

ADVANCES IN ENZYMOLOGY

**AND RELATED SUBJECTS OF
BIOCHEMISTRY**

Volume III

CONTRIBUTORS TO VOLUME III

- KJELL AGNER, *Medicinska Nobel Institutet, Stockholm, Sweden*
- W. T. ASTBURY, *Textile Physics Laboratory, University of Leeds, Leeds, England*
- E. S. GUZMAN BARRON, *Department of Medicine, University of Chicago, Chicago, Ill.*
- W. V. CRUESS, *College of Agriculture, University of California, Berkeley, Calif.*
- J. P. GREENSTEIN, *National Cancer Institute, National Institute of Health, U. S. Public Health Service, Bethesda, Md.*
- KLAUS HOFMANN, (at present) *Research Laboratories, Ciba Pharmaceutical Products, Inc., Summit, N. J.*
- H. A. KREBS, *Department of Biochemistry, Sheffield University, Sheffield, England*
- KURT H. MEYER, *École de Chimie de l'Université, Genève, Switzerland*
- A. E. MIRSKY, *The Hospital of the Rockefeller Institute for Medical Research, New York, N. Y.*
- IRWIN W. SIZER, *Department of Biology and Biological Engineering, Massachusetts Institute of Technology, Cambridge, Mass.*
- ROGER J. WILLIAMS, *Department of Chemistry, University of Texas, Austin, Texas*

ADVANCES IN ENZYMOLOGY
AND RELATED SUBJECTS OF BIOCHEMISTRY

Edited by

F. F. NORD
Fordham University, New York, N. Y.

C. H. WERKMAN
Iowa State College, Ames, Iowa

VOLUME III

INTERSCIENCE  **PUBLISHERS, Inc.**
NEW YORK 1943

123397

Copyright, 1943, by
INTERSCIENCE PUBLISHERS, INC.
250 Fifth Avenue, New York 1, N. Y.

First Printing1943
Second Printing (by photo-offset).....1945
Third Printing (by photo-offset).....1947
Fourth Printing (by photo-offset).....1957

Printed in the United States of America

CONTENTS

| | PAGE |
|--|------|
| In Memoriam—Richard Willstätter | xi |
| Chromosomes and Nucleoproteins. By A. E. MIRSKY, New York, N. Y..... | 1 |
| I. Introduction..... | 1 |
| II. Feulgen's Nuclear Reaction..... | 4 |
| III. Investigations of the Nucleus with the Quartz Microscope and Ultraviolet Light..... | 6 |
| IV. Preparation and Properties of Constituent Parts of Chromosomes..... | 13 |
| V. Nucleoproteins in Chromosomes..... | 19 |
| VI. Cytoplasmic Nucleoproteins..... | 23 |
| VII. Interrelations..... | 28 |
| VIII. Viruses..... | 29 |
| Bibliography..... | 32 |
| Effects of Temperature on Enzyme Kinetics. By IRWIN W. SIZER, Cambridge, Mass..... | 35 |
| I. Introduction..... | 35 |
| II. Chemical Kinetics as a Function of Temperature..... | 36 |
| 1. Interpretation of the Mechanism of Chemical Reactions..... | 37 |
| 2. Modified Forms of the Arrhenius Equation..... | 39 |
| 3. Kinetics in Heterogeneous Systems..... | 40 |
| III. The Inactivation of Enzymes by Heat..... | 41 |
| Relationship of Heat Inactivation of Enzymes to Protein Denaturation..... | 43 |
| IV. Kinetics of Enzyme-Catalyzed Reactions as a Function of Temperature.. | 45 |
| 1. Review of Early Work..... | 45 |
| 2. Review of Recent Work..... | 48 |
| 3. Effects of Various Factors upon the Activation Energy..... | 51 |
| 4. Relationship of the Activation Energy to the Nature of the Substrate..... | 53 |
| 5. The Relationship of the Activation Energy of an Enzyme to the Biological System from Which It Was Derived..... | 55 |
| 6. The Effect of Temperature on the Dissociation of the Enzyme-Substrate Complex..... | 57 |
| 7. Entropy Changes Accompanying Temperature Activation of Enzymes..... | 58 |
| V. Interpretation of Temperature Effects on Physiological Phenomena in Terms of Activation Energies of Enzyme Systems..... | 59 |
| Bibliography..... | 60 |
| X-Rays and the Stoichiometry of the Proteins. By W. T. ASTBURY, Leeds, England..... | 63 |
| I. Chemical Evidence on the Proportions of the Amino Acid Residues..... | 64 |
| II. The X-Ray Classification of the Fibrous Proteins..... | 71 |
| III. Silk Fibroin..... | 73 |
| IV. The Keratin-Myosin Group..... | 76 |
| V. The Collagen Group..... | 91 |
| VI. The Non-Fibrous or Corpuscular Proteins..... | 96 |
| VII. Summary..... | 104 |
| Bibliography..... | 105 |
| The Chemistry of Glycogen. By KURT H. MEYER, Geneva, Switzerland.... | 109 |
| I. The Recognition and Quantitative Determination of Glycogen..... | 110 |
| II. Isolation..... | 111 |
| III. Fractionation; Properties of the Separate Fractions..... | 113 |
| IV. The Molecular Weight..... | 114 |

| | | |
|---|---|-----|
| V. | The Shape and Size of the Glycogen Molecule..... | 116 |
| VI. | The Methods of Determining Constitution of Polysaccharides of the Starch Group..... | 119 |
| VII. | Determination of the Constitution of Glycogen..... | 122 |
| VIII. | The Biological Breakdown..... | 126 |
| IX. | The State of Glycogen in the Organs..... | 132 |
| | Bibliography..... | 133 |
| Verdoperoxidase. By KJELL AGNER, Stockholm, Sweden..... | | 137 |
| I. | Introduction..... | 137 |
| II. | The Preparation of Verdoperoxidase..... | 138 |
| III. | Spectroscopic Investigations and Light Absorption..... | 141 |
| IV. | Analysis of Verdoperoxidase..... | 142 |
| V. | The Activity of Verdoperoxidase..... | 143 |
| VI. | Discussion..... | 146 |
| | Bibliography..... | 147 |
| Mechanisms of Carbohydrate Metabolism. An Essay on Comparative Biochemistry. By E. S. GUZMAN BARRON, Chicago, Ill..... | | 149 |
| I. | Introduction..... | 149 |
| II. | Catabolic Process: Carbohydrate Fermentation..... | 151 |
| | 1. First Phase: Glycogen \rightarrow Pyruvate..... | 151 |
| | 2. Second Phase: Anaerobic Decomposition of Pyruvate..... | 161 |
| III. | Oxidative Breakdown of Carbohydrate..... | 163 |
| | 1. Without Previous Fermentation..... | 163 |
| | 2. Via Pyruvate..... | 164 |
| | 3. Aerobic Phosphorylation..... | 170 |
| | 4. Isolated Enzyme Systems, Extracts, Ground Tissues, Tissue Slices, the Living Cell..... | 172 |
| IV. | The Anabolic Process: Synthesis of Carbohydrate..... | 174 |
| V. | Regulatory Mechanisms..... | 178 |
| VI. | Orientation of Reactions (The Pasteur Effect)..... | 180 |
| VII. | Summary..... | 183 |
| | Bibliography..... | 184 |
| The Intermediary Stages in the Biological Oxidation of Carbohydrate. By H. A. KREBS, Sheffield, England..... | | 191 |
| | Scope and Layout of the Article..... | 191 |
| I. | Experimental Findings..... | 192 |
| | 1. Methods of Experimentation..... | 192 |
| | 2. Survey and Classification of Substances Metabolized in Muscle Tissue..... | 196 |
| | 3. Biochemical Reactions of Substances Metabolized in Muscle Tissue..... | 199 |
| II. | Reaction Schemes (Theory of Carbohydrate Oxidation)..... | 217 |
| | 1. General Principles Concerning the Theory of Carbohydrate Oxidation..... | 217 |
| | 2. Earlier Schemes of Carbohydrate Oxidation..... | 221 |
| | 3. The Citric Acid Cycle..... | 223 |
| | 4. Modified Scheme (Tricarboxylic Acid Cycle)..... | 235 |
| | 5. The Relations between the Szent-Györgyi Cycle and the Tricarboxylic Acid Cycle..... | 236 |
| | 6. Occurrence of the Tricarboxylic Acid Cycle in Various Materials..... | 238 |
| | 7. Alternative Schemes of Carbohydrate Oxidation..... | 242 |
| III. | Problems Related to the Oxidation of Carbohydrate..... | 244 |
| | 1. Introduction..... | 244 |
| | 2. Interrelations between Protein and Carbohydrate Metabolism..... | 245 |
| | 3. Interrelations between Fat and Carbohydrate Metabolism..... | 246 |
| | Bibliography..... | 248 |

| | |
|---|-----|
| The Chemistry and Biochemistry of Pantothenic Acid. By ROGER J. WIL- LIAMS, Austin, Texas..... | 253 |
| I. Name..... | 253 |
| II. Isolation..... | 254 |
| III. Recognition of Physiological Importance..... | 255 |
| IV. Chemical Structure and Synthesis..... | 256 |
| 1. Preliminary Findings..... | 256 |
| 2. β -Alanine as a Cleavage Product..... | 256 |
| 3. Nitrogen-Free Portion of the Molecule..... | 257 |
| 4. Methods of Condensation..... | 258 |
| 5. Resolution..... | 259 |
| 6. Specificity..... | 259 |
| V. Origin-Distribution-Quantitative Determination..... | 263 |
| VI. Physiological Functioning..... | 266 |
| 1. Fundamental Role or Roles..... | 266 |
| 2. Deficiencies and Requirements..... | 267 |
| 3. Pharmacology..... | 279 |
| 4. Functioning in Miscellaneous Organisms..... | 279 |
| Bibliography..... | 281 |
| | |
| The Chemistry and Biochemistry of Biotin. By KLAUS HOFMANN, Summit, N. J..... | 289 |
| I. Introduction..... | 289 |
| II. Biotin Standards..... | 291 |
| III. Assay Procedures..... | 291 |
| IV. Isolation of Biotin..... | 292 |
| V. Chemistry of Biotin..... | 294 |
| 1. Properties and Elementary Composition..... | 294 |
| 2. Functional Groups..... | 295 |
| 3. The Nature of the Side Chain..... | 296 |
| 4. The Nature of the Urea Ring..... | 298 |
| 5. Kögl's Attempt to Demonstrate a Sulfur Ring in Biotin..... | 300 |
| 6. The Structure of Biotin..... | 301 |
| VI. Occurrence of Free and Bound Biotin in Nature..... | 304 |
| VII. Avidin, the Substance in Egg White, Responsible for the Production of Egg White Injury..... | 305 |
| VIII. The Role of Biotin in Animal Nutrition..... | 307 |
| IX. The Possible Relationship of Biotin to Cancer..... | 309 |
| Bibliography..... | 311 |
| | |
| Recent Progress in Tumor Enzymology. By JESSE P. GREENSTEIN, Be- thesda, Md..... | 315 |
| I. Introduction..... | 315 |
| II. Comparison of the Enzymatic Activity of Tumors with that of the Normal Tissues of Origin..... | 318 |
| 1. Hepatomas and Liver..... | 318 |
| 2. Lymphomas and Lymph Nodes..... | 327 |
| 3. Mammary Tumors and Breast..... | 328 |
| 4. Rhabdomyosarcoma and Muscle..... | 329 |
| 5. Adenocarcinoma of the Stomach and Intestine and Normal Gastric and Intestinal Mucosa..... | 329 |
| 6. Carcinoma of the Prostate and Normal Prostate..... | 330 |
| 7. Osteogenic Sarcoma and Bone..... | 332 |
| 8. General Considerations..... | 333 |
| III. Comparison of the Activity of Enzymes and Concentration of Certain Components of the Tissues of Normal and of Tumor-Bearing Animals..... | 335 |
| 1. Tissues Other than Blood or Serum..... | 335 |

| | |
|--|------------|
| 2. Blood and Serum..... | 340 |
| 3. General Considerations..... | 344 |
| Bibliography..... | 345 |
| The Role of Microorganisms and Enzymes in Wine Making. By W. V. CRUESS, Berkeley, Calif..... | 349 |
| I. Yeasts..... | 350 |
| 1. Sequence of Microorganisms in Musts and Wine..... | 351 |
| 2. Yeasts Found on Grapes..... | 352 |
| 3. Use of Pure Cultures..... | 356 |
| 4. The Role of SO ₂ | 357 |
| 5. Effect of Temperature..... | 357 |
| 6. Effect of Acetic Acid on Yeast..... | 358 |
| 7. Alcohol-Forming Ability..... | 359 |
| 8. Syruped Fermentation..... | 359 |
| 9. Sherry and Arbois Film Yeasts..... | 360 |
| II. Microbial Spoilage of Wine..... | 362 |
| 1. Spoilage by Film-Forming Yeasts..... | 362 |
| 2. Spoilage by Vinegar Bacteria..... | 364 |
| 3. Spoilage by Certain Lactic Bacteria..... | 367 |
| 4. Pousse..... | 374 |
| 5. Mannitic Disease of Wine..... | 374 |
| 6. The "Bitter Ferment" of Wine..... | 377 |
| 7. Slimy Wine Spoilage..... | 378 |
| 8. Other Bacterial Diseases of Wine..... | 379 |
| 9. The "Hair Bacillus" of Fortified Wine..... | 379 |
| III Malic Acid Destruction by Bacteria..... | 380 |
| IV. Role of Enzymes in Wine Making..... | 381 |
| 1. Oxidase of the Grape..... | 381 |
| 2. Botrytus Mold Oxidase and Oxidasic Casse..... | 382 |
| 3. Pectic Enzymes..... | 383 |
| 4. Other Enzymes..... | 384 |
| Bibliography..... | 384 |
| Author Index..... | 387 |
| Subject Index..... | 402 |
| Cumulative Index of Volumes I, II, and III..... | 407 |



Richard Willstätter.