PREFACE

Sessile plants must rapidly respond to drastic environmental changes to survive and must timely adjust their growth and developmental behaviors in response to daily and seasonal environmental changes. Consequently, most differentiated plant cells are totipotent, and plants have flexible developmental programs that are highly adaptable to the environment. An intriguing and important question in our understanding of plant developmental program and responses to the environment is what kinds of strategies and mechanisms plant cells use for the transmission and the integration of various developmental and environmental signals. In recent years, we have witnessed an exponential increase in our knowledge of plant intracellular signaling mechanisms, pathways, and networks that plants utilize to monitor and process a specific extracellular signal and to modulate a given process. This rapid knowledge growth has been clearly aided by genetic and genomic approaches in model plant systems such as *Arabidopsis*. Many critical signaling components and pathways have been identified based on genetic mutations that affect a specific plant process. The availability of new biochemical, molecular, cell biological, and proteomic tools have also undoubtedly fueled our advancement in elucidating signaling mechanisms in plants.

The picture of intracellular signaling in plants that has emerged from these dramatic advances is such that plants use signaling mechanisms and networks that integrate ancient and universal intracellular signals and signaling mechanisms with their own inventions in essentially every plant signaling pathway/network known to date. Examples of conserved signaling mechanisms include the prokaryotic two-component regulatory systems, receptor and nonreceptor serine/threonine kinases, calcium, heterotrimeric G proteins, Rho family guanosinetriphosphatases (GTPases), and mitogen-activated protein kinase cascades, phospholipids, the cytoskeleton, and the ubiquitin-based protein turnover machinery. Many plant pioneer signaling components have also been uncovered, such as novel interactors of heterotrimeric G proteins and Rho GTPases, calcium-dependent protein kinases, and novel scaffolding proteins. The goal of this volume is to provide an in-depth discussion on many of these conserved and novel signaling mechanisms and to provide a few examples of how these conserved and novel signaling mechanisms are constructed into a signaling network that modulates a specific plant process. Obviously this volume is unable to cover several important topics in plant signaling either due to space limitation or due to significant coverage of these topics in other volumes. For example, the two-component systems have been

discussed in the volume on plant hormones, and photoreceptors on the photomorphogenesis volume.

Despite the tremendous progress in recent years, many important questions and challenges remain in the field of plant intracellular signaling. It is likely that many new signaling components and mechanisms have yet to be unraveled. The roles of most plant "pioneer" proteins in signaling are unknown. The picture for many signaling pathways is still incomplete, and we are missing the knowledge of the nature and the mechanism of perception for many signals. For example, the vast majority of >400 receptor-like kinases have no known functions and corresponding ligands. The understanding of signaling networks and cross talks between signaling pathways/networks are just starting. Clearly, the conventional approaches such as genetics and biochemistry will continue to be valuable and -omics will also start to pay their dues. However, we are also in need of elucidating signaling networks at the systems level by using mathematical and computational approaches. It is my hope that this volume would provide a catalyst for propelling our understanding of plant intracellular signaling to the next level.

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