Preface

IT HAS BEEN 11 YEARS SINCE THE FIRST EDITION of *Auxin Signaling: From Synthesis to Systems Biology* was published. Since then, auxin biology has continued to be a robust, dynamic, and multifaceted field. In the first edition of this collection, we noted that auxin has claimed center stage in many areas of plant biology and this continues to be the case. However, technological advances in analytical methods, imaging, genome-level studies, and computational biology have led to astounding new insights at every turn. In this volume, we once again attempt to highlight the latest exciting advances in each of the diverse areas of auxin biology.

In the first chapter, Jiří Friml reflects on the progress made in the broad auxin biology field, touching upon all other chapters in this book. He highlights 14 "stations" where exceptional progress has been made, where questions were answered, where unexpected turns have been taken, or where new questions arose. This chapter will likely convince readers that the auxin field will still be vital for decades to come.

This is followed by two chapters that explore the complex mechanisms that regulate auxin levels in both time and space. In their chapter about auxin metabolism, Casanova-Saéz et al. discuss how auxin biosynthesis, conjugation, and degradation are coordinated to achieve the spatiotemporal regulation of auxin levels that drive developmental processes. Complementing this chapter, Hammes et al. describe work on the various auxin transporters with an emphasis on their molecular mechanisms.

The next four chapters focus on mechanisms of auxin signaling. Morffy and Strader discuss the canonical auxin signaling pathway from a protein structural perspective and highlight recent work showing that formation of cytoplasmic condensates of certain ARF proteins has a regulatory function. The three next chapters address the exciting and fast-moving topic of noncanonical auxin signaling. Rapid, nontranscriptional auxin signaling has been investigated for many years. Dubey et al. discuss recent discoveries that have generated new interest in this area. Related to this topic, Napier contributes a historical perspective on auxin-binding protein 1 (ABP1), including the latest information on its potential function as an auxin receptor. McLaughlin et al. present recent work on novel auxin signaling mechanisms. One of these mechanisms involves direct binding of auxin to a transcription factor, thus affecting its interaction with binding partners, while another focuses on a small family of receptor kinases called the TMKs. Clearly there is more to learn about both canonical and noncanonical auxin signaling.

We have learned much in the last decade about the role of auxin during development. Seven chapters take a deep dive into auxin regulation of the development of different organs or tissues. Pernisová and Vernoux lead the way by describing how auxin maxima and minima are established in the shoot apical meristem and drive the development of new organs. There has been extensive progress in our understanding of auxin during root development and two chapters are devoted to this topic. Roychoudhry and Kepinski describe recent work on roots with an emphasis on root system architecture and branch angle. Cavallari et al. focus on the role of auxin in the integration of endogenous and environmental signals during lateral root development. Some of the oldest observations concerning auxin and plant development relate to the vascular system. Lavania et al. illustrate how the logic of vascular patterning is becoming clear. However, they also note that many of the molecular details are still unclear. Sticking to the theme of patterning, Verma et al. describe the profound role of auxin during embryogenesis and also point out the importance of emerging tools that may be important for future studies of auxin and embryogenesis. Of course, embryogenesis depends on the proper development of reproductive structures present on flowers, and Cucinotta et

al. present the latest work on the diverse roles of auxin during flower development. They also emphasize the importance of the comparative approach since flower development is amazingly diverse across all angiosperm lineages.

One of the most complex areas of hormone biology are the interactions between hormones. Mazzoni-Putman et al. tackle this topic in the context of auxin and illustrate how auxin interacts with most, perhaps all, of the major plant hormones. In fact, one need not venture beyond auxin itself to observe complex regulatory systems. Ma et al. document the many homeostatic mechanisms that govern the regulation of auxin levels and signaling output.

Throughout the volume, the important role that auxin plays in environmental response is never far from the surface. This topic is addressed directly in three chapters. Leftley et al. discuss how auxin facilitates changes in root system architecture in stress conditions while Kunkel and Johnson focus on the important role of auxin during plant–pathogen interactions. Casal and Estevez take a different approach to this topic by considering how auxin regulation enables the plant to maximize capture of limiting resources.

During the last few years, there has been increasing interest in the evolutionary history of auxin signaling. Bowman et al. take a broad approach to this topic by addressing changes in auxin biology during the evolution of land plants. On the other hand, Suzuki et al. focus on the Bryophyta, the descendants of the first land plants and sister group to the vascular plants. Both chapters illustrate how much we can learn about auxin biology by taking an evolutionary perspective.

The volume finishes with several very forward-looking topics: synthetic biology, computational biology, and chemical biology. Wright et al. describe efforts to establish the logic and mechanisms of auxin signaling by using synthetic systems. Two chapters, Rutten et al. and Cieslak et al., describe the latest efforts to produce robust computational models for root and shoot growth, respectively. Finally, Hayashi describes the development of powerful new chemical tools to study various aspects of auxin biology.

It has been more than 140 years since Charles Darwin first described a "substance" that moved from the tip of an oat coleoptile to its base and produced a growth response. We hope this book provides an informative overview of the current state of our knowledge, and offers viewpoints that can stimulate discussion. Of course, the most important purpose of such a volume is to illustrate what we don't know, and by doing so, provoke new questions from the next generation of curious scientists. We hope that we have succeeded in this respect as well. We are grateful to Richard Sever and Barbara Acosta from Cold Spring Harbor Laboratory Press for their encouragement and patience. Finally, we sincerely thank all the authors for the time and thoughtfulness they committed to these chapters.

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