

BOC

Study Guide

5th edition

Clinical Laboratory Certification Examinations

Oversight Editors

Patricia A. Tanabe, MPA, MLS(ASCP)^{CM}
Director, Examination Activities

E. Blair Holladay, PhD, SCT(ASCP)^{CM}
Vice President for Scientific Activities, ASCP
Executive Director, Board of Certification

and the ASCP Board of Certification Staff



American Society for
Clinical Pathology
Board of Certification

Publishing Team

Erik N Tanck & Tae W Moon (design/production)

Joshua Weikersheimer (publishing direction)

Notice

Trade names for equipment and supplies described are included as suggestions only. In no way does their inclusion constitute an endorsement of preference by the Author or the ASCP. The Author and ASCP urge all readers to read and follow all manufacturers' instructions and package insert warnings concerning the proper and safe use of products. The American Society for Clinical Pathology, having exercised appropriate and reasonable effort to research material current as of publication date, does not assume any liability for any loss or damage caused by errors and omissions in this publication. Readers must assume responsibility for complete and thorough research of any hazardous conditions they encounter, as this publication is not intended to be all-inclusive, and recommendations and regulations change over time.



American Society for
Clinical Pathology
Press

Copyright © 2009 by the American Society for Clinical Pathology. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of the publisher.

Printed in Hong Kong

Reprinted 2010

14 13 12 11 10

vi	<i>Acknowledgments</i>	130	<i>Electrolytes</i>
vii	<i>Preface</i>	130	<i>Proteins and Other Nitrogen-Containing Compounds</i>
ix	<i>The Importance of Certification, CMP, Licensure and Qualification</i>	132	<i>Heme Derivatives</i>
xi	<i>Preparing for and Taking the BOC Certification Examination</i>	133	<i>Enzymes</i>
1	Blood Bank	136	<i>Lipids and Lipoproteins</i>
	Questions	137	<i>Endocrinology and Tumor Markers</i>
1	<i>Blood Products</i>	139	<i>TDM and Toxicology</i>
8	<i>Blood Group Systems</i>	140	<i>Quality Assessment</i>
17	<i>Physiology and Pathophysiology</i>	141	<i>Laboratory Mathematics</i>
24	<i>Serology</i>	142	<i>Instrumentation</i>
42	<i>Transfusion Practice</i>	145	Hematology
	Answers		Questions
53	<i>Blood Products</i>	145	<i>Erythrocytes: Physiology</i>
55	<i>Blood Group Systems</i>	149	<i>Erythrocytes: Disease States</i>
59	<i>Physiology and Pathophysiology</i>	155	<i>Erythrocytes: Laboratory Determinations</i>
62	<i>Serology</i>	166	<i>Leukocytes: Physiology</i>
69	<i>Transfusion Practice</i>	168	<i>Leukocytes: Disease States</i>
75	Chemistry	178	<i>Leukocytes: Laboratory Determinations</i>
	Questions	187	<i>Platelets: Physiology</i>
75	<i>Carbohydrates</i>	189	<i>Platelets: Disease States</i>
78	<i>Acid-Base Balance</i>	191	<i>Platelets: Laboratory Determinations</i>
81	<i>Electrolytes</i>	194	<i>Hemostasis</i>
85	<i>Proteins and Other Nitrogen-Containing Compounds</i>	202	<i>Hematology Laboratory Operations</i>
95	<i>Heme Derivatives</i>		Answers
99	<i>Enzymes</i>	211	<i>Erythrocytes: Physiology</i>
104	<i>Lipids and Lipoproteins</i>	211	<i>Erythrocytes: Disease States</i>
107	<i>Endocrinology and Tumor Markers</i>	213	<i>Erythrocytes: Laboratory Determinations</i>
113	<i>TDM and Toxicology</i>	215	<i>Leukocytes: Physiology</i>
115	<i>Quality Assessment</i>	216	<i>Leukocytes: Disease States</i>
117	<i>Laboratory Mathematics</i>	219	<i>Leukocytes: Laboratory Determinations</i>
121	<i>Instrumentation</i>	220	<i>Platelets: Physiology</i>
	Answers	221	<i>Platelets: Disease States</i>
129	<i>Carbohydrates</i>	222	<i>Platelets: Laboratory Determinations</i>
129	<i>Acid-Base Balance</i>		

222	<i>Hemostasis</i>	359	<i>Anaerobes</i>
226	<i>Hematology Laboratory Operations</i>	361	<i>Fungi</i>
229	Immunology	363	<i>Mycobacteria</i>
	Questions	365	<i>Viruses and Other Microorganisms</i>
229	<i>Autoantibody Evaluation</i>	367	<i>Parasites</i>
240	<i>Infectious Disease Serology</i>	369	Molecular Biology
248	<i>Protein Analysis</i>		Questions
258	<i>Cellular Immunity and</i> <i>Histocompatibility Techniques</i>	369	<i>Molecular Science</i>
	Answers	370	<i>Molecular Techniques</i>
265	<i>Autoantibody Evaluation</i>	374	<i>Applications of Molecular Testing</i>
268	<i>Infectious Disease Serology</i>		Answers
271	<i>Protein Analysis</i>	378	<i>Molecular Science</i>
275	<i>Cellular Immunity and</i> <i>Histocompatibility Techniques</i>	378	<i>Molecular Techniques</i>
		379	<i>Applications of Molecular Testing</i>
279	Microbiology	381	Urinalysis and Body Fluids
	Questions		Questions
279	<i>Preanalytical and Susceptibility</i> <i>Testing</i>	381	<i>Urinalysis: Pre-Analytical</i> <i>Examination</i>
294	<i>Aerobic Gram-Positive Cocci</i>	383	<i>Urinalysis: Physical Examination</i>
300	<i>Gram-Negative Bacilli</i>	386	<i>Urinalysis: Chemical Examination</i>
313	<i>Aerobic Gram-Negative Cocci</i>	390	<i>Urinalysis: Microscopic Examination</i>
315	<i>Aerobic or Facultative Gram-Positive</i> <i>Bacilli</i>	399	<i>Urinalysis: Complete Examination</i>
317	<i>Anaerobes</i>	403	<i>Urine Physiology</i>
321	<i>Fungi</i>	405	<i>Other Body Fluids</i>
328	<i>Mycobacteria</i>		Answers
334	<i>Viruses and Other Microorganisms</i>	413	<i>Urinalysis: Pre-Analytical</i> <i>Examination</i>
337	<i>Parasites</i>	414	<i>Urinalysis: Physical Examination</i>
	Answers	415	<i>Urinalysis: Chemical Examination</i>
345	<i>Preanalytical and Susceptibility</i> <i>Testing</i>	417	<i>Urinalysis: Microscopic Examination</i>
352	<i>Aerobic Gram-Positive Cocci</i>	420	<i>Urinalysis: Complete Examination</i>
354	<i>Gram-Negative Bacilli</i>	421	<i>Urine Physiology</i>
358	<i>Aerobic Gram-Negative Cocci</i>	423	<i>Other Body Fluids</i>
359	<i>Aerobic or Facultative Gram-Positive</i> <i>Bacilli</i>		

427 Laboratory Operations

Questions

427 *Quality Assessment*

433 *Safety*

442 *Management*

445 *Laboratory Mathematics*

453 *Instrumentation and General
Laboratory Principles*

459 *Education and Communication*

462 *Laboratory Information Systems*

Answers

465 *Quality Assessment*

467 *Safety*

472 *Management*

473 *Laboratory Mathematics*

476 *Instrumentation and General
Laboratory Principles*

478 *Education and Communication*

479 *Laboratory Information Systems*

481 Reading & References

Acknowledgments

The editors would like to thank *Melissa Meeks* and *Edith Miller* for their painstaking efforts in combining and reviewing this body of work in accordance with the ASCP Press and production staff. Special thanks are also extended to all our volunteers (former examination committee members and recently recruited volunteers) for their commitment in assisting us on this essential resource for laboratory science students and their professors.

Thank you to my family – *Adam, Peter* and *Joe*, for their support and understanding during this project.

– Patricia A. Tanabe, MPA, MLS(ASCP)^{CM}

Good luck with your board examination—my best to each of you as you embark on an exciting career in laboratory medicine.

– E. Blair Holladay, PhD, SCT(ASCP)^{CM}

Preface

The 5th edition of the *Board of Certification Study Guide for Clinical Laboratory Certification Examinations* contains over 2000 multiple choice questions. Unique to this study guide is the differentiation of questions appropriate for both the Medical Laboratory Technician and Medical Laboratory Scientist levels from questions that are appropriate for the Medical Laboratory Scientist level **only** (clearly marked MLS ONLY). The questions in this edition are arranged in chapters which correspond to the major content areas on the examination. Within each chapter, the questions are further grouped by topic. New to this edition are short answer explanations and references for each practice question. Questions with images will appear as they would on the certification examination. Laboratory results will be presented in both conventional and SI units.

The practice questions are presented in a format and style similar to the questions included on the Board of Certification certification examinations. **Please note: None of these questions will appear on any Board of Certification examination.**

These practice questions were compiled from previously published materials and submitted questions from recruited reviewers. (Note: These reviewers do not currently serve on any Examination Committee.)

This book is not a product of the Board of Certification, rather it is a product of the ASCP Press, the independent publishing arm of the American Society for Clinical Pathology. Use of this book does not ensure passing of an examination. The Board of Certification's evaluation and credentialing processes are entirely independent of this study guide; however, this book should significantly help you prepare for your BOC examination.

*Our thanks to those who edited/
reviewed questions for this book.*

Blood Bank

**Margaret G. Fritsma, MA, MT(ASCP)
SBB, retired (co-Editor)**

Formerly, Associate Professor
University of Alabama at Birmingham
Birmingham, AL

**Joanne Kosanke, MT(ASCP)SBB^{CM}
(co-Editor)**

Manager, Immunohematology Reference
Laboratory
American Red Cross Central Ohio Blood
Services Region
Columbus, OH

**Patricia J. Ellinger, MSED, MASCP,
MLS(ASCP)^{CM}SBB^{CM}**

Laboratory Education and Training
Consultant
Minneapolis, Minnesota

**Deborah T. Firestone, EdD, MT(ASCP)
SBB**

Associate Dean
Stony Brook University
Stony Brook, NY

Carol McConnell, MS, MLS(ASCP)^{CM}

Laboratory Coordinator
St. Francis Memorial Hospital
San Francisco, CA

Chemistry

**Polly Cathcart, MMSc, MT(ASCP)SC,
retired**

Formerly, Chemistry Supervisor
Piedmont Hospital
Atlanta, GA

**Vicki S. Freeman, PhD, FACB,
MLS(ASCP)^{CM}SC**

Department Chair and
Distinguished Teaching Professor
University of Texas Medical Branch
Galveston, TX

**Ross J. Molinaro, PhD, MT(ASCP),
D(ABCC), FACB**

Medical Director, Core Laboratory, Emory
University Hospital Midtown & Assistant
Professor, Pathology and Lab Medicine,
Emory University School of Medicine
Emory University
Atlanta, GA

**Christine Papadea, PhD, MT(ASCP)SC,
retired**

Formerly, Professor
Pathology and Laboratory Medicine,
Medical University of South Carolina
Charleston, SC

Diane Wilson, PhD, MT(ASCP)

Program Director- Medical Technology
Morgan State University
Baltimore, MD

Hematology

**Donna D. Castellone, MS, MT(ASCP)SH
(Editor)**

Clinical Project Manager/Hematology &
Hemostasis
Siemens Healthcare Diagnostics
Tarrytown, NY

Sandra DiFalco, MS, MT(ASCP)
Education Coordinator

The Colorado Center for Medical
Laboratory Science
Denver, CO

Kathy W. Jones, MS, MLS(ASCP)^{CM}
Faculty – Clinical Laboratory Science
Program

Auburn University Montgomery
Montgomery, AL

Linda L. Myers, MEd, MT(ASCP)SH

Assistant Director Clinical Laboratory
St. Joseph Medical Center
Houston, TX

John K. Scariano, PhD, MT(ASCP)

Assistant Professor, Pathology & Internal
Medicine
University of New Mexico School of
Medicine
Albuquerque, NM

Ruth Scheib, MT(ASCP)SH

Medical Technologist
Cleveland Clinic
Cleveland, OH

Immunology

**Barbara Anne Maier, MPA,
MT(ASCP)SI, retired (Editor)**

Formerly, Technical Specialist
Immunology, Serology & Flow Cytometry
Geisinger Medical Center
Danville, PA

Linda E. Miller, PhD, SI(ASCP)MB^{CM}

Professor of Clinical Laboratory Science
SUNY Upstate Medical University
Syracuse, NY

**Kate Rittenhouse-Olson, PhD,
SI(ASCP)**

Professor, Director Biotechnology
Program
University at Buffalo, The State University
of New York
Buffalo, NY

Laboratory Operations

Ellen Boswell, MBA, MT(ASCP)SH

Director of Clinical Pathology Laboratory
Operations
University of Virginia Medical Center
Charlottesville, VA

**Cynthia S. Johns, MSA,
MLS(ASCP)^{CM}SH^{CM}**

Sr. IT Technical Specialist
Laboratory Corporation of America
Lakeland, FL

**Ross J. Molinaro, PhD, MT(ASCP),
D(ABCC), FACB**

Medical Director, Core Laboratory,
Emory University Hospital Midtown
Assistant Professor, Pathology and Lab
Medicine, Emory University School of
Medicine
Emory University
Atlanta, GA

Patricia A Myers, MT(ASCP)SM,SLS

Lead Technologist, Microbiology
Lancaster General Hospital
Lancaster, PA

**Lynn Schwabe, MBA, CHE, MT(ASCP)
(Editor-Safety)**

Senior Director, Lab Services
NorthShore University HealthSystem,
Evanston Hospital

Evanston, IL

Peggy Simpson, MS, MT(ASCP)

Administrative Director of Laboratories
Danville Regional Medical Center
Danville, VA

Microbiology

**Yvette S. McCarter, PhD, D(ABMM)
(Editor)**

Director, Clinical Microbiology Laboratory
University of Florida Health Science
Center - Jacksonville
Jacksonville, FL

JoAnn P. Fenn, MS, MT(ASCP)

Professor and Associate Division Head,
Medical Laboratory Science, Department
of Pathology
University of Utah School of Medicine
Salt Lake City, UT

**Dawn S. Lumpkin, BA,
MT(ASCP)SM,SV**

Manager of Microbiology Services
HCA Midwest Division, Research Medical
Center
Kansas City, MO

Karen Myers, MA, MT(ASCP)SC

The Colorado Center for Medical
Laboratory Science
Denver, CO

Patty Newcomb-Gayman, MT(ASCP)SM

Point of Care Testing Coordinator
Swedish Medical Center
Seattle, WA

Molecular Pathology

**Stephen T. Koury, PhD, MT(ASCP)
(Editor)**

Research Assistant Professor
Department of Biotechnical and Clinical
Laboratory Sciences, University at Buffalo
Buffalo, NY

Urinalysis and Body Fluids

**Kristina Jackson Behan, PhD,
MT(ASCP)**

Associate Professor and Program Director
University of West Florida Clinical
Laboratory Sciences Program
Pensacola, FL

**Susan Strasinger, DA, MT(ASCP),
retired**

Formerly, Visiting Assistant Professor
University of West Florida
Pensacola, FL

The Importance of Certification, CMP, Licensure and Qualification

The practice of modern medicine would be impossible without the tests performed in the laboratory. A highly skilled medical team of pathologists, specialists, laboratory scientists, technologists, and technicians works together to determine the presence or absence of disease and provides valuable data needed to determine the course of treatment.

Today's laboratory uses many complex, precision instruments and a variety of automated and electronic equipment. However, the success of the laboratory begins with the laboratorians' dedication to their profession and willingness to help others. Laboratorians must produce accurate and reliable test results, have an interest in science, and be able to recognize their responsibility for affecting human lives.

Role of the ASCP Board of Certification

Founded in 1928 by the American Society of Clinical Pathologists (ASCP—now, the American Society for Clinical Pathology), the Board of Certification is considered the preeminent certification agency in the US and abroad within the field of laboratory medicine. Composed of representatives of professional organizations and the public, the Board's mission is to: *"Provide excellence in certification of laboratory professionals on behalf of patients worldwide."*

The Board of Certification consists of more than 100 volunteer technologists, technicians, laboratory scientists, physicians, and professional researchers. These volunteers contribute their time and expertise to the Board of Governors and the Examination Committees. They allow the BOC to achieve the goal of excellence in credentialing medical laboratory personnel in the US and abroad.

The Board of Governors is the policy-making governing body for the Board of Certification and is composed of 25 members. These 25 members include technologists, technicians, and pathologists nominated by the ASCP and representatives from the general public as well as from the following societies: the American Association for Clinical Chemistry, the AABB, American College of Microbiology, American Society for Clinical Laboratory Science, the American Society of Cytopathology, the American Society of Hematology, the American Association of Pathologists' Assistants, Association of Genetic Technology, the National Society for Histotechnology, and the Clinical Laboratory Management Association (CLMA).

The Examination Committees are responsible for the planning, development, and review of the examination databases; determining the accuracy and relevancy of the test items; confirming the standards for each examination and performing job or practice analyses.

Certification

<http://www.ascp.org/certification>

Certification is the process by which a nongovernmental agency or association grants recognition of competency to an individual who has met certain predetermined qualifications, as specified by that agency or association. Certification affirms that an individual has demonstrated that he or she possesses the knowledge and skills to perform essential tasks in the medical laboratory. The ASCP Board of Certification certifies those individuals who meet academic and clinical prerequisites and who achieve acceptable performance levels on examinations.

In 2004, the ASCP Board of Certification implemented the **Certification Maintenance Program (CMP)**, which mandates participation every 3 years for newly certified individuals in the US. The goal of this program is to demonstrate to the public that laboratory professionals are performing the appropriate and relevant activities to keep current in their practice. Please follow the steps outlined on the website to apply for CMP and retain your certification. (<http://www.ascp.org/CMP>)

United States Certification

<http://www.ascp.org/certification>

To apply for a Certification Examination follow these step-by-step instructions:

- 1 Identify the examination you are applying for and determine your eligibility.
- 2 Gather your required education and experience documentation.
- 3 Apply for the examination. We offer 2 options:
 - a. Apply online and pay by credit card.
 - b. Or download an application, pay by credit card, check or money order and mail to:

ASCP Board of Certification
3335 Eagle Way
Chicago, IL 60678-1033
- 4 Schedule your examination at a Pearson Professional Center. Visit the Pearson site (<http://www.pearsonvue.com/ascp>) to identify a location and time that is convenient for you to take your ASCP examination.

International Certification

<http://www.ascp.org/certification/International>

ASCP offers its gold standard credentials in the form of international certification (ASCPⁱ) to eligible individuals. The ASCPⁱ credential certifies professional competency among new and practicing laboratory personnel in an effort to contribute globally to the highest standards of patient safety. Graduates of medical laboratory science programs outside the United States are challenged with content that mirrors the standards of excellence established by the US ASCP exams. The ASCPⁱ credential carries the weight of 80 years of expertise in clinical laboratory professional certification. Please visit the website to view the following:

- 1 Website information translated into a specific language.
- 2 Current listing of international certifications.
- 3 Eligibility guidelines.
- 4 Step-by-step instructions to apply for international certification.

State Licensure

<http://www.ascp.org/licensure>

State Licensure is the process by which a state grants a license to an individual to practice their profession in the specified state. The individual must meet the state's licensing requirements, which may include examination and/or experience. It is important to identify the state and examination to determine your eligibility and view the steps for licensure and/or certification. For a list of states that require licensure, please go to the website. (<http://www.ascp.org/statelicensureagencies>)

The ASCP Board of Certification (BOC) examinations have been approved for licensure purposes by the states of California and New York. The BOC examinations also meet the requirements for all other states that require licensure.

Qualification

<http://www.ascp.org/qualification>

A qualification from the Board of Certification recognizes the competence of individuals in specific technical areas. Qualifications are available in laboratory informatics, immunohistochemistry and flow cytometry. To receive this credential, candidates must meet the eligibility requirements and successfully complete an examination (QCYM, QIHC) or a work sample project (QLI). Candidates who complete the Qualification process will receive a Certificate of Qualification, which is valid for 5 years. The Qualification may be revalidated every 5 years upon receipt of completed application and fee. (Documentation of acceptable continuing education may be requested.)

Preparing for and Taking the BOC Certification Examination

Begin early to prepare for the Certification Examination. Because of the broad range of knowledge and skills tested by the examination, even applicants with college education and those completing formal laboratory education training programs will find that review is necessary, although the exact amount will vary from applicant to applicant. Generally, last-minute cramming is the least effective method for preparing for the examination. The earlier you begin, the more time you will have to prepare; and the more you prepare, the better your chance of successfully passing the examination and scoring well.

Study for the Test

Plan a course of study that allows more time for your weaker areas. Although it is important to study your areas of weakness, be sure to allow enough time to review all areas. It is better to spend a short time studying every day than to spend several hours every week or 2. Setting aside a regular time and a special place to study will help ensure studying becomes a part of your daily routine.

Study Resources

<http://www.ascp.org/studymaterials>

Competency Statements and Content Guidelines

<http://www.ascp.org/contentguidelines>

The Board of Certification has developed competency statements and content guidelines to delineate the content and tasks included in its tests. Current Content Guidelines for the Medical Laboratory Scientist (MLS) and Medical Laboratory Technician (MLT) examinations as well as other certification examinations offered by the ASCP BOC are available.

Study Guide

The questions in this study guide are in a format and style similar to the questions on the Board of Certification examinations. The questions are in a multiple choice format with 1 best answer. Work through each chapter and answer all the questions as presented. Next, review your answers against the answer key. Review the answer explanation for those questions, that you answered incorrectly. Lastly, each question is referenced if you require further explanation.

Textbooks

The references cited in this study guide (see pp 481-484) identify many useful textbooks. The most current reading lists for most of the examinations are available on the ASCP's website (<http://www.ascp.org/readinglists>). Textbooks tend to cover a broad range of knowledge in a given field. An added benefit is that textbooks frequently have questions at the end of the chapters that you can use to test yourself should you need further clarification on specific subject matter.

Online practice tests

<http://www.ascp-practice.com>

The online practice test is a subscription product. It includes 90-day online access to the practice tests, comprehensive diagnostic scores, and discussion boards. If you are an institutional purchaser that would like to pay by check or purchase order (minimum of 20 tests to use a check or purchase order), please download the order form from the website. Content-specific online practice tests can be purchased online.

Taking the Certification Examination

The ASCP Board of Certification (BOC) uses computer adaptive testing (CAT), which is criterion referenced. With CAT, provided you answer the question correctly, the next examination question has a slightly higher level of difficulty. The difficulty level of the questions presented to the examinee continues to increase until a question is answered incorrectly. At this point, a slightly easier question is presented. The importance of testing in an adaptive format is that each test is individually tailored to your ability level.

Each question in the examination pool is calibrated for difficulty and categorized into a subtest area, which corresponds to the content guideline for a particular examination. The weight (value) given to each question is determined by the level of difficulty. All examinations (with the exception of phlebotomy (PBT) and donor phlebotomy (DPT)) are scheduled for 2 hours and 30 minutes and have 100 questions. The PBT and DPT examinations are scheduled for 2 hours and have 80 questions. Your preliminary test results (pass/fail) will appear on the computer screen immediately upon completion of your examination. Detailed examination scores will be mailed within 10 business days after your examination, provided that the BOC has received all required application documents. Examination results cannot be released by telephone under any circumstances.

Your official detailed examination score report will indicate a “pass” or “fail” status and the specific scaled score on the total examination. A scaled score is statistically derived (in part) from the raw score (number of correctly answered questions) and the difficulty level of the questions. Because each examinee has taken an individualized examination, scaled scores are used so that all examinations may be compared on the same scale. The minimum passing score is 400. The highest attainable score is 999.

If you were unsuccessful in passing the examination, your scaled scores on each of the subtests will be indicated on the report as well. These subtest scores cannot be calculated to obtain your total score. These scores are provided as a means of demonstrating your areas of strengths and weaknesses in comparison to the minimum pass score.