

# Contents

CONTENTS

## Contributors, x

## Preface and Acknowledgements, xi

### 1 1 What is Biotechnology?, 1

I. J. HIGGINS

- 1.1 Introduction
- 1.2 Historical perspectives
- 1.3 Developments in the biotechnology industry since World War II
- 1.4 Future prospects for the development of biotechnology
  - 1.4.1 Medicine
  - 1.4.2 Energy
  - 1.4.3 Food and drink
  - 1.4.4 Chemicals
  - 1.4.5 Materials
  - 1.4.6 The environment
  - 1.4.7 Agriculture
- 1.5 Economic and business aspects of biotechnology
  - 1.5.1 Logistics of biotechnology development
  - 1.5.2 Protection of intellectual property in biotechnology
  - 1.5.3 Regulation of the safety of biotechnology procedures and products
- 1.6 Closing remarks
- 1.7 Recommended reading

### 2 2 Energy and Biotechnology, 24

D. O. HALL, J. COOMBS AND I. J. HIGGINS

- 2.1 Introduction
- 2.2 Biomass as a solar energy technology
  - 2.2.1 The resource base
- 2.3 Photosynthesis
  - 2.3.1 Photosynthetic efficiency
  - 2.3.2 Improving photosynthesis through biotechnology
- 2.4 Agriculture and forestry
  - 2.4.1 Energy ratios
  - 2.4.2 Forests and trees as a source of biomass fuels
  - 2.4.3 Algae and aquatic plants
  - 2.4.4 Oil plants
- 2.5 Conversion to fuels
  - 2.5.1 Feedstock preparation
  - 2.5.2 Fermentation
  - 2.5.3 Ethanol
  - 2.5.4 Energy balances
  - 2.5.5 Methane by anaerobic digestion
- 2.6 Cell free systems
  - 2.6.1 Combined systems for hydrogen production
  - 2.6.2 Electricity
- 2.7 Biofuel cells and other bioelectrochemical devices
- 2.8 Recommended reading

**3 Food, Drink and Biotechnology, 73**  
**G. A. BEECH, M. A. MELVIN AND J. TAGGART**

- 3.1 Introduction**
  - 3.1.1 Microorganisms and food**
  - 3.1.2 The two scales of biotechnology**
  - 3.1.3 The scope of biotechnology in the food and drink industry**
- 3.2 Dairy products**
  - 3.2.1 General points**
  - 3.2.2 Cheese**
  - 3.2.3 Yoghurt**
  - 3.2.4 Butter**
  - 3.2.5 Cultured butter-milk**
  - 3.2.6 Cultured sour cream**
  - 3.2.7 Novel products**
- 3.3 Cereal products**
  - 3.3.1 Bread and baked goods**
  - 3.3.2 Starch hydrolysates**
- 3.4 Brewing**
  - 3.4.1 Alcoholic beverage production**
  - 3.4.2 Beer**
  - 3.4.3 Wine**
  - 3.4.4 Spirits**
  - 3.4.5 Cider**
  - 3.4.6 Vinegar**
- 3.5 Protein products**
  - 3.5.1 Traditional fermented foods**
  - 3.5.2 Single cell protein**
  - 3.5.3 MycoProtein**
- 3.6 Food additives and ingredients**
  - 3.6.1 Acidulants**
  - 3.6.2 Amino acids**
  - 3.6.3 Vitamins and pigments**
  - 3.6.4 Flavourings**
  - 3.6.5 Oil and fats**
  - 3.6.6 Gums and thickeners**
- 3.7 Fruit and vegetables**
  - 3.7.1 Preserved vegetables**
  - 3.7.2 Soya products**
  - 3.7.3 Fruit juices—application of enzymes**
- 3.8 Overview**
  - 3.8.1 Short-term prospects**
  - 3.8.2 Long-term prospects**
- 3.9 Recommended reading**

**4 Chemistry and Biotechnology, 111**  
**D. J. BEST**

- 4.1 Introduction**
- 4.2 The development of current chemical biotechnology**
  - 4.2.1 The solvent fermentations**
  - 4.2.2 Organic acid production**
  - 4.2.3 Other organic acids**
  - 4.2.4 Amino acids**

4.2.5 Antibiotics and steroids  
4.2.6 The commercial exploitation of enzymes  
4.3 The generation of chemicals from biomass  
4.3.1 Plant cell biotechnology  
4.3.2 Chemicals from biomass  
4.4 Future prospects  
4.4.1 Reaction type  
4.4.2 Reactor configuration  
4.4.3 Future impact of biotechnology upon the chemical industry  
4.5 Recommended reading

**5 Materials and Biotechnology, 163**

**C. L. BRIERLEY, D. P. KELLY, K. J. SEAL AND D. J. BEST**

5.1 Introduction  
5.2 Microbial leaching  
5.2.1 The leaching microorganisms  
5.2.2 Commercial applications of bioextractive metallurgy  
5.2.3 Potential applications of bacterial leaching  
5.3 Metal transformation, accumulation and immobilization by microorganisms  
5.3.1 Volatilization  
5.3.2 Extracellular precipitation  
5.3.3 Extracellular complexation  
5.3.4 Intracellular and extracellular accumulation of metals by microorganisms  
5.4 Biopolymers  
5.4.1 Introduction  
5.4.2 Polysaccharides  
5.4.3 Polysaccharide production by fermentation  
5.4.4 Microbial polysaccharides: properties, applications and commercial potential  
5.4.5 Polysaccharide biosynthesis  
5.4.6 Approaches to the improvement of microbial polysaccharide production  
5.4.7 Poly- $\beta$ -hydroxybutyrate  
5.4.8 Other microbially derived polymers  
5.5 The biodeterioration of materials  
5.5.1 Introduction  
5.5.2 Definition of biodeterioration  
5.5.3 Classification of biodeterioration processes  
5.5.4 Materials subject to biodeterioration  
5.6 Recommended reading

**6 The Environment and Biotechnology, 213**

**D. J. BEST, J. JONES AND D. STAFFORD**

6.1 Introduction  
6.2 The processing of waste  
6.2.1 Aerobic processes: trickling/percolating filters, activated sludge, the fluidized bed  
6.2.2 The anaerobic digestion process  
6.3 Biological control of microbial waste treatment systems  
6.4 Pathogen control  
6.5 Resource recovery  
6.6 Biological processing of industrial waste  
6.6.1 Wastes from the dairy industry . . . whey  
6.6.2 Wastes from the pulp industry  
6.6.3 Wastes from the dye industry

6.7 The degradation of xenobiotic compounds in the environment  
6.7.1 The involvement of microbial communities in the biodegradation of xenobiotics  
6.7.2 Chlorinated hydrocarbons  
6.7.3 Other substituted simple aromatic compounds  
6.7.4 Polycyclic aromatic hydrocarbons  
6.7.5 Microbial treatment of oil pollution  
6.7.6 Pesticides  
6.7.7 Surfactants  
6.8 Recommended reading

## 7 Genetics and Biotechnology, 257

K. G. HARDY AND S. G. OLIVER

7.1 Introduction  
7.2 Conventional routes to strain improvement  
7.2.1 Mutagenesis and selection  
7.2.2 Hybridization by mating  
7.3 *In vivo* genetic manipulation  
7.3.1 Plasmids  
7.3.2 Protoplast fusion  
7.3.3 Cell fusion  
7.4 *In vitro* genetic manipulation  
7.4.1 Technology  
7.4.2 Expression of cloned genes  
7.4.3 Applications of genetic engineering  
7.5 Summary and prospects  
7.6 Recommended reading

## 8 Medicine and Biotechnology, 283

J. C. PICKUP

8.1 Introduction  
8.2 Unmodified or mutant cells and their products  
8.2.1 Antibiotics  
8.2.2 Other cell cultures  
8.2.3 Bioconversions  
8.3 Modified cells and their products  
8.3.1 Monoclonal antibodies  
8.3.2 Recombinant DNA technology  
8.4 Application of the techniques of molecular genetics and recombinant DNA technology in diagnosis and pathology of human disease  
8.4.1 Prenatal diagnosis in inherited disease  
8.4.2 Genetic influences in disease pathology  
8.5 Future prospects  
8.6 Recommended reading

## 9 Agriculture and Biotechnology, 305

F. A. SKINNER

9.1 Introduction  
9.2 The nutrient film technique  
9.2.1 Principle of the technique  
9.2.2 Basic requirements for a NFT installation  
9.2.3 Phytotoxicity  
9.2.4 NFT channel design

9.2.5 Supporting young plants

9.2.6 Disease

9.2.7 Prospects

9.3 Leguminous crops and symbiotic nitrogen fixation

9.3.1 Historical introduction

9.3.2 Inoculation with rhizobia

9.3.3 Seed inoculation

9.3.4 Modern solid-support inoculants

9.3.5 Methods of inoculation

9.3.6 Improving the legume-*Rhizobium* symbiosis

9.4 Vesicular-arbuscular mycorrhiza

9.4.1 Significance of vesicular-arbuscular mycorrhiza

9.4.2 Inoculation with the endophyte

9.4.3 Inoculation techniques

9.5 Biological control

9.5.1 Principles of biological control

9.5.2 Examples of biological control

9.5.3 Crown gall disease and its control

9.6 The aerobic treatment of agricultural wastes

9.6.1 The problem of waste storage and disposal

9.6.2 Aerobic treatment systems

9.7 Anaerobic digestion of agricultural wastes

9.7.1 Essential features of the process

9.7.2 Approach to agricultural waste treatment

9.7.3 Microbiology of the process

9.7.4 Modern developments

9.8 Plant breeding and protoplast techniques

9.8.1 Vegetative propagation

9.8.2 Regeneration of plants from protoplasts

9.8.3 Protoplast fusion techniques

9.9 Recommended reading

**10 Chemical Engineering and Biotechnology, 346**

**G. HAMER**

10.1 Introduction

10.2 Microbial factors affecting process performance and economics

10.2.1 Yield coefficients

10.2.2 Growth and product formation kinetics

10.2.3 Substrate affinity and microbial growth

10.2.4 Fastidiousness and culture stability

10.3 Process engineering factors affecting process performance and economics

10.3.1 Bioreactor classification and productivity

10.3.2 Dimensional analysis and scale up

10.3.3 Oxygen transfer

10.3.4 Heat transfer and process cooling

10.3.5 Conversion and recycle

10.3.6 Characteristics of microbial and mycelial suspensions.

10.4 Ancillary unit operations in biotechnological processes

10.4.1 Medium and air sterilization

10.5 Future developments in industrial biotechnological processes

10.6 Recommended reading

# Contributors

**Beech G.A.** RHM Research Limited, The Lord Rank Research Centre, Lincoln Road, High Wycombe, Buckinghamshire HP12 3QR

**Best D. J.** Biotechnology Centre, Cranfield Institute of Technology, Cranfield, Bedfordshire MK43 0AL

**Brierley C.L.** New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801, USA

**Coombs J.** Department of Plant Sciences, School of Biological Sciences, University of London, 68, Half Moon Lane, London SE24 9JF

**Hall D.O.** Department of Plant Sciences, School of Biological Sciences, University of London, 68, Half Moon Lane, London SE24 9JF

**Hamer G.** Institute for Aquatic Sciences, Swiss Federal Institute of Technology, Ueberlandstrasse 133, CH-8600 Dubendorf, Switzerland

**Hardy K.G.** Biogen S.A., Route de Troinex 3, 1227 Carouge, Geneva, Switzerland

**Higgins I.J.** Biotechnology Centre, Cranfield Institute of Technology, Cranfield, Bedfordshire MK43 0AL

**Jones J.** Biotechnology Centre, Cranfield Institute of Technology, Cranfield, Bedfordshire MK43 0AL

**Kelly D.P.** Department of Environmental Sciences, University of Warwick, Coventry CV4 7AL

**Melvin M.A.** RHM Research Limited, The Lord Rank Research Centre, Lincoln Road, High Wycombe, Buckinghamshire HP12 3QR

**Oliver S.G.** Department of Biochemistry and Applied Molecular Biology, University of Manchester Institute of Science and Technology, PO Box 88, Manchester M60 1QD

**Pickup J.C.** Unit for Metabolic Medicine, Department of Medicine, Hunts House, Guy's Hospital Medical School, London Bridge, SE1 9RT

**Seal K.J.** Biotechnology Centre, Cranfield Institute of Technology, Cranfield, Bedfordshire MK43 0AL

**Skinner F.A.** 5, Carrisbrooke Road, Harpenden, Hertfordshire AL5 5QS

**Stafford D.** Cardiff Laboratories for Energy and Resources Limited, Lewis Road, East Moors, Cardiff CF1 5EG

**Taggart J.** RHM Research Limited, The Lord Rank Research Centre, Lincoln Road, High Wycombe, Buckinghamshire HP12 3QR