Biochemistry of Industrial Micro-organisms

Edited by C. RAINBOW *and* A. H. ROSE

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ACADEMIC PRESS
LONDON and NEW YORK · 1963

ACADEMIC PRESS INC. (LONDON) LTD.
BERKELEY SQUARE HOUSE
LONDON, W.1

U.S. Edition published by
ACADEMIC PRESS INC.
111 FIFTH AVENUE
NEW YORK 3, NEW YORK

Library of Congress Catalog Card Number: 63–21393

Printed in Great Britain by Spottiswoode, Ballantyne & Co. Ltd.,
London and Colchester

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Preface

There are probably few better documented examples of Man's scientific and technological development than the harnessing of the activities of micro-organisms. Although micro-organisms were first applied over 6000 years ago to brew beer and to make wine, it has been only during the present century that the potential value of this exploitation of microbial activity has begun to be realized. Developments over the past few decades have led to processes for making a wide variety of industrial chemicals, including organic acids, vitamins, amino acids and enzymes. Probably the most significant development was the discovery of antibiotics, a discovery which established a close liaison between the microbiological and pharmaceutical industries. This liaison has since led to further notable advances in the industrial applications of micro-organisms, particularly in the field of steroid transformations. There has been also a change in our concept of the "industrial micro-organism". Some 20–30 years ago, there existed a small band of micro-organisms—some yeasts and a few bacteria and moulds—that were conveniently referred to as industrial micro-organisms. But today this term can no longer be justifiably reserved for this elite. Indeed, it would now seem that every micro-organism is potentially of industrial importance; once it has been shown to produce a commercially important chemical, or to bring about a chemical transformation that can be applied in the synthesis of an industrially important substance, then the potential of that micro-organism can be realized.

Although the size and scope of the microbiological industries have undergone a tremendous metamorphosis in recent years, the rationale behind the use of micro-organisms in industrial processes remains the same, namely, the exploitation of their chemical activities. Several recent developments have been possible only because we have had a basic understanding of the chemical activities of the micro-organisms involved. And there is every reason to believe that still greater rewards can be expected if research and development are based on a firm knowledge of microbial biochemistry. It is for this reason that the industrial applications of micro-organisms are here described in terms of their biochemical activities.

In order that this book should be of the greatest value to those concerned with industrial micro-organisms, it was essential that it be written not by one or two authors but by a team of contributors, each a specialist in his own field. Throughout its preparation, it has been our aim to allow contributors a wide degree of latitude in interpreting developments in their subject and in the manner in which these developments are presented. We should like to thank all contributors for their willing co-operation in this venture which, we hope, will be of value not only to industrial microbiologists, but also to the whole community of microbiologists.

C. RAINBOW
A. H. ROSE

June, 1963

List of Common Abbreviations and Symbols

AMP, CMP, GMP, IMP, UMP	5′ Phosphates of ribosyl-adenine, -cytosine, -guanine, -hypoxanthine, and -uracil
ADP, CDP, GDP, IDP, UDP	Adenosine, cytosine, guanosine, inosine and uridine diphosphates
ATP, CTP, GTP, ITP, UTP	Adenosine, cytosine, guanosine, inosine and uridine triphosphates
ABS	Alkyl benzene sulphonates
6-APA	6-Aminopenicillanic acid
BOD	Biochemical Oxygen Demand
CDPG	Cytidine diphosphate glucose
CoA, CoASH	Coenzyme A
DAP	Diaminopimelic acid
DNA	Deoxyribonucleic acid
EDTA	Ethylenediamine tetra-acetic acid
EMP	Embden–Meyerhof–Parnas pathway
FAD, $FADH_2$	Flavin adenine dinucleotide, oxidized and reduced forms
FMN	Flavin monophosphate
GSSG, GSH	Glutathione, oxidized and reduced forms
HMP	Hexose monophosphate shunt
MVA	Mevalonic acid
NAD, $NADH_2$	Nicotinamide adenine dinucleotide, oxidized and reduced forms
NADP, $NADPH_2$	Nicotinamide adenine dinucleotide phosphate, oxidized and reduced forms
$\sim P$	Energy-rich phosphate bond
P_i	Inorganic phosphate
PP	Inorganic pyrophosphate
RNA	Ribonucleic acid
TCA	Tricarboxylic acid cycle
TPP	Thiamine pyrophosphate
UDPG	Uridine diphosphate glucose

Contents

Contributors v
Preface vii

1. INTRODUCTION

A. H. Rose and C. Rainbow

2. BAKER'S YEAST

J. S. Harrison

I. Introduction 9
II. Basic Principles. 10
A. Chemical Anatomy of the Yeast Cell 10
B. Yeast Enzymes 11
C. Uptake of Nutrients and Excretion of Metabolic Products . 11
D. Carbon Utilization 14
III. Synthesis of Cell Material 16
A. Carbohydrates 16
B. Nitrogen-containing Cell Constituents 17
IV. Growth 20
A. Vegetative Propagation. 20
B. Oxygen Requirements 22
C. Growth Factors 23
V. Reproduction 23
A. Genetics 23
B. Cell Division 24
C. Hybridization 25
VI. Fermentation 26
VII. Conclusions 29
References 30

3. MICROBIAL FOOD

H. J. Bunker

I. Introduction 34
II. The Case for Microbial Food 34

III. Production of Essential Nutrients 35
A. Proteins 35
B. Lipids 47
C. Vitamins 53
D. Carbohydrates 61
IV. Acceptability of Microbial Food 61
References 63

4. MICROBIAL EXTRACELLULAR ENZYMES, THEIR USES AND SOME FACTORS AFFECTING THEIR FORMATION

R. Davies

I. Introduction and General Considerations 68
II. Uses of Microbial Extracellular Enzymes 70
III. Production of Microbial Extracellular Enzymes . . . 72
A. Survey of Previous Literature 72
B. Factors Affecting Synthesis of Extracellular Enzymes . 74
IV. Extracellular Enzymes of Bacteria and Fungi . . . 104
References 135

5. VITAMINS

T. W. Goodwin

I. Introduction 151
II. Riboflavin (Vitamin B_2) 151
A. Introduction 151
B. Flavinogenic Organisms 152
C. Biosynthesis 158
III. Cobamides (Vitamins B_{12}) 169
A. Introduction 169
B. Chemistry and Nomenclature 171
C. Biosynthesis 175
IV. Carotenoids 182
A. Introduction 182
B. General Factors Controlling Microbial Production of β-carotene 185
C. Biosynthesis 187
References 198

6. AMINO ACIDS

Shukuo Kinoshita

I. Introduction 206
II. L-Glutamate 207

III. L-Lysine 216
IV. L-Valine 218
V. L-Ornithine 218
VI. L-Homoserine 219
VII. L-Threonine 219
VIII. L-Isoleucine 220
IX. Miscellaneous Amino Acids 220
A. Alanine 220
B. L-Tryptophan 221
C. L-Phenylalanine 221
D. L-Tyrosine 221
E. L-Aspartate 221
X. Future Prospects for the Microbiological Production of Amino Acids 221
References 223

7. ANTIBIOTICS

D. J. D. Hockenhull

I. Introduction 227
II. Penicillin 228
A. Production 228
B. Biosynthesis 239
III. Griseofulvin 246
A. Production 246
B. Biosynthesis 247
IV. Streptomycin 249
A. Production 249
B. Biosynthesis 255
C. Mannosidostreptomycin 266
D. Other Streptomycins 267
V. Tetracyclines 267
A. Production 268
B. Biosynthesis 272
VI. Macrolides 276
A. Production 278
B. Biosynthesis 281
VII. Chloramphenicol 284
A. Production 285
B. Biosynthesis 286
VIII. Novobiocin 287
A. Production 288
B. Biosynthesis 289
IX. Conclusion 290
References 291

8. POLYSACCHARIDES

Ralph F. Anderson

I. Introduction 300
II. Historical Background 302
III. Biosynthesis of Homopolysaccharides from Disaccharides . 302
A. Dextransucrase 303
B. Levansucrase 305
C. Amylomaltase 307
D. Amylosucrase 308
IV. Biosynthesis of Polysaccharides from Monosaccharides . . 309
A. Cellulose 309
B. Heteropolysaccharides 312
C. Developmental Research on Microbial Gums . . . 314
References 316

9. GIBBERELLINS

John Frederick Grove

I. Introduction 320
II. Fungal Gibberellins 321
A. Historical Background 321
B. Physical and Chemical Properties 323
C. Detection and Estimation 324
D. Other Metabolic Products of *Gibberella fujikuroi* . . 326
III. Gibberellin Production by *Gibberella fujikuroi* . . . 327
A. Surface Culture 327
B. Shake Culture 328
C. Stirred Culture 328
IV. Biosynthesis of the Gibberellins 331
References 338

10. ALKALOIDS

L. C. Vining and W. A. Taber

I. Introduction 341
II. Ergoline Alkaloids 342
A. History 342
B. Chemical Structure 345
C. Detection and Assay 350
D. Sources 351

E. Nutrition of *Claviceps* sp. 353
F. Metabolic Pathways in *Claviceps* sp. 354
G. Saprophytic Production 357
H. Physiology of Alkaloid Production 362
I. Biosynthesis 365

III. Psilocybin and Psilocin 370
A. History and Sources 370
B. Production 371
C. Isolation, Structure and Properties 371
D. Biosynthesis 372

References 373

11. FERMENTATION PROCESSES

J. F. Wilkinson and A. H. Rose

I. Introduction 379

II. Biochemistry of Fermentations 380
A. Carbohydrate Fermentations 380
B. Fermentation of Nitrogenous Substances 410

References 412

12. PRODUCTION OF ORGANIC ACIDS BY MOULDS

S. M. Martin

I. Introduction 415

II. Pathways of Glucose Metabolism 417
A. Glycolysis 417
B. Pentose Phosphate Cycle 420
C. Entner–Doudoroff Pathway 424
D. Non-phosphorylative Glucose Oxidation 425

III. Products of Glucose Metabolism 426
A. Gluconic Acid 427
B. Kojic Acid 429
C. Lactic Acid 430

IV. Products of the Tricarboxylic Acid and Glyoxylate Cycles . 432
A. Biochemistry of the Cycles 432
B. Industrially Important Products 438

V. Miscellaneous Products 446
A. Gallic Acid 447
B. Ustilagic Acid 447
C. Gibberellic Acid 448

References 448

13. MISCELLANEOUS PRODUCTS OF FUNGAL METABOLISM

J. H. Birkinshaw

I. Introduction . . . 453
II. Aliphatic Metabolites . . . 453
A. Unsaturated Compounds . . . 453
B. Products Related to Citric Acid . . . 455
III. Heterocyclic Rings Containing One Oxygen Atom . . . 457
A. Epoxides . . . 457
B. Furane Rings . . . 457
C. Tetronic Acids . . . 458
D. Pyrones . . . 459
IV. Aromatic Metabolites . . . 460
A. Monocyclic Structures . . . 460
B. Biosynthesis of Phenolic Metabolites . . . 463
C. Bi- and Tri-cyclic Metabolites . . . 467
V. Quinones . . . 469
A. Benzoquinones . . . 469
B. Naphthaquinones . . . 470
C. Anthraquinones . . . 470
VI. Tropolones . . . 473
VII. Metabolites Containing Nitrogen . . . 473
A. Volatile Amines . . . 473
B. Oligopeptides . . . 474
C. Quaternary Ammonium Compounds . . . 475
D. Pyridine Derivatives . . . 476
E. Quinoline Derivatives . . . 476
F. Nitrogen Metabolites Related to Quinones . . . 477
G. Nitrogen Metabolites Related to Tetronic Acids . . . 478
H. Diazine Rings . . . 478
I. Indole Derivatives . . . 479
J. Unusual Types of Nitrogen Compounds . . . 480
VIII. Metabolites Containing Sulphur . . . 481
IX. Metabolites Containing Chlorine . . . 482
X. Metabolites Containing Arsenic etc. . . . 483
XI. Function . . . 484
References . . . 484

14. MICROBIAL SPOILAGE

the late B. P. Eddy

I. Introduction . . . 489
II. Carbohydrates and Related Substances . . . 490
A. Cellulose . . . 491
B. Wood—Hemicelluloses and Lignin . . . 493
C. Pectin . . . 494

D. Starch 495
E. Monosaccharides and Disaccharides 495
III. Proteins 495
A. Proteolysis 496
B. Putrefaction 499
IV. Lipids and Allied Compounds 500
A. Fats and Oils 500
B. Lecithin 502
V. Miscellaneous Types of Spoilage 503
VI. Conclusion 504
References 506

15. SEWAGE TREATMENT

D. Jenkins

I. Introduction 508
II. Nature of Sewage 509
III. Sewage Treatment Processes 511
A. Primary Treatment 511
B. Settled Sewage Treatment 511
C. Sludge Treatment. 514
IV. Biological Populations of Sewage Treatment Plants . . . 515
A. Activated Sludge 515
B. Biological Filters 518
V. Oxygen and Nutrient Supply 521
A. Oxygen 521
B. Nutrients 521
VI. Microbiological Activities 522
A. Removal of Organic Matter 522
B. Inorganic Nitrogen Metabolism 524
C. Sludge Digestion and Methane Formation 528
D. Breakdown of Synthetic Detergents 531
VII. Conclusions 533
VIII. Acknowledgements 534
References 534

16. MICROBIAL TRANSFORMATIONS OF STEROIDS AND THEIR APPLICATION TO THE PREPARATION OF HORMONES AND DERIVATIVES

Durey H. Peterson

I. Introduction 538
II. Oxidation Reactions 545
A. Simple Hydroxylations 545
B. Polyhydroxylations 557

C. Introduction of Oxygen as a Ketone 558
D. Epoxidations 559
E. Simple Side Chain Degradation with or without Lactonization of Ring D 560
F. Side Chain Degradations with Hydroxylation . . . 562
G. Introduction of Nuclear Double Bonds with no Side Chain Degradation 562
H. Introduction of Nuclear Double Bonds and Side Chain Degradation 563
I. Introduction of Nuclear Double Bonds with Hydroxylation of 3-Oxo-Δ^4 Steroids 566
J. Oxidation of Nuclear and Side Chain Hydroxyl Groups . 567
K. Opening of Rings, A, B and D 568
III. Reduction Reactions 571
A. Reduction of Side Chain Carbonyl Groups . . . 571
B. Reduction of Nuclear Double Bonds, Nuclear Ketones and Combinations thereof. 573
IV. Mixed Reactions 574
A. Reduction of Nuclear Double Bonds and Hydroxylation . 574
B. Reduction of Carbonyl Groups and Hydroxylation . . 575
C. Reduction of Carbonyl Groups and Introduction of Nuclear Double Bonds 575
D. Aromatization 575
E. Reversible Oxidation-Reduction Reactions . . . 576
V. Microbial Transformation of Cardiac Aglycones and Steroid Alkaloids 576
A. Digitoxigenin and Related Compounds 576
B. Steroid Alkaloids 576
VI. Esterification Reactions 577
VII. Esterases, Glucuronidases and other Enzymes . . . 578
VIII. Steroid Decarboxylase 579
IX. Preparation of Steroid Hormones and Derivatives . . . 580
A. Naturally Occurring Adrenal Corticosteroids . . . 580
B. Modified Adrenal Corticosteroids 583
C. Gonadal Hormones and Derivatives 585
X. Microbial Enzymes in Structure Proof and Classification of Micro-organisms 589
XI. Enzyme Mechanisms 589
XII. Acknowledgements 597
References 597

17. MISCELLANEOUS OXIDATIVE TRANSFORMATIONS

A. N. Hall

I. Introduction 607
II. Ketogenic Transformations of Polyols 608
A. Transformation of Sugar Alcohols in Growing Cultures . 608
B. Polyol Dehydrogenases of Micro-organisms 610

C. Conversion of Sorbitol to L-Sorbose 612
D. Conversion of Glycerol to Dihydroxyacetone . . . 612
E. Oxidation of Cyclitols by *Acetobacter suboxydans* . . 613
III. Some Transformation Products of Reducing Sugars . . 614
A. 5-Oxo-D-gluconic Acid 614
B. 2-Oxo-D-gluconic Acid 615
C. 2,5-Dioxogluconic Acid 616
D. 2-Oxo-L-gulonic Acid 617
E. L-Ascorbic Acid and D-araboascorbic Acid . . . 618
F. Keto-sugars 618
G. 2-Oxoglutaric acid 619
H. L-1-Phenyl-1-acetylcarbinol 619
IV. Conversion of 2-Oxoglutaric Acid to L-Glutamic Acid . . 621
V. Oxidative Transformations of *n*-Alkanes 621
A. Subterminal Oxidation 621
B. Terminal Oxidation 621
C. Di-terminal Oxidation 623
VI. Transformation of Alkaloids 623
A. Yohimbine 623
B. Nicotine 624
References 625
Author Index 629
Subject Index 669

CHAPTER 1

Introduction

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The harnessing of the activities of micro-organisms represents one of the most fascinating aspects of Man's scientific and technological development. Included among the industrial applications of micro-organisms are some of the oldest of Man's social and domestic activities, but it is only during the past few decades, following upon the dramatic advances that have been made in the science of biochemistry, that we have begun to appreciate fully the advantages that can be gained from this exploitation of microbial activity. The variety of ways in which micro-organisms have been used industrially are described in detail in several textbooks, including those of Underkofler and Hickey (1954) Prescott and Dunn (1959), Whitmarsh (1958) and Rose (1961). Each industrial microbiological process exploits the biochemical properties of a certain micro-organism or occasionally, as in sewage purification, of a mixed flora of micro-organisms.

The reasons why micro-organisms have proved such valuable agents in industrial processes are threefold and are based on those properties which distinguish them from higher plants and animals. A review by Gunsalus and Shuster (1961) deals with these distinguishing features in greater detail than is possible in this chapter.

Speed of Microbial Metabolism

Micro-organisms are extremely small with, on a weight-for-weight basis, a very high surface: volume ratio as compared with higher organisms. Because of the tremendous area available for absorption of nutrients, it follows that the speed at which micro-organisms carry out metabolic reactions is very much greater than the speed found in higher organisms, and this relatively high speed of metabolism helps to make micro-organisms valuable agents in industrial processes.

One of the best, and certainly the most often quoted, example