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Viral Transport in Plants

Volume Editors: Elisabeth Waigmann, Manfred Heinlein

With 5 Tables and 15 Figures, 2 in Color

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Editors

Manfred Heinlein studied biology and obtained his Ph.D. at the University of Cologne in 1992. Following a two year period as a post-doc continuing his studies on maize transposons in Cologne, he went for postdoctoral studies to the Scripps Research Institute (La Jolla, CA, USA), where he initiated his research on plant virus movement. In 1997, he went to Basel (Switzerland) where he became group leader at the Friedrich Miescher Institute for Biomedical Research (FMI) and habilitated (venia docendi) in Molecular Biology at the University (in 2001). In 2003, he obtained a professorship funded by the Swiss National Science Foundation to join the Botanical Institute in Basel as assistant professor. At the end of the same year, he became group leader at the Institut de Biologie Moléculaire des Plantes (IBMP-CNRS) in Strasbourg. His major research interests focus on cell-to-cell communication in plants, particularly on the mechanism and role of RNA transport in systemic gene regulation and RNA virus infection.

Elisabeth Waigmann is currently group leader at the Max F. Perutz Laboratories, a joint venture between the Medical University of Vienna and the University of Vienna, located at the Vienna Biocenter, Austria. She studied Chemistry, with specialization in Biochemistry, at the University of Vienna, and only later on became increasingly interested in cell biology. Her ongoing research focuses on transport processes in and between cells, with plant viruses as a model system.

Preface

Plants, as sessile organisms, are exposed to a multitude of stresses ranging from pathogens to environmental conditions. Not surprisingly, plants have developed sophisticated pathways to respond to and cope with those stresses. Plant viruses and viroids are pathogens and, as their life cycle is largely dependent on the plant host, they provide a valuable doorway to glimpse and analyze the intricate net of host-pathogen interactions. Of course, research on plant viruses provides insight into plant defense reactions. However, they also represent important tools for the analysis of the mechanisms involved in the transport of macromolecules through plasmodesmata, the channels in the plant cell wall through which adjacent cells communicate. In this book we provide a state-of-the-art overview about processes involved in virus transport and start by taking a view on the mechanisms involved in the transmission of viruses from plant to plant. Then we narrow our focus on single infected plants with the question how plant viruses and viroids exploit plasmodesmata and other host cell components to spread cell-to-cell and systemically. Since viruses trigger defense responses of the plant, a chapter is dedicated to the description of the battle between viruses and host plants that rages on the field of post-transcriptional gene silencing. Finally, the book ends by highlighting research performed in the model plant Arabidopsis, which serves as a valuable host for genetic approaches to identify novel factors involved in virus–host interactions.

To optimize entry into and transmission between plants, most plant viruses utilize insect or nematode vectors. Consequently, the majority of viral transport mechanisms associated to the transmission step has been approached through the study of virus–vector relationships. The chapter "Virus Transmission – Getting Out and In" by Stéphane Blanc concisely summarizes our knowledge on viral transport between plants by various vectors, and highlights a few examples in more detail. Blanc illustrates the concept that some viral trafficking within plants is specifically intended to prepare ulterior acquisition by the vectors, thereby providing a direct link to the following chapters dealing with *in planta* movement.

The chapter "Tobacco Mosaic Virus – a Model for Macromolecular Cell-to-Cell Spread" by Elisabeth Waigmann, Mirela Curin and Manfred Heinlein, illuminates the central role of the virus-encoded movement protein (TMV-MP)

in the cell-to-cell movement of TMV. As a pioneer among plant viruses, this virus has served as a favorite research object for more than a hundred years. Still firmly anchored at the forefront of research, TMV breaks the ground for novel insights into the principle mechanisms involved in the cell-to-cell transport of macromolecules, with implications that may go far beyond the field of virology.

While TMV movement involves the transport of the viral genome in a non-encapsidated form, i.e. as a ribonucleoprotein particle, other viruses move between cells in the form of entire virus particles. This type of movement involves the formation of transport tubules within plasmodesmata, which is summarized in the chapter "Tubule-Guided Movement of Plant Viruses" by Christophe Ritzenthaler and Christina Hofmann. The chapter describes the functional relevance of these tubules in the transport of viruses, speculates on models for this movement mechanism and discusses the host components that seem to contribute to this type of transport.

Mechanistically complex and clearly distinct from cell-to-cell transport are plant viral strategies for systemic movement and infection of the whole plant. In their chapter "Spread Throughout the Plant: Systemic Transport of Viruses" the authors Shoko Ueki and Vitaly Citovsky emphasize that systemic movement is indeed more than just the summary of numerous cell-to-cell movement events, since it involves many different types of cells and tissues, requires different cellular factors and proceeds at much higher speed than local movement. Moreover, systemic movement provides insight into the ability of the virus to interact with plant defense responses. For example, several viral and host factors involved in systemic movement act through the suppression of RNA silencing, which targets the viral genome for degradation.

A highly elegant model system for studies on intra- and intercellular transport are viroids, small non-coding and non-encapsidated RNA molecules that are able to replicate and systemically infect plants. Due to their lack of protein components, viroids are particularly dependant on the plant cellular machinery and may therefore represent the best model system to elucidate endogenous intercellular RNA transport processes. Biao Ding and Asuka Itaya summarize in the chapter "Intracellular and Intercellular Transport of Viroids" recent progress in the characterization of viroid structures and host proteins but also critically discuss issues that need to be addressed in future investigations.

As mentioned above, RNA silencing constitutes an important plant defense mechanism against viruses. Thus, no book on viral transport in plants can abstain from including a chapter on RNA silencing. The chapter by Thomas Hohn, Rashid Akbergenov and Mikhail Pooggin entitled "Production and Transport of the Silencing Signal in Transgenic and Virus-Infected Plant Systems" narrates the fascinating story of the race between silencing and virus replication.

Tyrell Carr and Steven A. Whitham dedicate their chapter "An Emerging Model System: Arabidopsis as a Viral Host Plant" to the molecular biologist's

pet plant, *Arabidopsis thaliana*. An amazing array of viruses has already been shown to infect one or more Arabidopsis ecotypes. Thus, although Arabidopsis has only recently entered the scene of plant virus research, it opens the door to genetic and reverse genetic approaches that are not feasible or practical in many agronomically important hosts. Indeed, a number of host genes involved in virus replication and spread have already been identified in Arabidopsis.

Overall, the book is intended for a readership of advanced students, teachers and interested researchers, and is intended to fill the gap that is created by the lack of information in many standard textbooks on the topic of plant viruses. We wish to particularly thank the authors who have contributed to the book with their chapters, especially for their enthusiasm and diligence in providing a state-of-the-art overview on the manifold fascinating aspects of viral transport in plants. We also thank Springer, represented by Christina Eckey and Anette Lindqvist, as well as series editor David Robinson, for undertaking the ambitious effort to create the "Plant Cell Monographs" series, dedicated to various highly interesting aspects of plant biology.

February 2007

Elisabeth Waigmann
Manfred Heinlein

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