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FIRST PERSON

First person – Robert Bloodgood and Roger Sloboda

First Person is a series of interviews with the authors of a selection of papers published in Journal of Cell Science. Here, established researchers Robert Bloodgood and Roger Sloboda, authors on 'The *Chlamydomonas* flagellar membrane glycoprotein FMG-1B is necessary for expression of force at the flagellar surface', published in JCS, talk about their paper and career. Robert is a Professor at Department of Cell Biology, University of Virginia School of Medicine, VA, and Roger is a Professor at Department of Biological Sciences, Life Science Center, Dartmouth College, NH. They are interested in understanding the mechanism of an unusual form of cell motility, flagellar-dependent whole-cell gliding in the bi-flagellate green alga *Chlamydomonas*.

Robert Bloodgood (left) and Roger Sloboda (right)

How would you explain the main findings of your paper in lay terms?

RB and RS: Movement of single-celled organisms occurs when the cell 'crawls' along a surface like an amoeba, or 'swims' through a liquid medium via the action of whip-like appendages called cilia or flagella. The green alga *Chlamydomonas* has the unusual ability to do both, using its pair of flagella to either crawl or swim. When liquid water is available, cells can swim by beating of the flagella. When a cell finds itself in something like soil, it can attach its flagella to the soil particles and glide along their surfaces using the flagella in a manner similar to a tractor tread. The machinery for both types of motility is located inside the flagella. But how does this flagellar machinery interact with the soil particles when there is a membrane covering the flagellum? The hypothesis is that a large flagellar membrane protein (FMG-1B) crosses the membrane and binds to soil particles on the outside and the force-producing machinery on the inside of the flagellum. Our paper shows that mutant cells that totally lack the FMG-1B membrane protein are still able to assemble full-length flagella and swim through a liquid medium but cannot perform gliding motility.

Were there any specific challenges associated with this project? If so, how did you overcome them?

RB and RS: We had tried for many years to obtain a mutant of *Chlamydomonas* totally lacking the FMG-1B flagellar membrane glycoprotein, without success. This led to much frustration and a lack of 'closure' on these studies. It was only with the advent of a large library of insertional mutants in *Chlamydomonas* developed by the lab of Martin Jonikas and distributed for a small fee by the NSF-supported *Chlamydomonas* Resource Center that were we able to address directly the role of FMG-1B in gliding motility. Our work also underscores the importance of the support of funding agencies for large mutant screens as well as model organism-based resource centers.

When doing the research, did you have a particular result or 'eureka' moment that has stuck with you?

RB: My eureka moment really came about in 1976, when as a postdoc I mixed polystyrene microspheres with live *Chlamydomonas* and unexpectedly saw the microspheres bind to and move rapidly and bidirectionally along the surface of the flagellum. This is illustrated in a movie provided as supplementary material for our paper. That observation opened up a lifetime of interesting work for me and led directly to the work in this paper.

RS: Although Bob and I were postdocs together at Yale in Joel Rosenbaum's lab at the time Bob performed the microsphere experiment, I did not work on *Chlamydomonas* until I went back to Joel's lab on a sabbatical leave early in 2002 to learn *Chlamydomonas* cell biology. My lab has worked on *Chlamydomonas* ever since, and so our collaboration on this project has brought us full circle in our many years of interaction with each other. This is our first, and likely our last, joint project.

Why did you choose Journal of Cell Science for your paper?

RB: I have read the journal during most of my career and have enjoyed the varied and unusual articles published in JCS and the many uncommon organisms represented. I have previously published in JCS. The absence of page charges is also much appreciated.

Have you had any significant mentors who have helped you beyond supervision in the lab? How was their guidance special?

RB and RS: We were both post-docs in Joel Rosenbaum's lab at Yale University at the same time in the 1970s. This was a stimulating time

Robert Bloodgood's contact details: Dept of Cell Biology, Box 800732, University of Virginia School of Medicine, Charlottesville, VA 22908.
E-mail: rab4m@virginia.edu
Roger Sloboda's contact details: Department of Biological Sciences, Life Science Center, 78 North College Street, Dartmouth College, Hanover, NH 03755.
E-mail: Roger.D.Sloboda@dartmouth.edu

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A *Chlamydomonas* stained with an antibody to the FMG-1B flagellar membrane glycoprotein (green). Chlorophyll autofluorescence is red.

to be in the Rosenbaum lab (filled with many very smart and very unusual, but always interesting and supportive, postdocs, grad students and techs) and it was there that we were both introduced to *Chlamydomonas* as a wonderful model organism, although neither of us started out in the lab working with *Chlamydomonas* (and one of us, as noted above, took about 25 years to see the 'green' light). It was in the Rosenbaum lab during this time that flagellar surface motility was 'rediscovered' in the form of bi-directional, salutatory movements of polystyrene microspheres along the flagellar surface. One of us (RB) had originally wanted to study *Chlamydomonas* flagellar membrane biogenesis and wanted to use microspheres to label positions along the flagellar surface, in order to assay how their positions might change during flagellar growth and resorption. Surprisingly, the pesky microspheres would not stay in place, leading to an entirely new research goal to study force transduction at the flagellar surface (and the gliding motility that ensues because of this). In 1977, we went our own ways (RS to spend over 42 years on the faculty at Dartmouth College and RB to spend three years at Albert Einstein College of Medicine followed by almost 39 years at the University of Virginia School of Medicine). We have kept in close touch over the many years since leaving the Rosenbaum lab and have been scientific mentors to each other in many ways. We had always hoped to publish together and this is our first collaborative research paper since the Yale days. Our paper helps clarify how force transduced within the flagellum by intraflagella transport (IFT; discovered in the Rosenbaum lab by Keith Kozminski and Paul Forscher in 1992) can be applied to a substrate to achieve a unique form of cell motility. This form of scientific reunion is a real source of satisfaction for us and this paper may represent the last major research paper either of us will publish. It is quite satisfying, therefore, to see our careers close that circle.

What motivated you to pursue a career in science, and what have been the most interesting moments on the path that led you to where you are now?

RB: I had an inspiring high-school biology teacher who kept a bat in the lab refrigerator and encouraged me to do a research project on planaria regeneration. Fifty years later, I would introduce my grandchildren to the pleasures of planaria taken from the pond in my backyard. From high school I went to Brown University, where a couple of inspiring mentors (Richard Ellis who taught me electron microscopy and Richard Goss who taught me about antler regeneration) helped me get into the PhD program at the new department that Keith Porter was starting at the University of Colorado in Boulder. There I had the pleasure to study with Dick McIntosh, who introduced me to the delights of the cytoskeleton. My new fascination with the cytoskeleton led me to do a postdoc at Joel Rosenbaum's lab at Yale where I was lucky to meet Roger, as we began at Yale within a few months of each other. Discovering surface motility on flagella (through microsphere movement) in the Rosenbaum lab really defined much of my later research interests.

RS: Neither of my parents graduated from high school (my Mom was a teenager in Britain during WWII, my dad a bomber crew member in the US Eighth Air Force; this is how they met). Both parents insisted I go to college, and for them that meant the university nearby, SUNY Albany; I was what would be called today a first-generation student. In my junior year, a biology professor, Charles Edwards, called me into his office and suggested I come to his lab and initiate a small research project. I knew nothing of research; indeed, I did not even know I had to buy books when I got to college, as my public school had always provided them. That little project excited me in amazing ways, and I began to attend Friday department seminars to learn about other things that were going on in the department. One of these seminars was given by Walter Auclair, who spoke of how sea urchin cilia can assemble themselves in the absence of protein synthesis, meaning all the precursors for the cilia pre-exist in the cytoplasm. That fact amazed me, and so I applied to graduate school at Rensselaer Polytechnic Institute, where Walter held a faculty appointment in biology (Susan Gilbert, one of my former students, now chairs that department). Walter also spent summers at the MBL in Woods Hole, MA, and insisted that all his students take a course there during the summer. I applied to a course called FERGAP, no longer extant, and was accepted. One of the course faculty was Joel Rosenbaum, with whom I was assigned to work and who invited me to come to his lab as a postdoc. In Joel's lab I worked on microtubule assembly from chick brain extracts, which defined my research interests for many years.

What's next for you?

Unlike most of the First Author interviews, we are both reaching the ends of our academic careers and hence do more looking back than looking forward but that has its own value.

RB: Even though I have spent most of my career at medical schools, I have had the opportunity to have a very balanced career between education and research and found that most satisfying; I would not have liked doing solely one or the other. While primarily teaching medical students and graduate students, I have gained additional pleasure from educational outreach activities (at the K-12 level) as well as work with undergraduate research students. It is so important that young learners have early scientific experiences that are positive.

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RS: Like Bob, and to make Charles Edwards proud, I have always actively hosted undergraduate students in research in my lab (also graduate students and postdocs). In the past ten years or so, my attention has turned not completely, but somewhat, to pre-college science education in an attempt to do my part to increase the number of students in the science pipeline. This phase of my career has been generously supported by two education awards from the Howard Hughes Medical Institute. Last month I was awarded a Science Education Partnership Award (SEPA) from the National Institutes of General Medical Sciences (NIH) to work with middle school teachers in underserved rural school systems in Vermont and New Hampshire.

Tell us something interesting about yourself that wouldn't be on your CV

RB: While in middle school in Saratoga Springs, NY, my mother arranged for me to shadow a large animal veterinarian. I vividly remembered watching him deliver a calf and that made a big impression on me and, for years afterwards, I dreamed about being a vet (or even better a zoo doctor). However, I ended up only studying organisms that could fit under a microscope!

RS: I grew up in Waterford, NY, a mere 21 miles south of Saratoga. One of my first classes in grad school was Cytology, with Roland Walker. The lab section began after lunch at about 1 pm. We looked at various organisms with a phase microscope. Around 5 pm I got up to leave, and Prof. Walker came over and asked me if I had seen everything. I responded affirmatively. He said, no, have you seen *everything?* I learned much about microscopic observation from Prof. Walker, which has informed my entire career.

Reference

Bloodgood, R. A., Tetreault, J. and Sloboda, R. D. (2019). The *Chlamydomonas* flagellar membrane glycoprotein FMG-1B is necessary for expression of force at the flagellar surface. *J. Cell Sci.* **132**, 233429. doi:10.1242/jcs.233429