Inside the Literature: An Interview with Sally G. Hoskins, 2017 Recipient of the Elizabeth W. Jones Award for Excellence in Education

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The Genetics Society of America's Elizabeth W. Jones Award for Excellence in Education recognizes significant and sustained impact on genetics education. The 2017 recipient is Sally G. Hoskins, in recognition of her role in developing and promoting the transformative science education method CREATE (Consider, Read, Elucidate hypotheses, Analyze and interpret data, and Think of the next Experiment). This innovative approach uses primary literature to engage students, allowing them to experience for themselves the creativity and challenge of study design, analysis, interpretation, collaboration, and debate. Comprehensive evaluation of CREATE has consistently found that students improve in difficult-to-teach skills like critical thinking and experimental design, while showing improved attitudes and beliefs about science.

This is an abridged version of the interview. The full interview is available on the *Genes to Genomes* blog, at genestogenomes.org/hoskins/.

Why did you choose to focus on primary literature as a teaching mode?

CREATE came about because I had been giving out papers with the very poor approach of just saying to the students, "Read this." I would be miffed that they did not really have a lot to say about the paper. It is a big jump from reading textbooks to reading papers, and I had not helped them at all.

Then at one point while we were studying a paper, a follow-up paper came out, and I thought it would be cool for them to read it. But the second paper was so much easier for everyone that a lightbulb went on for me. Now everyone understood the set-up, and the technology, and the basic questions, and they also now cared about the questions. So, I realized it would be smart to do these papers in series. Then my collaborator Leslie Stevens and I further developed the idea by first figuring out how we had learned to read papers in grad school, and then codifying that process.

In general, textbooks are easier reading than the original papers because they simplify papers drastically. But when our students get out into the world, if they do science they are going to be reading papers, not textbooks. It is a skill that is worth learning, and it is not as hard as it looks, it is just that the jargon is so dense. CREATE turned out to be successful, and we have tweaked and expanded it in various ways. For example, we started it as an elective course for upper-level undergraduates, a focus course to be taken after you have taken your prerequisites. Then we realized that there are some advantages to introducing this kind of thinking and science literacy in the Freshman year, so we have a version of it for Freshmen.

What is the most rewarding aspect of your work?

The idea that you are teaching students transferable skills. You are teaching them approaches and learning strategies that they can apply to any future challenging or analytical task. Especially because biology is changing so fast. There is maybe 30 years' more stuff in Intro Bio than when I took it. But the semester is still the same length. So, if you do the math, it does not work! How can we keep putting more and more information into these 14-week semesters and expect the students to be able to learn it, retain it, and apply it? With CREATE we do not try to do that, we try to teach an analytical skill set and an attitude that you can take with you, along with a deeper understanding of both how research is done and the people behind the papers.

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I have run a lot of workshops with faculty from a wide range of institutions, and all of them say, "Yes, my students took multiple prerequisite courses, and no, they do not come into my class knowing what they *should* know from the prerequisite classes." So, I think something is wrong. Part of the reason may be that most college teachers, including myself, had no training in teaching or in the science of learning. This secret is well kept from people's parents: that their kids could be being taught by somebody who has never been in the classroom before; or even if "experienced," someone who lacks training. Your third-grade teacher has studied something about teaching and learning, and has student-taught and been observed in the classroom, and that is not true for most scientists. Things are changing, but still some college faculty have this boot camp kind of thinking: "Well I went through it (being taught only through lectures), so why can't you?" Maybe there is a better way. Maybe there is a way that would not just get students *through* biology, but also get them excited about it. Many people are working on this; our way is through in-depth analysis of primary literature.

Who have been your most important mentors?

My students. Because of the feedback you get about what is working and what is not. Let me give you an example. Around the time we started CREATE I had had a PhD for 20 years and had been teaching in college for 15 years, and I did not even know science education journals existed! That is how out of it I was. A colleague brought me a bag of books about teaching and learning and I realized, "Oh my gosh, people actually study this!"

Anyway, I read up, and I wrote a grant on my sabbatical. It was totally hypothetical, we did not have pilot data. But the grant reviewers really loved the idea and we got the money. We started teaching the course, and it immediately started flopping. It was not working at all. I did not understand. The grant reviewers had loved it, and we were doing what we said we would, so what was wrong? It turns out that when scientists read a methods section, they can visualize what happened. But when students "read" the methods section, they either were not really reading it or else they were not reading it with an eye toward picturing what went on in the lab. And when I added a "Sketching" step—where they draw in their notebook how the study was done in the lab or field to generate the data represented in each figure—that was when everything started to work. The class was much more lively, and people were "getting it" and having things to say, rather than just limping along or waiting for me to revert to a lecture. Discussing the data made much more sense once students "saw" where it came from.

But it was the students who revealed that there was a gap in the approach, and it turned out to be really key to the whole thing: we needed to add a visualization step.

What would you say to someone concerned about trying the CREATE approach?

Some faculty, especially (and understandably) if they are only evaluated through student reviews, are very afraid of students' negative reactions to *any* change in teaching. With CREATE we have generally had ~75–80% positive reaction. We have also always looked at both cognitive gains, like critical thinking or experimental design, and affective gains, like students' attitudes and epistemologies of science. I am really happy that we see significant positive changes in both.

There is a big issue with science education reform where people say, "I would like to change but I cannot because I have to cover content." But (a) covering is not teaching and (b) CREATE includes content! To really understand a paper, you have got to understand key content. A huge amount of content is reviewed and consolidated in a CREATE class, but it is *in context*. In fact, you have a lot of opportunities in a CREATE classroom to integrate the sciences, for example quickly reviewing some of the underlying principles of chemistry or physics that are associated with the experiment that you are studying.

Some people are also a bit iffy about the e-mail interviews of authors. But the things we learn from the interviews are profound. Elaine Ostrander was asked what happens if an experiment does not work, and students always assume the answer will be "Oh, I feel so bad, I want to die!" But there are many rejected hypotheses on the road to success, which is not something you really learn in many Intro Bio labs. So, when Elaine Ostrander got that question, she said something like, "If all your experiments work, then you really are not asking very interesting questions." Failure is a normal part of science. If I had learned that as a sophomore it would have changed me!

Another cool thing that happens with the e-mails is the insider information that you can get. We send the same questions to the grad students and postdocs as we do to the principal investigators. So, the e-mails really complement the deep understanding of the papers by putting context around it and making it clear that these studies are done by "real people" who remind my students of themselves, and not only by famous senior principal investigators.

Ultimately, for change in education you have to get the teachers to change what they do. And that is challenging because for many people teaching cannot be their number one focus. When we invented CREATE, we felt like we were really helping in that regard, in the sense that we were leveraging people's deep understanding of research that they did not get to bring to class because they were busy lecturing, lecturing, lecturing. You can switch over your upper-level elective to a CREATE course pretty easily, especially if the elective is in your area of expertise. I think it is valuable for students to realize that their faculty are serious researchers and not just PowerPoint presenters. I understand that there are multiple pressures on people these days, but I think this is a much more fun way to teach. It is not just that it is good for the students, there is a big payoff for the faculty as well. Unless you really love your PowerPoint.

What advice would you give to younger scientists?

Be bold! Do not try to do everything yourself. Be willing to collaborate and travel and meet people widely. It is

hard for every person to do every technique. Do not be shy about asking for help. I think one thing that comes out in the CREATE e-mails with scientists that I kind of like is that people come across as quite open and friendly. Students comment, "Wow, I didn't think she would answer in such detail," or "I didn't realize that scientists collaborated or that you could call somebody up and they would send you antibodies." So, I think as a young scientist you may not have realized that yourself; even if someone is a big shot, try to chat to them at a meeting or talk to their postdoc. Many people really enjoy sharing their knowledge.

And also, there are all kinds of ways to be a scientist, so if you do an undergrad research project, and you are not thrilled with bioinformatics, for example, there are a million other things you could do. One thing nice about CREATE is that you can teach diverse modules where, say, one is all about regeneration in *Planaria*, and one is all about behavior in ants and so on. Some people love doing field work, some people would never do field work, and some people would never sit and look through a microscope all day; there are distinct research options available for all these individuals. Intensively analyzing papers in different fields can give you a taste of what the work is like.