FIFTH EDITION

CLINICAL MICROBIOLOGY PROCEDURES HANDBOOK

AMY L. LEBER • CAREY-ANN D. BURNHAM
EDITORS IN CHIEF

5TH EDITION

Clinical Microbiology Procedures Handbook

VOLUME 1

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Dedication

The *Clinical Microbiology Procedures Handbook* (CMPH), 5th edition, was created during the COVID-19 pandemic by clinical laboratory staff who worked tirelessly behind the scenes to develop and implement laboratory testing for SARS-CoV-2. Despite the hardships of responding to constant supply and staffing shortages, clinical laboratory professionals around the globe continued to make important contributions to patient care by working selflessly to support optimal patient outcomes. The 5th edition is dedicated to the CMPH authors and section editors for their tremendous work and their commitment to completion of this project, even in the context of the global pandemic.

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Preface

The fifth edition of the *Clinical Microbiology Procedures Handbook* (CMPH) is based on the content of the previous four editions of the manual in addition to user feedback and technologic advances. All of the existing sections have been revised and updated. Two new sections have been added, one on blood cultures and one on MALDI-TOF MS. The sections on molecular diagnostics and serology have been extensively revised and updated.

One important advancement since the fourth edition is the creation of the online, subscription-based resource ClinMicroNow.org. This resource publishes updates to CMPH between print editions to provide the most recent accepted procedures in clinical microbiology.

The purpose of this fifth print edition, similar to that of the past editions, is to provide those engaged in microbial analysis of clinical specimens with procedures for the detection, identification, and characterization of microorganisms involved in human infections. CMPH remains a procedure-based document that provides step-by-step descriptions of the numerous testing modalities used in the clinical microbiology laboratory. Highly knowledgeable laboratorians have written these procedures, and as appropriate, the format adheres to CLSI document GP02-A5 (5th ed., 2006).

All procedures have been reviewed extensively by section editors, the editors in chief, and the ASM Press editors. We continue to encourage the users of these documents to bring new methods of universal relevance to our attention so they can be incorporated into the next update and shared with the clinical microbiology community.

Readers are reminded that naming any specific product in CMPH is not intended as an endorsement of that specific product or a suggestion to exclude other equally acceptable products. CMPH is for laboratory use only by qualified, experienced individuals or by personnel under the direct supervision of qualified, experienced individuals. Microbiological analysis of clinical specimens is a constantly changing discipline; new methods and technologies regularly emerge. Every effort has been made to ensure that the contents of this update are comprehensive, accurate, reliable, and reproducible.

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We thank each of the section editors and authors for their important contributions to the fifth edition of the *Clinical Microbiology Procedures Handbook* (CMPH). There is a tremendous effort in planning and completing such a large document, and the commitment of time and effort by the parties involved is greatly appreciated.

The current version is built on the foundations provided by previous editions, so a special thanks to all participants in prior editions of CMPH. We continue to acknowledge and thank the late Dr. Henry D. Isenberg for his outstanding guidance and leadership during the development and updating of CMPH. All microbiologists owe him a tremendous debt of gratitude; he will always be known as the "father of CMPH" and its greatest supporter. We also acknowledge the exceptional work of Lynne S. Garcia, who continued Dr. Isenberg's vision overseeing the second and third editions of this manual.

Our editors and authors join us in thanking the leadership of the American Society for Microbiology, and especially ASM Press. As editors in chief, we particularly want to acknowledge Ellen Fox, managing developmental editor of ClinMicroNow, and Christine Charlip, director of ASM Press, for their efforts in supporting this edition of CMPH, as well as the exciting transition of the content onto the ClinMicroNow platform.

In the context of the COVID-19 pandemic, it has been an especially challenging and rewarding honor to work with this group of editors and authors on the fifth edition. Our hope is that this handbook will be used in clinical microbiology laboratories around the globe to provide the highest quality results and ultimately the best care for our patients.

Amy L. Leber
Carey-Ann D. Burnham

How To Use This Handbook

General Format

The fifth edition of this handbook has been divided into five volumes containing the front matter, 18 sections (composed of "procedures"), and an index. Volume 1 contains the front matter of the handbook plus sections 1 through 4. Volume 2 contains sections 5 through 9. Volume 3 contains sections 10 through 12. Volume 4 contains sections 13 through 15, and Volume 5 contains sections 16 through 18 and the index.

Included at the front of each volume is a short table of contents listing the items contained in the front and back matter and the 18 sections of the handbook. In addition to the table of contents for the entire handbook, each section is immediately preceded by a detailed table of contents for that section, giving the section editors' names, the procedure titles included in that section, and the authors' names for each procedure.

Sections

The content of the handbook has been organized into 18 sections as follows:

Section 1: Procedure Coding, Reimbursement, and Billing Compliance
Section 2: Specimen Collection, Transport, and Acceptability
Section 3: Aerobic Bacteriology
Section 4: Anaerobic Bacteriology
Section 5: Blood Culture
Section 6: MALDI-TOF MS
Section 7: Antimicrobial Susceptibility Testing
Section 8: Aerobic Actinomycetes
Section 9: Mycobacteriology and Antimycobacterial Susceptibility Testing
Section 10: Mycology and Antifungal Susceptibility Testing
Section 11: Parasitology
Section 12: Viruses and Chlamydiae
Section 13: Serology
Section 14: Molecular Techniques
Section 15: Epidemiologic and Infection Control Microbiology
Section 16: Quality Assurance, Quality Control, Laboratory Records, and Water Quality
Section 17: Biohazards and Safety
Section 18: Bioterrorism

Procedures

Each section listed above consists of procedures. The procedures have been numbered and are referred to by number in cross-references in the text. The procedure

number consists of the section number plus the number of the procedure (plus the number of a subprocedure if applicable). For example, "procedure 5.6" is the sixth procedure in section 5; "procedure 7.4.2" is the second subprocedure of the fourth procedure in section 7.

Page Numbers

The page number within a procedure is the procedure number followed by the number of the page within the procedure. Thus, from the examples given above, "page 5.6.10" is the 10th page within procedure 5.6, and "page 7.4.2.3" is the 3rd page within procedure 7.4.2. In all cases, the last number is the page number within a procedure.

The index is numbered beginning with an "I" followed by the number of the page within the index. For example, "page I.3" is the third page in the index.

Abbreviations

In this handbook, most abbreviations have been introduced in parentheses after the terms they abbreviate on their first occurrence, e.g., "a central nervous system (CNS) specimen." Some exceptions to this rule are explained below and given in Tables 1 to 4.

Because of their frequent use in this handbook and/or their familiarity to readers, the terms listed in Table 1 have been abbreviated in the procedures; i.e., they have not been spelled out or introduced. Based on the editorial style for books and journals published by the American Society for Microbiology (ASM), the abbreviations listed in Table 2 have also been used without introduction in this handbook. Table 3 lists abbreviations that have been used without introduction in the bodies of tables. Abbreviations for commonly accepted units of measurement have been used without definition if they appeared with numerical values. Table 4 lists some common units of measurement appearing in this handbook. These last two items are also based on ASM style.

As readers use the various procedures in this handbook and see unfamiliar abbreviations that are not defined in the procedures themselves, they should refer to these tables for definitions.

Table 1 Common abbreviations used without introduction in this handbook

Abbreviation	Definition
ATCC	American Type Culture Collection
BAP (*not* SBA)	5% Sheep blood agar plate
BHI	Brain heart infusion
BSL	Biosafety level
CAP	College of American Pathologists
CDC	Centers for Disease Control and Prevention
CHOC	Chocolate agar
CLSI	Clinical and Laboratory Standards Institute (formerly NCCLS)
CMPH	*Clinical Microbiology Procedures Handbook*
CSF	Cerebrospinal fluid
EIA	Enzyme immunoassay
ELISA	Enzyme-linked immunosorbent assay
EMB	Eosin-methylene blue
GLC	Gas-liquid chromatography
JCAHO	Joint Commission on Accreditation of Healthcare Organizations (The Joint Commission)
MAC	MacConkey agar

(continued)

Table 1 Common abbreviations used without introduction in this handbook *(continued)*

Abbreviation	Definition
MSDS	Material safety data sheet
N.A.	Numerical aperture
NBS	National Bureau of Standards (pertaining to a special calibrated thermometer)
NCCLS	National Committee for Clinical Laboratory Standards
NIH	National Institutes of Health
OSHA	Occupational Safety and Health Administration
PMNs	Polymorphonuclear leukocytes
PPE	Personal protective equipment
QA	Quality assurance
QC	Quality control
RBCs	Red blood cells *or* erythrocytes
SDS	Safety data sheet
TCBS	Thiosulfate citrate bile salt sucrose agar
THIO	Thioglycolate broth
TSA	Trypticase soy agar *or* tryptic soy agar
TSB	Trypticase soy broth *or* tryptic soy broth
WBCs	White blood cells *or* leukocytes

Table 2 Additional abbreviations used without introduction (according to ASM style)

Abbreviation	Definition
AIDS	Acquired immunodeficiency syndrome
AMP, ADP, ATP, GTP, dCMP, ddGTP, etc.	Adenosine 5′-monophosphate, adenosine 5′-diphosphate, adenosine 5′-triphosphate, guanosine 5′-triphosphate, deoxycytidine 5′-monophosphate, dideoxyguanosine triphosphate, etc.
ATPase, dGTPase, etc.	Adenosine triphosphatase, deoxyguanosine triphosphatase, etc.
cDNA	Complementary deoxyribonucleic acid
CFU	Colony-forming unit(s)
DEAE	Diethylaminoethyl
DNA	Deoxyribonucleic acid
DNase	Deoxyribonuclease
EDTA	Ethylenediaminetetraacetate, ethylenediaminetetraacetic acid
EGTA	Ethylene glycol-bis(β-aminoethyl ethyl)-*N*,*N*,*N*′,*N*′-tetraacetic acid
HEPES	*N*-2-hydroxyethylpiperazine-*N*′-2-ethanesulfonic acid
MIC	Minimal inhibitory concentration
mRNA	Messenger ribonucleic acid
NAD	Nicotinamide adenine dinucleotide
NAD+	Oxidized nicotinamide adenine dinucleotide
NADH	Reduced nicotinamide adenine dinucleotide
NADP	Nicotinamide adenine dinucleotide phosphate
NADPH	Reduced nicotinamide adenine dinucleotide phosphate
oligo(dT), etc.	Oligodeoxythymidylic acid, etc.
PCR	Polymerase chain reaction
PFU	Plaque-forming unit(s)
poly(A), poly(dT), etc.	Polyadenylic acid, polydeoxythymidylic acid, etc.
RNA	Ribonucleic acid
RNase	Ribonuclease
rRNA	Ribosomal ribonucleic acid
Tris	Tris(hydroxymethyl)aminomethane
tRNA	Transfer ribonucleic acid
UV	Ultraviolet