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THE SHOULDERS OF GIANTS

ILLUSTRATION: ALLAN M. BURCH

DARA HORN *is an undergraduate at Harvard University studying comparative literature. She is currently working with astronomer Margaret J. Geller on a documentary about Cecilia Payne-Gaposchkin.*

I have always been fascinated by scientists, because they appear to be the only people in the world who are immune to personal pettiness. Most people's careers are based on getting ahead, perhaps even at the expense of others. The scientists' goals, on the other hand, are not personal but collective. We imagine that their work is exclusively dedicated to the betterment of humankind.

As a student of literature, I am often asked to consider the life stories, motives, and intentions of the authors whose work I examine. If I were studying politics or history, I would concern myself even more about the personal conduct of the people I studied. But while a juicy biography of Darwin or Einstein would certainly make a good read, there exists a widespread belief among nonscientists that the motivations of researchers are secondary to their discoveries. Scientists are somehow outside of society, freed from its concerns in order to pursue knowledge for us all, or so those of us who are not scientists like to believe.

I imagine that most essays in this series will address the effects of science on society, whether good or bad. But the story I am about to tell demonstrates the effects of society on science—effects that have the potential to be very damaging. In 1925, a 25-year-old graduate student at Harvard discovered what the universe is made of. It was one of the most astonishing discoveries in the history of astronomic research. The problem was that no one believed her.

You have probably never heard of British-born Cecilia H. Payne (later Cecilia Payne-Gaposchkin), who in 1923 came to the United States to study stellar spectra at the Harvard College Observatory. In a remarkably short time, Payne managed to quantify and classify the stellar spectra in the plate collection at the Observatory, arriving at the startling conclusion that stars are "amazingly uniform" in their composition, and that hydrogen is millions of times more abundant than any other element in the universe. Her doctoral dissertation, *Stellar Atmospheres* (1925), demonstrated her theory concerning the chemical composition of stars and earned her the first doctoral degree ever offered to either man or woman by Harvard's astronomy department. A few years later, Otto Struve, an eminent astronomer, called it "the most brilliant Ph.D. thesis ever written" (p. 20).*

But in 1925, other scholars in the field were less impressed—or, perhaps, less courageous. Most astronomers at the time believed that stars are made of heavy elements. When her manuscript was presented to Henry Norris Russell, the leading contemporary astronomer dealing with stellar spectra, he wrote that her ideas concerning hydrogen's prevalence were "impossible" (p. 19). The director of Harvard's Observatory, Harlow Shapley, trusted Russell and convinced Payne to dilute her conclusion substantially. By the end of these machinations, Payne, despite the data in her thesis, asserted in writing that the abundance of hydrogen that she had detected was "almost certainly not real" (p. 20). Later, the same scholars who had led her to weaken her thesis steered her away from continuing her work on the Observatory's spectra, the area where she had demonstrated both promise and brilliance. At the Observatory she was pitted against one of Russell's students, thereby impeding the progress of both, and her research was redirected toward photometry and variable stars, which she studied for the rest of her career. Four years later, Russell published a paper of his own announcing that the sun is made mostly of hydrogen.

Payne-Gaposchkin eventually became Harvard's first female tenured professor and later the first female department chair, but her "promotion" did not come until 1956, when a new observatory director finally conceded that she deserved the position and a new university president finally permitted it. She had been passed over for positions several times; once, when the Observatory sought to fill a professorship, Shapley, unable to acknowledge the fact that one was standing in front of him, said to her, "What this Observatory needs is a spectroscopist" (p. 223). But by then, at Russell's suggestion, she had already been "pushed against my will into photometry" (p. 223).

Since her death in 1979, the woman who discovered what the universe is made of has not so much as received a memorial plaque. Her newspaper obituaries do not mention her greatest discovery. Even today, when it has become fashionable for historians to highlight the accomplishments of great female scientists, other astronomers are given precedence, or her name is listed as merely one of many. But there is no need to visit an Astronomy Hall of Fame to see how faint the memory of Payne-Gaposchkin has become. A glance at any elementary physical science textbook will do the trick. Every high school student knows that Isaac Newton discovered gravity, that Charles Darwin discovered evolution, and that Albert Einstein discovered the relativity of time. But when it comes to the composition of our universe, the textbooks simply say that the most abundant atom in the universe is hydrogen. And no one ever wonders how we know.

I believe that Payne-Gaposchkin's work on stellar spectra was stopped in its tracks by three factors that had absolutely nothing to do with astronomy: She was a woman, she was young, and she was outstanding. The first and second of these

The author is at Harvard University, Cambridge, MA 02138, USA.

*All quotations are from Cecilia Payne-Gaposchkin, *Cecilia Payne-Gaposchkin: An Autobiography and Other Writings*, K. Haramundanis, Ed. (Cambridge Univ. Press, Cambridge, ed. 2, 1986).

factors led other people to underestimate her, either by mistaking her genius for foolishness or by assuming (and perhaps even hoping) that she could not possibly be capable of doing what she did. The third, the brilliance that placed her research beyond the understanding of those who were supposedly older and wiser, ultimately made her underestimate herself—a fact that she acknowledged later in life. Long after the 1920s, when Otto Struve began working on a history of astrophysics, he offered to include her prior discovery of a particular effect in stellar spectra. But Payne-Gaposchkin was too angry with herself to accept. "I was to blame for not having pressed my point," she insisted. "I had given into authority when I believed I was right. That is another example of How Not To Do Research" (p. 169). Her marriage to astronomer Sergei Gaposchkin seems to have made her even more vulnerable. His work was in variable stars, and Payne-Gaposchkin soon found herself devoting almost all of her research to that field. This, in addition to the challenge of raising their two children, caused her to abandon spectroscopy altogether. In her autobiography, however, she rarely expresses frustration with anyone other than herself.

But more than underestimation and disbelief were working against her. If Payne had merely been misunderstood, her colleagues would have surely encouraged her to continue working on stellar spectra once they realized that she was right. But they did not. Instead, even after the importance of her work had become obvious, Payne was still cajoled into abandoning her specialty. I do not believe that this stemmed from scientific concerns about the merit of her research, but from something simpler and more universal, an emotion that every scientist and nonscientist can understand.

Jealousy, when dressed in the guise of science, becomes much more destructive than usual, for it can curtail our knowledge of the world. We will probably never be able to confirm why Russell and Shaply made the decisions that they made. Yet it is clear that discrimination as well as personal bitterness precluded scientific progress at many levels throughout Payne-Gaposchkin's career. In Payne's case, one might argue that the public was lucky. Her revelation is ours, even if we do not know her name. But what of the discoveries that might have been made if she had continued working on stellar spectra for another 20 years? Can we even begin to estimate the magnitude of the loss?

Like most people, I have almost no scientific training. What I know about scientific research comes from newspapers, magazines, television programs, and a few ill-remembered high school chemistry classes. But like most people, I have been taught to see science as an entirely pure and objective pursuit of knowledge, embarked upon for the benefit of people like me. This assumption may be ridiculous. Yet as knowledge expands beyond my grasp, it is an assumption that I have to make in order to avoid living in a state of perpetual and paralyzing doubt.

So if I read in the newspaper that a fat-substitute is safe for consumption, I do not question it. If a television program tells me that no one will ever find a cure for a particular disease, I believe it. If my college textbook explains to me that the universe is made of hydrogen, but does not tell me who discovered it, I trust that this fact was so obvious that it did not even need to be discovered. Along with millions of others, I have placed my faith in scientists—not because I am dull-witted, but because their pursuit is reputed to be noble and disinterested, unmarred by the jealousies and desires that motivate most of us. Perhaps I am naïve, but then so are many others. If scientists let us down, we will not know it.

The greatest loss to scientific research does not come from anything inherent in science, but rather from something inherent in society: our love of stars, particularly metaphoric ones. As students, we learn to associate the phenomena of our world with the names of the people who discovered them, never with their personalities, or with their networks of teachers and fellow researchers, or with their bibliographies of works upon which they built their own. On the elementary level, evolution is not taught as evolution, but as Darwinian evolution. We do not study relativity, but Einstein's theory of relativity. Our textbooks supply us with Planck's constant, Avogadro's number, and Newton's laws. Scarcely a theorem exists without someone's name attached to it, regardless of how many people may have contributed to it.

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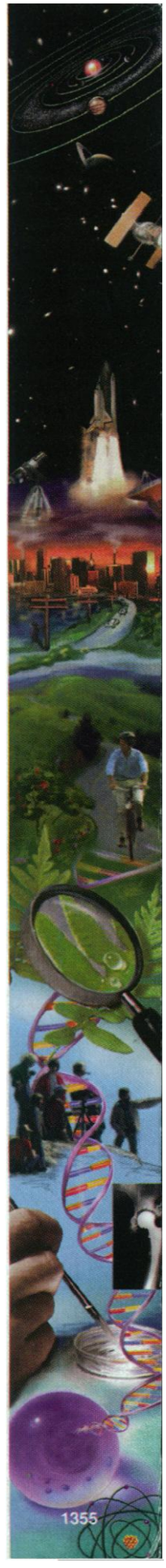
After spending so many years listening to the great geniuses' names repeated again and again, a young student entering the sciences might understandably believe that the supreme goal of the scientist is not to reach for the stars, but rather to become one. After all, among the constellations of scientific giants, do we ever see the light of their instructors, or their colleagues, or those who were their inspirations? Isaac Newton once said of himself, "If I have seen further than other men, it is because I have stood upon the shoulders of giants." But what happens when no one is content to offer his shoulders?

I am not in a position to judge how typical or unusual Payne-Gaposchkin's experience might be in the research of today. Nevertheless, I urge scientists to aspire to that which the rest of us already assume is taking place: to ensure that research is not just a solitary effort geared toward individual reward, but a joint effort to push back the boundaries of knowledge. That should be the highest and most impassioned goal. As the sciences become more specialized, "stardom" will become more elusive. Scientists will then be faced with a choice: to become more competitive in their quest for glory or to become more sincere in their quest for truth. The most crucial contributions to knowledge do not only come from those who make revolutionary revelations, but also from those who know how to appreciate and nurture the talents of others.

Cecilia Payne-Gaposchkin writes in her autobiography that she hopes to be remembered for what she considers her greatest discovery: "I have come to know that a problem does not belong to me, or to my team, or to my Observatory, or to my country; it belongs to the world" (p. 162). The shoulders of that discovery are the only ones strong enough to support us.



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