Natasha Raikhel

How did you spend your career?

My childhood was not like that of many scientists, who recall an interest in animals and plants and exploring outdoors. Instead, at an early age I was certain that piano and music would be my life. But then in my final year at the specialized music high school in Leningrad, my hopes were dashed. I realized that I was not in the class of musicians destined to become professional pianists. It was a difficult adjustment, but I was pragmatic. I worked as a music teacher to earn money to pay for tutoring in physics and math and gained entrance to Leningrad State University. I didn't want to be a physician or an engineer, but I loved nature, so I thought I would study biology.

At the university, I was recruited by the invertebrate biology department to study ciliates. For my master's degree, I used electron microscopy to observe the micro and macro nuclei of ciliates to study their mitotic and meiotic processes, which are complex. I earned my master's degree and wanted to go on to earn a PhD. I was already married to Alexander Raikhel, who was also a biologist. After graduation, we were assigned to work in Vladivostok, rather than Leningrad (now St. Petersburg). We knew if we went there, in the East, bordering China and North Korea, our careers would be finished, so we refused to sign the papers assigning us to Vladivostok. Finally, I was given a job as a technician at a water purification center in an agency equivalent to the USDA. The job was boring, but at least I was allowed to stay in Leningrad. For two years I worked during the day and spent evenings and weekends conducting research at the Institute of Cytology Academy of Sciences. My adviser, Igor Raikov, saw how hard I worked and offered me a technician position in his laboratory, enabling me to aim for a PhD in cellular biology. I defended in February 1975. As was customary then, I was given an assistant professor position, working in the institute's protozoan karyology group. A few months later, my first son, Eugene, was born.

By 1978, I was an assistant professor at the Institute of Cytology. One day I flew to Baku, Azerbaijan, to collect ciliate samples from the Caspian Sea. On the return flight on May 18, the plane crashed in a potato field between Moscow and Leningrad, killing some on board. It was a horrific experience. I survived, but my perspective on life changed. I had to get a statement from the Soviet airline Aeroflot to explain to my institute why my equipment and collected samples had gone missing. The airline told me there was no crash, it was just an "unexpected landing." It was one of the jarring experiences I had within the Soviet system that finally inspired me to emigrate.

To emigrate from the Soviet Union at the time, the only route was through Israel. First, we asked our advisers to fire us, as it was not acceptable to be associated with someone who abandoned the Soviet Union. My main professor, Polyansky, told me I was crazy to emigrate! He predicted I would be sweeping the streets of New York City and my son would be selling newspapers. But I was resolute and told him, "I could have been dead, and now I have this second chance at life." I wanted to go to the United States rather than Israel because it was a country of immigrants. We were first sent to Rome while we waited for permission to enter the United States. We were extremely lucky: less than one year after the airplane crash, Alex, Eugene, my mother, and I were in the free world, Italy, celebrating Eugene's fourth birthday.

We had to choose a destination in the United States, and we picked Athens, Georgia. From Vienna (our first stop), I wrote to Jerome Paulin, a protozoologist at the University of Georgia (UGA) who had been a visiting scientist in Igor Raikov's karyology group. He was the only American I knew. I asked him for advice on how to look for a research job.

I later received a telegram from Paulin stating that he had found

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postdoctoral positions to work with ciliates for my husband and for me in his own laboratory.

At the University of Georgia, I worked in Paulin's lab for one year, and then in 1980 I joined the lab of plant cell biologist Barry Palevitz in the Botany Department. This was a very active and fast-paced department with a lot of buzz about isolating genes and doing gene transformation in plants. This high-energy environment was thanks to Joe Key (early 1980s), who had a vision for plant molecular biology at UGA and in the United States. I made my first cDNA library and cloned wheat germ agglutinin (WGA) in Joe's lab. In the Palevitz lab, I worked with Michael Mishkind, joining his thesis project on lectins—proteins abundant in grains. Together, we discovered that the WGA protein is expressed in specific cell layers—the coleoptile and the embryonic root—in monocots. We published this in *Science,* which is one of the reasons I was hired for a position at Michigan State University (MSU) in the Plant Research Laboratory (PRL) three years later.

When I applied for an assistant professor position in the PRL, I didn't know it was the premier place in the country for plant biology. During my visit, I fell in love with the PRL because it was very international, and I felt at home there. In 1986, Hans Kende, the PRL director (1982–1988), offered me an assistant professor position. By then our second son, Andrew Vincent, had just turned two.

As my lab in the PRL continued to work on WGA, Thea Wilkins and Sebastian Bednarek—my first graduate students—noticed that WGA is synthesized as a precursor protein.

Members of the University of California, Riverside, Center for Plant Cell Biology in 2012, at the center's 10th anniversary celebration.

We observed that the C-terminus, which was removed, was acting as a sorting signal to the vacuole. Our studies were published at the same time that researchers found a different targeting signal for the yeast vacuole. By the early 1990s, I had found my research niche: intracellular organelle and membrane trafficking. We began to explore what these propeptides recognize and bind to and how vesicles move from one place to another. We continued to use a variety of standard biochemical and molecular biology approaches. In 1993, we adopted Arabidopsis as a plant model, and I had to learn a lot about genetics. I owe a great deal to my PRL colleagues, and especially Chris Somerville, who was particularly instrumental in advising me.

Another important project my lab started in collaboration with Kenneth Keegstra, a fellow plant biologist at the PRL, was the study of cell wall biosynthesis. In 1999, our laboratories were the first to isolate xyloglucan fucosyltransferase, a glycosyltransferase involved in plant cell wall biosynthesis. This paper was published in *Science,* and I learned a lot about carbohydrate chemistry and gas chromatography on the project!

In 2001, I was recruited to the University of California, Riverside (UCR), as a university distinguished professor. I was given the Ernst and Helen Leibacher Endowed Chair and the chance to build the Center for Plant Cell Biology (CEPCEB). I later became a director of the Institute for Integrative Biology, of which CEPCEB is a part. When we celebrated the CEPCEB's 10th anniversary, the directorship of CEPCEB was transferred to my colleague and good friend Julia Bailey-Serres, who continues to be its director.

At UCR, my lab applied genetics and proteomics approaches to vacuolar and protein trafficking. However, as had already been demonstrated with mammalian cells, I saw the merits of using chemicals to perturb these essential processes in plants. These small molecules would allow us

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to bypass the problems of both gene redundancy and lethality, very common features of the plant genome. Eventually, our lab identified several chemicals that could be used to study vacuolar sorting in Arabidopsis. We also discovered bioactive compounds that block endocytosis, the process of protein delivery via vesicles, as well as exocytosis, vesicular delivery to outside the cell. The chemicals could be useful to further elucidate these processes, something that several of my former postdocs are working on in their own labs.

What do you consider to be your most important contributions to plant science?

The following is a list of our discoveries and contributions:

- Identified the signal peptides that direct posttranslational processing of plant proteins and their transport to vacuoles
- Identified important genes that mediate vesicular trafficking machinery in plants
- In collaboration with Ken Keegstra's lab, identified genes required for biosynthesis of xyloglucan, a major component of the cell wall in plants
- Pioneered use of chemical genomics in plants, including the application of chemicals rather than genetic mutations to modify and study protein function
- Trained a fantastic cohort of undergraduate and graduate students and postdocs, most of whom became part of my very close scientific family
- Was founding director of the Center for Plant Cell Biology at the University of California, Riverside
- Served as editor-in-chief of *Plant Physiology* from 2000 to 2005, helping guide the journal into a high-impact plant biology publication.

When did you become a member of ASPP/ASPB?

I joined ASPB as soon as I moved to the PRL in 1986 and was actively involved in its activities for many years.

Former graduate students and postdocs who were able to attend my retirement symposium at the University of California, Riverside, in March 2016.

How did the Society impact your career, and what motivated you to become a Founding Member of the Legacy Society?

I benefited a lot from ASPB by attending the meetings and learning about new scientific developments and exchanging ideas. I had a great time serving as editor-in-chief of *Plant Physiology* and working with a fantastic group of colleagues who agreed to serve as associate editors and monitoring editors. I also contributed to several editions of *Biochemistry & Molecular Biology of Plants* and used this textbook every single year for teaching. ASPB is a fantastic society that allows plant biologists to coalesce across different subdisciplines. ASPB also gives us a voice and presence in the greater scientific community. I always feel an innate necessity to give back when I get a lot. I got a lot from coming to this country and succeeding in my field of study, and ASPB played a big part in my growth and development. Thus, I was delighted when Brian Larkins invited me to become a Founding Member of the Legacy Society.

What important advice would you give to individuals at the start of their career in plant science?

In biology research, when you ask a question, you always end up somewhere unexpected. Biology takes you on its own path. So my motto has always been, listen to nature, think, and do only experiments you have to do and *can* do; work hard, be open, and share your experi-

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ences and data freely; and the more you give, the more you get back. This is life.

I would like to finish with one example of collegiality within the ASPB community. I have been fortunate to be surrounded by strong and caring women scientists at ASPB, some of whom remain my closest friends: Gloria Coruzzi (New York University), Pamela Green (University of Delaware), Joanne Chory (Salk Institute), Susan Wessler (now at UCR), Vicki Chandler (now at Minerva Schools), and June Nasrallah (Cornell University). Among my favorite memories is the 1994 Plant Molecular Biology Gordon Research Conference (GRC), where eight women, including organizer Vicki Chandler, were at the helm. By comparison, at the previous GRC Gloria and Vicki were the only two invited women speakers. So now the momentum had changed. Colleagues dubbed us the "Power Women" that year (Photo 4). It was a pivotal time and a turning point: amidst our laughter, we suddenly realized that it was women who were in charge of most of the sessions and were giving the major talks. We recognized that we had a strong voice, and from that time on, we really were a team. We knew that we had made an impact when, in future years, colleagues would ask, "Who is going to be the next Power Women group?" So my advice for the future generation is to be supportive, helpful, and attentive to one another and care for the next generation.

At the Plant Molecular Biology Gordon Conference in 1994. From left to right: Susan Wessler, Joanne Chory, June Nasrallah, Vicki Chandler, Natasha Raikhel, Pamela Green, and Gloria Coruzzi.

Academic Tree of former Natasha Raikhel lab members:
https://academictree.org/chemistry/tree.php?pid=519702

Annual Reviews of Plant Biology:
http://www.annualreviews.org/doi/abs/10.1146/annurev-arplant-042916-040829