

Jo Handelsman: Adviser, Teacher, Role Model, Friend

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Effective mentoring can be learned, but not taught. Good mentors discover their own objectives, methods, and style by mentoring. And mentoring. And mentoring some more.

Jo Handelsman and colleagues, *Entering Mentoring: A Seminar To Train a New Generation of Scientists* (1)

During the time I spent as a postdoc in the lab of Dr. Jo Handelsman (2002 to 2006) at the University of Wisconsin, we frequently discussed issues encountered while mentoring undergraduate scientists. A common theme throughout those talks was the title of the National Academy Press book *Adviser, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering* (2). We asked ourselves, is an effective mentor really able to be an adviser, teacher, role model, and a friend? Which attribute is most important? Are they all critical to a productive mentoring relationship? These intriguing conversations each illuminated different parts of the mentor-mentee relationship. Because Jo exemplifies all of these and more with each of her trainees, I had the fortune of learning by example. My time in her lab was paramount to my development as a scientist, and more than a decade later, I can honestly say that I am most grateful for what she taught me about mentoring (Fig. 1).

The morning of my thesis defense in November of 2001, I emailed Jo Handelsman to ask for a position as a postdoctoral trainee in her lab in the

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Figure 1 Jo Handelsman mentoring former graduate student Zakee Sabree in her laboratory at the University of Wisconsin. Zakee is an assistant professor in the Department of Evolution, Ecology and Organismal Biology at the Ohio State University. Photograph credit: Jeff Miller, University of Wisconsin-Madison (<http://www.hhmi.org/news/howard-hughes-medical-institutes-million-dollar-professors-0>).

Department of Plant Pathology at the University of Wisconsin. As I look back on my nondescript email, I find it amazing that I got a response only an hour later wishing me good luck and telling me to give her a call once I had calmed down from the defense. A few months after “cold-emailing” her, I drove my young family to Madison to start my position in Jo’s lab.

I was interested in Jo’s lab because I was intrigued by her use of metagenomics—a word that she coined for an approach that her research group had been using to study the treasure trove of microbial natural products in soil (3, 4). Although today we tend to think of metagenomics as shotgun sequencing of DNA from an environmental sample, her initial work described how she and her team could assess the genomic and functional characteristics of uncultured bacteria. They were able to clone DNA from uncultured populations and coerce other commonly used species, usually *Escherichia coli*, to express the foreign genes so they could be studied in the context of a biological system. At the time, sequencing was quite expensive and we needed to be selective about what we sequenced. Jo’s group used genetic selections and screens to identify the cloned DNA that they would sequence. Others, most notably Ed DeLong, sequenced DNA fragments cloned into fosmids that harbored rRNA genes, a process that led to the discovery of bacteriorhodopsins in the ocean (5). Later, Jill Banfield’s lab

pioneered shotgun sequencing using bulk samples of community DNA, thereby leading to what most think of as modern-day metagenomics (6). Jo's lab pioneered their functional approach by sequencing the cloned DNA after demonstrating that it conferred a desirable function on *E. coli*. Typically the gene products included enzymes like proteases or lipases, but Jo's passion was, and continues to be, the discovery of novel antibiotics and antibiotic resistance genes. It's funny how things worked out; despite joining Jo's lab to learn and apply her brand of metagenomics, I never built my own metagenomic libraries or attempted to find any novel enzymes or small molecules.

Only after I joined her lab did I learn that Jo is also a person who thinks deeply about what it means to be a teacher and mentor. In recognition of this, shortly after I joined Jo's lab, she was named a Howard Hughes Medical Institute (HHMI) Professor and given a mandate to develop instructional materials related to scientific teaching and mentorship. One of the resources that Jo would use with trainees when discussing how to mentor undergraduates in a laboratory setting was a book published by the National Academy Press, *Adviser, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering* (2). Now, after more than 15 years and as a professor myself, I mentor junior scientists and help them to plan their careers. I regularly think about these attributes in my own relationships with my trainees and hope that they can see them in our interactions. As I think back on Jo's role as my mentor and as a mentor to others, I can see that she has been an adviser, a teacher, a role model, and a friend.

ADVISER

In the mentoring workshop sessions that Jo facilitated, we would frequently discuss that mentoring can go in two directions. A mentor should provide good advice to their mentee on such topics that include the direction of their project, career development, and integration into their professional network. But sometimes, it is important for a mentee to know how to mentor their mentor, to nudge the mentor to provide feedback on a manuscript and remain engaged in the mentee's project, and perhaps to help focus the mentor's attention on what is truly important.

During my time in Jo's lab there was a point when I was struggling to make sense of metrics for measuring the diversity of microbial communities. We were interested in finding the total number of bacterial taxa in soil by sampling the lowest number of 16S rRNA sequences required to detect low-abundance taxa. The main problem with such an approach is that it is difficult to validate the solution, and thereby the methods, without already

having a solution in hand. Not making much headway on the problem, I started hiding in fear that Jo would corner me and ask why I had not made more progress on the project.

Since I did not trust my programming abilities or myself, I started using the word usage distribution in books to effectively ask, “How far would I have to read to know the number of different words in a book?” I started with *Goodnight, Moon*, because I had been reading it multiple times each night to my daughter and had memorized the book. After about 3 weeks, Jo popped her head in my office and asked, “How are things going?” I felt embarrassed to admit the truth.

I told Jo about integrating *Goodnight, Moon* into my research, and she loved the idea on the condition that I also included her favorite book, *The Portrait of a Lady*. From that point forward, she actively encouraged me to push the “books model” as a way to think about bacterial community diversity. We eventually published the model, and many educators have since told me how they have used it to teach their students about microbial community diversity (7). Years later, Jo was awarded the D. C. White Research and Mentoring Award for excellence in mentoring at the 2011 ASM General Meeting. I was late to her talk. As I walked into the packed room, and without missing a beat, I heard Jo say, “Coming into the room right now is the author of this model.” Jo was on a slide describing the books model. Where another adviser might have told me that the idea was silly, Jo embraced it and encouraged me to think of accessible models that people can use to understand abstract ideas.

Just as Jo was effective at mentoring her trainees, I frequently heard stories of Jo mentoring administrators who she would normally look to for mentoring. In one instance, she met with Harvard president Larry Summers after he made disparaging comments about the ability of women to do math. By all accounts, she was able to have a frank but constructive conversation on how to meaningfully empower female faculty and students on his campus. Afterwards, she was able to take this experience and turn it into a published policy statement (8).

What stands out to me the most about her role as an adviser, however, was that between 2014 and 2017, Jo served the Obama administration as the Associate Director for Science in the Office of Science and Technology Policy (OSTP). In an interview at the 2017 Microbe meeting (Fig. 2), Jo commented that a highlight of this position was the opportunities she had to engage President Obama in discussions about science (9). (Watch the interview with Jo here: http://bit.ly/WIM_Handelsman.) She recounted



Figure 2 Jo Handelsman talks with her former trainees Patrick Schloss, Nichole Broderick, and Courtney Robinson at the 2017 Microbe Meeting in New Orleans. The three are currently tenure-track faculty at the University of Michigan, the University of Connecticut, and Howard University.

that when the administration was coming to a close and she went to say good-bye to the President, he thanked her for teaching him about science and for “his microbes.” Whenever Jo would go to brief the President on some policy, she would take a stuffed microbe for his collection. Whether it was to discuss biodefense (e.g., Black Death) or climate change (e.g., cyanobacteria), she would give him a memento to remember their conversation. In these discussions, the President engaged Jo in a conversation linking back to the other microbes she had brought him. The effectiveness of this exchange would be on display when the President then used the stuffed microbes to tell others about the science. At OSTP, Jo was able to “mentor up” for many of the policies in science that were important to her, including preserving the integrity of soil and demonstrating that many of our supposed science-driven forensic techniques were biased and anything but scientific. Just as Jo encouraged me to break down complex problems into simple concepts that may seem silly to others, she had used the same approach to advise and teach President Obama.

TEACHER

The typical postdoctoral trainee receives minimal practice honing his or her teaching skills. Again, because of her HHMI Professorship, I was able to

benefit from the concept of “scientific teaching” that Jo developed at the University of Wisconsin and later at Yale University (10). As she and her colleagues would state in a Policy Forum article in *Science*, scientific teaching is “teaching that mirrors science at its best—experimental, rigorous, and based on evidence” (11). Talking with Jo about teaching, it becomes clear that her command of the educational literature is on par with her command of the microbial ecology literature. She would frequently question why we worked so tirelessly to follow the scientific method in our research, but as soon as we stepped foot in the classroom, we would shun the same tools—the literature and experimentation—that make us successful in the laboratory. She practiced what she taught: integrating an educational evaluator into all of her work and publishing the results of her “Entering Mentoring” and “Scientific Teaching” workshops (11, 12). The concept that scientists should scientifically teach science left an indelible mark on me as an educator. A curriculum becomes a series of experiments rather than lecture notes that are etched in stone. Seeing teaching as a series of experiments also takes a considerable burden off the instructor; we should expect some of the experiments to fail and some to succeed. Over time, the instructional materials improve because we start asking the right questions.

As Jo and her colleagues lay out, effective instructional materials should also allow students to see the scientific method at work (10). Laboratory exercises should not be a series of “cookbook” lessons where the instructor knows the answer ahead of time because in a research environment, scientists rarely know the answer ahead of time. I remember the first time I saw Jo break down an effective lesson plan on the topic of bacterial ice nucleation. The first step was to identify the preconceived misconceptions that students had. As a 20-something with a Ph.D., I just *knew* that water froze at 0°C. Jo then had us measure the temperature of the liquid water in test tubes sitting in our ice buckets. The temperatures were just below 0°C. Then we dropped a culture of *Pseudomonas syringae* into the tubes—the water froze solid. Even today, watching YouTube videos of others dropping *P. syringae* into water and seeing it flash freeze makes me excited (13). She then challenged us to take this lesson, which she intentionally taught us in a cookbook manner, and convert it into a student-driven laboratory exercise using other things we found around the room. From this seed of a lesson plan we could see the value of educational concepts such as constructivism, active learning, and, most importantly, scientific teaching.

I was quite taken by the concept of scientific teaching. When I started to plan the research talk I would give while interviewing for faculty positions,

I realized that a research talk is really an opportunity to teach about what I have learned. With Jo's encouragement, my presentation involved handing out brown paper bags of M&Ms to people at the seminar. I would have them break into groups and define what would make up a species of candy. Then they had to determine how far to sample before they would know the number of candy species in the bag. Having seen the difficulty of the exercise, they were eager to hear how I approached the problem based on 16S rRNA gene sequences extracted from soil, feces, or any other environment. More than a decade later, people still come to me and tell me they remember this activity. The concept of scientific teaching is powerful and continues to have a significant impact on my teaching. It is also evident in the growing number of experiential laboratory activities, including the Small World Initiative that Jo started at Yale to have classrooms from around the world isolate bacteria from various environments to identify and characterize potential antibiotics (<http://www.smallworldinitiative.org>).

ROLE MODEL

While I was in Jo's research group, one had to walk through a bank of computers to get to her office. By sitting at these computers analyzing data, I benefited from overhearing Jo's conversations and having numerous informal opportunities to chat with Jo. Learning from Jo in this environment was unique and unscripted. She would ask people sitting in the computer room for their thoughts on writing, conversations from seminars would spill over, and there were numerous opportunities to expand our professional network by having Jo introduce us to other scientists who were visiting. This was one place where I would learn how important it was to Jo that her lab be diverse in terms of gender, racial, and cultural composition but also in terms of scientific background—not only because it was just but also because it allowed the group to answer questions in a way different from anyone else. I learned a lot about being a professor from sitting at those computers and watching Jo.

Aside from being the gateway to Jo's office, this room had another architectural component that was unique. Lining the walls of the room was every issue of the *Journal of Bacteriology* and *Applied and Environmental Microbiology*, two journals published by the American Society for Microbiology (ASM). ASM has taken on a special significance to me because of the importance Jo gave it both through the display of these journals and also because of her dedication as a reviewer and editor for *Applied and Environmental Microbiology* and then as President of ASM. She instilled in

me the belief that if I wanted the bioinformatics tools we developed to have the greatest possible audience, we should publish them in an ASM journal. With this example, I see serving the society as a reviewer, editor, and now Chair of the Journals Board as a great honor and privilege.

Another venue where Jo served as a role model to the members of her research group was through her tireless efforts to address gender and racial discrimination in science as a whole. Jo worked with a colleague from the Engineering school, Molly Carnes, to cofound and direct the Women in Science and Engineering Leadership Institute at the University of Wisconsin. Similar to the methods she extolled in scientific teaching, Jo used data-guided approaches to quantify bias and make suggestions to overcome it.

While I was a postdoc, Jo and her colleagues set out to demonstrate that the process used to nominate and select NIH Pioneer Award winners was plagued with biases against women (14). I still recall Jo sharing the work with us to demonstrate the power of our implicit biases. Later she would go on to show that male and female faculty express biases against female students in how they review identical application materials that were submitted with either a male or female name (15). She also partnered with the ASM to quantify the representation of female presenters at its meetings and develop a strategy for overcoming bias against female presenters. In the end, she was able to demonstrate that with very simple interventions it was possible to have a more equitable gender makeup of speakers (16). Issues of gender and racial bias raise important questions on college campuses. Through her passion for the issues involved and scientific approach, she has been a role model to many for how to engage these topics in a scientific and data-informed manner.

FRIEND

In our discussions of mentoring, “friend” was the most frequent role to raise eyebrows. Does someone really need to be your *friend* to be an effective mentor? Of the four, it is probably the least critical that your mentor is your friend. Needless to say, a mentoring relationship is considerably different when someone shares that bond of friendship or personal understanding with their mentor. During my time in Jo’s lab, I had a series of personal ups and downs: my wife gave birth to two children, my mom passed away, and we learned that one of my children was profoundly deaf. None of these should have necessarily impacted my research or career development. Regardless, Jo exhibited great empathy to share in my excitement and

frustrations when other friends would feel awkward bringing up the difficulties. Although she would regularly say, “See you in the morning!” on a Friday afternoon, she knew and appreciated the value of family and the importance of maintaining a work-life balance. Jo’s father lived in Madison and would regularly come into the lab to talk to Jo and members of the lab. His presence with Jo and the time Jo spent with him made clear the value that Jo placed on her family. Though it has been years since I left the lab, Jo still asks about my wife and children and can remember interacting with them while I was in her lab.

Friendships can withstand tension and grow stronger. During her time in the OSTP, Jo took on the herculean effort of bringing together government agencies, nonprofit organizations, and companies to launch the National Microbiome Initiative (17). No doubt to her annoyance, I took to Twitter to indicate that I thought that this was a bad idea. I nearly instantly got a message back saying, “What would you do differently?” and an opportunity to talk through my concerns on the phone. At the end of the conversation, I do not think we were any closer to agreeing on the benefits of big top-down team-based science versus a small bottom-up investigator-driven approach. Regardless, she encouraged me to write a letter to the editor of *Science* to describe what my concerns were with the initiative (18). Had there been no personal bond, Jo could have ignored me, but instead, our relationship was important enough to her to reach out to me and hear my thoughts. At the same time, as a former trainee, I learned that I could disagree with my mentor and not be punished. This is possible only if the mentor and mentee have a strong foundation of friendship and, with it, respect underlying their relationship.

MOVING ON

After leaving the OSTP, Jo decided to move her research group from Yale University back to the University of Wisconsin, where she is now the Director of the Wisconsin Institute for Discovery. Jo continues to train exceptional scientists who are benefiting enormously from her mentorship. Among the people in the research group while I was there, my colleagues and I are established as tenure-track faculty at the University of Michigan, Oklahoma University, Howard University, the Ohio State University, the University of Connecticut, the University of Kentucky, and Colorado State University. In addition, other trainees are researchers in labs across government agencies, industry, and academia. We all take with us the mentoring skills that we learned from being part of Jo’s group.

Mentoring is clearly important to Jo. If one were to take nothing else away from their interaction with Jo, they should appreciate the priority that she placed on trainees. Several years ago, I was invited by students to speak at their department's seminar series. It had been a busy year and I didn't really feel like going. I had been working very hard to limit the amount of travel I do to help maintain a work-life balance. When I told my wife about the invitation, she responded, "Well you have to go, right? Isn't that Jo's rule—if students invite you, then you go. Right?" And so, I went reminded of my mentor's training and my obligation to help the next generation of young scientists.

While Jo was working in the OSTP, she invited me to have lunch with her at the White House the next time I was in Washington, DC. I hadn't seen Jo in a number of years, and so I was little sheepish to go see her and was a bit overwhelmed at the prospect of being in the White House. As her previous meeting finished and I sat in a chair outside her office, those memories of sitting in the computer room outside her office all came back to me. As she greeted me, I felt obligated to show her some piece of data from the previous week or to update her on the latest draft of a manuscript. That bond of mentorship still remains long after I left her research group. Many have benefited enormously from Jo's mentorship, and it is our obligation to carry these lessons on.

CITATION

Schloss PD. 2018. Jo Handelsman: adviser, teacher, role model, friend, p 159–169. In Whitaker RJ, Barton HA (ed), *Women in Microbiology*. American Society for Microbiology, Washington, DC.

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