

# CHLOROPLAST BIOGENESIS

# Chloroplast Biogenesis

From Proplastid to Gerontoplast

*by*

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The background ultrastructures of proplastid, chloroplast, and gerontoplast are modified from Kutik et al., 1984 and Hudak, 1997"

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## Foreword

Chloroplast is the organelle where the life-giving process photosynthesis takes place; it is the site where plants and algae produce food and oxygen that sustain our life. The story of how it originates from proplastids, and how it ultimately dies is beautifully portrayed by three authorities in the field: Basanti Biswal, Udaya Biswal and M. K. Raval. I consider it a great privilege and honor to have been asked to write this foreword.

The book ‘Chloroplast biogenesis: from proplastid to gerontoplast’ goes much beyond photosynthesis. The character of the book is different from that of many currently available books because it provides an integrated approach to cover the entire life span of the organelle including its senescence and death. The books available are mostly confined to the topics relating to the ‘build up’ or development of chloroplast during greening. The story of organelle biogenesis without description of the events associated with its regulated dismantling during genetically programmed senescence is incomplete. A large volume of literature is available in this area of chloroplast senescence accumulated during the last 20 years. Although some of the findings in this field have been organized in the form of reviews, the data in the book are generalized and integrated with simple text and graphics.

This book describes the structural features of proplastid and its transformation to fully mature chloroplast, which is subsequently transformed into gerontoplast exhibiting senescence syndrome. The book consists of five major chapters. Chapter 1 describes an introduction to plastid transformation; thermodynamic characteristics of the transformation, signaling systems involved, and coordinated action of nuclear and plastid genes during the organelle biogenesis. This chapter also summarizes the techniques used for the study of organelle biogenesis and the limitation of writing such a book. The data on the formation and regulation of thylakoid network, assembly of individual thylakoid complexes and Rubisco (Ribulose bis-phosphate carboxylase oxygenase) are critically discussed in chapter 2. Chapter 3 includes a critical review of the recent findings on the structure and function of a mature chloroplast and its response to environmental stress. In chapter 4, the authors highlight the events associated with the transformation of mature chloroplast to gerontoplast when green leaves turn yellow during senescence. The regulated disorganization of thylakoid membranes, loss in Rubisco protein and its activity with concomitant expression of senescence-associated genes (*SAGs*) is discussed in details in this chapter. Chapter 5 concludes and summarizes the data described in the previous chapters and brings forward several questions to be addressed in the future.

The book by the Biswals (Udaya, husband, and Basanti, wife) and M.K. Raval is a research and teaching monograph on chloroplast biogenesis. It also includes updated information on several related areas of plant sciences. Although it is primarily intended for researchers in and graduate students in Plant Physiology, Plant Biology and Integrative Biology, it is an excellent background book for graduate students in Plant Biochemistry, Plant Biophysics and Cellular and Molecular Biology.

Govindjee (E-mail: gov@uiuc.edu)  
Urbana, Illinois  
June 9, 2003

## PREFACE

The book 'Chloroplast biogenesis: from proplastid to gerontoplast' describes biogenesis of the organelle that involves several events associated with the transformation of proplastid to chloroplast, which is subsequently transformed to gerontoplast during senescence. The description of the biogenesis covers the structural and functional changes, different signaling systems for induction of the changes and gene expression leading to establishment of structural transients of the plastid.

We have designed the book in such a way that it can be used as a good source of reference for the teachers and research scholars working in the areas of photosynthesis, biophysics, biochemistry, molecular biology and photobiology. It is also designed to be used as a textbook by the graduate and undergraduate students for the courses like plant physiology and development.

The book consists of 5 chapters. Chapter 1 deals with the introduction highlighting the basics of plastid transformations and approach to study them, chapter 2 with the development of proplastid to chloroplast, chapter 3 with the mature chloroplast: its structure and function, chapter 4 with the conversion of mature chloroplast to gerontoplast during leaf senescence and chapter 5 with the conclusion and perspective of research in the area of chloroplast biogenesis. It was a difficult time for us to organize our thoughts and determine the sequence of the chapters. Initially we thought to keep mature chloroplast before describing the development of proplastid to mature chloroplast. Our idea was to provide a clear picture of structure and function of a mature chloroplast in the first instance followed by its biogenesis. It would have been perhaps easier for a general reader to understand and appreciate the events associated with the organelle biogenesis after knowing the basics of its structure and function. However, in that case, we would have failed to give justice to the description of sequence of the organelle biogenesis since mature chloroplast is the product of biogenetic process and is developed from proplastid.

One of the strengths of this book lies in organizing the recent available data on the formation of gerontoplast, the last phase of organelle biogenesis (chapter 4). Our attempt was to establish gerontoplast as a form of plastid with active genetic potential and its role in leaf physiology during senescence particularly in the dynamics of nutrient mobilization. For a long time, it was difficult to characterize the precise nature of transformation of mature chloroplast to gerontoplast. But due to the availability of genetic and molecular tools, it has now become possible to study some of the complicated events associated with the transformations.

In this book, we have attempted to use uniform terminology and style of presentation.

We feel fortunate and privileged to have Professor Govindjee of the University of Illinois at Urbana-Champaign as our advisor during the preparation of this book. He recommended our book proposal to Kluwer Academic Publishers and edited the first chapter, table of contents and figures of the book. We had continuous correspondence with him for his guidance. We are grateful to him for writing the 'Foreword' for our book.

The book includes the results (both text and graphics) of many outstanding scientists working in the field of chloroplast biogenesis and metabolism. We are thankful to them for permitting us to use their materials including some of their figures. We are

also fortunate in being able to present colored pictures including crystal structures of some of the thylakoid complexes from the available databases.

It was an enjoyable experience to have frequent correspondence with Dr. Jacco A. Flipsen, Publishing Manager, Plant Sciences Unit, Kluwer Academic Publishers. Jacco was very patient and agreed to shifting the deadline for submission of the manuscript on several occasions.

We would like to thank Prof. N.K.Choudhury, Prof. T.V.Rao and Mr. L. Nayak for reading the manuscript and for their suggestions. Sanjukta Badhai and Alokmay Behera, research scholars from our laboratory are acknowledged for checking the references. We wish to thank Prof. Yasar Demirel, Department of Chemical Engineering, Virginia Tech., USA and Dr.B.K.Mishra, Department of Chemistry, Sambalpur University, India for their valuable suggestions on the thermodynamic part of chloroplast biogenesis in the introduction chapter. Bikas Biswal, Manas Biswal, Hemant Raval and Rakesh Rawal are duly acknowledged for helping us in the preparation of the text and graphics of the book. M.K.Raval wishes to thank his wife, Praveena for her cooperation during preparation of the manuscript. Last but not the least, we would like to thank all our research colleagues, who have directly or indirectly helped us during preparation of the manuscript.

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## **Colorplates**

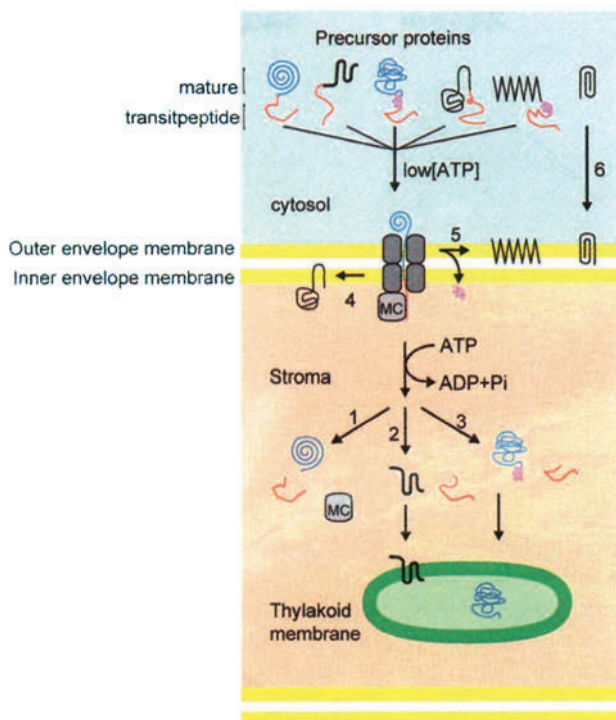
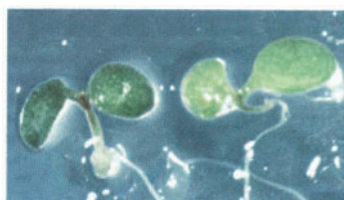


Figure 16

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Figure 17

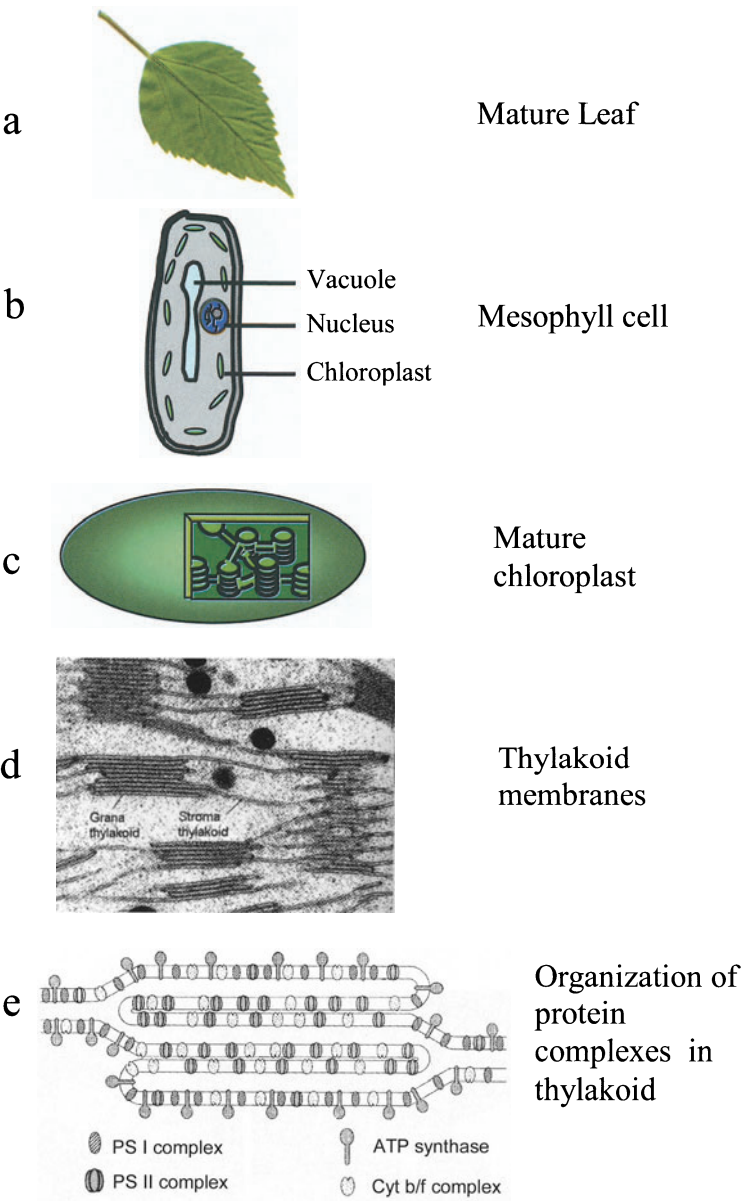
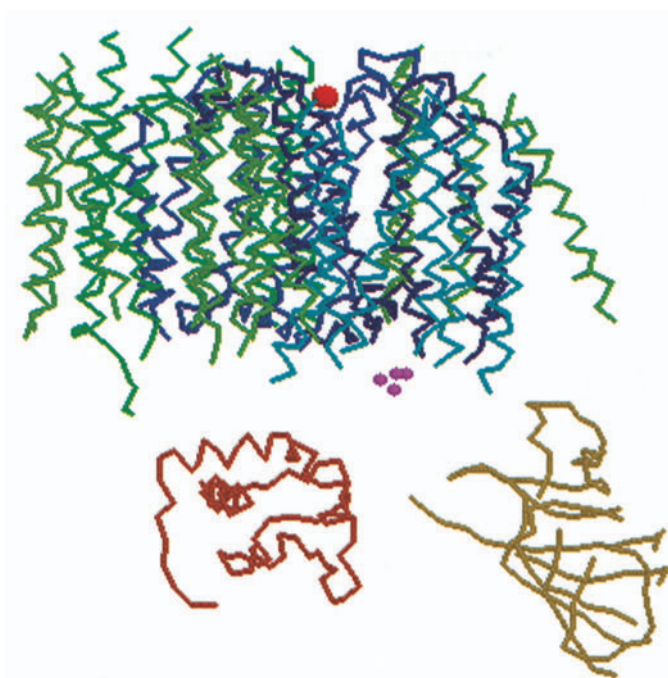
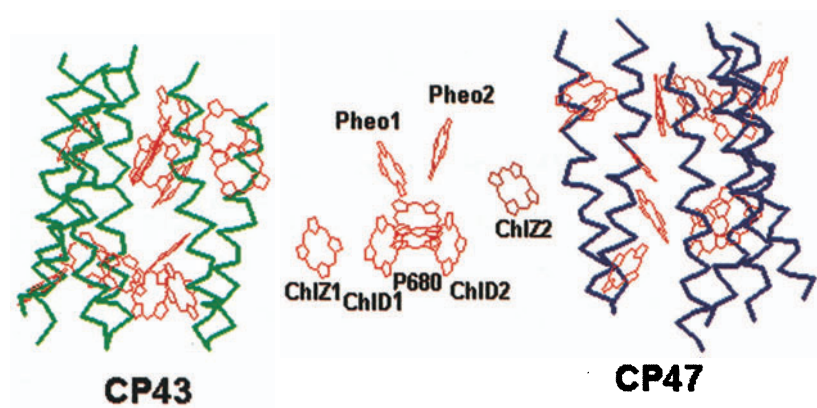


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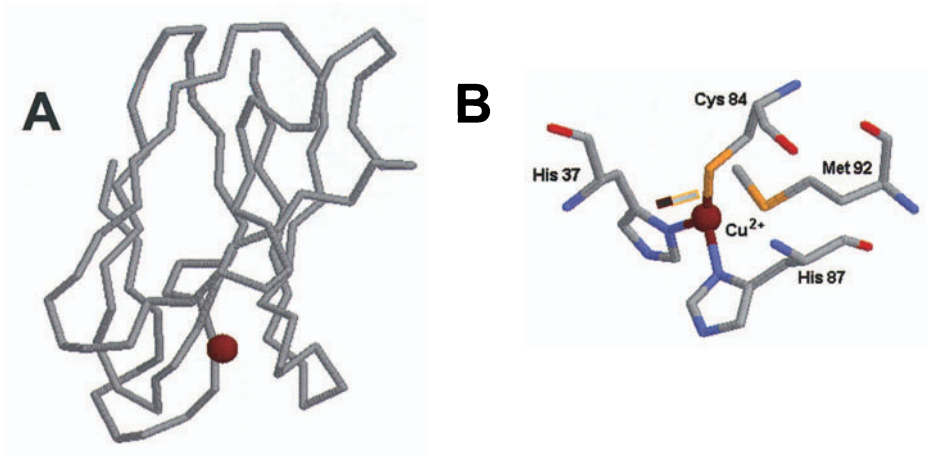


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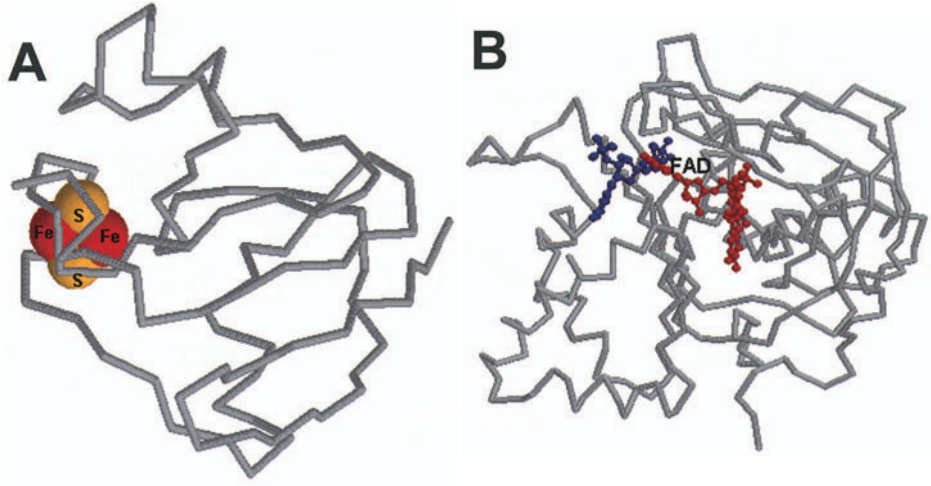


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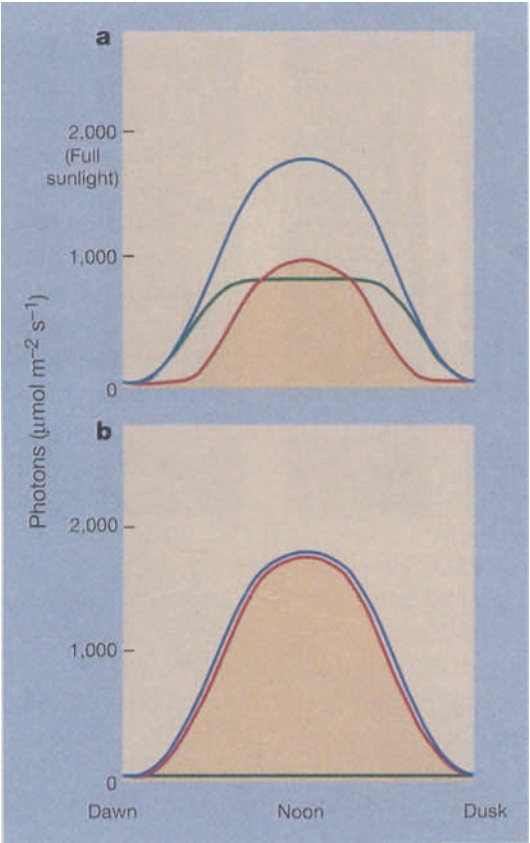


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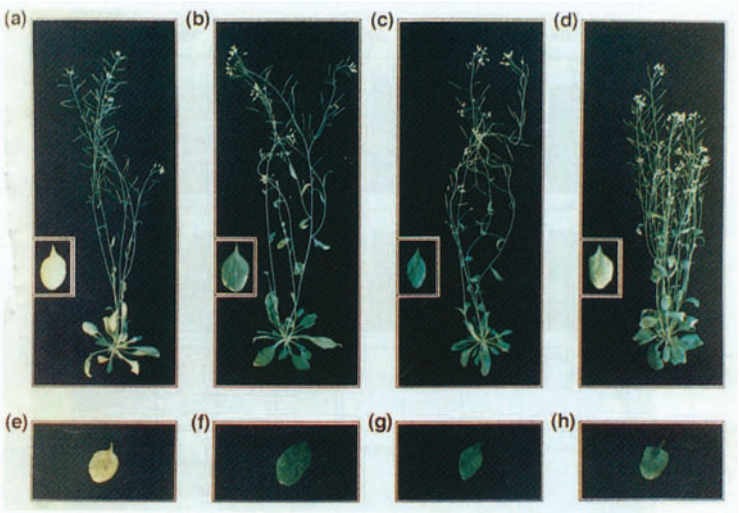


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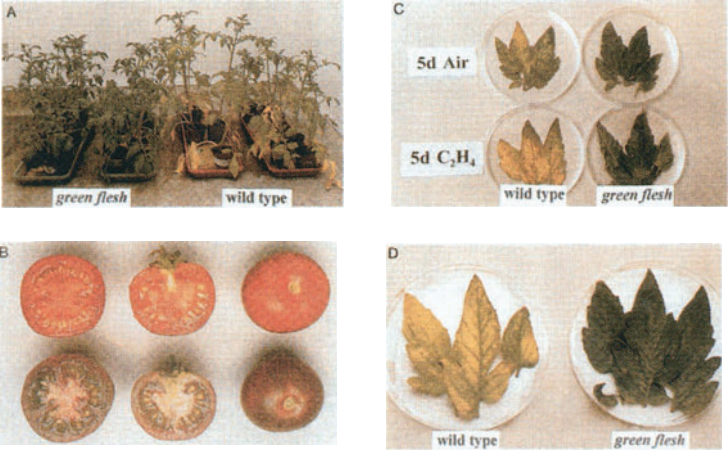


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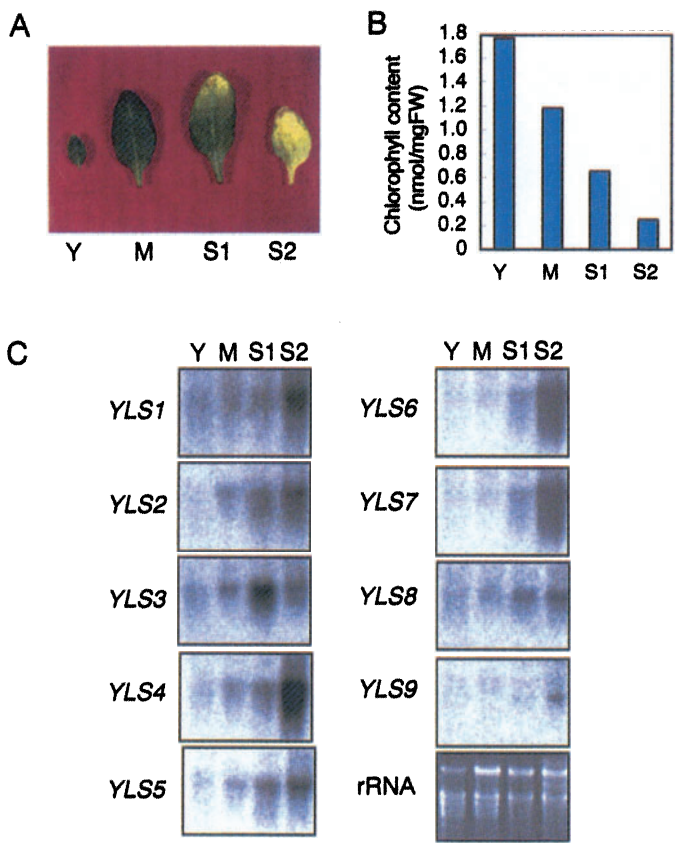


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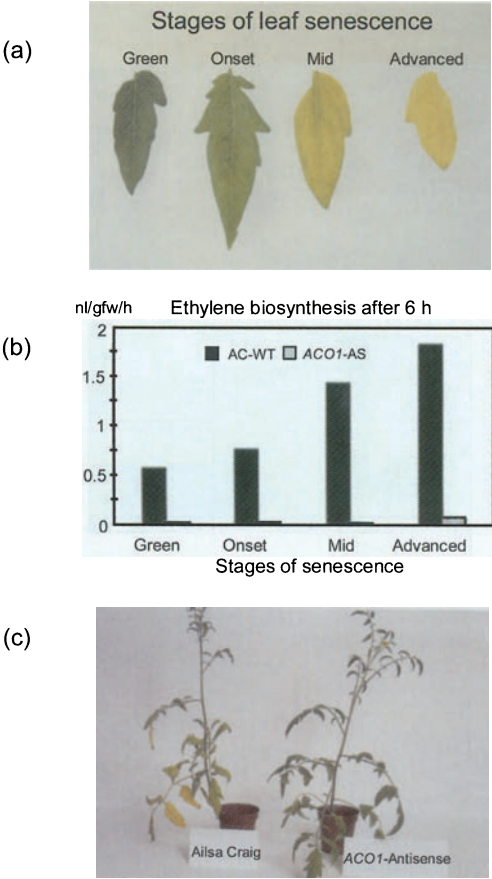


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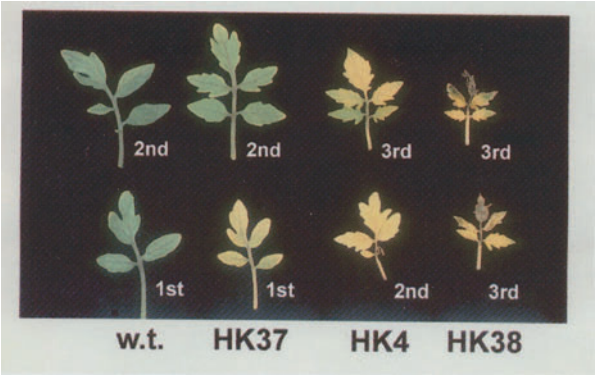


Figure 93



Figure 94

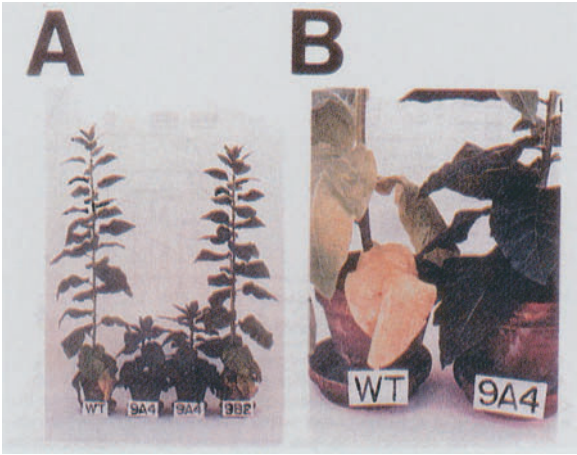


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