A career at the interface of cell and developmental biology: a view from the crest

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ABSTRACT Just as neural crest cells migrate great distances through the embryo, my journey has taken me from a childhood in a distant land to a career as a biologist. My mentoring relationships have shaped not only the careers of my trainees, but also the trajectory of my own science. One of the most satisfying aspects of mentoring comes from helping to empower the next generation of scientists to do more tomorrow than is possible today. This, together with a passion for discovery and learning new things, motivates me and makes science such a rewarding career.

First, let me say how honored I am to receive the Women in Cell Biology Senior Award. I am particularly thankful to my former postdoctoral fellows and students. I have learned as much, or more, from them as they have from me and take great pride and vicarious pleasure from their successes. My goal as a mentor has been to impart an enthusiasm for science and for the satisfaction it can bring at both a professional and personal level. It is the pleasure of discovery and the bonds of collegiality that make being a scientist not only a worthwhile and interesting but also a very fulfilling career.

When looking back upon my life as a biologist, many of the “choices” made along my career path were more of a random walk than a premeditated trajectory. Perhaps the most important and constant influences come from my family background, wonderful friends and colleagues, and an inherent interest in the natural world. For me, these were mixed with a good deal of luck and the generous mentorship of valued colleagues.

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Abbreviations used: EMT, epithelial to mesenchymal transition; MBL, Marine Biological Laboratory.
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EARLY YEARS
Born behind the Iron Curtain and the child of Holocaust survivors, I learned to be strong and not take life for granted. My family escaped from Hungary when I was 4 years old and my younger brother was a newborn. We crossed the border with nothing but the clothes on our backs and no notion of where life would take us. This was a decision my parents made for the good of their young children. I learned from my mother to always be optimistic, even when things look bleak. I also acquired a deep desire to give back to others, since I was so fortunate to be given great opportunities and a new life in a free country. I suppose this is why mentoring has become so important to me.

Given our lack of resources, my parents emphasized the importance of a good education as a way to a better life. As an undergraduate at Brown University, I knew I wanted to be a scientist, but narrowing down the choice of field to physics, chemistry, or biology was difficult. So I decided to combine them all into a single degree: biophysics. I didn’t really know what that meant at the time, but it sounded really interesting. I applied to graduate school programs in biophysics and decided to go to Johns Hopkins, excited that I would actually get paid to go to grad school. It was only when taking classes to fill holes in my biology background that I discovered my true passion: developmental biology. I learned about the experiments of Professor Nicole Le Douarin and her beautiful quail–chick chimera. Her work inspired me, and she provided an excellent role model of a successful woman in what was a largely male-dominated world at the time.
As I learned about Nicole Le Douarin’s work, I was fascinated by the ability of the neural crest to give rise to so many diverse derivatives, ranging from neurons to pigment cells to cartilage. I was equally taken by the fact that they underwent the most extensive migrations of any embryonic cell type and were prone to metastasis in the adult. They were mysterious cells, displaying stem cell properties before the concept of stem cells became widely known. What directed the complicated migratory patterns of these cells and controlled their multitude of cell fate decisions? From the first time I learned about these amazing cells, I knew that I wanted to work on the neural crest, and I have been studying it ever since!

After graduate school, I took the unusual step of accepting a non–tenure track faculty position at one of the new University of California campuses in Irvine. This was risky, since I hadn’t done a postdoc, and my graduate advisor left science to pursue a career in medicine. Thus, I had little in the way of mentors and had to seek my own group of advisors. I was fortunate at UC Irvine to meet a wonderful and very supportive group of colleagues at the Developmental Biology Center, among them Susan Bryant, Hans Bode, and Peter Bryant. Their help and guidance eventually secured me a tenure-track job in which I climbed the academic ladder and gradually obtained a full professorship. They also taught me much about the fascination of other developmental systems, ranging from limb development/regeneration to Hydra biology and Drosophila genetics. Their support and mentorship were invaluable. I am also grateful to the late Malcolm Steinberg at Princeton University, who took me under his wing and advised and guided me, despite the fact that I hadn’t trained with him.

In 1996, I was made an offer I couldn’t refuse and moved my laboratory to the California Institute of Technology. Moving from a huge university with tens of thousands of students to one with a few hundred was quite a change! I was fortunate to meet an amazing and diverse group of world-class scientists and am particularly grateful for the influence of Eric Davidson, whose formulation of gene regulatory networks controlling developmental processes has had a profound influence on my work. The unique nature of the university made it possible for me to expand in new directions and thrive in a rich, supportive, and truly interdisciplinary environment. At Caltech, new ideas and new technologies are constantly pushing the envelope of what can be accomplished in science. My group has benefited enormously from our interactions with other laboratories here and the “can do” spirit that permeates the campus. In my time at Caltech, the number of women faculty members has doubled, and it has become a much more welcoming atmosphere for women scientists. For example, I had the privilege of serving as the first woman chair of the faculty, and two other women have since held that position.

THE ASCB AND THE SOCIETY FOR DEVELOPMENTAL BIOLOGY

The ASCB played an integral role in my scientific development, particularly in the early years of my career. As a young assistant professor, I attended my first ASCB meeting and gave a short talk. It was one of the first talks I had ever given, and to say that I was nervous would be an understatement. I got lots of good questions, including one from Betty Hay, who was a pioneering woman of her generation, studying and coining the descriptor “epithelial to mesenchymal transition” (EMT) for the process by which cells such as neural crest cells and cancer cells become migratory and invasive. After my talk, I ran into Betty in, of all places, the ladies room. She complimented me on giving a very interesting talk. I thought I had died and gone to heaven! I was again struck by the importance of having positive role models for becoming a successful scientist.

Much later, in the mid-1990s, I had the privilege of serving on the Council of the ASCB. It is a wonderful organization that does so much for the community, from organizing an excellent annual meeting and publishing an outstanding scientific journal to playing important roles in science policy and educational outreach. Similarly, I had the honor of being on the board and president of its smaller sister organization, the Society for Developmental Biology, in 2009. Both societies play key roles in supporting, mentoring, and fostering the careers of young investigators.

THE MARINE BIOLOGICAL LABORATORY

Another pivotal step in my personal development was being asked to teach in, and later direct, the embryology course at the Marine Biological Laboratory (MBL) at Woods Hole. Not only was this a wonderful source of truly excellent postdoctoral fellows, but it was also an amazing atmosphere for personal learning. Listening to all the other lecturers reminded me of the great excitement of being a biologist, making it possible to step back and consider the field as a whole and from a much broader perspective. I am truly grateful to my colleagues from my many years of participation at the MBL for sharing their friendship, enthusiasm, and knowledge. They inspired me to pursue new directions, initiating my work on evolution of the neural crest and a foray into the use of “nonmodel” organisms, such as lamprey and amphioxus. This has proved interesting, challenging, at time frustrating, but overwhelmingly rewarding.

The importance of meeting colleagues and “networking” at places like Woods Hole and at conferences cannot be overemphasized. Science is an international endeavor with few borders or boundaries. Meeting with colleagues and collaborators all over the world makes it possible to make progress that would not be possible alone. Sometimes an offhand comment or suggestion by a colleague can alter the trajectory of your work. Getting an outside perspective can help you focus on the forest when you might otherwise get stuck in the trees.

THANKS TO MY STUDENTS AND POSTDOCS

In looking back at my career, I can see how science has changed in the past 30 years. When I started my lab, it was only me for many years. I slowly added students, technicians, and postdocs. The smartest thing I ever did was to allow my postdocs to do what they wanted to do. My goal was to provide a comfortable playground for them to be creative and think outside the box. My major role was to be a cheerleader, publicity person, fund-raiser, and paper-pusher (i.e., trying to get them to write early and often). However, my postdocs and students guided me as much, or more, as I guided them. I owe my career success to their hard work, wonderful new ideas, and lack of fear to try things that previously were thought to be impossible. That’s what moves science forward.

Importantly, the mentoring relationship that arises between professor and trainee does not and should not end upon leaving the lab. I am delighted to hear from my former postdocs and students on a regular basis, often when they have a problem or simply need an understanding ear. As they move from postdoctoral to faculty life, the need for mentorship often grows. Navigating the world as a faculty member is far different from being a postdoc, and one for which postdoctoral training often ill prepares one.

I am pleased to say that I have trained numerous graduate students and postdocs, about two dozen of whom are now faculty members around the world. I am equally proud of those who have gone into other areas, including biotech, program officer careers at
our favorite granting agencies, and other creative endeavors. I am happy to have played some small role in their development. In looking back on my long career, these achievements in mentoring are those of which I am most proud.

ACKNOWLEDGMENTS
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