

**Biotechnology 2nd Ed**  
**Volume 11b**  
**Environmental Processes II**

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A Multi-Volume Comprehensive Treatise

# Biotechnology

Second, Completely Revised Edition

Edited by  
H.-J. Rehm and G. Reed  
in cooperation with  
A. Pühler and P. Stadler

Volume 11b

## Environmental Processes II

Soil Decontamination

Edited by  
J. Klein



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Series Editors:

Prof. Dr. H.-J. Rehm  
Institut für Mikrobiologie  
Universität Münster  
Corrensstraße 3  
D-48149 Münster  
FRG

Dr. G. Reed  
1029 N. Jackson St. #501-A  
Milwaukee, WI 53202-3226  
USA

Volume Editor:

Prof. Dr. J. Klein  
DMT-Gesellschaft für  
Forschung und Prüfung GmbH  
Franz-Fischer-Weg 61  
Postfach 6980  
D-45307 Essen  
FRG

Prof. Dr. A. Pühler  
Biologie VI (Genetik)  
Universität Bielefeld  
P.O. Box 100131  
D-33501 Bielefeld  
FRG

Prof. Dr. P. I. W. Stadler  
Artemis Pharmaceuticals  
Geschäftsführung  
Pharmazentrum Köln  
Neurather Ring  
D-51063 Köln  
FRG

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Volume 11b

## Environmental Processes II

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Edited by

W. J. L. van der Meer, J. L. H. van der Meer, J. L. H. van der Meer

Volume 11b  
Environmental Processes II  
Legal, Economic and  
Ethical Dimensions  
A. Puri and P. A. Puri

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# Preface

In recognition of the enormous advances in biotechnology in recent years, we are pleased to present this Second Edition of "Biotechnology" relatively soon after the introduction of the First Edition of this multi-volume comprehensive treatise. Since this series was extremely well accepted by the scientific community, we have maintained the overall goal of creating a number of volumes, each devoted to a certain topic, which provide scientists in academia, industry, and public institutions with a well-balanced and comprehensive overview of this growing field. We have fully revised the Second Edition and expanded it from ten to twelve volumes in order to take all recent developments into account.

These twelve volumes are organized into three sections. The first four volumes consider the fundamentals of biotechnology from biological, biochemical, molecular biological, and chemical engineering perspectives. The next four volumes are devoted to products of industrial relevance. Special attention is given here to products derived from genetically engineered microorganisms and mammalian cells. The last four volumes are dedicated to the description of special topics.

The new "Biotechnology" is a reference work, a comprehensive description of the state-of-the-art, and a guide to the original literature. It is specifically directed to microbiologists, biochemists, molecular biologists, bioengineers, chemical engineers, and food and pharmaceutical chemists working in industry, at universities or at public institutions.

A carefully selected and distinguished Scientific Advisory Board stands behind the

series. Its members come from key institutions representing scientific input from about twenty countries.

The volume editors and the authors of the individual chapters have been chosen for their recognized expertise and their contributions to the various fields of biotechnology. Their willingness to impart this knowledge to their colleagues forms the basis of "Biotechnology" and is gratefully acknowledged. Moreover, this work could not have been brought to fruition without the foresight and the constant and diligent support of the publisher. We are grateful to VCH for publishing "Biotechnology" with their customary excellence. Special thanks are due to Dr. Hans-Joachim Kraus and Karin Dembowsky, without whose constant efforts the series could not be published. Finally, the editors wish to thank the members of the Scientific Advisory Board for their encouragement, their helpful suggestions, and their constructive criticism.

H.-J. Rehm  
G. Reed  
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P. Stadler

# Scientific Advisory Board

*Prof. Dr. M. J. Beker*

August Kirichenstein Institute of Microbiology  
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Forschungszentrum Jülich  
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National University of Singapore  
Singapore

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Université de Compiègne  
Compiègne, France

*Prof. Dr. W. Verstraete*  
Laboratory of Microbial Ecology  
Rijksuniversiteit Gent  
Gent, Belgium

*Prof. Dr. E.-L. Winnacker*  
Institut für Biochemie  
Universität München  
München, Germany



# Contributors

Dr. Alan J. M. Baker  
Department of Animal and Plant Sciences  
University of Sheffield  
Western Bank  
Sheffield, S10 2TN  
UK  
*Chapter 17*

Prof. Dr. Karl-Heinz Blotevogel  
Fachbereich Biologie/Mikrobiologie  
Universität Oldenburg  
Postfach 2503  
D-26111 Oldenburg  
Germany  
*Chapter 11*

Prof. Dr. Wilhelm G. Coldewey  
Universität Münster  
Corrensstraße 3  
D-48149 Münster  
Germany  
*Chapter 2*

Dr. Mary F. DeFlaun  
Envirogen, Inc.  
41000 Quakerbridge Road  
Lawrenceville, NJ 08648  
USA  
*Chapter 18*

Dr. rer. nat. Helmut Dörr  
Arcadis Trischler & Partner GmbH  
Berliner Allee 6  
D-64295 Darmstadt  
Germany  
*Chapter 15*

Dr. James P. Easter  
Center for Environmental Biotechnology  
University of Tennessee  
676 Dabney Hall  
Knoxville, TN 37996  
USA  
*Chapters 20, 21*

Dr. Adolf Eisenträger  
Institut für Hygiene und Umweltmedizin  
RWTH Aachen  
Pauwelstr. 30  
D-52057 Aachen  
Germany  
*Chapter 5*

Prof. Dr. Wolfgang Fritsche  
Institut für Mikrobiologie  
Universität Jena  
Philosophenweg 12  
D-07743 Jena  
Germany  
*Chapter 6*

Dr. Thomas Gorontzy  
Fachbereich Biologie/Mikrobiologie  
Universität Oldenburg  
Postfach 2503  
D-26111 Oldenburg  
Germany  
*Chapter 11*

Dr. Thomas Held  
Arcadis Trischler & Partner GmbH  
Berliner Allee 6  
D-64295 Darmstadt  
Germany  
*Chapter 15*

Dr. Martin Hofrichter  
Institut für Mikrobiologie  
Universität Jena  
Philosophenweg 12  
D-07743 Jena  
Germany  
*Chapter 6*

Dr. Kerstin Hund  
FH-Institut für Umweltchemie  
D-57392 Schmallenberg-Grafschaft  
Germany  
*Chapter 5*

Dr.-Ing. Karsten Hupe  
Arbeitsbereich Abfallwirtschaft  
TU Hamburg-Harburg  
Harburger Schloßstr. 37  
D-21079 Hamburg  
Germany  
*Chapter 12*

Dr. Johan E.T. van Hylckama Vlieg  
University of Groningen  
Nijenborgh 4  
NL-9747 AG Groningen  
The Netherlands  
*Chapter 8*

Prof. Dr. Dick B. Janssen  
University of Groningen  
Nijenborgh 4  
NL-9747 AG Groningen  
The Netherlands  
*Chapter 8*

Dr. Matthias Kästner  
UFZ – Umweltforschungszentrum Halle-  
Leipzig  
Sektion Sanierungsforschung  
Permoserstr. 15  
D-04318 Leipzig  
Germany  
*Chapters 4, 9*

Prof. Dr. Jürgen Klein  
DMT-Gesellschaft für  
Forschung und Prüfung GmbH  
Franz-Fischer-Weg 61  
D-45307 Essen  
Germany  
*Chapter 22*

Dr. René H. Kleijntjens  
Partners in Milieutechniek b.v.  
Mercuriusweg 4  
NL-2516 AW's-Gravenhage  
The Netherlands  
*Chapter 14*

Dr. Christoph Klinger  
DMT-Gesellschaft für Forschung und  
Geschäftsbereich GUC  
Am Technologiepark 1  
D-45307 Essen  
Germany  
*Chapter 2*

Dr.-Ing. Michael Koning  
Arbeitsbereich Abfallwirtschaft  
TU Hamburg-Harburg  
Harburger Schloßstr. 37  
D-21079 Hamburg  
Germany  
*Chapter 12*

Dr. Fu-Min Menn  
Center for Environmental Biotechnology  
University of Tennessee  
676 Dabney Hall  
Knoxville, TN 37996  
USA  
*Chapters 20, 21*

Dr. David E. Salt  
Department of Chemistry  
Northern Arizona University  
Flagstaff, AZ 86011-5698  
USA  
*Chapter 17*

Prof. Dr. Karel Ch. A. M. Luyben  
Technical University of Delft  
Julianalaan 67a  
NL-2628 Delft 8  
The Netherlands  
*Chapter 14*

Dr. Gary S. Saylor  
Center for Environmental Biotechnology  
University of Tennessee  
676 Dabney Hall  
Knoxville, TN 37996  
USA  
*Chapters 20, 21*

Prof. Dr. Bernd Mahro  
Fachbereich 3  
Hochschule Bremen  
Neustadtswall 30  
D-28199 Bremen  
Germany  
*Chapter 3*

Prof. Dr. Bernhard Schink  
Institut für Mikrobielle Ökologie  
Universität Konstanz  
Universitätsstr. 10  
D-78457 Konstanz  
Germany  
*Chapter 7*

Prof. Dr. Rudolf Müller  
Arbeitsbereich 2-100  
TU Hamburg-Harburg  
Denickestr. 15  
D-21073 Hamburg  
Germany  
*Chapter 10*

Prof. Dr. Jerald L. Schnoor  
116 Engineering Research Facility  
The University of Iowa  
330 S. Madison St.  
Iowa City, Iowa 52242-1000  
USA  
*Chapter 16*

Prof. Dr. Hans-Jürgen Rehm  
Institut für Mikrobiologie  
Universität Münster  
Corrensstraße 3  
D-48149 Münster  
Germany  
*Chapter 19*

Dr. Volker Schulz-Berendt  
Umweltschutz Nord GmbH & Co.  
Industriepark 6  
D-27767 Ganderkesee  
Germany  
*Chapter 13*

Dr. Michael Roemer  
Melatener Str. 79  
D-52074 Aachen  
Germany  
*Chapter 23*

Dr. Robert J. Steffan  
Envirogen, Inc.  
41000 Quakerbridge Road  
Lawrenceville, NJ 08648  
USA  
*Chapter 18*

Prof. Dr. Rainer Stegmann  
Arbeitsbereich Abfallwirtschaft  
TU Hamburg-Harburg  
Harburger Schloßstr. 37  
D-21079 Hamburg  
Germany  
*Chapter 12*

Dr. Wolfgang Ulrici  
Blücherstr. 17  
D-53115 Bonn  
Germany  
*Chapter 1*

Dr. Ronald Unterman  
Envirogen, Inc.  
4100 Quakerbridge Road  
Lawrenceville, NJ 08648  
USA  
*Chapter 18*

Dr. Catrin Wischnak  
Arbeitsbereich 2-100  
TU Hamburg-Harburg  
Denickestr. 15  
D-21073 Hamburg  
Germany  
*Chapter 10*

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# Introduction

JÜRGEN KLEIN

Essen, Germany

The use of biological processes for treatment of liquid wastes from human activities is an established technology dating back at least 4000 years. For more than a century natural biochemical processes (nature's self-cleaning abilities) have been utilized to treat effluent, and reactors and plant systems had been adapted with increasing effect to cope with the difficult conditions. The knowledge of the biodegradation mechanisms of organic pollutants and especially of synthetic compounds, however, is more recent and has only been developed in the second part of this century.

Over the past few decades environmental protection has primarily meant protection of air and water. Only with the increasing use of land in industrialized societies and the highlighting of possible hazards from contaminated soil did the public become aware of soil protection in the early 1980s. This has also prompted industry to take up this market segment. Engineers and scientists have thus been spurred on to look for technically optimized, ecologically sound, and economically appropriate solutions.

The experience accumulated in biological soil clean-up in the first few years was characterized by both, success and failure, including

those of unprofessional suppliers. Initially, therefore, acceptance of biological soil clean-up was only limited. But now, due to intensive and interdisciplinary work, impressive success is in evidence. Consequently, biological soil clean-up methods now enjoy a high technical level and a broad acceptance.

The aim is to maintain and apply this level, even if at present the prospects for soil clean-up are seen from a more modest point of view. The enthusiasm that has accompanied soil decontamination in the last few years has now given way to a realistic attitude of more appropriate proportions. The discussion on the equivalence of securing and decontamination techniques must not lead to clean-up on a low level, but rather to ecologically and economically appropriate solutions.

The original objective of multifunctional use through the restoration of a "natural" soil is not feasible in most cases for technical and financial reasons. In view of this, biological clean-up techniques still have to be improved and optimized in order to provide cost-effective, technically simple, and near-natural processes.

In the First Edition of *Biotechnology* there was no contribution regarding biological pro-

cesses for the remediation of contaminated soil. But the increasing need of remediation techniques and the increasing scientific and industrial interest in biological methods for soil remediation generated the necessity of a special volume on the topic: *Environmental Processes II – Soil Decontamination*.

The field of biodegradation and thereby bioremediation has experienced a dynamic evolution and remarkable developments over the past few years. It seems to have entered its most interesting and intense phase yet. The isolation and characterization of new microorganisms with novel catabolic activities continues unabated, and the use of plants and plant-microbe associations in bioremediation is expanding strongly. The continuously growing knowledge on catabolic pathways and critical enzymes provides the basis for the rational genetic design of new and improved enzymes and pathways for the development of more performant processes.

This volume *Environmental Processes II* summarizes the state of the art of scientific research in the field of biodegradation of xenobiotics, of transferring the knowledge obtained into commercial application, and the future developments necessary to cope with the requirements of sustainable strategies for ecological, but economically appropriate solutions.

The first part is dedicated to more general aspects of bioremediation: firstly, a survey on the different international approaches of dealing with soil contamination problems, then elucidating inherent aspects of soil, i.e., geochemical and hydrogeological features as well

as bioavailability and humification processes influencing the interaction between microorganisms and contaminants in soil and methods to assess the ecotoxic potential of contaminated and the treated soil.

The second part of this volume summarizes the results of scientific research on the biodegradation of those substance groups which count as relevant in terms of contaminated sites, e.g., aliphatic and aromatic hydrocarbons and their halogenated derivatives, pesticides, and nitro compounds.

In the third part the different commercially methods of *in situ* and *ex situ* bioremediation are described, including advanced strategies proposing to use the abilities of plant-microbe associations called phytoremediation, and the enhancement of natural attenuation processes, especially biostimulation and bioaugmentation, and, last but not least, the potential of genetic modifications of the microorganisms applied. In the final chapter methods for reliable and representative sampling and chemical analysis of the processed samples are explained.

It is beyond the scope of any book to cover all aspects of soil bioremediation and to have considered all relevant results which are obtained in the huge community of researchers in science and industry. But the Volume Editor and the Series Editors hope that this book will give sufficient, elucidating and stimulating insight into the biology and technology of soil decontamination processes.

Essen, November 1999

Jürgen Klein



# I General Aspects