

# Letter to a Young Scientist

## *"From Marigolds to Molecules to Meaningful Learning"*

By STACEY LOWERY BRETZ, PhD

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**A**S A LITTLE GIRL, I CONSTANTLY ASKED MY parents and teachers the same two questions: Why did that happen? How did that happen? But being told the answers to my questions was oddly unsatisfying—I only wanted to know *how* the grown-ups came to know that. To the best of my knowledge, there were no predecessors to the *Next Generation Science Standards* when I was in elementary school in the 1970s. My earliest memory of knowing that “science” was a subject that I could learn in school was in fifth grade. I have no memory of studying anything even remotely related to biology, chemistry, physics, or earth science before fifth grade!

### *Fifth Grade—First Science Fair*

But in fifth grade, I was required to design and carry out a science fair project. I wanted to know more about how flowers grow. The idea of putting seeds in the ground, covering them with soil, and then seeing beautiful flowers bloom was almost magical. I planted three new marigold seeds every day for a month—one got sun and water and one got only water. It did not occur to me to have a “control” for my experiment by planting seeds that were denied both sun and water! For the next few months I faithfully watched over my seeds, carefully writing down the changes I saw each day when I came home from school. I went to the library to look through books and encyclopedias

(there were no computers or Google® back then!) to see what other people already knew about how flowers grow. I learned a lot about being a scientist from those beautiful yellow marigolds, including the importance of keeping good records and the importance of following directions for my experiment. My flowers needed to be watered even on the weekends! Most importantly—I learned I was allergic to marigolds!

### *Middle School*

In middle school, my science teacher told me that I would never become a doctor because girls were meant to be moms instead. And while it’s true I did not become a physician, I proved my science teacher wrong because I earned my PhD from Cornell University (an Ivy League institution in Ithaca, New York) *and* I became a mom. There is no rule forcing a scientist to choose. You can have both a family and a career in science!

### *High School Sophomore Year—State Science Day*

In high school I took honors chemistry as a sophomore, and one day my teacher, Mrs. Palmer, asked me to stay after school. I thought I was in trouble because I had never been asked to stay after school by a teacher! But I wasn’t in trouble; she told me that she had a group of students who stayed after school to do research, and wanted to know if I might be interested in trying to do a research project. I had no idea what that would involve, nor how life changing that would be for me—but I sure am glad I said yes! For the next three years I spent many afternoons in the chemistry lab, investigating enzyme catalysis. My experiments took so long that I needed a lab assistant to make my solutions for me during the day so I could get started immediately after school and finish before marching band practice and musical practice! That lab assistant was a senior named Richard who had been doing his own research project for two years. In Mrs. Palmer’s classroom I had seen multiple pictures

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of him holding giant 5-foot-tall trophies from The Ohio Academy of Science State Science Day. (Spoiler alert: Richard and I became high school sweethearts, and we married while both of us were in graduate school. We're about to celebrate 38 years together!) Many Saturday mornings in the spring, my parents carefully helped me load my poster and equipment into our station wagon. We set off to colleges around northern Ohio so I could compete in district science days, earning my way as a member of Mrs. Palmer's team to State Science Day for three years in a row.

#### *High School—AJAS and AAAS*

In my junior year of high school, my project was awarded the best chemistry research award from Dow Chemical. I was invited to represent The Ohio Academy of Science at the American Junior Academy of Science (AJAS) the following year at the international meeting of the American Association for the Advancement of Science (AAAS) in Los Angeles, California. I had never been on an airplane before. I had never attended a "conference" before. And I certainly had never presented my research at a conference with "real" scientists before.

Attending the AAAS meeting in May 1985 made me realize that I wasn't "just" a high school student who had won a trip as a prize. I was at an international meeting with scientists from countries around the world. They were presenting their research. I was presenting my research. It was the first time I ever thought of myself as a scientist.

#### *Cornell University*

I became the first person in my family to graduate from college when I earned my bachelor's degree in chemistry from Cornell University. Today that makes me a "first gen" student, but I didn't even know that was a label applied to some students until about 5 years ago! I earned my master's degree in chemistry at Penn State, and then returned to Cornell for my PhD in chemistry education research. My questions about how people come to learn about ideas were still rattling around in my mind—except they were

now focused on molecules and learning about molecules. How could people learn about chemistry when molecules were too small to see? I spent a year at the University of California, Berkeley, as a postdoctoral research fellow (funded by the National Science Foundation) to learn more about how to investigate the process by which students learn, and teachers teach, chemistry.

#### *Miami University*

Many students (and teachers) think of chemistry as equations and rules to memorize. For 30 years, I've been researching meaningful learning—the opposite of rote memorization. I'm keen to understand how students both visualize and reason about the structure and properties of atoms and molecules. I've had the honor to be the "Mrs. Palmer" for thousands of college students who have been in my classrooms. And, I have had the special privilege to mentor dozens and dozens of students in their own research projects.

#### *You Are a Scientist*

This column is titled "Letter to a Young Scientist." There was a time in my life when I might not have stopped to read this article because I didn't think of myself as a scientist; I was "just" a student. But I was very fortunate to have had a teacher who saw possibilities in me that I didn't even know existed.

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I was a scientist when I got on my first airplane and presented my research at the AAAS meeting. I'm still a scientist all these years later, even though I don't do experiments in the chemistry laboratory anymore—my experiments and research projects are about how students think about molecules and learn how to learn chemistry. Back when I was in high school, I could never have imagined someday doing this type of work. And that, my young scientist, is the message I want you to hold onto for yourself. You don't have to know how your story as a scientist will unfold or what experiments you might do when you are in college or as an adult. All you need to know right now is that if you like to ask questions, such as *how* and *why*, and you enjoy chasing down the answers—then you are on your way!