Physiology of Plant Cells

James Albard

Intelliz Press

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Plant cells are eukaryotic cells, or cells with a membrane-bound nucleus. Unlike prokaryotic cells, the DNA in a plant cell is housed within the nucleus. In addition to having a nucleus, plant cells also contain other membrane-bound organelles, or tiny cellular structures, that carry out specific functions necessary for normal cellular operation. Plant cells are similar to animal cells in that they are both eukaryotic cells and have similar organelles. Plant cells are generally larger than animal cells. While animal cells come in various sizes and tend to have irregular shapes, plant cells are more similar in size and are typically rectangular or cube shaped. A plant cell also contains structures not found in an animal cell. Physiology of Plant Cells focuses on the structure and function of plant cell walls. This book will be useful as a general reference for teachers and scientists interested in certain aspects of the field, as well as for students of biology and agriculture. First chapter aims to investigate ameliorating effects of signaling molecules, antioxidants and essential ions (AS, GSH, AA, Fe, Ca, Zn and Gd) on impact of the heavy metals Cd, Cr and Pb on the alga Micrasterias denticulata in order to obtain insight into heavy metal uptake mechanisms and intracellular targets. Second chapter summarizes the current knowledge of three major Na+ transporters, namely NHX, SOS1, and HKT transporters, including recently revealed characteristics of these transporters. Third chapter presents a systems approach to regulating plant cell physiology by 2-oxoglutarate-dependent dioxygenases. In Fourth chapter, we summarize the currently available molecular toolbox of probes for cell wall polysaccharide imaging in plants, with particular emphasis on recent advances in small molecule-based fluorescent probes. We also discuss the potential for further development of small molecule probes for the analysis of cell wall architecture and dynamics. Fifth chapter focuses on tubulin tyrosine nitration regulates microtubule organization in plant cells and Sixth chapter gives an overview of common mass spectrometry techniques applied to the analysis of plant cell wall carbohydrates. It presents examples in which mass spectrometry has been used to elucidate the structure of oligosaccharides derived from hemicelluloses and pectins and illustrates how information on sequence, linkages, branching, and modifications are obtained from characteristic fragmentation patterns. Seventh chapter presents an overview of the applications of tissular and intra-cellular localization of these intrinsic fluorophores in leaves and fruits. Eighth chapter provides an alternative system to investigate the production of cell wall polysaccharides, particularly the synthesis and modification of pectin. Ninth chapter summarizes the available evidence suggesting that formins participate in membrane trafficking and endomembrane, especially ER, organization also in plants. The aim of Tenth chapter was to examine cross-talk interactions of soluble sugars (sucrose, glucose and fructose) and infection caused by Fusarium. Eleventh chapter summarizes current literature aimed at elucidating VSR-mediated vacuolar trafficking and compare the two models with respect to the sorting signals of vacuolar proteins, as well as the molecular machinery involved in VSR-mediated vacuolar trafficking and its action mechanisms. Last chapter reveals an arabidopsis mitochondrial uncoupling protein confers tolerance to drought and salt stress in transgenic tobacco plants.

James Albard has received Ph.D. in Plant Science. He has more than six years of teaching experience. He has written numerous articles, research papers, and journals on plant tissue culture, plant morphology, and plant cell structure.

ISBN 978-1-68251-257-9

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Editor:

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Intelliz Press
www.intellizpress.com

Intelliz Press LLC
1 Radisson Plaza # 800
New Rochelle, New York
NY 10801
United States of America

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ISBN: 978-1-68251-257-9

Printed in Republic of Korea

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Preface

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Editors

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List of Contributors

Stefanie Volland

Plant Physiology Division, Cell Biology Department, University of Salzburg, Hellbrunnerstraße 34, 5020 Salzburg, Austria

Elisabeth Bayer

Plant Physiology Division, Cell Biology Department, University of Salzburg, Hellbrunnerstraße 34, 5020 Salzburg, Austria

Cornelius Lütz

Institute of Botany, Faculty of Biology, University of Innsbruck, Sternwartestraße 15, 6020 Innsbruck, Austria

Toshio Yamaguchi

Department of Microbiology, Faculty of Pharmacy, Niigata University of Pharmacy and Applied Life Sciences, Niigata, Japan

Shin Hamamoto

Department of Biomolecular Engineering, Graduate School of Engineering, Tohoku University, Sendai, Japan

Nobuyuki Uozumi

Department of Biomolecular Engineering, Graduate School of Engineering, Tohoku University, Sendai, Japan

Siddhartha Kundu

School of Computational and Integrative Sciences, Jawaharlal Nehru University, New Delhi, India

Ian S. Wallace

Energy Biosciences Institute, University of California, Berkeley, CA, USA

Department of Plant and Microbial Biology, University of California, Berkeley, CA, USA

Charles T. Anderson

Department of Biology, The Pennsylvania State University, University Park, PA, USA

Yaroslav B. Blume

Department of Genomics and Molecular Biotechnology, Institute of Food Biotechnology and Genomics, National Academy of Sciences of Ukraine, Kyiv, Ukraine

Yuliya A. Krasylenko

Department of Genomics and Molecular Biotechnology, Institute of Food Biotechnology and Genomics, National Academy of Sciences of Ukraine, Kyiv, Ukraine

Stefan Bauer

Energy Biosciences Institute, University of California, Berkeley, CA, USA

Pascale Talamond

Institut des Sciences de l'Evolution Montpellier ISE-M, Université Montpellier, CNRS, IRD, EPHE, CC 065, Place Eugène Bataillon, 34095 Montpellier, France

Jean-Luc Verdeil

Histocytology and Plant Cell Imaging platform PHIV, UMR AGAP (CIRAD, INRA, SupAgro)-UMR B&PMP (INRA, CNRS, SupAgro, Montpellier University), 34095 Montpellier, France

Geneviève Conéjéro

Histocytology and Plant Cell Imaging platform PHIV, UMR AGAP (CIRAD, INRA, SupAgro)-UMR B&PMP (INRA, CNRS, SupAgro, Montpellier University), 34095 Montpellier, France

Bo Yang

Institute for Botany and Molecular Genetics (IBMG), RWTH Aachen University, 52056 Aachen, Germany

Markus Günl

Institute for Bio- and Geosciences (IBG-2: Plant Sciences), Forschungszentrum Jülich, 52425 Jülich, Germany

Fatima Cvrčková

Department of Experimental Plant Biology, Faculty of Sciences, Charles University, Viničná 5, 128 43 Prague 2, Czech Republic

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RESCUE OF HEAVY METAL EFFECTS ON CELL PHYSIOLOGY OF THE ALGAL MODEL SYSTEM *MICRASTERIAS* BY DIVALENT IONS

Stefanie Volland[1], Elisabeth Bayer[1], Verena Baumgartner[1], Ancuela Andosch[1], Cornelius Lütz[2], Evelyn Sima[1] Ursula Lütz-Meindl[1]

[1] Plant Physiology Division, Cell Biology Department, University of Salzburg, Hellbrunnerstraße 34, 5020 Salzburg, Austria

[2] Institute of Botany, Faculty of Biology, University of Innsbruck, Sternwartestraße 15, 6020 Innsbruck, Austria

ABSTRACT

Recent studies have shown that metals such as copper, zinc, aluminum, cadmium, chromium, iron and lead cause severe dose-dependent disturbances in growth, morphogenesis, photosynthetic and respiratory activity as well as on ultrastructure and function of organelles in the algal model system *Micrasterias denticulata* (Volland et al., 2011, Volland et al., 2012 and Andosch et al., 2012). In the present investigation we focus on amelioration of these adverse effects of cadmium, chromium and lead by supplying the cells with different antioxidants and essential micronutrients to obtain insight into metal uptake mechanisms and subcellular metal targets. This seems particularly interesting as *Micrasterias* is adapted to extremely low-concentrated, oligotrophic conditions in its natural bog environment. The divalent ions of iron, zinc and calcium were able to diminish the effects of the metals cadmium, chromium and lead on *Micrasterias*. Iron showed most ameliorating effects on cadmium and chromium in short- and long-term treatments and improved cell morphogenesis, ultrastructure, cell division rates and photosynthesis. Analytical transmission electron microscopic (TEM) methods (electron energy loss spectroscopy (EELS) and electron

spectroscopic imaging (ESI)) revealed that chromium uptake was decreased when *Micrasterias* cells were pre-treated with iron, which resulted in no longer detectable intracellular chromium accumulations. Zinc rescued the detrimental effects of chromium on net-photosynthesis, respiration rates and electron transport in PS II. Calcium and gadolinium were able to almost completely compensate the inhibiting effects of lead and cadmium on cell morphogenesis after mitosis, respectively. These results indicate that cadmium is taken up by calcium and iron transporters, whereas chromium appears to enter the algae cells via iron and zinc carriers. It was shown that lead is not taken up into *Micrasterias* at all but exerts its adverse effects on cell growth by substituting cell wall bound calcium. The antioxidants salicylic acid, ascorbic acid and glutathione were not able to ameliorate any of the investigated metal effects on the green alga *Micrasterias* when added to the culture medium.

INTRODUCTION

Metals are necessary components of all ecosystems and occur naturally in the earth's crust (Pinto et al., 2003). They appear in a wide range of oxidative states and coordination numbers, influencing their chemical characteristics and thus their bioavailability and toxicity (Pinto et al., 2003 and Verbruggen et al., 2009). Certain metals such as iron (Fe), copper (Cu) and zinc (Zn) are considered essential nutrients to plants and are needed for photosynthesis and as cofactors for many enzymes (e.g. Kovacik et al., 2010 and Shanmugam et al., 2011). Plants take up essential elements from their surroundings, but they are also able to accumulate elements, which have no known biological function, such as heavy metals like cadmium (Cd), chromium (Cr) or lead (Pb) (Mendoza-Cozatl and Moreno-Sanchez, 2005 and Peralta-Videa et al., 2009). These nonessential metals are able to enter plant cells via metal transporters and carriers for the uptake of essential metals (Clemens, 2001 and Shanker et al., 2005). Aquatic environments are particularly exposed to increasing amounts of industrial and agricultural wastes (Kovacik et al., 2010). They may contain Cd, Cr and Pb which are toxic to most organisms at low concentration and have serious negative effects on plant growth, development and photosynthesis (di Toppi and Gabbrielli, 1999, Panda and Choudhury, 2005, Sacan et al., 2007 and Peralta-Videa et al., 2009). Experimental amelioration of heavy metal effects by addition of antioxidants or essential ions provides insight into uptake and distribution mechanisms as well as on physiological and sub-structural targets of metals and increases our understanding on possibilities to limit damage to an aquatic ecosystem.