can be useful to show the public health or clinical impact.

View clusters with caution. When you hear of a very high number of cancer cases clustered in a neighborhood or town, more study may be warranted, but not panic. With so many communities across our nation, by chance alone a few will have many more than their share of cancer cases (or birth defects or whatever). This is the Law of Small Probabilities.

Put the burden where it belongs. Someone says, "How do they know this stuff isn't causing harm?" Science can't prove a negative. The burden of providing at least some evidence is on the person making a claim of harm.

Potential Perils in Polling

Polls go beyond politics. They can help us learn what people do (and don't do) to stay healthy, and whether the public thinks we should spend more on space exploration or whatever. But to be credible, polls must pass scientific analysis.

The people interviewed must be a *random sample* of the population whose views we want to learn about (for instance, registered voters in the Midwest, or teenage smokers). Caution: TV talk shows often ask people to phone in their poll answers. But only the show's viewers will know to call, and only those with strong views are likely to call. That's not a random sample, and it's not a scientific poll.

The more people interviewed in a poll, the smaller the *margin of sampling error.* This margin of error may be, for example, "3 percentage points, plus or minus." That means that in 19 out of every 20 cases (the statistically significant standard), the poll's results will be accurate to within 3 percentage points—*if* all else is right with the poll.

The poll's questions must be crafted to eliminate any bias that might nudge those polled to answer in a particular way. Ask, *What's the exact wording of the questions? Who paid for this poll?*

And polls are only a snapshot of what people say at a particular time. This may change.

The bottom line for polls and all sorts of scientific studies: Look at the numbers, keeping in mind that bigger tends to be better. Ask yourself if there are any alternate explanations for the poll's, or study's, conclusions. Consider any possible biases, intentional or otherwise. And keep in mind the certainty of some uncertainty.

This chapter is based on concepts covered in detail in *News & Numbers: A Guide to Reporting Statistical Claims and Controversies in Health and Other Fields* (Iowa State Press; 1st ed., by Victor Cohn, 1989; 2nd ed., by Victor Cohn and Lewis Cope, 2001).

4

Writing Well About Science: Techniques From Teachers of Science Writing

While the rest of this book deals with how to handle a variety of jobs, cover certain topics, and use specific tools to get the job done, this chapter opens the classrooms of some teachers of science writing. Their techniques help correct common problems and reveal strategies for writing clearly and beautifully.

Deborah Blum is a professor of journalism at the University of Wisconsin–Madison. Mary Knudson teaches science writing in Johns Hopkins University's Master of Arts in Writing Program in Washington, D.C. Ruth Levy Guyer teaches in the same Hopkins program, as well as at Haverford College in Pennsylvania, and at the UCLA School of Medicine. Sharon Dunwoody is the Evjue Bascom Professor of Journalism and Mass Communication at the University of Wisconsin–Madison. Ann Finkbeiner runs the graduate program in science writing at the Writing Seminars at Johns Hopkins in Baltimore. And John Wilkes is the director of the Science Writing Program at UC–Santa Cruz.

Ten Time-Tested Tips

1. *Read your work out loud.* You will be able to hear rhythm and flow of language this way, and you really cannot hear it when reading silently.
2. *Don't be shy.* Ask other writers to read a draft for you. Everyone gets too close to the story to see the glitches, and a dispassionate reader is a writer's best friend. Good writers gather readers around

them for everything from newspaper stories to whole books (which require really good friends).

3. *Think of your lead as seduction.* How are you going to get this wary, perhaps uninterested reader, upstairs to see your etchings? You need to begin your story in a way that pulls the reader in. My favorite basic approach goes seductive lead, so-what section (why am I reading this), map section (here are the main points that will follow in this story). That approach leads me to my next tip, which is
4. *Have a clear sense of your story and its structure before you begin writing.* If you think of a story as an arc, in the shape of a rainbow, then it's helpful to know where it will begin and where it will end so that you know in advance how to build that arc.
5. *Use transitions.* A story has to flow. Leaping from place to place like a waterstrider on a pond will not make your prose easy to follow.
6. *Use analogies.* They are a beautiful way to make science vivid and real—as long as you don't overuse them.
7. *In fact, don't overwrite at all.* And never, never, never use clichés. If you want to write in your voice, generic language will not do. In my class, there are no silver linings, no cats let out of bags, no nights as black as pitch. A student who uses three clichés in a story gets an automatic C from me.
8. *Write in English.* This applies not only to science writing but to all beats in which a good story can easily sink in a sea of jargon.
9. *Picture your reader.* I find it helpful to imagine a specific reader who is unnerved by science to begin with and would stop reading my story the minute I threw a multisyllabic medical term in her face. Yes, her face. My reader is an elderly woman with curlers in hair, half-dozing over the paper. If I can snare her, the science-savvy reader is a snap.
10. *Have fun.* Science is intriguing, funny, and essential to everyday life. If we write too loftily, we lose some of the best stories and the ones that our readers most relate to.

DEBORAH BLUM

On Explaining Science

1. The question is not "should" you explain a concept or process, but "how" can you do so in a way that is clear and so readable that it is simply part of the story?

2. Use explanatory strategies such as . . .
   - Active-voice verbs
   - Analogies and metaphors
   - Backing into an explanation, that is, explaining before labeling
   - Selecting critical features of a process and being willing to set aside the others, as too much explanatory detail will hurt rather than help.
3. People who study what makes an explanation successful have found that while giving examples is helpful, giving *nonexamples* is even better.

   Nonexamples are examples of what something is *not.* Often, that kind of example will help clarify what the thing *is.* If you were trying to explain groundwater, for instance, you might say that, while the term seems to suggest an actual body of water, such as a lake or an underground river, that would be an inaccurate image. Groundwater is not a body of water in the traditional sense; rather, as Katherine Rowan, communications professor, points out, it is water moving slowly but relentlessly through cracks and crevices in the ground below us.

   Or if you were trying to explain what a good survey is, you might reflect on the importance of a representative sample, a good response rate, and so on, but then offer examples of what a good survey is *not*: stopping people at the local mall (haphazard sample), asking magazine subscribers to return a survey insert in their magazine (lousy response rate), and so forth. This gives your reader a different way of looking at a new idea.
4. Be acutely aware of your readers' beliefs. You might write that chance is the best explanation of a disease cluster; but this could be counterproductive if your readers reject chance as an explanation for anything. If you are aware that readers' beliefs may collide with an explanation you give, you may be able to write in a way that doesn't cause these readers to block their minds to the science you explain.

SHARON DUNWOODY

On Writing Clearly and Logically

In fiction where events are chosen for their emotional tone—a character disappears, a word is misspoken—any number of events will suit. Nor do two neighboring events need any connection other than emotion: Chronology doesn't much matter; logic certainly doesn't. Just add that scene with the misspoken word to the scene where the character disappears into the fog, and the reader knows exactly what happened. In fiction, connections don't have to be explicit; we get it.

In science writing, where events proceed on logic, order counts. In each paragraph, the sentences have a right order; and in each sentence, the words have a right order; and all you have to do is find the order. A Sid Harris cartoon shows Johannes Kepler telling his colleagues, "So you see, the orbits of the planets are elliptical," and the colleagues thinking one by one, "What's an orbit?" "What's a planet?" "What's elliptical?" Those colleagues' biggest problem isn't the jargon; it's that Dr. Kepler obviously didn't present his case in the right order.

Sometimes when the order doesn't seem right, it really is; and what's wrong is that some of the logic is missing. The easiest examples of missing logic are on the small scale. "Because the speed of light is constant, we see galaxies that are distant in space also distant in time." That sentence is grammatically respectable and factually accurate, but for the lay reader, it's close to nonsense. The problem is that the logic connecting light, the galaxy in space, and the galaxy in time is missing. The reader needs to be held by the hand, and walked through the idea, every step, step by step. One way of doing this is a brilliant but obvious rule that I made up: Begin each sentence with the word or phrase that ended the previous sentence. So: "The only way we see galaxies is by their light. Light leaving a galaxy at a certain distance and traveling a fixed speed takes, say, 100 years before we see it. We see the image of the galaxy as it was 100 years ago." The pattern is A–B, B–C, C–D.

The AB/BC rule also works on the mid-scale, with paragraphs. In fact, the rule is just another way of making transitions. If each paragraph is a single idea—as Strunk and White rightly assert it should be—then transition sentences provide the connections between ideas. Transition sentences tell the reader why, having read that, he is about to read this. If the transition to a new paragraph seems awkward—"But first, some background"—the ideas are probably in the wrong order and you've got structural trouble. Another symptom of structural trouble is the repetition of subjects in an article: "As pointed out earlier," or "Getting back to the early universe," or "We will come back to this subject in a later section." When you discover these symptoms, return to the AB/BC rule, take a deep breath, and start over.

AB/BC also works nicely with Strunk and White's most unbreakable rule: The most important word in a sentence comes at its end. I happened to be interviewing the psychologist Marvin Minsky once and asked him about that sentence's-end rule: Naturally, he said, you remember best what you heard last. That rule also applies to paragraphs: The most important sentence comes at the end. The reason the rule is so good is that by the time you've finished writing a paragraph full of sentences ending with their most important words, you probably can figure out what the paragraph was about. And by the time you've written a story full of paragraphs ending with their most important sentences, you probably know what the article was about.

ANN FINKBEINER

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Think of the path of logic as comparable to the alphabet. In order to recite the alphabet correctly, one must begin at A and go logically to B and then to C and so on to Z. Not one letter can be skipped in the alphabet, and not one step can be overlooked in the path of logic pursued through the story. The writer should envision a smart reader who is unfamiliar with and uninformed about the subject, but not stupid. That reader can learn anything she needs to know as long as the writer writes what the reader needs to know when she needs to know it. Make no leaps of knowledge or faith. The task of explaining something new to this attentive reader is straightforward, precise, interesting, and extremely challenging.

RUTH LEVY GUYER

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Deletable phrases: "There are," "it is," and so on. "There" and "it" are pronouns that refer to nothing and only take up space. The sentence accordingly loses zip: "There are 10 billion neurons in the brain" versus "The brain has 10 billion neurons."

Deletable words: Excess "the's" and all "very's." "Very" is fine in spoken English but is counterproductive in written: "She is very beautiful" versus "She is beautiful." Ration adverbs strictly.

ANN FINKBEINER

Storytelling

Science is a process rather than a product, and this is why it lends itself to storytelling. Scientific discoveries are made by people; they don't just happen. Good writers give readers a picture of scientists carrying out experiments, recording cause-and-effect relations, documenting observations, disturbing steady states, and being excited and sometimes startled by their findings. Authentic scientists expect the unexpected, and when it happens they love it.

Explaining the general, broader significance of a discovery is also crucial. There may be little that is absolutely new. Nature is said to be parsimonious. If something works one time, nature uses it elsewhere.

A thoughtful writer will dig deep into his or her own interests, strengths, biases, and agendas and not only develop the story itself but also tie it to other things in the world—in science and also in the broader literature and culture—that add interest and insight to the story. The writer who attends closely to both deep and broad issues is the one who will create something that is different from what other writers are producing. This writer will write the story that is worth the readers' time.

RUTH LEVY GUYER

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Set a pace. Once you've drawn readers in, you want them to be able to read quickly through your story. If you can read a story quickly, it means the story was well written. A well-written story has a good pace—at times leisurely, describing scenes, building anticipation; at times quickened, revealing action, terse dialogue. The pace of the story is what will keep your readers reading to the end. If you don't set a pace and sustain it through the last graph, you won't have very many readers reading that last graph.

So, how do you set a pace? Frankly, you have to play with it a lot. But you can start with a framework. Use active voice and powerful verbs. Use present tense to create immediacy and adventure. Use past tense if immediacy is not needed. Put short sentences in strategic places as segues to the next segment of your story. Alliteration, using examples in sets of three, and varying your sentence structure all help to create a rhythm. And, very important, eliminate clutter.

Narrative writing is essentially a combination of fiction techniques that are very useful in telling medical and science stories. Even if you are not writing a narrative, think of yourself as a storyteller. Use narrative writing for an entire piece or only a portion of a story. Here are the basics: details, anticipation, quotes.

Details give such vivid descriptions that you reach out and put the reader smack into the story. Anticipation builds interest in reading on by giving a hint of what is to come. Quotes bring your story to life, are authoritative, raise provocative questions. Quotes are heartbreaking, whimsical, funny. Quotes make the complex understandable. Quotes give the other side of the story. Conversational quotes help set the rhythm of a narrative. If you put a quote in a