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ISSN 0724-6145
ISBN 3-540-41849-0
Springer-Verlag Berlin Heidelberg New York

Library of Congress Catalog Card Number 72-152360

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

http://www.springer.de

Printed in Germany

Typesetting: Fotosatz-Service Köhler GmbH, Würzburg
Cover: E. Kirchner, Heidelberg
Printed on acid-free paper SPIN: 10753451 02/3020hu – 5 4 3 2 1 0

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Preface

Plants produce more than 30,000 types of chemicals, including pharmaceuticals, pigments and other fine chemicals, which is four times more than those obtained from microbes. Plant cell culture has been receiving great attention as an alternative for the production of valuable plant-derived secondary metabolites, since it has many advantages over whole plant cultivation. However, much more research is required to enhance the culture productivity and reduce the processing costs, which is the key to the commercialization of plant cell culture processes. The recent achievements in related biochemical engineering studies are reviewed in Chapter 1. The effect of gaseous compounds on plant cell behavior has been little studied, and Chapter 2 focuses on these gas concentration effects (including oxygen, carbon dioxide, ethylene and others, such as volatile hormones like methyl jasmonate) on secondary metabolite production by plant cell cultures. Two metabolites of current interest, i.e., the antimalarial artemisinin (known as "qing hao su" in China) that is produced by *Artemisia annua* (sweet wormwood) and taxanes used for anticancer therapy that are produced by species of *Taxus,* are taken as examples. Bioprocess integration is another hot topic in plant cell culture technology. Because most of the plant secondary metabolites are toxic to the cells at high concentrations during the culture, removal of the product *in situ* during the culture can lead to the enhanced productivity. Various integrated bioprocessing techniques are discussed in Chapter 3.

To improve the productivity of commercially important compounds in plants or plant cell cultures, or even to produce completely new compounds, metabolic engineering of plant secondary metabolite pathways has opened a new promising perspective. Different strategies used for the genetic modification are discussed in Chapter 4, including single-gene and multiple-gene approaches, as well as the use of regulatory genes for increasing productivity. These approaches are, among others, illustrated with work on the terpenoid indole alkaloid biosynthesis. With the development of genetic engineering of plant cells or organs, a lot of recombinant products can be obtained in cheap plant cell culture media. Production of these high- value products in plant cells is an economically viable alternative to other systems, particularly in cases where the protein must be biologically active. Chapter 5 reviews foreign protein production from genetically modified plant cells, and the implications for future development of this technology are also discussed.

Plant micropropagation is another important application of plant cell culture, which is an efficient method of propagating disease-free, genetically uniform

and massive amounts of plants *in vitro*. The prospect of micropropagation through somatic embryogenesis provides a valuable alternative to the traditional propagation system, and the micropropagation of elite hairy roots offers other attractive advantages in the large-scale production of artificial seeds. Large-scale production of somatic embryos and hairy roots in appropriate bioreactors is essential if micropropagation and artificial seed systems are to compete with natural seeds. Chapter 6 identifies the problems related to large-scale plant micropropagation via somatic embryogenesis and hairy roots, and the most recent developments in bioreactor design are summarized. Emphasis is given to immobilization technology and computer-aided image analysis employed in the mass micropropagation. As promising materials in plant cell cultures, hairy roots are recently shown to be responsive to physical stimuli such as exposure to light. However, physiological properties of hairy roots caused by environmental conditions have been hardly investigated in engineering aspects. In Chapter 7, the authors have developed the photomixotrophic and photoautotrophic hairy roots of pak-bung (water spinach) from the heterotrophic originals under light conditions. The physiological and morphological properties and growth kinetics of these hairy roots have been characterized. The relationships between growth potential of photoautotrophic hairy roots and energy acquired by photosynthesis in the cells are discussed in terms of maintenance energy.

I would like to thank Professor Thomas Scheper, the managing editor of this series, and Dr. Marion Hertel, chemistry editorial of Springer-Verlag, for their strong support. The excellent work and very pleasant cooperation of Mrs. Ulrike Kreusel, desk editor (chemistry) of Springer-Verlag, is greatly appreciated. I am also grateful to the supports from the Cheung Kong Scholars Program of the Ministry of Education of China, the National Natural Science Foundation of China, and the East China University of Science and Technology.

ECUST Shanghai
February 2001

Jian-Jiang Zhong

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