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Science Writing as Storytelling

A good story cannot be devised; it has to be distilled.

—RAYMOND CHANDLER

Elizabeth Kolbert, the author of the extraordinary book on climate change *Field Notes from a Catastrophe*, once said that the problem she has with scientists is that we don't tell stories. That statement bothered me, because we do. If we didn't tell stories, we would write papers with only Methods and Results; we could skip the Introduction and Discussion. We also wouldn't read Charles Darwin's *Origin of Species*; instead, we would read his notebooks and get the raw data.

But, we do write papers with an Introduction and a Discussion, and we do read *Origin of Species*. A paper doesn't only present our data—it also interprets them. A paper tells a story about nature and how it works; it builds the story from the data but the data are not the story. The papers that get cited the most and the proposals that get funded are those that tell the most compelling stories.

Somehow, though, our kind of storytelling didn't connect with Kolbert; in fact, it connected so poorly that she didn't recognize our stories as stories. Why? I suspect three reasons for this. First, scientists tell stories using a formalized structure that doesn't match well with that used by journalists. Our stories get lost in the struggle of cross-cultural communication. Second, many of us are poor

storytellers; either we don't see the story clearly or we just can't tell it clearly. Finally, some (perhaps most) scientists are uncomfortable with thinking about what we do as "telling stories." Many associate the idea of "stories" with fiction. Scientists are supposed to be objective and dispassionate. Arguing that you are writing a story may seem to suggest that you have left that objectivity behind and with it, your professionalism. Rather, many scientists feel that their job is simply to "present their work," and so do a poor job of highlighting the story. The result is that even an outstanding journalist who spends a lot of time talking with scientists doesn't recognize that we *are* telling stories.

That lack of recognition raises several issues that scientists should consider. The first is the formalism of how we write papers and proposals. I won't argue that we should change how we structure these documents; they serve our needs to communicate among ourselves. (The phenomenon that they don't communicate well to the rest of the world is a different concern.) The second issue is how to become better storytellers and better communicators. That is something we can all work on.

The final issue is more complex. Is seeing science writing as storytelling professional or not? Journalists are also supposed to be objective and dispassionate (and the best ones are), yet their entire discipline is grounded in the concept of "story." So there is nothing inherently unobjective or unprofessional in the idea of storytelling. To tell a good story in science, you must assess your data and evaluate the possible explanations—which are most consistent with existing knowledge and theory? The story grows organically from the data and is objective, dispassionate, and fully professional. Where you run into problems is when the authors know the story they want to tell before they collect the data and then try to jam those data into that framework. Anne Lamott captures this conundrum well. Although she was discussing fiction, her advice applies equally to science.

> Characters should not, conversely, serve as pawns for some plot you've dreamed up. Any plot you impose on your characters will be onomatopoetic: PLOT. I say don't worry about plot. Worry about the characters. Let what they say or do reveal who they are, and be involved in their lives, and keep asking yourself, Now what happens?"
>
> ANNE LAMOTT, *Bird by Bird*

Lamott highlights the importance of listening to your characters to draw the story out of them, rather than imposing it on them. How do we, as scientists, take this advice? Do we even have "characters" to listen to? Of course we do. Our characters, however, aren't people; instead, they may be molecules, organisms, ecosystems, or concepts. Nitrogen cycling in the arctic tundra, benzene and its reactions, or genes and their functions can be characters that we "listen to" by carefully analyzing our data with an open mind. Then we can develop these characters in a paper as we discuss them and what makes them tick.

Kolbert's difficulty with understanding our stories raises the social imperative of our becoming better storytellers. As science has moved from esoteric, ivory-tower natural philosophy to something that directly affects the lives and well-being of the public, our inability to communicate has grown into a crisis. Science is often ignored, misunderstood, or misrepresented in the public arena and in policy decisions, a phenomenon many of us bemoan. How can we solve problems as serious as global warming or cancer without basing the solutions on the best available science? Ensuring that science is used properly requires more than just presenting facts to decision makers. Unfortunately, our approach to communicating to them is often analogous to traveling overseas and speaking louder when the locals don't understand English. Going to Washington, D.C. and speaking loudly to the locals in "science" is about as successful—it doesn't get our point across, and it makes us seem arrogant, a good way to get dismissed. Our inability to communicate outside the narrow confines of our specializations undermines our ability to influence policy and to generate new sources of funding. We don't have to become science popularizers like Stephen Jay Gould or Carl Sagan, we just have to become better storytellers. Doing so will make us more effective with each other, with our professional translators (science journalists like Kolbert), with policy makers, and with the public.

2.1. FINDING THE STORY

The distinction between presenting results and telling a story embodies a challenge for many when writing papers. If you believe that writing a paper is about presenting results, then it would seem reasonable to outline everything you did and then say something about it. But somewhere in that mass of data is a story trying to come out. Find it, and give it to us.

In looking for the story, remember that when we do science, we get data from the mass spectrometer, the DNA sequencer, or the telescope, but our ultimate goal is not those data –it is the understanding we derive from them. In the discovery of the structure of DNA and the molecular basis for heredity, it wasn't Rosalind Franklin's Photo 51,[1] the critical X-ray diffraction image of DNA (figure 2.1a) that gained fame but the sketch of the molecular structure of DNA that Francis Watson and James Crick built from it (figure 2.1b).[2] Franklin's lack of credit for her role in the discovery has created controversy over the years because there can be no story without the underlying data, but that controversy is a separate issue. My point is that raw data have limited direct value and are usually interpretable by only a small group of experts—Photo 51 means nothing to me beyond its role as a historical artifact. The double helix model of DNA, however, I understand. It is interpretable by many and is at the core of the work of thousands of scientists spanning from medicine to soil microbiology. Watson and Crick's groundbreaking paper

1. R. E. Franklin and R. G. Gosling, "Molecular Configuration in Sodium Thymonucleate," *Nature* 171 (1953): 740–41.

2. J. D. Watson and F. H. C. Crick, "Molecular Structure of Nucleic Acids—A Structure for Deoxyribose Nucleic Acid," *Nature* 171 (1953): 737–38.

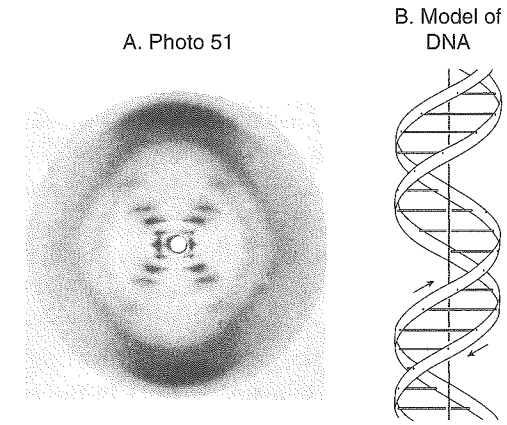

Figure 2.1. Photo 51, Rosalind Franklin's critical X-ray diffraction image of crystallized DNA and the simple model of its structure developed by James Watson and Francis Crick.

Figure 2.2. The flow of science, from data to understanding.

had power because they used the data to tell a story about nature and how it works, developing an intellectual model of DNA structure and what that implies for heredity. We look for and value such insights and understanding.

The role of scientists is to collect data and transform them into understanding. Their role as authors is to present that understanding. However, going from data to understanding is a multi-step process (figure 2.2). The raw data that come from an instrument need to be converted into information, which is then transformed into knowledge, which in turn is synthesized and used to produce understanding. In the case of DNA, Photo 51 was data—an image of X-ray scattering. Franklin used that data to produce actual, critical information on the atomic structure of crystallized DNA. Watson and Crick used that information to produce knowledge—the double helix structure. The last step is understanding—taking that knowledge about the molecule's structure to explain how it allows cell replication and heredity.

The further along the path from data to understanding you can take your work and your papers, the more people will be able to assimilate your contributions and use them to motivate their own work and ideas—and that should be your goal. If you don't provide understanding (or at least knowledge) readers will be left searching for it. The data are supporting actors in the story you tell. The lead actors are the questions and the larger issues you are addressing. The story grows from the data, but the data are not the story.

This recognition leads to a process that I think is critical to developing good stories and writing good papers, a process that hearkens back to Lamott's comments about listening to your characters: develop your story from the bottom up, then tell it from the top down. Start with the data, think about them, listen for the story they are trying to tell, and find that story. Don't listen just to your characters' loud proclamations, though; listen also to their quiet, uncertain mutterings. What might that shoulder on the spectrum mean? If that nonsignificant treatment effect were real, what would that say about your system? Is that outlier a flag for something you hadn't thought about but may be important? Overinterpret your data wildly, and consider what they might mean at those farthest fringes. Explore the possibilities and develop the story expansively. Then, take Occam's razor and slash away to find the simple core.

Why go through this "elaborate and slash" process? Isn't elaborating a waste of time if you're going to come back to a simple story in the end? Why not start there? Well, if you start with the first simple story that comes to mind, you are probably imposing plot onto your characters and falling into the trap Lamott describes. Only by exploring the boundaries and limits of your data can you find the important story.

The power of the exploring the fringes is well illustrated by Bill Dietrich's graduate research. Dietrich is now a professor of geomorphology at the University of California, Berkeley, and is a member of the U.S. National Academy of Sciences. For his doctorate, he worked on how hill slope steepness controlled soil depth in the Pacific Northwest. Most of the data fit a nice tight relationship (figure 2.3), which made a perfectly good story.[3] But there were outliers where soils were much deeper than they "should" be. He could have ignored them and focused on the main story. He didn't. He looked at the deep soils and what created them; he found that along a hill slope, the bedrock is uneven and in places forms hollow "wedges" (figure 2.3). Over time, those wedges fill up with debris and soil. Once filled, they aren't obvious on the landscape, but woe to the person who buys a house below one—in a heavy rainstorm, they can flush out, creating lethal mud flows. Evaluating the processes that fill and flush these wedges became a focus of Dietrich's early research career. Because he listened to his characters carefully, recognized that the most important story wasn't in the average but in the outliers, and then explored those outliers, he came up with more novel, exciting, and important science.

Learning to explore the fringes of your data, however, can be difficult and frustrating. When I was a graduate student, I would sometimes go to my advisor, Mary Firestone, with what I thought was a simple question. Then we might spend weeks discussing issues that wandered all over the intellectual map and didn't appear to fit on the straight road from my question to the answer. Many of the issues Mary raised seemed irrelevant and extraneous. What on Earth did the kinetics of bacterial glutamine synthetase have to do with my data on how plant roots compete against microorganisms for available nitrate in the soil? Over the years I worked with her, I came to understand what we were really doing in those conversations. Mary saw more of the system and how it fit together than

3. W. E. Dietrich and T. Dunne, "Sediment Budget for a Small Catchment in Mountainous Terrain," *Zeitschrift für Geomorphology* Suppl. Bd. 29 (1978): 191–206.

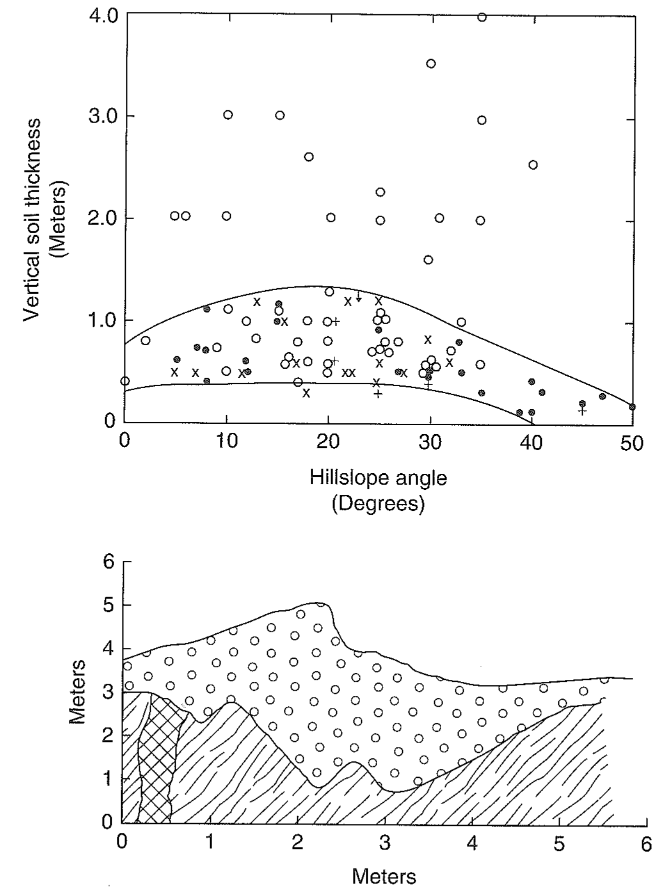

Figure 2.3. The top figure illustrates the relationship between hill steepness and soil depth in the U.S. Pacific Northwest; the bottom figure illustrates a cross-section through a wedge. Redrawn from Dietrich and Dunne (1978).

I did; she was teaching me how to do good science. She was exploring the issues to deepen our thinking, to ensure we found the story that tied together the sometimes apparently contradictory data, and to identify issues that might trip us up later. Though not always easy, it was an important lesson, one I remain grateful for.

So listen to your characters carefully—take the time to hear what they have to say and figure out what they mean. Fight the pressure to publish prematurely. One good paper can launch a career; many mediocre ones build a rather different one. Think well, write well, and then think some more while you write. Let the story grow from the data and then structure the paper to tell that story.

When we recognize that writing a paper is writing a story, it raises the obvious point that we can become better storytellers, better writers, and better scientists by studying what makes a good story, how other writers do it, and how to apply those ideas to science. We *can* communicate more effectively while remaining rigorously professional.

There are three aspects to effective storytelling. The first is content—what makes a story engage and stay with us? The second is structure—how do you put together that content to make it easy for us to get? The third is language—how do you write the story in the most compelling way possible? This book is about these three issues.

EXERCISES

2.1. Analyze published papers

Pick several papers from the primary literature. You will come back to these, chapter after chapter. I suggest you pick:

A paper from a specialist journal written by a leader recognized as a strong writer.
A "normal" paper from a specialist journal.
A review or synthesis paper.
A paper from *Nature* or *Science* or some journal that targets a broad audience.
Identify what you think the key story points are. Did the authors do good job of highlighting that story? How far along the flow from data to understanding did the paper go? Could they have taken it further?

2.2. Write a short article

Step 1. Identify the Key Story Points for your Work.
(This is adapted from an exercise developed Ruth Yanai at SUNY-ESF.[4]) For each question, write a short paragraph—no more than two to three sentences. These identify the essential story elements.

1. What is your opening? This should identify the larger problem to which you are contributing, give readers a sense of the direction your paper is going, and make it clear why it is important. It should engage the widest audience practical.
2. What is your specific question or hypothesis?
3. What are the key results of your work? Identify these in a short list. There should be no more than two to three points.

4. She credits it to Bill Graves, Dick Gladon, and Mike Kelly at Iowa State University.

4. What is your main conclusion? What did you learn about nature? This should use the results from section 3 to answer the question from 2, and should address the larger problem identified in 1.

Step 2. Write the Article.
Write a short article describing your research. Your target audience is scientists who are not specialists in your discipline. You are trying to tell the story of your work and engage and educate your readers, not write a technical paper. The tone can range between somewhat technical and more casual, but it must be something that technical readers would find interesting. Use your answers from step 1 to frame the story you write in this part of the exercise.

The word limit is strict: 800–850 words.

Step 3. Analyze your writing.
Circulate your articles among your writers' group (a group of three to four people seems ideal for this). Analyze and edit each other's work. Then discuss the articles. Ask and answer the following questions:

1. What did the author do well? (It's always good to start positive.)
2. Was the topic interesting? Was it cast at the right level and hit the right audience? Could you have rewritten it to engage a wider audience? Did it make you want to read the rest of the piece?
3. Was the specific question clear?
4. Were the results clear? Did they relate to the topic and the specific question?
5. Were the Conclusions true *conclusions*, or were they merely a restatement of the results? Did they relate to the large issues raised in the opening? Did they answer the specific question asked? Did they clearly grow from the results presented in the piece?
6. What did you get as the "take-home" message of the story? Do you believe that this was the message the author was trying to give you?
7. Was the writing clear? If not, can you figure out why and identify ways to make it clearer?