Twelve years before the mast: A voyage in academia

A reflective essay

Submitted in association with application for promotion to full professor

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October, 2011

In Dana's famous novel, *Two Years Before the Mast*, Narrator flees a life in academia and takes his readers on a sea journey traversing the breadth of the globe and lasting a full two years, describing various highlights of a typical mid-1800's sailing voyage. The story is told from the forecastle - the dirty, wet, cramped area in the bow where the common sailors must live. My essay below is neither a travelogue of my somewhat longer (albeit geographically more limited) tenure at the Department of Horticulture at MSU, nor an attempt to allegorize my position with that of the reeking sailor in the forecastle (that being off point) (and unwise considering the goal that this task would serve). Rather, my intention is to narrate the breadth of my activities as an Assistant and Associate Professor, while highlighting those that I feel have had, and will have, the greatest impact on science and society, those that have affected me most profoundly in my outlook, and those that I believe offer unique and novel contributions to MSU, in the areas of research, teaching/mentoring, and service. I also take this opportunity to discuss the future heading of my program and where I believe I will take it in the next decade.

First, however, note that my work can be most accurately described as Molecular Genetics of Plant Development, although it touches on several related disciplines (genetics, molecular biology, cell biology, biochemistry, plant physiology, to name a few). I will attempt to define. Development (biology) is thought of as the origin of form as an organism grows, and in plants includes many aspects such as seed germination, leaf formation, flowering, and fruiting. Genetics is understood as the study of genes – how they function and how traits are inherited. *Molecular* genetics is distinguished by the study of the molecular aspects of genes – including how genes are made to produce RNA and proteins, or mechanisms by which genes are regulated. Thus, my work centers on how plant genes are regulated to drive formation of plant parts during growth. This concentration is nearly unique within the plant sciences at MSU.

With that introduction, and because I was appointed with primarily a **research** position (technically, '80% research' and '20% teaching'), I will embark with Reader in this area. I have been fortunate in finding a position that not only requires combining *fundamental* with *applied* research, but that also offers a tremendously positive and rewarding setting in which to pursue and integrate these.

I first highlight my research in the area of chromatin. Chromatin is the combination of DNA and the proteinaceous matrix in which the DNA is packaged. This packaging is essential to fit long DNA molecules into the nucleus, but also poses obvious challenges for mechanisms that depend on access to the DNA – such as gene regulation. The bulk of chromatin proteins are the histones, and histones can be subject to numerous kinds of post-translational modifications. In 2008, we published a report that included the first full, genome-wide integrated map of several specific histone modifications for any plant (Oh et al, 2008). Through this work, we found that specific types of histone modifications tend to be part of the packaging for specific *types* of gene, and for specific *regions* of genes. This was a high point in my career not only because of the potential impact of the finding, but because we also incorporated several new and challenging molecular and biocomputational tools to obtain the data. Besides its publication in a trendy, new high-impact journal (an article that has been viewed *nearly 3,000 times* so far), this research has led to awarding of a major, single-investigator grant from National Science Foundation (NSF). This type of work can be directly exploited to facilitate sequence analysis of gene-rich regions in plants with complex genomes, to improve genome annotation, and to uncover cryptic and previously unanticipated features of the genome. Currently, with the NSF grant, I am making excellent headway in each of these three areas, and plan to stay this course for at least the next ten years.

A second summit of my research work has been in the area of (so-called) transcriptional memory. This term refers to the maintenance of patterns of gene activity during cell division. Proper 'memory' of gene activity is required in order to establish tissues (fields of cells with the same function), whereas this memory must be suspended for cells to assume new identities and functions. Regulation of the flowering inhibitor gene *FLC* in the reference plant *Arabidopsis thaliana* has become a model for the study of this process. In some natural strains of Arabidopsis, *FLC* becomes silenced during growth in cold, leading to flowering (the well-known phenomenon of vernalization). Over the past ten years, we identified numerous genes required for the maintenance of *FLC* gene activity, and characterized how these genes function. We found that many of these genes encode protein subunits of an enigmatic transcription cofactor, termed PAF, that is evolutionarily conserved, existing also in yeasts, humans, and other higher organisms. We now know that PAF links mechanisms that promote gene activity with machinery that modifies the chromatin environment of the *FLC* gene. This provides a potential explanation for transcriptional memory in this case. I highlight this project partly because of its impact, but also because it demonstrates a focused, persistent effort over nearly the full span of my work at MSU (van Nocker and Ransom, 2002; Zhang and van Nocker, 2002; Zhang et al 2003; Oh et al 2004; Oh et al 2008; Park et al 2010; 2011). Having established this core body of knowledge, I will continue to develop this over the next decade, while expanding the work to attempt to understand how this mechanism might function for other genes and other developmental transitions.

How can study of fundamental mechanisms of molecular genetics of development be applied, especially to Michigan horticulture? Some of the most significant production problems in tree fruit crops (of paramount importance to Michigan horticulture) are rooted in development. Flowering and abscission provide excellent examples. In the domestic

apple, the initiation of flowers is inhibited by developing fruit. Because in apples (similar to many trees) flowers are initiated in one year and then complete development (and bloom) the following year, large numbers of developing fruit can suppress initiation of flowering (thus lowering fruit load) the subsequent year. This phenomenon, termed biennial bearing, is of tremendous importance to the apple industry, because fruit must actually be removed (thinned) in order to ensure flowering the following year. Effective fruit removal requires accurate manipulation of abscission – the natural tendency of the plant to retain or drop fruit. However, there is no manageable way for growers to do this in the field, and biennial bearing remains a severe limitation to production and growth of the industry. Studies of the underlying genetic mechanisms of flowering and fruit abscission will allow us to chart a course forward to sophisticated methods of control (potentially involving undiscovered signaling molecules) and to engineer novel varieties (through traditional breeding or biotechnology) in which problematic traits are suppressed.

Within the next ten years, biology will include the field of *developmental engineering* – using biotechnology not only as it has been commonly applied – to alter biochemistry or pest resistance – but to engineer new *forms* of plants. This will require better knowledge not only of the developmental processes themselves, but how the associated genes are regulated and can be manipulated. Above I give but one example. However, the opportunities to apply such studies to agricultural problems are essentially limitless. In addition, the nature of our global economy will increasingly require development of international approaches and teams to tackle such issues. I have so far forged strong collaborations with researchers in Great Britain, Germany and Canada. I look forward to maintaining these collaborations while expanding my activities to developing countries as well.

I note that my appreciation for horticultural production problems has developed almost entirely from my personal interactions with industry, and the opportunity for such interaction is a very positive aspect of my position. I have found growers to be exceptionally knowledgeable and sharp, engaged, and most of all supportive of my work. My positive interactions with growers are reflected in my consistent track record of industry funded research grants, and maintaining these interactions is a high priority for my program.

My experience in the area of **teaching and mentoring** has been not only very productive, but extremely rewarding. The high point here was my development of a new course, Plant Developmental Genetics, that covered topics that were not available elsewhere at MSU (note: the course was rolled into Jan Zeevaart's Plant Development (PLB865) course upon his retirement, and is now team taught by myself and Dr. Jianping Hu in the Department of Plant Biology). The course is now part of the curriculum for multiple graduate programs, and attracts a consistent audience of very interactive and bright graduate and undergraduate students. I have had numerous opportunities to disseminate findings from my research in the areas of flowering and chromatin biology in this class; the ensuing discussions with students have had a definite impact on the trajectory of my research. My portion of the course includes entirely web-based content, and I have experimented with various web media to enhance teaching (eg, Twitter: students find that to answer a

question using exactly 140 characters, or about 20 words, they must truly understand the material!). I have found that this internet-based media is an excellent tool for engaging those students (typically about a fourth of my class) who have difficulty participating in a classroom setting. With additional training in web authoring, I hope to expand the course website to provide a clearing house of plant development-related educational resources.

I offer teaching this course as a high point not only because it fills a hole in the plant science curriculum at MSU, but also because it has contributed greatly to my development as an instructor. In my first attempts at teaching this material, I found it intimidating to face an audience of graduate students, some not much younger than myself. In the ensuing years, I have come to view teaching not so much as a one-way means for instilling knowledge, but instead as a venue for sharing of information and experiences among colleagues. I believe that the students appreciate this, and that this has led to wonderful dynamics in the classroom. In addition to this core course, and as I have done in the past, I will continue to offer a variety of additional, special topic and seminar courses that center on development, while also touching on topics that address needs of the MSU plant science students and exploit unique educational opportunities as they arise.

Another high point in this area is my mentoring activities with undergraduates participating in research in my lab. I first employed undergraduates in a research setting several years ago, in response to an initiative from the Provost's Office to 'expand the teams of undergraduates and faculty participating in research'. Although I was wary at first, I quickly learned that, properly mentored, undergraduates can be quickly trained and can be very productive lab members. I now offer a very structured experience for undergraduates in my lab, involving proposal and report writing, formalized training in lab techniques and safety, exposure to responsible conduct of research and other issues, and presentation/publication opportunities. I believe that a position in my lab is highly desirable, as I have received over 30 applications in a semester. A memorable reward for my mentoring efforts was seeing one my students (I Rin, Lyman Briggs College) receive the Grand Prize in Science and Engineering for her presentation at the University Undergraduate Research and Arts Forum. It is my hope that my mentoring structure for undergraduates in research can be widely adopted.

Regarding **service**, perhaps my best moments have been as the coordinator of the College of Agriculture and Natural Resources Undergraduate Research Program, a position that I held since the inception of the Program in late 2006 until just recently. Organized by then-Associate Dean Eunice Foster in response to an initiative from the Provost's Office to stimulate undergraduate research at MSU, this Program has so far supported over 200 students and faculty in team research. As coordinator, I worked with Dr Foster and led a faculty committee to establish structure for the program, mediate application and awards, track progress and outcomes of projects, and develop seminars and workshops for participants. This position also resulted in my participation as College representative in many other undergraduate research-related activities and programs at the University level. I believe that my efforts in this area have played a significant role in establishing an undergraduate research culture in the College, and that they will reflect MSU very positively through placement of well-trained and knowledgeable undergraduates in

professional and graduate positions at institutions throughout the country and around the world. Although I will miss this position, I recognize that there are numerous opportunities for building similar Programs on campus, and for utilizing undergraduate research as a building block of grant proposals and curriculum establishment, and I will use my experience in this area as a compass to direct me forward in such efforts.

A second 'best moment' in service that I would like to mention is my participation in the University Academic Integrity Review Board. In truth, the Board was seldom convened. However, the cases that we reviewed were always extremely thought-provoking and controversial (by nature, since the Board was the final arbitrator of cases that could not be resolved at the Department or College levels). For example, in 2010 the Board met in special sessions, in which I acted as Chair, to review a case in which a student challenged a failing grade given by a faculty instructor as a consequence of cheating (as interpreted by the faculty). In the end, the case was balanced on the question: To what extent does a faculty member have unlimited authority to define the action of cheating? The case not only had obvious consequences for the career of the student and reputation of the faculty member, but also helped to establish precedence in what seems often to be a very gray area.

In all of this I have demonstrated a strong **commitment to diversity and inclusiveness**. This encompasses significant efforts, such as actively participating in the Multicultural Apprentice Program that targets underserved students, or learning Spanish through a four-week intensive course in order to communicate my work bilingually when the opportunity arises, but also small steps, such as ensuring that posting for new positions are distributed broadly. I believe this commitment has had numerous and very positive impacts on both my team and the University. I envision expansion of such activities in the future. I am currently in discussions with a former postdoc of mine, Maria Julissa Ek-Ramos, about how she and I can build such a pipeline from recruitment at the K-12 level to undergraduate/graduate success.

My yarn ends as Reader may grow weary and as we swiftly approach the page limit. In summary, my voyage as a faculty member in MSU Horticulture has been exciting, interesting, enjoyable, and (I believe) highly productive and significant. I now look forward to the new challenges and opportunities that accompany a promotion to full professor, not only on campus, but literally to all corners of the globe.