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Society for Integrative and Comparative Biology

SYMPOSIUM INTRODUCTION

Celebrating a New Division of Botany at SICB: An Introduction to the Integrative Plant Biology Symposium

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Synopsis The Society for Integrative and Comparative Biology (SICB) should, in theory, be a home for scientists working across the entire Tree of Life. In practice, SICB has remained principally a society that supports integrative zoological research. Here we highlight a broad collection of what we consider to the best in integrative and comparative plant biology, gathered together for a special symposium at the 2019 SICB meeting. This symposium and special issue mark the initiation of a new Division of Botany within SICB, which we hope will usher in a new era of SICB where botanists and zoologists engage, collaborate, and celebrate together in this especially creative period of integrative and comparative biology.

In 1996, after 94 years of existence, the American Society of Zoologists voted to change its name, and the Society for Integrative and Comparative Biology (SICB) was born (Quinn 1982; Hadfield 1996). We presume the name change was in part to better reflect the research interests of its current members. But it was clearly also an aspirational statement of taxonomic expansion—a desire to draw new membership from a broader scientific community, and to create an inclusive society of like-minded, organismally focused comparative biologists. As a concept, this kind of society seems undeniably wonderful to us—but how successful has SICB been in expanding its scope? Twenty-three years on, the society's annual meeting is still primarily a showcase of cutting edge integrative and comparative *zoology*, and society journals rarely see submissions concerning organisms from the other major branches of the Tree of Life. Contributions from botanists in particular have remained few and far between, with no hint of any organic or spontaneous increase in botanical membership or participation. It does not appear to be enough to simply change a society name. Rather, we have to make a case for why integrative biologists working on the full diversity of life forms should be talking to one another—and we need to deliberately infuse the annual meeting with integrative biologists who do not work on animals.

With this in mind, SICB President Beth Brainerd asked the two of us to organize a day-long symposium at the 2019 meeting in Tampa that would highlight what we consider to be the most exciting areas of Integrative Plant Biology. The hope was that a more proactive approach could kick start a botanical awareness of SICB in a way that might snowball into a permanent and significant presence in the society. To provide some extra momentum around this idea, a "SICB Special Focus Meeting in Organismal Botany" was set up—this was conceptualized as a sort of plant mini-meeting within the larger SICB conference. The special focus meeting included a complementary contributed-talk session on integrative plant biology, a "Rising Star in Organismal Botany" award session for graduate student research, and a roundtable "Botany at SICB?" luncheon to explore the possibility of creating a new Division of Botany in the society.

Without a doubt, these efforts were successful; the botanists who attended the meeting discovered a

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delightful group of scientists whom they would never run across at Botany meetings, and who might also attend Ecology and/or Evolution meetings but would be diluted by the many other subdisciplines who also call those societies home. Reciprocally, the SICB regulars seemed to like having us botanists around. By the end of the meeting, the SICB executive council voted unanimously to create a new Division of Botany, and a set of inaugural officers has been appointed: Christopher Martine (Chair), Janet Stevens (Program Officer), and Christopher Muir (Secretary). And away we go!

For the new division to be successful in SICB, we believe it will take deliberate and sustained encouragement to create a dedicated cohort of botanists that will call an additional society their home. This is an uphill battle, but there has never been a better time to increase interaction and collaboration among botanists and zoologists. As the field of genomics explodes, it becomes mind-boggling to contemplate the questions we can now ask in any system we like. Research programs that were once limited to *Drosophila* and *Arabidopsis* can now be undertaken in any species, in multiple species, across large clades (e.g., Pease et al. 2016). The rate at which we are improving our understanding of the Tree of Life opens new doors for comparative biology (Soltis et al. 2018). Imaging technology and rapid phenotyping are revolutionizing the scale of what we can measure and the scope of what we can see (Earles et al. 2019). The amount and diversity of data types has created a hyper-creative moment in organismal biology, where researchers are exploring all sorts of audacious ideas and combining and analyzing data in new ways, and plant and animal researchers need to share their ideas, approaches, and challenges with one another.

So, what is "integrative plant biology"?

At some point mid-way through organizing this symposium, we eventually asked ourselves, what do we mean when we say "integrative"? What is integrative plant biology? Is it a "know it when you see it" sort of thing, or can we put a finer point on this term? In reality, "integrative" is such a broad term that it could actually refer to almost any kind of biological research—and certainly, most scientists would consider themselves to be integrative in one way or another. So what kind of work do we tend to label as integrative, and why did we choose to highlight the scientists that we did?

Classical questions of organismal form and function often act as the poster children for "integrative biology," and much of the work we consider to be integrative plant biology does also fall into this category. Similarly, much of integrative plant biology is comparative, with analyses grounded in a phylogenetic perspective, but these are not necessarily essential features either. More broadly, we view the defining nature of integrative plant research (and common to all of the contributions in this special volume) is that it brings together multiple disparate approaches and/or perspectives to bear on a single problem, making connections between different phenomena, scales, patterns, or attributes that had not been noticed before. Integrative plant biologists tend to be open to using whichever tools are most appropriate to the question at hand, to approaching questions from a holistic perspective, and to creatively combining methodology and conceptual frameworks in novel ways. The contributions presented in this special issue are all brilliant examples of this kind of integration—the weaving of multiple strands of evidence to reach consilience on a difficult problem.

Olson (2019) begins the issue by celebrating the "woken giant" (*sensu* Ackerly and Monson 2003) of plant evolutionary ecology, and then quickly takes a deep dive into unintended consequences of the use of standard conceptual dichotomies of "genetic vs. plastic," and "adaptation vs. constraint" explanations in such studies. He presents these (and others) as apparently innocent but ultimately limiting concepts that we need to be wary of as we continue to build a deeply thoughtful discipline. The following two empirical papers directly tackle some of the dichotomies highlighted by Olson (2019), and Emery and La Rosa (2019) could be considered almost a direct response to Olson's call for a more nuanced consideration of genetic/plastic aspects of the phenotype. In this work, they experimentally manipulated environmental variability in three closely related species of *Lasthenia*, which grow in the ephemeral vernal pools of California, and highlighted the integrated nature of developmental, genetic, and plastic responses. Hancock et al. (2019) also tackle issues of phenotypic plasticity in a large-scale drought experiment of 23 Australian *Calandrinia* species, which differ in their ability to upregulate Crassulacean acid metabolism (CAM) photosynthesis in response to water limitation. They demonstrate significant evolutionary lability in the degree of CAM expression, and suggest that a facultative CAM phenotype is both adaptive and is also an important evolutionary precursor to a strong constitutive CAM syndrome.

The next set of papers represent a different vein of integrative plant biology, one that dives deeply into

more classical problems of organismal form and function. Rosell (2019) breaks apart a long-held assumption about the primary function of thick bark in woody plants as a protectant from fire; she highlights the complexity and functional pleiotropy of bark as a tissue system, and emphasizes the exceptionally strong relationship between bark thickness and stem diameter, which now requires new hypotheses about the functional significance of bark thickness. In a similar vein, Leslie and Losada (2019) describe the multiple roles that conifer female reproductive structures play during their developmental trajectories (pollen collection vs. seed dispersal), and how this functional interplay ultimately influences the morphological diversity of cone types that are found across the major conifer clades. Diggle and Mulder (2019) present an entirely new angle on the varied response of plants to warming temperatures in seasonal temperate regions: whether a species' flowering time is becoming earlier, is non-responsive, or is becoming later may be largely due to their specific pattern and timing of preformation of tissues in buds during the previous growing season.

Finally, the last two contributions are examples of multi-disciplinary approaches to basic problems in plant biology. These studies illustrate how we can incorporate insights from modeling and empirical datasets to address fundamental questions about evolutionary convergence. Muir (2019) investigates the striking bimodal pattern of stomatal distribution on the upper and lower leaf surfaces across angiosperms using optimality models to predict the tradeoffs between photosynthesis and water loss in different environments. He discovered that a bimodal pattern is predicted only when the costs of amphistomy (stomata on both leaf surfaces) strongly co-vary with environment. Wheeler and Smith (2019) simulate mutational pathways of anthocyanin metabolism to predict the convergent evolution of different floral colors, accounting for pleiotropic effects of mutational changes in the substrate specificity of pigment enzymes.

All of this work inspires us, as did many other talks, posters, and conversations we engaged with at the Tampa meetings. We see the enormous potential of integrating plant biology into SICB, for both botanists and SICB as a whole, and sincerely hope this new effort to create a permanent home for botanists at SICB takes hold. It's clear that SICB also sees the value of this direction, but success in this new venture will require *botanists* to fully engage and actively recruit colleagues to come along, especially in the next few years. Botanists who get involved in this early stage have the opportunity to strongly influence the direction of the new SICB Division of Botany. We hope that the work presented in this special volume illustrates the breadth of integrative and comparative botanical research, and inspires a genuine shift in participation that will finally create a productive flow of ideas and collaboration between botanists and zoologists who are united by their integrative approaches to studying the diversity of life.

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