

OPINION

When All the Giants Are Gone

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It is one of the most often repeated aphorisms in the history of science: “If I have seen further it is by standing on the shoulders of giants.” Although this form of the aphorism can be attributed to Sir Isaac Newton, the actual sentiment can be traced at least to the Middle Ages, suggesting that Newton was standing on others’ shoulders not only in his science but in his reflections upon science (Merton, 1993). This opinion piece is about the giants of neuroscience and was motivated by three things. The first was my reading of Michael Gazzaniga’s recent memoir, *Tales from Both Sides of the Brain: A Life in Neuroscience* (2014). I was amazed by the scope of the scientific life it described. The second was the recent announcement by the neurologist, Oliver Sacks (2015), that he has terminal cancer¹. The announcement, which appeared as an op-ed piece in the New York Times, was widely praised for its candor (<http://nyti.ms/17u5LNP>). And the third was my reading of the obituaries page on the SfN website: <http://www.sfn.org/member-center/member-obituaries>.

Among other names, I found the following (in alphabetical order): Ted Bullock, Gerald Edelman, David Hubel, Robert Galambos, Patricia Goldman-Rakic, Andrew Huxley, Rita Levi-Montalcini², Vernon Mountcastle, and Richard Thompson. These were some of the giants of our modern era of neuroscience, and it got me thinking: What happens when all of the giants are gone?

One possible answer to this question is, perhaps, very little. Anyone who knew these scientists personally will certainly feel their loss more acutely, but the rest of us, who knew them primarily through their works, might go on largely as before. For many of us, what made these giants giant after all were their ideas. These ideas have been and likely will be the points of leverage for future generations of neuroscientists and neuroscience educators. While we might mourn their passing, we can take comfort in their scientific and programmatic legacies. It is also possible that just as there always have been giants, there will always be giants. Paul Simon, a giant of popular music, once wrote, “...every generation throws a hero up the pop charts” (Motloheloa and Simon, 1986). Perhaps my motivation for this opinion is misguided and reflects a confusion of “our giants of neuroscience” and “the giants of neuroscience.” Have I begged the question? Did Galvani and Cajal yearn for the good old days, too?

I am not convinced that the loss of this generation’s giants will be so inconsequential, continuance of their ideas notwithstanding. Hume might urge us to be wary of the fallacy of induction. In this context he might say that just because we have had a long history of new giants in neuroscience up to the present (and it is hard to say where such a lineage would begin), there is no promise of more giants in the future. There will undoubtedly be many

productive, respected, and even celebrated scientists to come, but will they be equal to the measure of the giants who came before? Inspired by Thomas Kuhn (1996), I propose that what leads to the establishment of a giant is radical change or, in Kuhn’s words, scientific revolution. A fledgling science, as neuroscience was in the 1950s and 60s, is all revolution. For example, Hodgkin and Huxley’s characterization of action potential propagation (1952), Levi-Montalcini’s work with nerve growth factor (Levi-Montalcini and Angeletti, 1968), Hubel and Wiesel’s studies in the physiology of the visual cortex (1962), Sperry and Gazzaniga’s research with split brain patients (Gazzaniga et al., 1965), and Kandel’s discoveries concerning the neurobiology of memory (Kandel, 2001) were transformative for the discipline as a whole and served to establish several distinct fields within it. Although the following remark was made about another discipline, neuroscience might also be described as having “...a long past and a short history” (Ebbinghaus, 1908; as cited in Fancher and Rutherford, 2012). We’re at an interesting point in the discipline’s modern period. Just 44 years on from the establishment of the Society for Neuroscience (SfN), the discipline has grown tremendously, and yet many who were there at the outset are still with us. But this is changing, as evidenced by the fact that the names of several presidents of SfN can be found in the opening paragraph. Despite this short history, neuroscience might now be sufficiently mature that its activities could be characterized as “normal science” (Kuhn, 1996). I propose that absent the upheavals that mark the emergence of a discipline, periods of normal science are unlikely to be as conducive to the creation of new giants.

Eric Kandel was once asked whether it was easier to start a career in science now than it was 50 years ago (Kandel, 2005). His response, likely to the surprise of very few, was:

“Actually it is much more difficult. It was much easier in my day – there was more funding and almost any person who was at all competent didn’t have to worry about funding. There are more people in science now and it is much more competitive, the reviewing bodies, with the exception of the Howard Hughes Medical Institute, are very cautious. Before you get supported for a particular project, you have to show that you are able to do it – which is a bit ridiculous. (p. 302; emphasis added)”

We can have talent and drive in abundance but in a time of normal science, with its associated conservatism, it is more difficult for it to find full expression. Similar sentiments were offered by Gazzaniga (2014) who claimed that he was simply the right person, in the right place, at the right time. Being the right person in the right place might not

suffice if it is just not the right time; it seems to be the trinity or bust. I'm not suggesting that in an era of normal science there is a moratorium on new discoveries, new revolutions, and new giants, but I would argue that we might now be in a diminishing age of plenty.

This brings me to an uncertain conclusion. Although some of what made our giants so important to the establishment of our discipline was beyond their control (we might call it luck), the fact remains that the fields to which we have been drawn were products of their talents, efforts, and good fortunes. The question I began this opinion with was: What happens when all the giants are gone? You've probably noticed that I haven't yet addressed this question. Instead, I have simply advanced my prediction that eventually they will be gone and that, given the nature of normal science, they are unlikely to be replaced in like number or in equal stature. Honestly, I'm not sure what happens when they're gone but I will admit that I have been thinking a lot about it lately. One day, in the not-so-distant future, there will come a generation of neuroscientists who will never have the opportunity to attend a lecture offered by one of these giants or, better yet, happen upon one while waiting for a flight home after a meeting. I'm being nostalgic, yes. But if it's not *just* a matter of nostalgia, there will be something different about our discipline and little if anything we can do about it.

I began the previous paragraph by saying that my conclusion was *uncertain*. One part of my conclusion is absolutely certain, however, and I'll leave it to one of my favorite giants, the neurologist Oliver Sacks (2015), to explain how:

"I have been increasingly conscious, for the last 10 years or so, of deaths among my contemporaries. My generation is on the way out, and each death I have felt as an abruption, a tearing away of part of myself. There will be no one like us when we are gone, but then there is no one like anyone else, ever. When people die, they cannot be replaced. They leave holes that cannot be filled, for it is the fate — the genetic and neural fate — of every human being to be a unique individual, to find his own path, to live his own life, to die his own death."

With reflections like that, he is one giant who may have grown a little more in my estimation, even now. But the uncertain part of my conclusion is that it is hard to say what this will mean for neuroscience. It's easy to take giants and their discoveries for granted. After all, what was at first a revolutionary insight can quickly become textbook gospel. Consider again the aphorism that began this opinion, "If I have seen further it is by standing on the shoulders of giants." Newton's point was that the advances of one generation are made possible by the advances of preceding generations. Scientific giants are meant to be surpassed. I think this is true in a technical sense, for example, in the way that a foundational

understanding of action potential propagation allowed us to see further. But I also think this is true in an inspirational sense, where previous discoveries—and those who made them—make us *want* to see further. My concern is that as the giants of previous generations become increasingly remote from our memories and those of the present generation achieve the more modest stature normal science allows³, the next generation will be content to simply rub shoulders, rather than stand upon them.

¹ Sacks died August 30, 2015, after this manuscript had been submitted.

² It is worth noting that on the author's template for this journal the authors of the sample paper are Rita L. Neurotrophin, Eric Aplysia, and Santiago R. Anatomy.

³ I appreciate that I have been fairly one-sided in my treatment of this issue and that there are arguments to be made in favor of a scientific community with fewer giants. Some giants, like large trees in a forest, can stunt the development of those in the generations that follow.

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