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# WINTROBE

# 临床血液病学

## WINTROBE'S

## CLINICAL HEMATOLOGY

## 11TH EDITION

(第11版)

第1卷

JOHN P. GREER

JOHN FOERSTER

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山东科学技术出版社 [www.lkj.com.cn](http://www.lkj.com.cn)



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LIPPINCOTT WILLIAMS & WILKINS



图书在版编目 (CIP) 数据

WINTROBE 临床血液病学 / (美) 格里尔 (Greer, J. P.) 等编.  
影印本. — 济南: 山东科学技术出版社, 2004. 5  
ISBN 7-5331-3708-6

I. W... II. 格... III. 血液病—诊疗—英文 IV. R55

中国版本图书馆 CIP 数据核字 (2004) 第 027508 号

*Wintrobe's Clinical Hematology*, 11/e by John P. Greer, M. D.,  
et. al; First published by Lippincott Williams & Wilkins, Inc.  
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图字: 15-2004-024

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出版者: 山东科学技术出版社

地址: 济南市玉函路 16 号

邮编: 250002 电话: (0531) 2065109

网址: [www.lkj.com.cn](http://www.lkj.com.cn)

电子邮件: [sdkj@jn-public.sd.cninfo.net](mailto:sdkj@jn-public.sd.cninfo.net)

发行者: 山东科学技术出版社

地址: 济南市玉函路 16 号

邮编: 250002 电话: (0531) 2020432

印刷者: 莱芜市圣龙印务书刊有限责任公司

地址: 莱芜市凤城西大街 149 号

邮编: 271100 电话: (0634) 6113596

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开本: 889mm×1194mm 1/16

印张: 176.5

字数: 6500 千

版次: 2004 年 5 月第 1 版第 1 次印刷

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ISBN 7-5331-3708-6

R · 1104

定价 (共 2 卷): 480.00 元

# WINTROBE'S CLINICAL HEMATOLOGY

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*ELEVENTH EDITION*

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VOLUME 1

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LIPPINCOTT WILLIAMS & WILKINS

A Wolters Kluwer Company

Philadelphia • Baltimore • New York • London  
Buenos Aires • Hong Kong • Sydney • Tokyo

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530 Walnut Street  
Philadelphia, PA 19106 USA  
LWW.com

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Printed in the USA  
First Edition, 1942  
Second Edition, 1946  
Third Edition, 1951  
Fourth Edition, 1956  
Fifth Edition, 1961  
Sixth Edition, 1967  
Seventh Edition, 1974  
Eighth Edition, 1981  
Ninth Edition, 1993  
Tenth Edition, 1999

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10987654321



*To Dr. Maxwell M. Wintrobe*



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# Preface

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Blut ist ein ganz besondrer Saft.

—Goethe, 1808

Maxwell M. Wintrobe often cited Goethe, "Blood is a very special kind of fluid," and the Eleventh Edition of *Wintrobe's Clinical Hematology* is a testimony to Dr. Wintrobe's legacy and commitment to the field of hematology. This edition extends the chronicle of progress to 60 years since the first edition of the book. The first six editions were the sole work of Dr. Wintrobe. When he retired from the editorship, Dr. Wintrobe recruited five former fellows to take over the task: Jack Athens, Tom Bithell, Dane Boggs, John Foerster, and Richard Lee. John Foerster remains an editor from the original group, and John Lukens joined the editorship in the eighth edition. John Greer, Frixos Paraskevas, and George Rodgers contributed to the ninth edition and became editors of the tenth edition. Bert Glader is a welcome addition to the present edition. Of the present group of editors, three (Foerster, Lukens, and Rodgers) worked directly with Dr. Wintrobe, whereas the other three (Glader, Greer, and Paraskevas) have been associated with Wintrobe-trained individuals.

Dr. Wintrobe recognized the work of predecessors and the foundation of clinical hematology in basic research. In *Blood, Pure and Eloquent. A Story of Discovery, of People and of Ideas* (1980), Dr. Wintrobe edited historical milestones in hematology and emphasized three lessons of history:

1. Research starts with an idea, which may take many directions before becoming a valid concept: "The path of progress is anything but straight. It is rough and rocky and often seems to wander endlessly and in all directions; it has many blind alleys and is strewn with the debris of false hopes, of failures, and discouragement. The course of research has been likened to the flow of a stream that ultimately becomes a rushing torrent."
2. A sense of skepticism is warranted in the practice of medicine: "What was held to be the truth yesterday may not be so regarded today, and tomorrow the story may again be somewhat different."
3. Perseverance is required to make progress: "... many look, but few see. It is the exceptional person who recognizes the unusual event or manifestation. Still fewer pursue it to a new understanding. Many may ask questions but few have the imagination, the energy, and the overpowering drive to persist in the search for an answer, especially when this must be done in the face of difficulties and failures and even in spite of scorn from their peers" (1).

Although his statements may seem pessimistic, Dr. Wintrobe optimistically recognized the importance of building on prior contributions and the relationship between clinical hematology and basic research. Hematology has many stories characterized initially by clinical observations that are now understood at a molecular genetic level (2,3). Sickle cell anemia, pernicious anemia, hemophilia, Burkitt lymphoma, acute promyelocytic leukemia,

and chronic myeloid leukemia are among the most interesting topics in medicine. The speed of basic research to the clinical bedside was remarkable in the twentieth century, and it promises to be even faster and more widely applied in the future.

The Eleventh Edition of *Wintrobe's Clinical Hematology* ushers in the twenty-first century with the same principles found in the prior editions and with the additional availability of the knowledge base through the Internet. The value of books has been questioned in this new era. This edition retains the historical perspective of *Wintrobe's Clinical Hematology*, with extensive references; brings together the body of information on hematology in a single source; and bridges topics to the Internet with Web links cited by many of the authors in their chapters. As with other multiauthored textbooks, there are occasional redundancies, which are important observations that allow a chapter to stand alone, and there are cross references to other chapters that indicate the interdependence of the topics.

We appreciate each author's contribution to the book. We have brought together clinician educators, pathologists, and physician scientists to review their topics of expertise. All of the chapters except Dr. Wintrobe's introduction to the approach to hematologic problems either have been revised or are new with an emphasis on molecular aspects of hematology. This edition recognizes the transition from a morphologic classification of hematopoietic neoplasms to the World Health Organization's classification that incorporates molecular genetics.

We appreciate the efforts of Jonathan Pine, Senior Executive Editor at Lippincott Williams & Wilkins; Alyson Forbes, Developmental Editor, and Tanya Lazar, Managing Editor at Lippincott; Mary Ann McLaughlin, Supervising Editor at Lippincott; and Lucinda Ewing and Jane McQueen, Production Editors at Silverchair Science + Communications. Their unique combination of persistence and kindness and their commitment to the principles of prior editions brought the project to completion. We hope the readers find the information they seek in the Eleventh Edition of *Wintrobe's Clinical Hematology*.

Below, each of us acknowledges people who have assisted him in this endeavor.

Debbie Saurette, my faithful secretary and colleague, has provided invaluable services in the completion of this edition. My wife, Gisela, and our children David, Steven, and Susan, physicians all, have been a constant source of support and inspiration. Special thanks go to my mentors, Dr. L. G. Israels, whose enthusiasm for hematology and his ability to combine effectively clinical service, teaching, and research, drew me to this specialty as a medical student; Dr. M. M. Wintrobe, who taught me in his own unique way and gave me the opportunity to contribute to several editions of this great textbook; Dr. B. Benacerraf, who nurtured my interests in immunology; and my colleagues at the Mayo Clinic and elsewhere who have contributed valuable chapters to this text.

—John Foerster

I wish to thank Jennifer Lu, Kari Costa, Theresa McCann, and Annamarie Coelho for administrative help. I also wish to acknowledge the many outstanding authors I have had the privilege to work with in the preparation of this edition. Last, but most of all, I want to acknowledge the understanding and support of my wife, Lou Ann; my children, Laurie, Anders, and Eric; their families; and our friends.

—Bert Glader

I wish to thank Billi Bean, my assistant and colleague; Patti Lee at the Eskin Library of the Vanderbilt University School of Medicine; my wife, Gay; and our children, Lesley, Adam, and Scott; my mentors, including Robert Collins, John Flexner, Stanley Graber, Sanford Krantz, and John Lukens; Ellen Benneyworth and other nurses; and our patients.

—John P. Greer

My contribution to this edition could not have been made without the understanding and unselfish support of my wife, Cauley Lukens. She and our children have weathered long hours and aborted vacations with encouragement and grace.

—John N. Lukens

I want to express my deeply felt gratitude and appreciation to my wife Maria for her support and unwavering encouragement

throughout the period of writing and especially when deadline worries became unmanageable. Maria, as a pathologist, has also been the testing ground for fine-tuning of complex concepts, helping me to lift them from the unfathomable depths of technicality and into the light of understanding. I want to thank Ms. Lynne Savage for her expert secretarial assistance and perseverance when "last copy" was proved to be just another in a never-ending line of typing. Our librarian, Donna Pacholok, helped me navigate the complex connections with the Internet. My sincere thanks to several colleagues for providing literature assistance or photography from their own data: A. A. Anderson, G. G. Gao, J. E. Gretz, L.A. Herzenberg, H. Kogelberg, J. Lambris, D. Y. Mason, C. Morales, K. H. Roux, P. Nickerson, H. Seguchi, S. Shaw, and H. Zimmerman.

—Frixos Paraskevas

I acknowledge Robyn LeMon and Sherry Hartline for typing assistance, my numerous contributors for their hard work and timely submissions, and my family and friends for their support.

—George M. Rodgers

## REFERENCES

1. Wintrobe MM. Blood, pure and eloquent. A story of discovery, of people, and of ideas. New York: McGraw-Hill, 1980:720.
2. Wintrobe MM. Hematology, the blossoming of a science: a story of inspiration and effort. Philadelphia: Lea & Febiger, 1985.
3. Lichtman MA, Spivak JL, Boxer LA, et al., eds. Hematology: landmark papers of the twentieth century. San Diego: Academic Press, 2000.



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**PART I**

# **Laboratory Hematology**

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