"*How The Leopard Gets Its Spots*" The Catalyst of My Mathematical Biology Journey!

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"*How The Leopard Gets Its Spots*" flyers were peppered all over the walls of the mathematics department at Arizona State University in the fall of 1992. They were advertising an upcoming lecture by Jim Murray. I was an undergraduate mathematics major beginning my junior year of study in classical analysis. I walked by this flyer every day for about a week and was simply perplexed as to why this lecture was being advertised in the Mathematics department. Finally, I read a bit of the abstract, which said something about how a single mechanism could underlie the wide variety of animal coat markings found in nature and that results from mathematical models are opening lines of inquiry for developmental biologists. I had never been exposed to mathematical efforts aimed at the biological sciences, so I decided to attend my first-ever departmental colloquium to hear Jim Murray speak.

William Butler Yeats said that education is not the filling of a pail, but the lighting of a fire. The day I heard Jim Murray speak sparked the fire for mathematical biology that has been burning in me ever since. At that time, I did not understand much of the underlying theory that Jim presented, but I walked away from that seminar with the belief that mathematics could profoundly impact the biological and biomedical sciences. That day, I made a promise to myself that I would do everything in my power to eventually become one of Jim Murray's students. Those were pretty big thoughts from a sheltered 20 year-old math major. It was, after all, rather late in my undergraduate training. It would be difficult for me to completely switch gears and embark on learning a science that I was very unfamiliar with, while still trying to take a few graduate level mathematics courses that would help me get into a PhD program. So, I had a steep hill to climb. My first step was a Research Experience for Undergraduates (REU) with Professor Betty Tang, an Applied Mathematician, working in mathematical biology, which led to my first publication. I also participated in the NIH-funded Minority Access to Research Careers (MARC) program, which gave me a crash course in biological research.

These experiences helped me to be admitted into the PhD program in Applied Mathematics at the University of Washington and to achieve my goal of working under the direction of Jim Murray - the person who unknowingly started me on this path. Jim provided an atmosphere for his students that I have never seen recreated. It was honestly the best possible place for me to learn to become a steward of the discipline. My PhD thesis was based on a problem presented to our Applied Math Clinic, where researchers brought their scientific problems to a group of motivated graduate students to work on. At that time, considerable research was being aimed at improving the efficacy of chemotherapeutic agents for cancer therapy. Dr. Peter Senter, a Biochemist working for Bristol Myers Squibb Pharmaceutical Research Institute, was pioneering a promising two-step approach designed to minimize systemic drug toxicity while maximizing activity in tumors by employing monoclonal antibody (mAb)-enzyme conjugates for the activation of anticancer prodrugs. Their research questions were ideal for mathematical modeling. By combining theory and experiment, were able to quantify the biodistribution, pharmacokinetics and localization properties of mAb-enzyme conjugates in tumor tissue and in the bloodstream. This was the first time I experienced the satisfaction and sense of accomplishment that working at the interface of mathematics and biology now brings me everyday. My four years of graduate school, where I was able to work closely with experimentalists, taught me the power of collaboration and to communicate mathematics to biological audiences. It also opened my eyes to the potential for applied mathematics to become an integral part of cancer research.

When I earned my PhD in 1998, mathematical biology was a booming and exciting field that had gained international attention. Although I had a tenure-track job offer, I decided that I needed time to explore and expand my research portfolio in order to become a productive and independent mathematical biologist. Fortuitously, the Institute for Mathematics and Its Applications at the University of Minnesota was hosting its first annual thematic program on Mathematics and Biology. I spent one amazing year there as a Postdoctoral Associate. Many of the international leaders in Mathematical Biology - Lee Segal, Alan Perelson, Lisa Fauci, Zvia Agur and many others - rotated through the IMA that year, which gave me the opportunity to see the many different configurations that a successful career could take.

My year at the IMA was an excellent introduction to the worldwide community to which I wanted to belong. I had the good fortune to share an office with Helen Byrne, who took me under her wing and became a long-time mentor and collaborator. The following year I moved to a second post-doc at Duke University. There I came to know Mike Reed who, together with Jim Murray and Peter Senter, is one of the three greatest influences on my career as a Mathematical Biologist. Mike facilitated research connections and collaborations and allowed me the space to become an independent researcher. While at Duke, I was first introduced to the angiogenesis research that has been become a major emphasis in my research program.

During my first year at Duke, I applied to just five places to test the waters for the potential of tenure-track positions. I accepted an offer from the University of Michigan in the fall of 2000. To date, I have had the opportunity to work with an outstanding group of collaborators, graduate students, and postdocs. Together, we have developed a variety of cell-based and hybrid mathematical models of tumor angiogenesis designed to untangle some of the complexities associated with vascular tumor growth, in the hopes of manipulating new knowledge for therapeutic gain.

As an educator, I have always been interested in the training and education of the next generation of interdisciplinary mathematical scientists. Therefore, I quickly began developing courses and educational experiences in Mathematical Biology when I arrived at the University of Michigan. Previously, there had been no institutional mechanism for faculty and students interested in quantitative methods in biology. To change this, Patrick Nelson and I cofounded the Mathematical Biology Research Group (MBRG) at the University of Michigan, which was a campus wide initiative to foster interdisciplinary research at the interface of Mathematics and Biology. We also developed the SUBMERGE (Supplying Undergraduate Biology and Mathematics Education and Research Group Experiences) program, which aimed to merge the subjects of mathematics and biology for undergraduate students by exposing them to mentored, team-based research on real problems in mathematical biology.

Currently, I am coordinating a new Applied and Interdisciplinary Mathematics Bridge to the PhD program at the University of Michigan in order to address the national challenge of educating and training a diverse scientific workforce capable of unifying the fields of mathematics and the natural sciences. The program aims to impart on the next generation of under-represented minority (URM) scholars the foundational skills required to combine a deep knowledge of applied science with the mathematical, computational, and physical sophistication needed to address the increasingly complex problems that are on the international horizon.

It is hard for me to believe that I have been in this field for 16 years, but I know I would not be where I am today if it were not for my biggest academic and research supporters, especially, Jim Murray, Peter. Senter, and Mike Reed I met each of them at a different, yet critical, juncture in my career and have benefited greatly from knowing and working with them. After all this time, it still energizes me to know that many of the various sub-disciplines of mathematical biology are on the verge of critical scientific advances. I am excited to see what the future holds and am proud to call myself a Mathematical Biologist.

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