Recent Advances in Plant Biotechnology

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We dedicate this book to the memory of Ara Kirakosyan' parents, Anna and Benik Kirakosyan, and to the memory of Peter B. Kaufman's wife, Hazel Kaufman.

Preface

Plant biotechnology applies to three major areas of plants and their uses: (1) control of plant growth and development; (2) protection of plants against biotic and abiotic stresses; and (3) expansion of ways by which specialty foods, biochemicals, and pharmaceuticals are produced. The topic of *recent advances in plant biotechnology* is ripe for consideration because of the rapid developments in this field that have revolutionized our concepts of sustainable food production, cost-effective alternative energy strategies, environmental bioremediation, and production of plant-derived medicines through plant cell biotechnology. Many of the more traditional approaches to plant biotechnology are woefully out of date and even obsolete. Fresh approaches are therefore required. To this end, we have brought together a group of contributors who address the most recent advances in plant biotechnology and what they mean for human progress, and hopefully, a more sustainable future.

Achievements today in plant biotechnology have already surpassed all previous expectations. These are based on promising accomplishments in the last several decades and the fact that plant biotechnology has emerged as an exciting area of research by creating unprecedented opportunities for the manipulation of biological systems. In connection with its recent advances, plant biotechnology now allows for the transfer of a greater variety of genetic information in a more precise, controlled manner. The potential for improving plant productivity and its proper use in agriculture relies largely on newly developed DNA biotechnology and molecular markers. A number of methods have been developed and validated in association with the use of genetically transferred cultures in order to understand the genetics of specific plant traits. Such relevant methods can be used to determine the markers that are retained in genetically manipulated organisms and to determine the elimination of marker genes. As a result, a number of transgenic plants have been developed with beneficial characteristics and significant long-term potential to contribute both to biotechnology and to fundamental studies. These techniques enable the selection of successful genotypes, better isolation and cloning of favorable traits, and the creation of transgenic organisms of importance to agriculture and industry.

We start the book by tracing the roots of plant biotechnology from the basic sciences to current applications in the biological and agricultural sciences, industry, and medicine. These widespread applications signal the fact that plant biotechnology is increasingly gaining in importance. This is because it impinges on so

many facets of our lives, particularly in connection with global warming, alternative energy initiatives, food production, and medicine. Our book would not be complete unless we also addressed the fact that some aspects of plant biotechnology may have some risks. These are covered in the last section.

The individual chapters of the book are organized according to the following format: chapter title and contributors, abstract, introduction to the chapter, chapter topics and text, and references cited for further reading. This format is designed in order to help the reader to grasp and understand the inherent complexity of plant biotechnology better.

The topics covered in this book will be of interest to plant biologists, biochemists, molecular biologists, pharmacologists, and pharmacists; agronomists, plant breeders, and geneticists; ethnobotanists, ecologists, and conservationists; medical practitioners and nutritionists; and research investigators in industry, federal labs, and universities.

Ann Arbor, MI — Peter B. Kaufman
Ann Arbor, MI — Ara Kirakosyan

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About the Authors

Ara Kirakosyan, Ph.D., D.Sc. is an associate professor of biology at Yerevan State University, Armenia, and is currently a research investigator at the University of Michigan Medical School and University of Michigan Integrative Medicine Program (MIM). He received a Ph.D. in molecular biology in 1993 and Doctor of Science degree in biochemistry and biotechnology in 2007, both from Yerevan State University, Armenia. Dr. Kirakosyan's research on natural products of medicinal value in plants focuses on the molecular mechanism of secondary metabolite biosynthesis in selected medicinal plant models. His primary research interests focus on the uses of plant cell biotechnology to produce enhanced levels of medicinally important, value-added secondary metabolites in intact plants, and plant cell cultures. These studies involve metabolic engineering coupled with integration of functional genomics, metabolomics, transcriptomics, and large-scale biochemistry. He carried out postdoctoral research in the Department of Pharmacognosy at Gifu Pharmaceutical University, Gifu, Japan, under the supervision of Prof. Kenichiro Inoue. The primary research topic was molecular biology of biosynthesis of several secondary metabolites in plants, particularly this was applied to the sweet triterpene glycyrrhizin in cell cultures of *Glycyrrhiza glabra* and dianthrones in *Hypericum perforatum.* In addition, he took part in several visiting research investigator positions in Germany. First, he was a visiting scientist under collaborative grant project DLR in Heinrich-Heine-University, Düsseldorf (project leader Prof. Dr. W.A. Alfermann). The research here concerned a lignan anticancer project, i.e., the production of cytotoxic lignans from Linum (flax). The second involved a carbohydrate-engineering project as a DAAD Fellow in the Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben, under supervision of Prof. Dr. Uwe Sonnewald. His collaboration with US scientists started with the USDA-founded project on plant cell biotechnology for the production of dianthrones in cell/shoot cultures of *H. perforatum* (St. John's wort). This research has been carried out with Dr. Donna Gibson at USDA Agricultural Research Service, Plant Protection Research Unit, US Plant, Soil, and Nutrition Laboratory, Ithaca, New York, USA. In 2002, he was a Fulbright Visiting Research Fellow at the University of Michigan, Department of Molecular, Cellular, and Developmental Biology in the Laboratory of Prof. Peter B. Kaufman. Dr. Kirakosyan is principal author of over 50 peer-reviewed research papers in professional journals and several chapters in

books dealing with plant biotechnology and molecular biology. He is second author of the best-selling book, *Natural Products from Plants*, 2nd edition (2006). Ara Kirakosyan is a full member of the Phytochemical Society of Europe and European Federation of Biotechnology. He serves as an editorial board member in the *Open Bioactive Compounds Journal*, Bentham Science Publishers, and as an editor as part of the editorial board of 19 scientific domains journals, Global Science Books (GSB), Isleworth, UK. He has received several awards, fellowships, and research grants from the United States, Japan, and the European Union.

Peter B. Kaufman, Ph.D., is a professor of biology emeritus in the Department of Molecular, Cellular, and Developmental Biology (MCDB) at the University of Michigan and is currently senior scientist, University of Michigan Integrative Medicine Program (UMIM). He received his B.Sc. in plant science from Cornell University in Ithaca, New York, in 1949 and his Ph.D. in plant biology from the University of California, Davis, in 1954 under the direction of Prof. Katherine Esau. He did post-doctoral research as a Muelhaupt Fellow at Ohio State University, Columbus, Ohio. He has been a visiting research scholar at University of Calgary, Alberta, Canada; University of Saskatoon, Saskatoon, Canada; University of Colorado, Boulder, Colorado; Purdue University, West Lafayette, Indiana; USDA Plant Hormone Laboratory, BARC-West, Beltsville, Maryland; Nagoya University, Nagoya, Japan; Lund University, Lund, Sweden; International Rice Research Institute (IRRI) at Los Banos, Philippines; and Hawaiian Sugar Cane Planters' Association, Aiea Heights, Hawaii. Dr. Kaufman is a fellow of the American Association for the Advancement of Science and received the Distinguished Service Award from the American Society for Gravitational and Space Biology (ASGSB) in 1995. He served on the editorial board of *Plant Physiology* for 10 years and is the author of more than 220 research papers. He has published eight professional books to date and taught popular courses on plants, people, and the environment, plant biotechnology, and practical botany at the University of Michigan. He has received research grants from the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the US Department of Agriculture (USDA) BARD Program with Israel, National Institutes of Health (NIH), Xylomed Research, Inc, and Pfizer Pharmaceutical Research. He produced with help of Alfred Slote and Marcia Jablonski a 20-part TV series entitled, "House Botanist." He was past chairman of the Michigan Natural Areas Council (MNAC), past president of the Michigan Botanical Club (MBC), and former secretary-treasurer of the American Society for Gravitational and Space Biology (ASGSB). He is currently doing research on natural products of medicinal value in plants in the University of Michigan Medical School in the laboratory of Steven F. Bolling, M.D. and serves on the research staff of UMIM.

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