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The Metaphor, Unchained

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SCIENTISTS WRITE, first of all for other scientists. It's not publish or perish, but rather that an open system of communication, a commitment (shading to an addiction) to telling others what you have done, is essential to the functioning of science.

The primary medium of communication in the profession is the peer-reviewed article. This, our stock in trade, has a ritual format with strong historical roots. Once more diverse, the language of published articles is now 85 percent English, or an approximation thereto. Declining mastery of language aside, it's probably okay for most papers to be written in a bare style, for the vast majority of more than 500,000 articles published in chemistry and related fields last year is highly specialized (and routine) science. I do wonder about the collective effect of so much stylistically undistinguished writing. Is more harm done by selling lesser science through good style (I'm not talking about hype), or by poor writing pulling down sound science?

A second intersection of science and writing reaches out to nonspecialists. Here we have science journalism and the popularization of science. The best examples shape a genre onto itself. Some are authored by writers, by journalists or historians, and are just superb, as in K. C. Cole's tours through higher dimensions. But let me focus on practicing scientists who write in this mode. I would claim that when scientists themselves write for a general audience, their research is likely to improve. Why? Because writing sets free the oft-suppressed metaphor.

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Scientists improve their craft by writing about it

Paragons among the kind of general-audience books I have in mind are those of Oliver Sacks, Carl Sagan, George Klein and Jacques Monod, all of whom are (or were) both distinguished scientists and gifted authors. In their volumes, stories of science are told in a strong narrative vein. In some, a philosophical framework is explicit; in others, it remains for us to find. Such books have recently won Pulitzer Prizes, National Book Awards and their world-wide equivalents. This recognition is something new in letters, and well deserved.

Another facet of the genre is made up of articles written by scientists who lay out their research in popular terms. These authors write for many reasons. Some may be driven by the stick of outreach requirements from governmental granting agencies. But more often a carrot is at work—an invitation that cannot be but flattering, a lecture series that naturally suggests a published *précis.* Ultimately it doesn't matter what combination of pressures and incentives leads to writing an article for *American Scientist* or a similar publication. A process that initially appears painful grows quickly into the desire to do it again.

Metaphor

Short of research papers, the audience of the scientist-writer is not in one's own trade. So the author cannot use too much jargon; the gatekeepers will make sure of that. One must simplify or say it in another way. Metaphors, similes, analogies—all the ways human beings have devised to explain that A is sort of like B—come to the surface. If I want to explain the uncertainty implicit in measuring simultaneously the position and velocity of a moving electron using photons, I resort to a thought experiment that measures the same observables for a baseball, with, say, tennis balls thrown at it. As I think about how to explain the vibrational-translational energy transfer necessary for the greenhouse gas carbon dioxide, CO_2, molecules of which have absorbed infrared radiation, to heat the rest of the atmosphere (predominantly oxygen, nitrogen and argon), I envision the bending and unbending CO_2 molecule as a gym rat exercising, once in a while kicking an O_2 dumbbell that comes near.

These thought mappings (let's loosely call them metaphors) also pulse deep in the heart of science. By this I mean they exist in the daily practice of doing research—in the way scientists generate hypotheses, theories and experiments. But … people don't much admit to it. My observation is that scientists sanitize their papers to remove as many explicit admissions as possible of the fecund, generative utility of such metaphors. Why? Because metaphors are (mistakenly) thought to impress no one—they are not mathematicizable; they are less "rational."

Along comes science writing. Now the scientist needs to explain something to the partially literate masses. All of a sudden, the metaphor, previously suppressed, is set free. Its use is intuitive; in fact, it's desperately needed.

But there's more to letting loose the beast than merely lifting the lock. Infused with the red blood of real ideas, metaphor, simile and analogy become explicit. They are reified, and importantly so in the mind of the scientist-writer. He or she may have used the thought map to design an experiment, or try out an analysis. Yet few allow

themselves to pursue it, fully. It may be their loss: A naked metaphor clearly shows the analogy's limitations, its capacity for misinterpretation and its productive extensions. It aids its creator as well as its audience.

Two-way Teaching

Science writing is inherently pedagogical. And the scientist-writer will be able to both express and understand the specialized science he or she does more clearly as a consequence of the act of writing. Let me explain.

Our minds are full of inchoate ideas, inklings and partial explanations. Once verbalized, at a research-group meeting, for instance, or in the process of writing a paper, the ideas become real. Being human, we then marshal support, adduce arguments. The scientific paper explains. It has to teach—and to teach one must use those slippery words, eternally straying, lacking fidelity to the idea. But it is only with words that the removed reader may be reached. I see no dichotomy between teaching and research, only a continually varying set of audiences.

Good science writing has the audience firmly in mind—it teaches you (and a good editor can help so much) to teach others. This is not the mindless teaching of techniques or arid tables of dates and names: That requires neither acuity nor imagination. Rather, the act of skillful writing schools its author in ways of explaining structure and significance, of explaining ideas. Which is just what you need to do good science.

Narrative

I can hear in my mind one reaction to what I have said: "Are not observations, objective facts and reproducible data the foundations of science? Does it not suffice to report these, without embellishment?" Well, no. Science cannot exist without narrative. And making the effort to write of science for the general public sensitizes the practicing scientist to the importance of telling stories.

I recently reviewed a paper that tried to embody Sgt. Joe Friday's laconic ideal ("All we want are the facts, ma'am"). It consisted of 25 tables taking up some 35 pages and a handful of written pages. The text, such as it was, effectively said, "this and that are true; just look at Table 16." The failure of such a paper is transparent. The facts are mute; people need words, spoken or written, to make sense of data.

There is an interesting dance here, in that data (observations, equations, structural formulas, spectra) are useless without the narrative, theoretical framework to make a story out of them. So one is open to the criticism that the narrative prejudices the content, or, in other words, is "theory-laden." But—and this is the dance—the exact language used, be it English, Japanese or Arabic, should not matter. The stories that are told aspire to the universal, or, to use Gunther Stent's idea, to the infinitely paraphrasable. The valuable stories (I would call them "myths," using the most respectful meaning of the word) are essences. And this is the lovely paradox: These essential stories are, in a way, stripped of the supposed subjectivity of language—subjectivity that is absolutely necessary to tell the story in the first place (and even more necessary for it to be believed).

Science or art, it's not easy to build a new way of seeing. In Mark Tansey's metaphor for getting the new off the ground, Georges Braque and Pablo Picasso (or is it the Wright Brothers?) launch the cubist airplane. *(Picasso & Braque*, 1992 by Mark Tansey, courtesy of the Gagosian Gallery, New York.)

Like metaphor, storytelling is not mathematical. Yet it also is essential to good science, for two reasons. First, when simplicity (always the first aesthetic criterion) fails, human beings prefer to organize their hard-won knowledge of reality in the form of a story. We find a pattern, which means we find a story. Second, the classical workings of the scientific method demand the formulation of not one but several alternative hypotheses. What is a hypothesis, if not a story? Better learn to weave not one, but many.

People love stories. The best science writing, such as the remarkable case studies in *The Man Who Mistook His Wife for a Hat* by Oliver Sacks, teaches us narrative. That skill, to tell a story, is most unlikely to be part of a technical education. Yet it is not lost on scientists.

Better Science Through Writing

I am convinced that I have become a better theoretical chemist, a better explainer of the common and strange things molecules do, because I had to teach undergraduate courses. And also because I chose to write about science for people who do not share my academic background. Metaphor, teaching, storytelling were set loose within me because I was addressing a general audience of students and readers. There was no formula—I wanted to catch and hold their interest, no more. This approach proved to be at once more natural and more effective than one comprised solely of facts, however rational their presentation.

They have no substance, these mental fetters that constrain metaphor and teaching and narrative in the communication of science. Break them. And when they are gone, still a scientist, you will understand better, see things more clearly, know what we cannot see.

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