This issue of The FASEB Journal marks a transition with respect to an aspect of our enterprise for the last five years—editorials exclusively penned by the Editor-in-Chief. Combining editorial and essay forms, they have addressed both professional scientists and broader audiences, in keeping with his many engaging books (e.g., Ref. 1). By now inviting other members of the editorial board to pen editorials for The FASEB Journal, our Editor-in-Chief hopes that a diversity of opinions will rouse our broad readership to vigorous response. Here, I take the bait and address the topic of conveying science to general audiences.

DIMENSIONS AND VARIANCES OF THE CRAFT

I was first exposed to the challenge of explaining tough science to a broad audience in 1976 when I was asked to address the board of trustees of the institution where I worked at the time, the Worcester Foundation for Experimental Biology, in Shrewsbury, Massachusetts. I was apprehensive but somehow managed to slosh through remarks about my research on RNA-binding proteins (2). In this initial experience, I learned that addressing a lay audience is not simply one valence level out from the s orbital to the p, but out to several more layer lines to achieve audience comprehension.

As we take up the topic of scientists addressing a broader audience, we might begin by recognizing the obvious, viz., that this consists of many variations on the theme. Jim Watson’s The Double Helix (3) is a very familiar example, and though it is marred by an infamous inaccuracy in regard to a primary character (4), there can be no question the story was spellbinding as was the author’s manner of presenting it. Another differentiation is between those efforts that remain within the context of the scientist’s immediate expertise (for example when Joseph Goldstein or Michael Brown address a lay audience on the discovery and therapeutic impact of statins) and the contrasting endeavor in which scientists use their own work and stature as a launch pad to be a broader spokesperson for the cause of science and the joy of discovery (as the physicists Steven Weinberg and Leon Lederman have done so wonderfully, for example). Another front is defined by the efforts scientists have made to boost funding for science. There, the imperative is to emphasize the non-linkage between current vogues and discovery, as was done heroically by Vannevar Bush in his report to President Franklin Roosevelt on the state of U.S. science. Related “white papers” of transformative power were Abraham Flexner’s crushing analysis of American medical education and Warren Weaver’s prescient look at U.S. biological research institutions in his role as a program officer at the Rockefeller Foundation (during the course of which he coined the term “molecular biology”). These papers were not in the standard domain of scientists writing for the public but are historically of great import and thus deserve mention at least in passing. Finally, there are of course many extraordinary biographies of scientists (e.g., Ref. 5) as well as memorable autobiographies (e.g., Ref. 6) that are masterpieces of exposition and erudition. But they are special cases and lie beyond the theme being developed in this piece.

ONE’S OWN SCIENCE

This is presumed to be every scientist’s favorite subject, but many of those most talented in addressing the general public enjoy conveying the work of others just as much, and often take even greater satisfaction from discussing broader dimensions of a field or the profession of science itself. But in the simple case of conveying one’s own work, a number of points arise. In that first encounter when I addressed my institution’s trustees it took some metamorphosis in imagery, vocabulary, and detail relative to my talks on this same research to my peers. I quickly recognized that this is the hardest part. But with some cerebral foreplay one can learn how to do it and, like anything, it gets easier—and the product gets better with experience. Needless to say, a key ingredient is that one wants to do this in the first place. Many scientists don’t and some even have frank disdain for it.

It is perhaps not surprising that those skilled at this can do it as readily in casual conversation in with laypersons as in a prepared talk or written article for such an audience. At a dinner party in the mid-1970s my wife asked one of the guests what he did professionally. He said “I work on lipids in the bloodstream.” She replied “And…?” He said, “Certain ones are elevated in some people and cause disease—we are trying to understand why but we don’t know yet.” This was Donald Frederickson, soon to become NIH Director, speaking to a marine biologist in a mixed crowd about familial hypercholesterolemia, notably Tangier disease, without any need to employ those or other shoptalk terms.

AIMING BEYOND

Many scientists quite willing and able to write for or speak to a lay audience about their own work, balk
when asked to address a broader dimension of their fields or science itself, the latter being the most challenging but often the most noble as to purpose. Let us now look at some paragon cases of scientists who moved out beyond their immediate expertise and became statespersons of science for general audiences. Readers will understand that space does not allow presentation of a fully developed slate.

**Louis Pasteur** (Fig. 1). In his unsurpassed biography (7) Rene Dubos wrote: “Pasteur, as we shall see, was also to become involved in many public debates and in demonstrations of technical problems to laymen and artisans. When, in 1861, he delivered in the Sorbonne his famous lecture on spontaneous generation, one could recognize in the audience such celebrities as Victor Duruy, Alexandre Dumas senior, George Sand, Princess Mathilde. A few years later, a farm at Pouilly le Fort became a center of international interest—when journalists and scientists, as well as farmers, assembled there to witness the demonstration that sheep could be immunized against anthrax. Medical science had become front-page news.” Later, when he had become a “statesman,” Pasteur wrote and spoke more broadly, and it was worth waiting for. Consider these words from a pamphlet he published in 1868:

*Take interest, I beseech you, in those sacred institutions which we designate under the expressive name of laboratories. Demand that they be multiplied and adorned, they are the temples of wealth and of the future. There it is that humanity grows, becomes stronger and better. There it learns to read in the works of nature, symbols of progress and of universal harmony, whereas the works of mankind are too often those of fanaticism and destruction (8).*

How gorgeously expressed, and how prescient. Pasteur had by then gone far beyond his lab to play on a very large stage, to his credit and to science’s good fortune.

**Margaret Mead** (Fig. 2). Anthropology had seen only one entrepreneur in the public eye before Margaret Mead—her mentor Franz Boas. He never became a household word, but she did. Two factors played into this. One was the public’s fascination with a discovered and “unspoiled” native culture and Mead’s interpretation of how their culture shaped adolescence and adulthood. The second factor was Mead’s skill as a writer and orator. Her powerful ego and commanding presence shaped the public’s reaction. In her later years she used a cane and often waved it at opponents as if it were her index finger. After her death, Mead’s claims were subjected to intense debate but a consensus now prevails that she got the story quite right. She stands as a memorable figure in conveying not only anthropology, but discovery to the public.

**Stephen Jay Gould** (Fig. 3). In an enduring run of monthly columns for an audience of biologists and through a great many books for the general public, Stephen Jay Gould displayed an artistry of expository style that has never been excelled in biology’s modern era. Although his Harvard colleague Ernst Mayr was often called, in his mature career, “the greatest biologist in the world,” he did not reach the public audience to anywhere the extent of Gould’s penetration. Rarely resorting to metaphor or standard methods of “science writing,” Gould wrote about biology and evolution as a combined microscopic observer, agent of synthesis, conveyer of conceptual coherence, and natural philosopher. Reading him, or listening to him lecture, one had the sense that he didn’t even ponder what was going to come out—it was all just there. Including him in this list is almost illegitimate because he was so magically gifted that how he did it may not be that
instructive to mortals. But to omit him from this list would be unthinkable.

**Lewis Thomas (Fig. 4).** Someone who is a physician, a biology watcher, and a gifted writer comes along very rarely. Lewis Thomas was without equal as a master of explaining how biological and biomedical science arises and is done. Some observers, though admirers, were somewhat puzzled that many of his writings were not on medicine *per se* (e.g., Ref. 9). But he perfectly understood that disease is biology and thus its clues can be found everywhere, even on the seashore. I once had the pleasure of hosting him for a visit and talk. The half hour before, in my office, he shared his philosophy and career motivations with surprising candor on this, our first meeting, and with expressive passion. I got a sense of why, and how, he had been able, and inclined, to make such a truly memorable impact through his writings for a broad audience.

**Carl Sagan (Fig. 5).** Together with Gould and Thomas, there is no one in our time who more exemplified, indeed defined, the art of conveying science to the public than Carl Sagan. He did not confine this rhapsody to his fields of expertise, geology and cosmology, but extended it as a metaphor about the passion for discovery, in any field. His eloquence in writing was formidable but his style and bearing as a speaker was even more so. Some of his peers viewed his connectivity with lay audiences as a lack of professional bearing and he may have paid prices for this in certain honors he did not get. I have long pondered his career and character and suspect that some of his detractors recognized that he was doing something that they could not do, or had not the grit to try. Knowing what a true wonder he was, preaching the joy of discovery, I invited him to come to the Worcester Foundation and address our constituency. His letter declining the invitation was gracious but all the more remarkable because he took the time to write and send it, to someone he did not even know, just weeks before his death.

**Mahlon Hoagland (Fig. 6).** A biochemist who achieved early success in an abbreviated research career, discovering the amino acid activation step in protein synthesis and transfer RNA, Hoagland was possessed, almost demonically, by a passionate desire to excite laypersons about science and had an exceptionally effective gift for engaging the public. In contrast to Gould, he employed analogy as a constant device, always effectively. More than any scientist I have known, he had a zeal for reaching the public that exceeded his desire to reach (and comport with) his peers in biochemistry. His books for the public (e.g., Ref. 10) rival his early scientific work in defining his legacy (11).

**Rachel Carson (Fig. 7).** Here was a rare case of a scientist writing for the public. There was no book tour or appearances on TV talk shows. And yet, the impact
of *Silent Spring* was more powerful than she, her publisher or anyone else had anticipated. Her breakthrough discovery hadn’t involved infrared spectroscopy or the like. Rather, she had noted a reduced level of birdsong over successive years and from this made an inspired, inductive leap. Much of readers’ admiration for her and her book, and there was high admiration for both, was due to their preparedness to understand the “simple” observation she had made. As to style, she wrote in a hybrid of dry, observational prose combined with a passionate vision. The impact of *Silent Spring* was due less to the author’s skill as a writer than the audience’s immediate sense of the plausibility of her case. She and the book were not without detractors, notably the chemical industry and their lobbyists. When taking our grandchildren through the National Museum of Natural History during their Washington school vacation in April we saw that Rachel Carson holds a prominent display position. Nearby that museum, on K Street, lobbyists come and go, while she lives on.

Richard Feynman (Fig. 8). There was no one ever quite like Feynman either in physics or science. His inclusion in this “pantheon” is somewhat awkward because his writings for the public were mostly autobiographical and I said at the outset that this form of writing would be excluded. But he never wrote a true autobiography. Rather, he wrote vignettes and perspectives dispersed over many books, generating a deeper glimpse of him than a “standard” autobiography might have. Few physicists have displayed as great a zeal for “wanting to explain” (to the general public) their work as did Feynman. His writing style was choppy and would not have earned him the same distinction in literature as Stockholm awarded him in physics. But he vividly conveyed to lay readers the process of science (including the habit of intense skepticism, as he made famous when serving on the panel investigating the *Challenger* space launch...
accident) as well as anyone has in our collective memory, while also often brilliantly explaining the findings of science. In one of his books for the public he explained quantum theory via the famous analogy of photons passing through a slit under two observational conditions in a way that led me to grasp the idea, at least to some degree, for the very first time, and many other non-physicists have had the same sense of suddenly grasping this (difficult) concept. Feynman was also unrivaled in combining humor with an uncommon quirkiness, to consistent effectiveness.

CODA

The inclination and even the ability to “leave” one’s discipline and reach out to the public are within the reach of many more scientists than ever try. As mentioned, there is little in our training to prepare us, or even give us a hint, for addressing lay audiences about our work or about science as a profession or process. The best practitioners of this will always be those with a pre-existing bent toward story-telling. Second, at least from my experience, it seems that getting a sense of enjoyment from first addressing a lay audience is a positive indicator.

When this all comes to fruition, a scientist finally dares to address a lay audience. I remember another of my first tries. Unlike the trustee meeting I mentioned, in this case scientist peers were in the audience. Their reaction was mixed. For one thing, they had not ever seen me wearing a tie before. After the talk, a scientist in the audience came up to the rostrum and said, “You should have shown data.” But then another peer said, “I couldn’t do what you just did.” (I replied: “I couldn’t either when I was at your stage”). We should all contemplate trying, and if it feels good, dear friends, please keep at it. It is the other side of our profession, and we get there via the corpus callosum, as a contralateral catalyst whose conductive cooperation awaits our input from the other side. This art is all about metaphor, from the Latin, meaning “carry to the middle,” and so it is to the middle of our brain that our first drafts go. May all who choose this challenge continue to strive to achieve it—and be found in translation.

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Found in Translation: Crossing the Corpus Callosum to Explain Science

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