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EDITOR PROFILE

Sebastian Bednarek

The cell. For such an infinitesimal unit, this has been a constant and, sometimes controversial, subject of study. Although major developments in genomics, synthetic biology, and imaging have led to advances in our understanding of the cell, it still represents a universe of myriad mysteries to this day. One of these mysteries is the cell's decision to divide. Not afraid of taking deep dives and plunging into the unknown, *The Plant Cell* Senior Editor Sebastian Bednarek (University of Wisconsin–Madison) has spent his career answering this very difficult, but quite tantalizing, question.

Sebastian Bednarek.

THE SEEDS ARE SOWN

Sebastian is no stranger to the importance of hard work and facing life's challenges. Starting at a young age, he was encouraged by his parents to value education and perseverance. Education was especially emphasized as a key to success and a driver of future opportunities. In school, two teachers stood out in his early education. His high school math teacher, Mr. Egre, knew just the right balance of being challenging and being encouraging. Mr. Williams, his high school chemistry and physics teacher, would "democratize" the labs and give a few students free reign to do independent experiments.

Drawing from his positive influences in his parents and teachers, Sebastian set out to pursue a bachelor's degree at the University of Wisconsin in Madison. He eventually settled for a Biochemistry degree, not by design but through a random (albeit fateful) walk. For the first two years in university, Sebastian mainly took courses that interested him – Math, Chemistry, Physics, Biology. Around the beginning of his third year, it became necessary to declare a major, and he was heavily leaning toward electrical engineering. As fate would have it, the class he needed for an engineering major was full, after a mad dash across campus to physically sign up for courses. He was forced to register for a different one, deciding on introductory biochemistry because it fit well into his schedule. Biochemistry would turn out to be a revelation to Sebastian. This pivotal decision changed his trajectory from engineering to biochemistry. In hindsight, he remarks that "this wasn't such a radical shift; biochemistry is after all, a study of how biological molecular machines and circuits work."

DISCOVERING HIS LOVE OF THE LAB

After finishing his undergraduate degree, Sebastian was unsure whether to pursue graduate studies or not. This uncertainty led him to try out lab work before making a final decision. His first lab experience was working as a technician in a reproductive endocrinology lab, but the prospect of regularly sacrificing mice did not prove alluring. Concurrently, he also had been taking a Plant Biotechnology seminar course. This opened him to the possibility that plants are fantastic models to study not just plant-specific problems but fundamental biological questions in general. Fortunately, he managed to make fruitful connections while attending the seminar course, which led to an opportunity to work in the labs of Brent McCown (plant tissue culture) and Rick Amasino (plant hormones).

Rick strongly encouraged Sebastian to pursue graduate studies elsewhere, in order to expand his horizons and broaden his scientific network. After visiting several graduate programs, he ultimately chose the Plant Research Lab at Michigan State University and joined Natasha Raikhel's lab. His Ph.D. thesis project was characterizing the mechanistic details of protein trafficking. In Natasha's lab, he investigated the cell biology of barley lectin and found that it undergoes post-translational proteolytic processing, with the propeptide being important for sorting (Bednarek et al., 1990; Bednarek and Raikhel, 1991).

ESTABLISHMENT OF THE RESEARCH PROGRAM

Sebastian's Ph.D. research specializing in cell biology stimulated his interest in the field and made him cognizant of the important knowledge gaps in plant cell biology. He became interested in understanding the molecular machinery that regulates plant cytokinesis, especially how the cell plate is assembled during cell division. Although his plan was to ultimately tackle plants, he spent his postdoctoral program to gain cutting-edge expertise in the state-of-the-art laboratory of Randy Schekman at UC Berkeley. Using a plethora of biochemical and genetic approaches, Sebastian demonstrated that the two vesicular coatomer proteins COPI and COPII facilitate distinct transport pathways from the endoplasmic reticulum (Bednarek et al., 1995). Although he worked solely in yeast, he kept abreast with the exciting developments in plant biology, knowing fully well that his ultimate goal was to study plant cell biology.

Sebastian next joined the Department of Biochemistry at UW Madison as an assistant professor. There, he developed a new research program aimed at investigating the molecular basis of plant cytokinesis and cell expansion – a long-term dream even before joining Randy's lab as a postdoc. He is very grateful to the department because they took a chance with him. As his postdoc program was in yeast, there were no preliminary data for his new research projects. Several years were necessary to establish sufficient materials to get the lab running. During these seminal years, his lab developed methodologies to analyze membrane trafficking and pioneered genetic screens to identify cytokinesis-defective mutants.

TO DIVIDE OR NOT TO DIVIDE

One of the initial projects that he pursued was to study dynamins and dynamin-related proteins (DRPs) in Arabidopsis. The classical dynamins are involved in endocytosis in mammalian systems, while the non-classical ones are plant-specific. Even though there is sequence homology between the two types, the non-classical dynamin proteins are structurally different because they lack the necessary clathrin modules. The DRP project came as a low-hanging fruit to pursue since the lab of Deshpal Verma (Ohio State University) previously had shown that these were involved in the soybean division plane (Gu and Verma, 1996). This conceptual advance was useful in getting Sebastian's lab started with optimizing screens, characterizing phenotypes, and developing tools. One of the cutting-edge technologies pioneered in the Bednarek laboratory was variable angle epifluorescence microscopy, where a critical angle is necessary to capture the perfect image (Konopka and Bednarek, 2008) similar to total internal reflection fluorescence (TIRF) microscopy.

The screens and tools were essential to the lab's discoveries of Arabidopsis cell plate-associated dynamin-related proteins and their role in plant cell division and growth (Kang et al., 2001; Kang et al., 2003) and pollen development (Backues et al., 2010). Through a productive collaboration with Antje Heese (University of Missouri-Columbia), the DRPs have also been shown to be essential in plant innate immune signaling (Smith et al., 2014).

A UBIQUITIOUS ENZYME FOR PLANT GROWTH AND DEVELOPMENT

A second line of research in the lab had a more directed approach. Based on earlier observations in yeast, it was known that CDC48 was important for membrane fusion (Latterich et al., 1995). CDC48 is a hexameric AAA-ATPase that functions as a molecular chaperone in various processes. Eventually, the same case was demonstrated in plants in Sebastian's laboratory (Rancour et al., 2002).

Using a proteomic screen, his group found that CDC48 assembly and disassembly is regulated by the plant ubiquitin regulatory X (UBX) domain-containing protein 1 or PUX1 (Rancour et al., 2004). Characterization of the *cdc48a* T-DNA insertion mutant lines showed its involvement in various aspects of plant physiology—from cytokinesis to cell expansion to development (Park et al., 2008).

THE SEARCH FOR CELL DIVISION-DEFECTIVE MUTANTS

The third line of research originated from a forward genetic screen in collaboration with the late Fred Sack (Ohio State University), who was a giant in field of stomatal development. In Fred's guard cell patterning screen, they found some interesting mutants that were defective in cytokinesis. One of these mutants was the temperature-sensitive *stomatal cytokinesis-defective 1-1* (*scd1-1*). When grown at the non-permissive temperature, this mutant had binucleate guard cells and had incomplete ventral cell walls (Falbel et al., 2003). Sebastian's lab eventully isolated the *SCD1* gene and the encoded protein was found to be homologous to animal proteins necessary for the protein transport machinery. Further investigations led to the discovery of a protein interaction network composed of the SCD proteins, Rab GTPases, and the exocyst (McMichael et al., 2013; Mayers et al., 2017). Similar to the dynamin-related proteins, SCD proteins were shown to be important in plant immunity through a collaborative study with Antje Heese (Korasick et al., 2010).

PAVING THE WAY FOR THE NEXT GENERATION

When asked what his advice to junior researchers, not just in plant biology, but in other fields of research as well, he stresses the importance of possessing drive and passion. These qualities help one to push the boundaries during the "good days" and help one get through the obstacles during the "bad days." It is also very important to be collegial and collaborative because "science is not made in a vacuum."

For Sebastian, performing experiments in the laboratory to answer fundamental questions and solve scientific problems involves a lot of thinking outside the box. This only happens when one amasses a wide range of practical experience, critical understanding of the literature, inherent interest in asking the right questions and brave willingness to learn through failure. He has advised both his students and children to regularly engage and hone these primary elements of teaching and learning. As a research mentor, he has always encouraged his students to explore questions that they find interesting, while providing the necessary guidance and environment to do so. One common pitfall that Sebastian has observed in early career researchers is taking on too many projects. He admits that everyone can be prone to this, so it is important to be aware that this could happen to anyone. People—from the most junior students to the most senior PIs—always benefit from focus.

ONWARD AND FORWARD

Looking back at his career, one of his regrets is that he could have been more involved with the university and/or academic community at large when he was still a graduate student/postdoc. Taking the initiative to serve on campus committees or having service roles can facilitate one's meeting with fellow researchers and a continuous exchange of new ideas. True to his word, Sebastian has served as a Senior Editor of *The Plant Cell* for the past 15 years. Additionally, in 2012 he organized the first *MidWest Plant Cell Dynamics* meeting together with Dan Szymanski from Purdue and his UW colleagues Marisa Otegui and Simon Gilroy. This is a smaller, student/postdoc-centered conference with a heavy focus on intensive discussions and brainstorming after the talks.

Sebastian believes the future is bright in plant cell biology. He looks forward to further understanding the evolutionarily conserved and plant-specific mechanisms that control membrane trafficking during cytokinesis and cell expansion. The dream project someday would be biomass improvement for biofuel production, leveraging our knowledge on cell division, cell expansion, and cell wall biogenesis.

"How do cells divide?" is a question worth pursuing not just for its potential applications in medicine and agriculture, but also because it lies at the heart of why living things reproduce and why there are multicellular organisms. It changed the course of natural history. In this quite existentialist of biological questions, Sebastian went into uncharted territory and carved his own research niche. Although research obstacles and bottlenecks will always be there along the way, he is prepared to face them head on. After all, that is the beauty of science, isn't it?

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REFERENCES

Backues SK, Korasick DA, Heese A, Bednarek SY (2010). The Arabidopsis dynamin-related protein2 family is essential for gametophyte development. Plant Cell 22:3218-3231. doi: 10.1105/tpc.110.077727.

Bednarek SY, Raikhel NV (1991). The barley lectin carboxyl-terminal propeptide is a vacuolar protein sorting determinant in plants. Plant Cell 3:1195-1206.

Bednarek SY, Ravazzola M, Hosobuchi M, Amherdt M, Perrelet A, Schekman R, Orci L (1995). COPI- and COPII-coated vesicles bud directly from the endoplasmic reticulum in yeast. Cell 83:1183-1196.

Bednarek SY, Wilkins TA, Dombrowski JE, Raikhel NV (1990). A carboxyl-terminal propeptide is necessary for proper sorting of barley lectin to vacuoles of tobacco. Plant Cell 2:1145-1155.

Falbel TG, Koch LM, Nadeau JA, Segui-Simarro JM, Sack FD, Bednarek SY (2003). SCD1 is required for cytokinesis and polarized cell expansion in Arabidopsis thaliana. Development. 130:4011-4024.

Gu X, Verma DP (1996). Phragmoplastin, a dynamin-like protein associated with cell plate formation in plants. EMBO J 15:695-704.

Kang BH, Busse JS, Bednarek SY (2003). Members of the Arabidopsis dynamin-like gene family, ADL1, are essential for plant cytokinesis and polarized cell growth. Plant Cell 15:899-913.

Kang BH, Busse JS, Dickey C, Rancour DM, Bednarek SY (2001). The arabidopsis cell plate-associated dynamin-like protein, ADL1Ap, is required for multiple stages of plant growth and development. Plant Physiol 126:47-68.

Konopka CA, Bednarek SY (2008). Variable-angle epifluorescence microscopy: a new way to look at protein dynamics in the plant cell cortex. Plant J 53:186-196.

Korasick DA, McMichael C, Walker KA, Anderson JC, Bednarek SY, Heese A (2010). Novel functions of Stomatal Cytokinesis-Defective 1 (SCD1) in innate immune responses against bacteria. J Biol Chem 285:23342-23350. doi: 10.1074/jbc.M109.090787.

Latterich M, Fröhlich KU, Schekman R (1995). Membrane fusion and the cell cycle: Cdc48p participates in the fusion of ER membranes. Cell. 82:885-893.

Mayers JR, Hu T, Wang C, Cárdenas JJ, Tan Y, Pan J, Bednarek SY (2017). SCD1 and SCD2 Form a Complex That Functions with the Exocyst and RabE1 in Exocytosis and Cytokinesis. Plant Cell. 2017 29:2610-2625. doi: 10.1105/tpc.17.00409.

McMichael CM, Reynolds GD, Koch LM, Wang C, Jiang N, Nadeau J, Sack FD, Gelderman MB, Pan J, Bednarek SY (2013). Mediation of clathrin-dependent trafficking during cytokinesis and cell expansion by Arabidopsis stomatal cytokinesis defective proteins. Plant Cell 25:3910-3925. doi: 10.1105/tpc.113.115162.

Park S, Rancour DM, Bednarek SY (2008). In planta analysis of the cell cycle-dependent localization of AtCDC48A and its critical roles in cell division, expansion, and differentiation. Plant Physiol 148:246-258. doi: 10.1104/pp.108.121897.

Rancour DM, Dickey CE, Park S, Bednarek SY (2002). Characterization of AtCDC48. Evidence for multiple membrane fusion mechanisms at the plane of cell division in plants. Plant Physiol 130:1241-1253.

Rancour DM, Park S, Knight SD, Bednarek SY (2004). Plant UBX domain-containing protein 1, PUX1, regulates the oligomeric structure and activity of arabidopsis CDC48. J Biol Chem 279:54264-54274.

Smith JM, Leslie ME, Robinson SJ, Korasick DA, Zhang T, Backues SK, Cornish PV, Koo AJ, Bednarek SY, Heese A (2014). Loss of Arabidopsis thaliana Dynamin-Related Protein 2B reveals separation of innate immune signaling pathways. PLoS Pathog 10:e1004578. doi: 10.1371/journal.ppat.1004578.

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