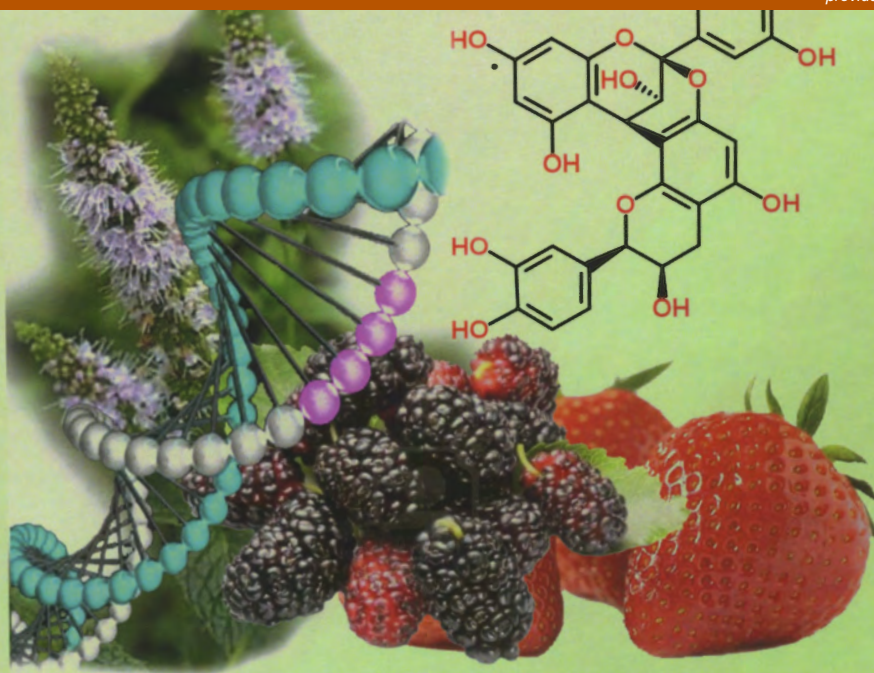


Plant Bioactive Molecules

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Massimo Maffei

Plants have always been a source of nourishment and healing for living things. Their dual task of producing nutrients and medicines has played a key role in the evolution of herbivore and omnivore organisms. The so-called secondary metabolites are molecules with well-defined functional roles. These compounds are produced to defend plants from abiotic and biotic stresses. The complexity of the molecular structures produced by plants is only equal to their versatility and chemical diversity, while the harmonic intertwining of biosynthetic and metabolic pathways offers a perfect picture of the adaptive plasticity of plants to changing environmental conditions.

This book is divided into three parts designed to provide the reader with a general overview, a biochemical and a biotechnological approach to plant bioactive molecules.

The first part analyses the concepts of chemical diversity, sustainability and functional role of bioactive molecules, by exploring the sites of synthesis and accumulation, the plant defence strategies and the use of bioactive molecules as food supplements and as a source for natural products to fight diseases. The first part ends with the study of chemotaxonomy.

The second part is dedicated to plant biochemistry, with the detailed description of the main biosynthetic pathways leading to the synthesis of phenols and flavonoids, terpenes, oxylipins and nitrogen-containing substances.

The third and final part describes plant biotechnology and production of bioactive molecules with industrial processes, both in vivo and in vitro. Special attention is paid to cell and tissue cultures, roots and shoots cultures, technological aspects describing bioreactors, biofermenters and photobioreactors. The book concludes with a chapter describing the genetic engineering strategies for the production of plant bioactive molecules, facing with ethical problems, risks and benefits of using recombinant DNA in genetically modified organisms (GMOs) and the use of molecular pharming, with a general discussion on food safety.

Massimo Maffei graduated in Plant Biology from the University of Turin, Italy, where he is currently a Professor of Plant Physiology in the Department of Life Sciences and Systems Biology. His current research interest is the study of the biochemistry and molecular biology of plant bioactive molecules. He also studies the early signals in plant-plant and plant-insect interaction. He has published more than 150 scientific papers in international journals and is the Editor-in-Chief of the Open Access JCR *Journal of Plant Interactions*.

978-1-5275-1314-3

www.cambridgescholars.com

Cover image © Massimo Maffei, 2018



Plant Bioactive Molecules

By

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Cambridge
Scholars
Publishing



Plant Bioactive Molecules

By Massimo Maffei

This book first published 2018

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

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ISBN (10): 1-5275-1314-9

ISBN (13): 978-1-5275-1314-3

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PREFACE

Plants have always been a source of nourishment and care for living beings. Their dual task as producers of nutrients and drugs played a fundamental role in the evolution (and co-evolution) of herbivorous and omnivorous organisms.

The so-called secondary (or special) metabolites are molecules with well-defined functional roles, aimed primarily at defending plants from abiotic (temperature, light, water availability, etc.) and biotic (attacks of herbivores, fungi, bacteria and viruses) stress. The complexity of the molecular structures produced by plants is only equal to their versatility and biodiversity, while the harmonious interweaving of biosynthetic and metabolic pathways offers a perfect picture of the adaptive plasticity of plants as environmental conditions change.

This book is divided into three units to offer the reader a general, biochemical and biotechnological framework of bioactive plant molecules.

The first unit analyses the concepts of biodiversity and sustainability and the functional roles of bioactive molecules, exploring the sites of synthesis and accumulation, the strategies adopted by plants to defend themselves from stress and the use of bioactive molecules as food supplements and as a source for natural medicines to combat diseases. The first unit also includes chemotaxonomy, where bioactive molecules and other secondary products play a fundamental role in support of the identification of plant species.

The second unit describes plant biochemistry with a detailed discussion on the main biosynthetic pathways leading to the synthesis of aromatic compounds (phenols and flavonoids) and terpenes (from volatile substances to phytosterols, to antioxidant molecules such as carotenoids and astaxanthin) to conclude with the biosynthetic pathways leading to the synthesis of nitrogen-containing bioactive molecules, including alkaloids, glucosinolates and cyanogenic glucosides. In this unit, one chapter is also dedicated to oxylipins, describing the biochemistry of jasmonates and

green leaf volatiles, substances typical of plant reactions to biotic stress and mechanical damage.

The third and last unit deals with plant biotechnology and the production of bioactive molecules both *in vivo* and *in vitro*. The main techniques are described, such as cell and tissue cultures and root and shoot cultures, with particular attention to the *in vitro* production of bioactive molecules of industrial interest. In addition to the defining of plant biotechnology, a chapter deals with its technological aspects by describing bioreactors, photobioreactors and cryopreservation techniques. The unit concludes with a chapter dedicated to genetic engineering for the production of bioactive molecules, where in addition to the definition of transgenic plants ethical problems, risks and benefits of using recombinant DNA in genetically modified organisms (GMOs) are discussed. Several examples of terpene, phenolic compound and alkaloid engineering are presented along with methods and techniques for industrial application. Molecular pharming is also described, revealing its peculiarities and potential, with examples of bioactive molecules produced to treat infectious diseases and to improve the quality of human life. Finally, a paragraph is dedicated to food safety issues and bioethical considerations.

I wrote this book for science students of university undergraduate and graduate courses, but the language used (especially in the first and third unit) is simple enough to be understood by all people who are interested in bioactive natural molecules. Writing a book on these issues is always a challenge, especially due to the continuous stream of new notions being published every day across hundreds of international scientific journals. The intent was to collect most of the recent notions, being fully aware of the limits imposed by the vastness of the subject.

I wish you a very good reading.

Massimo Maffei