

2nd Edition

# Genetically Modified Crops



N i g e l   G   H a l f o r d

Imperial College Press

2nd Edition

**G**enetically  
**M**odified  
**C**rops

**This page intentionally left blank**

2nd Edition

**G**enetically  
Modified  
Crops

Nigel G Halford

Rothamsted Research, UK

ICP

Imperial College Press

*Published by*

Imperial College Press  
57 Shelton Street  
Covent Garden  
London WC2H 9HE

*Distributed by*

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

*USA office:* 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

*UK office:* 57 Shelton Street, Covent Garden, London WC2H 9HE

**British Library Cataloguing-in-Publication Data**

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

**GENETICALLY MODIFIED CROPS**

**2nd Edition**

Copyright © 2012 by Imperial College Press

*All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.*

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN-13 978-1-84816-838-1

ISBN-10 1-84816-838-1

Typeset by Stallion Press  
Email: [enquiries@stallionpress.com](mailto:enquiries@stallionpress.com)

Printed in Singapore.

# CONTENTS

---

<i>Preface</i>	ix
<b>1. DNA, Genes, Genomes and Plant Breeding</b>	<b>1</b>
1.1 A Brief History of Genetics	1
1.2 Deoxyribonucleic Acid (DNA)	4
1.3 Genes	8
1.4 Gene Expression	9
1.5 Genomes	10
1.6 Genetic Change	11
1.7 Plant Breeding	11
1.8 Modern Plant Breeding	15
1.9 Wide and Forced Crossing and Embryo Rescue	18
1.10 Radiation and Chemical Mutagenesis	19
1.11 The Advent of Genetic Modification	20
<b>2. The Techniques of Plant Genetic Modification</b>	<b>23</b>
2.1 A Brief History of the Development of Recombinant DNA Technology	23
2.2 <i>Agrobacterium tumefaciens</i>	26
2.3 Use of <i>Agrobacterium tumefaciens</i> in Plant Genetic Modification	27
2.4 Transformation of Protoplasts	30
2.5 Particle Gun	31

2.6	Other Direct Gene Transfer Methods	32
2.7	<i>Agrobacterium</i> -mediated Transformation Without Tissue Culture	34
2.8	Selectable Marker Genes	34
2.9	Visual/Scoreable Marker Genes	38
2.10	Design and Construction of Genes for Introduction into Plants	40
2.11	Promoter Types	43
2.12	The Use of GM to Characterise Gene Promoters	45
2.13	Gene Over-Expression and Silencing	47
<b>3.</b>	<b>The Use of GM Crops in Agriculture</b>	<b>51</b>
3.1	Why Use Genetic Modification (GM) in Plant Breeding?	51
3.2	Slow-ripening Fruit	55
3.3	Herbicide Tolerance	57
3.4	Insect Resistance	64
3.5	Virus Resistance	68
3.6	Modified Oil Content	70
3.7	Modified Starch for Industrial and Biofuel Uses	80
3.8	High Lysine Corn	83
3.9	Vitamin Content: Golden Rice	84
3.10	Fungal Resistance	88
3.11	Drought, Heat and Cold Tolerance; Climate Change	90
3.12	Salt Tolerance	94
3.13	Biopharming	97
3.14	Removal of Allergens	103
3.15	Conclusions	105
<b>4.</b>	<b>Legislation Covering GM Crops and Foods</b>	<b>107</b>
4.1	Safety of GM Plants Grown in Containment	107
4.2	Safety of Field Releases of GM Plants	111

4.3	Safety of GM Foods	115
4.4	European Union Regulations	118
4.5	Labelling and Traceability Regulations	120
4.6	Safety Assessment and Labelling Requirements in the USA	124
<b>5.</b>	<b>Issues that have Arisen in the GM Crop and Food Debate</b>	<b>127</b>
5.1	Are GM Foods Safe?	133
5.2	Will Genetic Modification Produce New Food Allergens?	134
5.3	Is it Ethical to Transfer Genes Between Different Species?	136
5.4	Animal Studies	137
5.5	GM Crops 'Do Not Work'	138
5.6	Did Tryptophan Produced by Genetic Modification Kill People?	139
5.7	The Monarch Butterfly	141
5.8	The Pusztai Affair	142
5.9	Alarm Caused by Contradictory Results of Biosafety Studies	144
5.10	'Superweeds'	146
5.11	Insect Resistance to Bt Crops	147
5.12	Segregation of GM and non-GM Crops: Co-existence of GM and Organic Farming	148
5.13	Antibiotic Resistance Marker Genes	150
5.14	Patenting	152
5.15	Loss of Genetic Diversity	153
5.16	The Dominance of Multinational Companies	154
5.17	The StarLink and ProdiGene Affairs	155
5.18	The <i>Cauliflower mosaic virus</i> 35S RNA Gene Promoter	157
5.19	Implications for Developing Countries	158
5.20	'Terminator' Technology	160
5.21	Unintentional Releases	161



viii *Contents*

5.22	Asynchronous Approvals	163
5.23	The United Kingdom Farm-Scale Evaluations	163
5.24	Conclusions	165

<i>Index</i>		169
--------------	--	-----