# Signaling and Communication in Plants

## Series Editors

František Baluška
Department of Plant Cell Biology, IZMB, University of Bonn, Kirschallee 1,
D-53115 Bonn, Germany

Jorge M. Vivanco
Center for Rhizosphere Biology, Colorado State University, 217 Shepardson Building,
Fort Collins, CO 80523-1173, USA

For further volumes:
http://www.springer.com/series/8094

Helen R. Irving • Christoph Gehring
Editors

# Plant Signaling Peptides

Springer

*Editors*
Helen R. Irving
Monash Institute of Pharmaceutical Sciences
Monash University
Parkville
Australia

Christoph Gehring
Division of Chemistry
Life Science and Engineering
4700 King Abdullah University of Science and Technology
Thuwal
Kingdom of Saudi Arabia

ISSN 1867-9048 ISSN 1867-9056 (electronic)
ISBN 978-3-642-27602-6 ISBN 978-3-642-27603-3 (eBook)
DOI 10.1007/978-3-642-27603-3
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2012940197



Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

# Preface

Proteins and peptides form integral parts of all living cells where their function is essential for the survival of the cell and organism. Proteins are dynamic biomolecules that function in maintaining structure, metabolism, and also cellular communication. Peptides are loosely defined as small proteins containing 50 amino acids or less. In plants, as in animals and other organisms, peptides have diverse roles and participate in communication between cells. The focus of this volume is on the diverse roles that peptides and small proteins have in intercellular and intracellular communication in plants. In part because of their immobile nature, plants have evolved a complex array of signaling molecules to facilitate their growth and development and their interactions with the environment. A vast number of different peptide molecules make an important, but until relatively recently overlooked, component among these signaling molecules. As discussed in chapter "Plant Peptide Signaling: An Evolutionary Adaptation," plant signaling peptides have evolved in several independent events with distinct and separate phylogenies to create a diverse repertoire of signaling molecules.

This volume focuses on the roles of various peptide signaling molecules in plant growth, development, defense, and homeostasis. The roles of plant peptides in growth and development are discussed in chapters "Peptides Regulating Apical Meristem Development," "Peptides Regulating Root Growth," "Peptides Regulating Plant Vascular Development," and "The S-LOCUS CYSTEINE RICH PROTEIN (SCR): A Small Peptide with a High Impact on the Evolution of Flowering Plants." Chapter "Peptides Regulating Apical Meristem Development" reviews the well-understood role of peptide signaling in the shoot apical meristem of the model plant *Arabidopsis* that in turn has led to the discovery of related peptides in other plants. In fact, the major peptide protagonist in *Arabidopsis* CLAVATA 3 (CLV3) and its maize homolog EMBRYO SURROUNDING REGION (ESR) contributed to the naming of one of the largest signaling peptide groups, the CLE peptides. CLE peptides are involved in regulating organogenesis and have roles in the root growth and development which is discussed in chapter "Peptides Regulating Root

Growth." Members of the CLE peptides are also involved in regulating the development of the vascular cambium which is reviewed in chapter "Peptides Regulating Plant Vascular Development." In addition, members of the CLE family are co-opted by legumes during the symbiosis between legumes and rhizobia bacteria, as described in chapter "The Role of Plant Peptides in Symbiotic Interactions." However, the story of peptide signaling is not restricted to one family of peptides and certainly in development is integrated with signals from other plant growth regulators. Other peptides that contribute to organogenesis and the maintenance of stem cells include phytosulfokines (PSKs), ENOD40, rapid alkalinization factors (RALFs), and the recently discovered root growth factor (RGF). Specific and novel peptides are involved in various developmental processes. The family of S-LOCUS CYSTEINE RICH PROTEINs (SCRs) has an important role as a determinant of self-incompatibility in members of the *Brassicaceae* which is discussed in chapter "The S-LOCUS CYSTEINE RICH PROTEIN (SCR): A Small Peptide with a High Impact on the Evolution of Flowering Plants." While another recently characterized small family of peptides called EPIDERMAL PATTERNING FACTORs (EPFs) are also cysteine-rich peptides that have a role in regulating stomatal development, as reviewed in chapter "Peptides Modulating Development of Specialized Cells."

Signaling peptides also function in a wide range of plant defense responses. In fact, the first signaling peptide to be discovered and characterized was systemin which induces synthesis of proteinase inhibitors in leaves as a wound response. Since then, a myriad of plant defense proteins with diverse structures have been identified. Many of these are antimicrobial proteins and include defensins, thionins, and knottin-like peptides, as described in chapter "Plant Antimicrobial Peptides." Other signaling peptides function as endogenous amplification signals of plant innate immune responses as part of the pattern and/or microbe-associated molecular pattern (PAMP/MAMP) response which is discussed in chapter "Peptides as Danger Signals: MAMPs and DAMPs." The signal exchange initiated by rhizobia employs and/or co-opts several plant signaling peptides in the host legume, as reviewed in chapter "The Role of Plant Peptides in Symbiotic Interactions." Plant signaling peptides also have roles in maintaining overall plant homeostasis in addition to organogenesis and development, and in chapter "Peptides and the Regulation of Plant Homeostasis," the role of the small protein plant natriuretic peptide is described.

As it is highly likely that to date, only a few of the signaling peptides are known, and further plant peptide signaling molecules remain to be discovered, the last section of this volume takes a practical look at methods to identify new peptides and characterize their function. Signaling peptides usually contain an N-terminal signal motif and are secreted into the extracellular matrix (apoplast) where, in some cases, they are proteolytically cleaved. Peptides such as PSK and RGF are also sulfated on tyrosine residues, and some CLE peptides are hydroxylated on proline residues before secretion. The processing of peptides is described in chapter "Processing of Peptides" along with strategies for investigating these processes. In chapter "Methods to Isolate and Identify New Plant Signaling Peptides," the principles and methods for peptide purification are discussed. For signaling peptides to be successful as communicators in the plant, specific partners are required, and genetic and biochemical approaches to identify these partners are described in chapter "Methods to Identify New Partners of Plant Signaling Peptides." Finally, a computational approach is outlined in chapter "Computational-Based Analysis to Associate the Function of Plant Signaling Peptides with Distinct Biological Processes" where proteins co-expressed with PROPEP2 are identified.

May 2012
Parkville, Australia — Helen R. Irving
Thuwal, Kingdom of Saudi Arabia — Chris Gehring

# Contents