Mechanizing Microbiology

Edited by

Anthony N. Sharpe, Ph.D., F.R.I.C.

Head, Microbiology Automation Section, Bureau of Microbial Hazards
Food Directorate, Health Protection Branch
Health and Welfare, Ottawa, Ontario, Canada

David S. Clark, Ph.D.

Chief, Division of Microbiological Research
Bureau of Microbial Hazards, Food Directorate
Health Protection Branch, Health and Welfare
Ottawa, Ontario, Canada

With a Foreword by

ALBERT BALOWS, Ph.D.
Director, Bacteriology Division
Center for Disease Control
Atlanta, Georgia

Microbiologists, pathologists and laboratory technicians interested in the improved quality and speed inherent in computerized and automated microbiological analysis will find this material to be professionally advantageous. The book is an up-to-date analysis of automated and semi-automated instruments now available, combined with research from leading commercial corporations concerning technological advances in the field. Automated bacterial counting by spiral plater and laser colony counter, hydrophobic grid-membrane filters, mechanized *Salmonella* detection, microtiter plate and antibiotic susceptibility tests, electrical impedance methods, fecal coliform determination by radiotracer technique, semi-automatic control of gel strengths, and computer identification of microorganisms are also covered.

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CHARLES C THOMAS • PUBLISHER

Springfield • Illinois • U.S.A.

Published and Distributed Throughout the World by

CHARLES C THOMAS • PUBLISHER
BANNERSTONE HOUSE
301-327 East Lawrence Avenue, Springfield, Illinois, U.S.A.

ISBN 0-398-03658-6
Library of Congress Catalog Card Number: 77 2668

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Printed in the United States of America
N-1

Library of Congress Cataloging in Publication Data

Main entry under title:

Mechanical microbiology.
(American lecture series, publication ; no. 1010)
"This book grew out of the International Conference on Mechanized Microbiology held at Ottawa in September, 1975."
Bibliography: p.
Includes index.
1. Microbiology—Automation—Congresses. 2. Microbiology—Technique—Congresses. I. Sharpe, Anthony N. II. Clark, David S. III. International Conference on Mechanized Microbiology, Ottawa, 1975.
QR65.M38 576'.028 77-2668

CONTRIBUTORS

N. B. BISCIELLO, JR.
Microbiologist
Food and Drug Administration
Brooklyn, New York

D. W. BLAIR, B.S.
Microbiologist
The Procter and Gamble Company
Cincinnati, Ohio

T. L. BLANEY, Ph.D.
Biochemist
The Procter and Gamble Company
Cincinnati, Ohio

Dr. med. Vet. R. BÖHM
Scientific Assistant
Fachrichtung fur Microbiologie
Institut fur Tiermedizin und Tierhygiene mit Tierklinik
Universitat Hohenheim
Stuttgart, Federal Republic of West Germany

W. W. BRINER, Ph.D.
Microbiologist
The Procter and Gamble Company
Cincinnati, Ohio

L. R. BROWN, Ph.D.
Professor of Microbiology and Associate Dean
College of Arts and Sciences
Mississippi State University
State College, Mississippi

G. E. BUCK, B.S.
Department of Pathology
Utah College of Medicine
Salt Lake City, Utah

P. CADY, Ph.D., M.D.
President
Bactomatic Inc.
Palo Alto, Califorina

J. E. CAMPBELL, Ph.D.
Chief
Microbial Biochemistry Branch
Food and Drug Administration
Cincinnati, Ohio

G. W. CHILDERS, Ph.D.
Research Microbiologist
College of Arts and Sciences
Mississippi State University
State College, Mississippi

I. D. COSTIN, M.D.
Chief
Laboratory for Microbiological Quality Control of Pharmaceutical Raw Materials and Culture Media
Darmstadt, Federal Republic of West Germany

A. CURTISS, M.M.E.
Manager
Mechanical Engineering
Pfizer Diagnostics Division
Groton, Connecticut

J. G. EDWARDS, Ph.D.
Senior Research Microbiologist
Norwich Pharmacal Company
Norwich, New York

E. ENGELBRECHT, M.D.
Chief
Microbiology Dept.
Stichting Samenwerking Delftse Ziekenhuizen
Reynier de Graefweg
Delft, Holland

D. FREEDMAN
President
New Brunswick Scientific Company Inc.
New Brunswick, New Jersey

E. E. GELDREICH, M.S.
Chief
Microbiological Treatment Branch
Water Supply Research Division, MERL
U.S. Environmental Protection Agency
Cincinnati, Ohio

R. GRAPPIN, Ing.Agr.
Ingenieur Principal
Institut National de la Recherche Agronomique
Station Experimentale Laitiere de Poligny
Jura, France

R. G. HOLCOMB, M.S.
Research Fellow
School of Public Health
University of Minnesota
Minneapolis, Minnesota

W. E. JORDAN, Ph.D.
Microbiologist
The Procter and Gamble Company
Cincinnati, Ohio

D. W. LAMBE, JR., Ph.D.
Director
Regional Diagnostic and Developmental Microbiology Laboratory of Pathology
New England Deaconist Hospital
Boston, Massachusetts

W. W. LASLIE, M.S.
Supervisor
Regional Diagnostic and Developmental Microbiology Laboratory of Pathology
New England Deaconist Hospital
Boston, Massachusetts

J. D. MacLOWRY, M.D.
Chief
Microbiology Service
National Institutes of Health
Bethesda, Maryland

J. M. MATSEN, M.D.
Head
Division of Clinical Pathology
Department of Pathology
University of Utah College of Medicine
Salt Lake City, Utah

J. McKIE, Ph.D.
Manager
Microbiological Research and Development Division
Pfizer Diagnostics
Groton, Connecticut

G. L. MICHAUD, B.S.
Bureau of Microbial Hazards
Food Directorate
Health Protection Branch
Health and Welfare
Ottawa, Ontario, Canada

T. E. MUNSON, B.S.
Microbiologist
Food and Drug Administration
Brooklyn, New York

J. J. PARRAN, M.S.
Microbiologist
The Procter and Gamble Company
Cincinnati, Ohio

I. J. PFLUG, Ph.D.
Professor, Food Science and Nutrition
Department of Food Science and Nutrition
University of Minnesota
Minneapolis, Minnesota

R. B. READ, JR., Ph.D.
Acting Director
Division of Microbiology
Bureau of Foods
Food and Drug Administration
Washington D. C.

D. J. REASONER, Ph.D.
Research Microbiologist
Microbiological Treatment Branch
Water Supply Research Division, MERL
U.S. Environmental Protection Agency
Cincinnati, Ohio

E. A. ROBERTSON, M.D.
Assistant Chief
Laboratory Computer Service
National Institutes of Health
Bethesda, Maryland

J. P. SCHRADE, B.S.
Supervising Microbiologist
Food and Drug Administration
Brooklyn, New York

J. SEO, Ph.D.
Senior Scientist
Department of Research and Development
Pfizer Diagnostics
Groton, Connecticut

A. N. SHARPE, Ph.D., F.R.I.C.
Head
Microbiology Automation Section
Bureau of Microbial Hazards
Food Directorate
Health Protection Branch
Health and Welfare
Ottawa, Ontario, Canada

B. H. SIELAFF, Ph.D.
Project Director
Pfizer Diagnostic Division
Groton, Connecticut

R. E. TROTMAN, M.Sc., Ph.D C.Eng., M.I.E.E., F.Inst.P.
Director
Bio-Engineering Department
St. Mary's Hospital Medical School
London, England

J. S. WINBUSH, M.S.
Acting Director
Division of Mathematics
Food and Drug Administration
Washington D.C.

J. A. WUNDER, B.A.
Microbiologist
The Procter and Gamble Company
Cincinnati, Ohio

FOREWORD

THE GENESIS of this series, *The American Lecture Series in Clinical Microbiology,* stems from the concerted efforts of the Editor and the Publisher to provide a forum from which well-qualified and distinguished authors may present, either as a book or monograph, their views on any aspect of clinical microbiology. Our definition of clinical microbiology is conceived to encompass the broadest aspects of medical microbiology not only as it is applied to the clinical laboratory but equally to the research laboratory and to theoretical considerations. In the clinical microbiology laboratory we are concerned with differences in morphology, biochemical behavior, and antigenic patterns as a means of microbial identification. In the research laboratory or when we employ microorganisms as a model in theoretical biology, our interest is often focused not so much on the above differences but rather on the similarities between microorganisms. However, it must be appreciated that even though there are many similarities between cells, there are important differences between major types of cells which set very definite limits on the cellular behavior. Unless this is understood it is impossible to discern common denominators.

We are also concerned with the relationships between microorganism and disease—any microorganisms and any disease. Implicit in these relations is the role of the host which forms the third arm of the triangle: microorganisms, disease, and host. In this series we plan to explore each of these; singly where possible for factual information and in combination for an understanding of the myriad of interrelationships that exist. This necessitates the application of basic principles of biology and may, at times, require the emergence of new theoretical concepts which will create new principles or modify existing ones. Above all, our aim is to present well-documented books which will be informative,

instructive, and useful, creating a sense of satisfaction to both the reader and the author.

Closely intertwined with the above *raison d'être* is our desire to produce a series which will be read not only for the pleasure of knowledge but which will also enhance the reader's professional skill and extend his technical ability. The *American Lecture Series in Clinical Microbiology* is dedicated to biologists—be they physicians, scientists, or teachers—in the hope that this series will foster better appreciation of mutual problems and help close the gap between theoretical and applied microbiology.

Attention has been sharply focused over the past decade on the development of automated instruments which lend themselves to one or more time, labor, or material saving aspects of laboratory effort. Simultaneously, automated or semiautomated analytical devices have also been developed in the laboratories of innovative researchers. As a result of these and related activities, a number of instruments, devices, and methodology improvements have occurred in several areas within the broad scope of microbiology.

There has been at least one European international conference designed specifically to provide a forum for the presentation and discussion of rapid methods and automation as applied to microbiology. However, no such meetings had been organized for the Western Hemisphere until Dr. A. N. Sharpe and Dr. D. S. Clark of the Health and Welfare Branch of the Canadian Ministry of Health and Welfare put such a conference together. The conference was held in Ottawa in the autumn of 1975. It was international in scope and broad in the coverage of mechanization in microbiology. The meeting was well received and the organizers of the conference were urged to publish the proceedings. Thus, Drs. Sharpe and Clark assumed the role of editors and made possible this addition of the *American Lecture Series in Microbiology*. It is a most welcome addition and one which should serve not only as a source of baseline information and data on certain aspects of mechanization but also to serve as an inspiration to those readers who will be motivated to improve on these instruments described in this book so that microbiology will continue to keep time with the new drummer—automation.

ALBERT BALOWS, PH.D.
Editor

PREFACE

THIS book grew out of the International Conference on Mechanized Microbiology held at Ottawa in September, 1975. We hoped that by inviting conference contributors to rewrite their manuscripts in the light of the general outcomes of the conference, instead of simply publishing a verbatim conference report, a more coherent and valuable work would be obtained. By so doing, we also enabled many of the contributors to widen the scope of their papers, particularly by the inclusion of more review material.

Two other chapters, not originally presented as papers at the conference, have been added. Chapter 1, by R. E. Trotman, describes in very readable terms some of the frustrations, problems, and prejudices surrounding the whole business of mechanizing microbiology. Chapter 3, by A. N. Sharpe, attempts to show that the detection of microorganisms, contrary to the opinions of many microbiologists, is subject to the same laws as the detection of anything else. Other sciences have benefited from the application of theories of communication, and the further exploration of microbiology by such means may well uncover processes inherently more suited to mechanization than those we use at present.

The would-be inventor should find several areas described within the book from which useful developments might be made. The field of microbiology, particularly food microbiology, badly needs new ideas, new enthusiasms, and strong research and development investment. Chapter 5, by R. B. Read, paints a slightly gloomy picture. However, the scientist-inventor should find in Chapter 4, by D. Freedman, a friendly encouragement, some useful guides and, for those who may have seen their brainchildren dashed against the rocks, some appreciation that inventions are not lightly tossed into the sea of commerce.

A.N.S.
D.S.C.

CONTENTS

MECHANIZING MICROBIOLOGY

Chapter 1

MECHANIZING MICROBIOLOGY: THE ADVANTAGES AND FUTURE PROSPECTS

R. E. TROTMAN

IT IS usually claimed that the primary advantages of mechanization in any discipline are that it increases productivity and that it relieves human beings of having to perform soul-destroying, menial, and repetitive tasks (sometimes necessarily performed in unhealthy environments) so that they may be released to perform mainly those tasks requiring the special training and skills only the technologist possesses. Those are undoubtedly some of the advantages of mechanizing microbiology (except perhaps in the developing countries in which there is a profusion of unskilled labor). However, despite the many attempts to devise and introduce automatic methods into routine use, even simple aids such as semiautomatic dilutors, dispensers, and turbidometric devices, as well as more sophisticated techniques based on the computer or on impedance or on differential light-scattering measurements, are still used sparingly in medical and other branches of microbiology. Those techniques will be discussed later in this volume, and in Hedén & Illéni (1975) and in Trotman (1977), but the question of why this is so will be examined here.

One reason sometimes advanced is that the technology is not available. It is of course true that it is not yet possible to, for instance, identify the organisms in a mixed culture without first isolating them, although claims that one can do this with some techniques, such as impedance measurements, differential light scattering, and gas-liquid chromatography, have been made. However there is a great deal of technology available. Very much is technically feasible.

Of course, it does not follow that, because development of a

specific technique and/or apparatus is technically feasible, it is a useful objective; many designers, both amateur and professional, have fallen into the trap of devising very ingenious but rarely required methods and devices. Some designers have attempted, and failed, to overcome the many technical problems involved, especially in mechanically handling infected material. Furthermore, badly designed, unreliable, costly to run, and misapplied equipment, of which, unfortunately, one knows so many examples, will put an apparatus into disrepute, even though in principle it is very valuable, thereby raising doubts about its value and that of similar equipment. This encourages the belief that it is not possible to produce useful automatic methods in microbiology. Additionally, designers have produced apparatus capable of such outputs that only a few machines would be required to perform all the work in a country of the size of the United Kingdom. These practices waste resources and can permanently discourage a microbiologist from introducing mechanization. One should not rush in and develop one's brainchild without having first firmly established that it really is potentially a tool that is *needed* and likely to be economic when *all* overheads, not just the cost of the capital equipment and consumables, are taken into account.

We are far from having produced all the feasible and practical methods and devices for use in routine laboratories and are far from overcoming the difficulties of introducing good equipment into routine use. The latter is a major problem arising partially because there are those who doubt that mechanizing microbiological laboratories, even if technically feasible, serves a useful purpose. But there is no doubt that there are many advantages, in addition to the primary ones outlined above, in using automatic methods, provided equipment is designed to perform a specific microbiological function. Modifying equipment designed for a different application can be valuable but is often carried out badly and inappropriately.

The variations in the results obtained by two or more workers, ostensibly carrying out identical test procedures, even in the same laboratory, are well known (Gavan, 1974). Much of this variation can be eliminated by the use of a well-designed and constructed

machine, provided it is functioning properly, because it is more consistent than human beings. Furthermore, the contribution of the observer error to the total variation is significantly reduced. In addition, machines can be more sensitive and more accurate than human beings. We must stop such practices as holding a culture up to the light and saying "Oh yes, that's about 10^6 organisms per ml." In this day and age a more scientific approach should be the norm.

An additional advantage of automatic methods is that the results obtained from machines are readily sent directly to data processing equipment. Furthermore, mechanized equipment can be programmed, and it can and should be designed in such a way as to indicate when parameters are outside predetermined limits, when it is out of sequence, and when it has failed. However, one must not overlook the fact that even well-designed and well-constructed equipment needs routine calibration, maintenance, and servicing, and that its proper use requires an operator with appropriate aptitudes.

There is at present very little quality control in microbiology, although the situation is beginning to improve. The use of automatic apparatus facilitates much wider use of such control, although control of media and reagents is required even in manual methods (Russell et al., 1969).

The above seem to be very important reasons for introducing automatic methods into microbiology, but are they in themselves adequate to justify the investments needed to design, develop, and produce such methods? Bearing in mind the harsh world in which we live, can automatic methods be more than bonuses, the main or sole purpose of introducing them being to increase productivity?

One wonders whether the cost of developing automated equipment is a justifiable deterrent, because the bases for economic comparisons are difficult to determine. For example, it would be very difficult to establish the cost of, say, a false diagnosis due to an error in performing a manual test (although some industrialists no doubt have a shrewd idea). Also, is not an improvement in the quality of service to clinicians or food technologists, ensuing from the introduction of well-designed automatic methods, suffi-