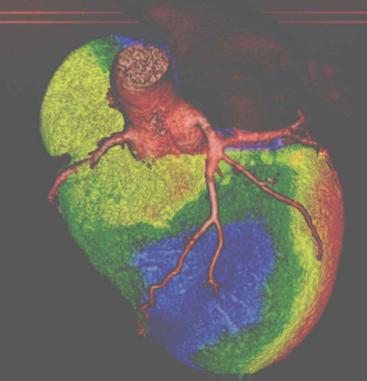


# HEART DISEASE

A TEXTBOOK OF CARDIOVASCULAR MEDICINE

EIGHTH EDITION

SAUNDERS



LIBBY BONOW MANN ZIPES

#### BRAUNWALD'S



## Heart Disease

#### A Textbook of Cardiovascular Medicine

#### **EIGHTH EDITION**

#### EDITED BY

#### Peter Libby, MD

Mallinckrodt Professor of Medicine Harvard Medical School Chief, Cardiovascular Division Brigham and Women's Hospital Boston, Massachusetts

#### Robert O. Bonow, MD

Max and Lilly Goldberg Distinguished Professor of Cardiology Northwestern University Feinberg School of Medicine Chief, Division of Cardiology Co-Director, Bluhm Cardiovascular Institute Northwestern Memorial Hospital Chicago, Illinois

#### Douglas L. Mann, MD

Don W. Chapman Chair
Professor of Medicine and Molecular Physiology and Biophysics
Chief, Section of Cardiology
Baylor College of Medicine
St. Luke's Episcopal Hospital
Texas Heart Institute
Houston, Texas

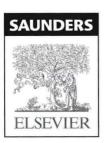
#### Douglas P. Zipes, MD

Distinguished Professor Professor Emeritus of Medicine, Pharmacology, and Toxicology Director Emeritus, Division of Cardiology and the Krannert Institute of Cardiology Indiana University School of Medicine Indianapolis, Indiana

#### FOUNDING EDITOR AND E-DITION EDITOR

#### Eugene Braunwald, MD, MD(HON), ScD(HON), FRCP

Distinguished Hersey Professor of Medicine
Harvard Medical School
Chairman, TIMI Study Group
Brigham and Women's Hospital
Boston, Massachusetts





1600 John F. Kennedy Boulevard Suite 1800 Philadelphia, PA 19103-2899

BRAUNWALD'S HEART DISEASE: A Textbook of Cardiovascular Medicine, Eighth Edition
Two-volume set
Single volume
978-1-4160-4107-8
978-1-4160-4106-1
Two-volume e-dition
978-1-4160-4105-4
Single volume e-dition
978-1-4160-4104-7
International edition
978-0-8089-2385-5
Online edition
978-1-4160-4103-0

Copyright © 2008, 2005, 2001, 1997, 1992, 1988, 1984, 1980 by Saunders, an imprint of Elsevier Inc.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Permissions may be sought directly from Elsevier's Health Sciences Rights Department in Philadelphia, PA, USA: phone: (+1) 215 239 3804, fax: (+1) 215 239 3805, e-mail: healthpermissions@elsevier.com. You may also complete your request online via the Elsevier homepage (http://www.elsevier.com) by selecting "Customer Support," then "Obtaining Permissions."

#### Notice

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our knowledge, changes in practice, treatment, and drug therapy may become necessary or appropriate. Readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of the practitioners, relying on their own experience and knowledge of the patient, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions. To the fullest extent of the law, neither the Publisher nor the Editors assume any liability for any injury and/or damage to persons or property arising out of or related to any use of the material contained in this book.

The Publisher

Library of Congress Cataloging-in-Publication Data

Braunwald's heart disease : a textbook of cardiovascular medicine / Peter Libby . . . [et al.].—8th ed.

p.; cm. Includes bibliographical references and index. ISBN 978-1-4160-4106-1

Heart—Diseases.
 Cardiology.
 Libby, Peter.
 Title: Heart disease.
 [DNLM: 1. Heart Diseases.
 Cardiovascular Diseases.
 WG 210 B825 2008]

RC681.H36 2008 616.1'2—dc22

2007009890

Executive Publisher: Natasha Andjelkovic Developmental Editor: Anne Snyder Publishing Services Manager: Frank Polizzano Senior Project Manager: Robin E. Hayward Multimedia Producer: David Wisner Design Direction: Steve Stave

Printed in the United States of America.

Last digit is the print number: 9 8 7 6 5 4 3 2 1

Working together to grow libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

BOOK AID

Sabre Foundation

Beryl, Oliver, and Brigitte

Pat, Rob, and Sam

Laura, Stephanie, Jonathan, and Erica

Joan, Debra, Jeffrey, and David

## Contributors 💋

Stephan Achenbach, MD

Professor of Medicine, Department of Cardiology, University of Erlangen, Erlangen, Germany Computed Tomography of the Heart

Philip A. Ades, MD

Professor of Medicine, University of Vermont College of Medicine; Director, Cardiac Rehabilitation and Prevention, Fletcher-Allen Health Care, Burlington, Vermont

Exercise and Sports Cardiology

Elliott M. Antman, MD

Professor of Medicine, Harvard Medical School; Senior Investigator, TIMI Study Group, and Director, Samuel A. Levine Cardiac Unit, Brigham and Women's Hospital, Boston, Massachusetts

ST-Elevation Myocardial Infarction: Pathology, Pathophysiology, and Clinical Features; ST-Elevation Myocardial Infarction: Management

Donald S. Baim, MD

Chief Medical and Scientific Officer, Boston Scientific Corporation, Natick, Massachusetts Percutaneous Coronary and Valvular Intervention

Gary J. Balady, MD

Professor of Medicine, Boston University School of Medicine; Director, Preventive Cardiology, Boston Medical Center, Boston, Massachusetts Exercise and Sports Cardiology

Arthur J. Barsky, MD

Professor of Psychiatry, Harvard Medical School; Director of Psychiatric Research, Brigham and Women's Hospital, Boston, Massachusetts

Psychiatric and Behavioral Aspects of Cardiovascular Disease

Joshua A. Beckman, MD, MSc

Assistant Professor of Medicine, Harvard Medical School; Director, Cardiovascular Fellowship Program, Brigham and Women's Hospital, Boston, Massachusetts Diabetes Mellitus, the Metabolic Syndrome, and Atherosclerotic Vascular Disease

Michael A. Bettmann, MD

Professor of Radiology, Wake Forest University School of Medicine; Vice Chair, Department of Radiology, Wake Forest University Baptist Medical Center, Winston-Salem, North Carolina

The Chest Radiograph in Cardiovascular Disease

Robert O. Bonow, MD

Max and Lilly Goldberg Distinguished Professor of Cardiology, Northwestern University Feinberg School of Medicine; Chief, Division of Cardiology, and Co-Director, Bluhm Cardiovascular Institute, Northwestern Memorial Hospital, Chicago, Illinois Nuclear Cardiology; Cardiac Catheterization; Care of Patients with End-Stage Heart Disease; Valvular Heart Disease; Guidelines: Management of Valvular Heart Disease

Eugene Braunwald, MD, MD(Hon), ScD(Hon), FRCP

Distinguished Hersey Professor of Medicine, Harvard Medical School; Chairman, TIMI Study Group, Brigham and Women's Hospital, Boston, Massachusetts ST-Elevation Myocardial Infarction: Pathology, Pathophysiology, and Clinical Features; Unstable Angina and Non-ST Elevation Myocardial Infarction

Hugh Calkins, MD

Professor of Medicine, Johns Hopkins University School of Medicine; Director, Electrophysiology, Johns Hopkins Hospital, Baltimore, Maryland Hypotension and Syncope

Christopher P. Cannon, MD

Associate Professor of Medicine, Harvard Medical School; TIMI Study Group, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts Approach to the Patient with Chest Pain; Unstable Angina and Non-ST Elevation Myocardial Infarction

John M. Canty, Jr., MD

Albert and Elizabeth Rekate Professor of Medicine and Chief of Cardiovascular Medicine, University at Buffalo School of Medicine and Biomedical Sciences, The State University of New York, Buffalo, New York Coronary Blood Flow and Myocardial Ischemia

John D. Carroll, MD

Professor of Medicine, Division of Cardiology, University of Colorado Health Sciences Center; Director, Cardiac and Vascular Center, and Director, Interventional Cardiology, University of Cardiology Hospital, Denver, Colorado

Clinical Assessment of Heart Failure

Agustin Castellanos, MD

Professor of Medicine, University of Miami Leonard M. Miller School of Medicine; Director, Clinical Electrophysiology, Jackson Memorial Hospital, Miami, Florida

Cardiac Arrest and Sudden Cardiac Death

Bernard R. Chaitman, MD

Professor of Medicine and Director of Cardiovascular Research, St. Louis University School of Medicine; Attending Physician, Division of Cardiology, St. Louis University Hospital, St. Louis, Missouri Exercise Stress Testing viii Danny Chu, MD

Assistant Professor, Baylor College of Medicine; Staff Physician, Michael E. DeBakey VA Medical Center, Houston, Texas

Traumatic Heart Disease

Heidi M. Connolly, MD

Professor of Medicine, Mayo Clinic College of Medicine; Consultant, Cardiovascular Diseases and Internal Medicine, Saint Marys Hospital, Rochester Methodist Hospital, Rochester, Minnesota Echocardiography

Rebecca B. Costello, PhD

Nutrition Scientist, Office of Dietary Supplements, National Institutes of Health, Bethesda, Maryland Complementary and Alternative Approaches to Management of Patients with Heart Disease

Mark A. Creager, MD

Professor of Medicine, Harvard Medical School; Simon C. Fireman Scholar in Cardiovascular Medicine and Director, Vascular Center, Brigham and Women's Hospital, Boston, Massachusetts Diabetes Mellitus, the Metabolic Syndrome, and Atherosclerotic Vascular Disease; Peripheral Arterial Diseases

Werner G. Daniel, MD

Professor of Medicine and Chair, Department of Cardiology, University of Erlangen, Erlangen, Germany Computed Tomography of the Heart

Charles J. Davidson, MD

Professor of Medicine, Northwestern University Feinberg School of Medicine; Chief, Cardiac Catheterization Laboratories, Northwestern Memorial Hospital, Chicago, Illinois

Cardiac Catheterization

Vasken Dilsizian, MD

Professor of Medicine and Radiology, University of Maryland School of Medicine; Director of Cardiovascular Nuclear Medicine and Cardiac Positron Emission Tomography, University of Maryland Medical Center, Baltimore, Maryland Nuclear Cardiology

Stefanie Dimmeler, PhD

Professor of Molecular Cardiology, University of Frankfurt Medical School, Frankfurt, Germany Emerging Therapies and Strategies in the Treatment of Heart Failure

Pamela S. Douglas, MD

Ursula Geller Professor of Research in Cardiovascular Diseases and Chief, Division of Cardiovascular Medicine, Duke University Medical Center, Durham, North Carolina Cardiovascular Disease in Women

Kim A. Eagle, MD

Albion Walter Hewlett Professor of Internal Medicine, University of Michigan Medical School; Chief, Clinical Cardiovascular Medicine, University of Michigan Health System, Ann Arbor, Michigan

Anesthesia and Noncardiac Surgery in Patients with Heart Disease Andrew C. Eisenhauer, MD

Assistant Professor of Medicine, Harvard Medical School; Director, Interventional Cardiovascular Medicine Service, Brigham and Women's Hospital, Boston, Massachusetts

Endovascular Treatment of Noncoronary Obstructive Vascular Disease

Linda L. Emanuel, MD, PhD

Professor of Medicine and Director of the Buehler Center on Aging, Health & Society, Northwestern University Feinberg School of Medicine, Chicago, Illinois Care of Patients with End-Stage Heart Disease

James C. Fang, MD

Associate Professor of Medicine, Case Western Reserve University School of Medicine; Associate Chief of Clinical Affairs and Medical Director of Heart Failure, Transplant, and Circulatory Assistance, University Hospital/Case Medical Center, Cleveland, Ohio The History and Physical Examination: An Evidence-Based Approach

Stacy D. Fisher, MD

Director, Cardiac Education for Internal Medicine Residency, Johns Hopkins/Sinai Hospital of Baltimore, Baltimore, Maryland Cardiovascular Abnormalities in HIV-Infected Individuals

Thomas Force, MD

Professor of Medicine, Jefferson Medical College, Thomas Jefferson University; Clinical Director, Center for Translational Medicine, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania The Cancer Patient and Cardiovascular Disease

Lee A. Fleisher, MD

Robert D. Dripps Professor of Anesthesiology and Critical Care and Professor of Medicine, University of Pennsylvania School of Medicine; Chair, Department of Anesthesiology and Critical Care, University of Pennsylvania Health System, Philadelphia, Pennsylvania

Anesthesia and Noncardiac Surgery in Patients with Heart Disease

Apoor S. Gami, MD

Assistant Professor of Medicine, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota

Sleep Apnea and Cardiovascular Disease

J. Michael Gaziano, MD, MPH

Associate Professor of Medicine, Harvard Medical School; Chief, Division of Aging, Brigham and Women's Hospital; Director, Massachusetts Veterans Epidemiology and Research Information Center (MAVERIC), Boston Veterans Affairs Healthcare System, Boston, Massachusetts

Global Burden of Cardiovascular Disease; Primary and Secondary Prevention of Coronary Heart Disease

Jacques Genest, MD

Professor of Medicine, McGill University Faculty of Medicine; Chief, Department of Cardiology, McGill University Health Center, Montreal, Quebec, Canada Lipoprotein Disorders and Cardiovascular Disease Bernard J. Gersh, MD, DPhil

Professor of Medicine, Mayo Clinic College of Medicine; Consultant in Cardiovascular Diseases and Internal Medicine and Associate Chair of Academic Affairs and Faculty Development, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota Chronic Coronary Artery Disease

Ary L. Goldberger, MD

Professor of Medicine, Harvard Medical School; Associate Director of Interdisciplinary Medicine and Biotechnology and Director of the Margaret and H. A. Rey Institute for Nonlinear Dynamics in Physiology and Medicine, Boston, Massachusetts Electrocardiography

Samuel Z. Goldhaber, MD

Professor of Medicine, Harvard Medical School; Senior Staff Cardiologist, Director of the Venous Thromboembolism Research Group, and Director of the Anticoagulation Service, Brigham and Women's Hospital, Boston, Massachusetts Pulmonary Embolism

Larry B. Goldstein, MD

Professor of Medicine, Division of Neurology, Duke University School of Medicine; Director, Center for Cerebrovascular Disease, Duke University Medical Center; Durham VA Medical Center, Durham, North Carolina

Prevention and Management of Stroke

Richard J. Gray, MD

Medical Director, Sutter Pacific Heart Centers, California Pacific Medical Center, San Francisco, California Medical Management of the Patient Undergoing Cardiac Surgery

William J. Groh, MD, MPH

Associate Professor of Medicine, Krannert Institute of Cardiology, Indiana University School of Medicine, Indianapolis, Indiana

Neurological Disorders and Cardiovascular Disease

Joshua M. Hare, MD

Louis Lemberg Professor of Medicine, Professor of Cellular and Molecular Pharmacology, Chief of Cardiology, and Director of the Interdisciplinary Stem Cell Institute, University of Miami Leonard M. Miller School of Medicine, Miami, Florida The Dilated, Restrictive, and Infiltrative Cardiomyopathies

David L. Hayes, MD

Professor of Medicine, Mayo Clinic College of Medicine; Chair, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota Cardiac Pacemakers and Cardioverter-Defibrillators

Otto M. Hess, MD

Professor of Cardiology, Swiss Cardiovascular Center, University Hospital, Bern, Switzerland Clinical Assessment of Heart Failure

L. David Hillis, MD

Daniel W. Foster Distinguished Chair in Internal Medicine and Vice-Chair of Medicine, University of Texas Southwestern Medical Center, Dallas, Texas Toxins and the Heart Mark A. Hlatky, MD

Professor of Health Research and Policy and Professor of Cardiovascular Medicine, Stanford University School of Medicine, Stanford, California Economics and Cardiovascular Disease

Gary S. Hoffman, MD

Professor of Medicine, Cleveland Clinic Lerner College of Medicine of Case Western Reserve University; Harold C. Schott Chair of Rheumatic and Immunologic Diseases, Cleveland Clinic, Cleveland, Ohio Rheumatic Diseases and the Cardiovascular System

David R. Holmes, Jr., MD

Professor of Medicine, Mayo Clinic College of Medicine; Consultant, St. Marys Hospital, Mayo Clinic, Rochester, Minnesota

Primary Percutaneous Coronary Intervention in the Management of Acute Myocardial Infarction

Eric M. Isselbacher, MD

Associate Professor of Medicine, Harvard Medical School; Associate Director of the Heart Center and Co-Director of the Thoracic Aortic Center, Massachusetts General Hospital, Boston, Massachusetts Diseases of the Aorta

Suraj Kapa, MD

Physician, Mayo Clinic College of Medicine, Rochester, Minnesota Cardiovascular Manifestations of Autonomic Disorders

Norman M. Kaplan, MD

Clinical Professor of Internal Medicine, University of Texas Southwestern Medical Center at Dallas; Attending Physician, Parkland Memorial Hospital, Dallas, Texas Systemic Hypertension: Mechanisms and Diagnosis; Systemic Hypertension: Therapy

Adolf W. Karchmer, MD

Professor of Medicine, Harvard Medical School; Chief, Division of Infectious Diseases, Beth Israel Deaconess Medical Center, Boston, Massachusetts Infective Endocarditis

Irwin Klein, MD

Professor of Medicine and Cell Biology, New York University School of Medicine; Associate Chair, Department of Medicine, North Shore University Hospital, Manhasset, New York Endocrine Disorders and Cardiovascular Disease

Barbara A. Konkle, MD

Professor of Medicine and of Pathology and Laboratory Medicine and Director of the Penn Comprehensive Hemophilia and Thrombosis Program, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

Hemostasis, Thrombosis, Fibrinolysis, and Cardiovascular Disease

Ronald M. Krauss, MD

Adjunct Professor, Department of Nutritional Sciences, University of California, Berkeley, Berkeley; Senior Scientist and Director, Atherosclerosis Research, Children's Hospital Oakland Research Institute, Oakland, California

Nutrition and Cardiovascular Disease

Contributors

#### x Mitchell W. Krucoff, MD

Professor of Medicine, Division of Cardiology, Duke University School of Medicine; Director, CU Devices Unit; Director, ECG Core Lab, Duke Clinical Research Institute, Duke University Medical Center, Durham, North Carolina

Complementary and Alternative Approaches to Management of Patients with Heart Disease

#### Harlan M. Krumholz, MD

Harold J. Hines, Jr. Professor of Medicine and Epidemiology and Public Health, Yale University School of Medicine; Director, Center for Outcomes Research and Evaluation, Yale-New Haven Hospital, New Haven, Connecticut

Clinical Decision-Making in Cardiology

Gary E. Lane, MD

Assistant Professor of Medicine, Mayo Clinic College of Medicine; Director, Cardiac Catheterization Laboratory, St. Luke's Hospital, Mayo Clinic, Jacksonville, Florida Primary Percutaneous Coronary Intervention in the Management of Acute Myocardial Infarction

Richard A. Lange, MD

E. Cowles Andrus Professor of Cardiology and Chief of Clinical Cardiology, Johns Hopkins Hospital, Baltimore, Maryland

Toxins and the Heart

Cheng-Han Lee, MD, PhD

Department of Pathology and Laboratory Medicine, University of British Columbia Faculty of Medicine; Vancouver General Hospital, Vancouver, British Columbia, Canada

Primary Tumors of the Heart

#### Thomas H. Lee, MD

Professor of Medicine, Harvard Medical School; Network President, Partners Healthcare System, Boston, Massachusetts

Measurement and Improvement of Quality of Cardiovascular Care; Guidelines: Electrocardiography; Guidelines: Exercise Stress Testing; Guidelines: Use of Echocardiography; Guidelines: Nuclear Cardiology; Guidelines: Appropriateness Guidelines: Cardiovascular Magnetic Resonance; Guidelines: Appropriateness Guidelines: Cardiac Computed Tomography; Guidelines: Coronary Arteriography; Guidelines: Management of Heart Failure; Guidelines: Ambulatory Electrocardiographic and Electrophysiologic Testing; Guidelines: Cardiac Pacemakers and Cardioverter-Defibrillators; Guidelines: Atrial Fibrillation; Guidelines: Treatment of Hypertension; Approach to the Patient with Chest Pain; Guidelines: Primary Percutaneous Coronary Intervention in Acute Myocardial Infarction; Guidelines: Unstable Angina and Non-ST Elevation Myocardial Infarction; Guidelines: Chronic Stable Angina; Guidelines: Percutaneous Coronary and Valvular Intervention; Guidelines: Management of Valvular Heart Disease; Guidelines: Infective Endocarditis; Guidelines: Pregnancy and Heart Disease; Guidelines: Reducing Cardiac Risk with Noncardiac Surgery

#### Martin M. LeWinter, MD

Professor of Medicine and Molecular Physiology and Biophysics, University of Vermont College of Medicine; Attending Cardiologist, Fletcher Allen Health Care, Burlington, Vermont Pericardial Diseases

Peter Libby, MD

Mallinckrodt Professor of Medicine, Harvard Medical School; Chief, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts The Vascular Biology of Atherosclerosis; Risk Factors for Atherothrombotic Disease; Lipoprotein Disorders and Cardiovascular Disease; Diabetes Mellitus, the Metabolic Syndrome, and Atherosclerotic Vascular Disease; Peripheral Arterial Diseases

Steven E. Lipshultz, MD

Professor and Chair, Department of Pediatrics, University of Miami, Leonard M. Miller School of Medicine, Miami, Florida

Cardiovascular Abnormalities in HIV-Infected Individuals

#### Peter P. Liu, MSc, MD

Heart & Stroke/Polo Chair and Professor of Medicine,
Toronto General Research Institute, University Health
Network; Heart & Stroke/Richard Lewar Centre of
Excellence in Cardiovascular Research, Toronto,
Ontario, Canada
Myocarditis

Brian F. Mandell, MD, PhD

Professor of Medicine, Cleveland Clinic Lerner College of Medicine of Case Western Reserve University; Vice Chairman of Medicine for Education and Staff, Rheumatic and Immunologic Disease, Center for Vasculitis Care and Research, Cleveland Clinic, Cleveland, Ohio

Rheumatic Diseases and the Cardiovascular System

Douglas L. Mann, MD

Don W. Chapman Chair and Professor of Medicine and Molecular Physiology and Biophysics; Chief, Section of Cardiology, Baylor College of Medicine; St. Luke's Episcopal Hospital, Texas Heart Institute, Houston, Texas

Pathophysiology of Heart Failure; Management of Heart Failure Patients with Reduced Ejection Fraction; Emerging Therapies and Strategies in the Treatment of Heart Failure

JoAnn E. Manson, MD, DrPH

Professor of Medicine and Elizabeth F. Brigham Professor of Women's Health, Harvard Medical School; Chief, Division of Preventive Medicine, Brigham and Women's Hospital, Boston, Massachusetts Primary and Secondary Prevention of Coronary Heart Disease

Daniel B. Mark, MD, MPH

Professor of Medicine, Division of Cardiology, Duke University School of Medicine; Director, Outcomes Research Group, Duke Clinical Research Institute, Durham, North Carolina Economics and Cardiovascular Disease Barry J. Maron, MD

Director, The Hypertrophic Cardiomyopathy Center, Minneapolis Heart Institute Foundation, Minneapolis, Minnesota; Adjunct Professor of Medicine, Tufts University School of Medicine, Tufts—New England Medical Center, Boston, Massachusetts Hypertrophic Cardiomyopathy

Kenneth L. Mattox, MD

Professor of Surgery, Baylor College of Medicine; Chief of Surgery and Chief of Staff, Ben Taub General Hospital, Houston, Texas

Traumatic Heart Disease

Patrick M. McCarthy, MD

Heller-Sacks Professor of Surgery, Northwestern
University Feinberg School of Medicine; Chief, Division
of Cardiothoracic Surgery, Co-Director, Bluhm
Cardiovascular Institute, Northwestern Memorial
Hospital, Chicago, Illinois
Surgical Management of Heart Failure

Peter A. McCullough, MD, MPH

Consultant Cardiologist and Chief, Division of Preventive Medicine, William Beaumont Hospital, Royal Oak, Michigan

Interface Between Renal Disease and Cardiovascular Illness

Vallerie V. McLaughlin, MD

Associate Professor of Medicine, University of Michigan Medical School; Director, Pulmonary Hypertension Program, University of Michigan Health System, Ann Arbor, Michigan Pulmonary Hypertension

Bruce McManus, MD, PhD

Professor of Pathology and Laboratory Medicine,
University of British Columbia Faculty of Medicine;
Director of the James Hogg iCapture Centre and
Scientific Director of the Heart Centre, St. Paul's
Hospital, Providence Health, Vancouver, British
Columbia, Canada
Primary Tumors of the Heart

John M. Miller, MD

Professor of Medicine, Krannert Institute of Cardiology, Indiana University School of Medicine, Indianapolis, Indiana

Diagnosis of Cardiac Arrhythmias; Therapy for Cardiac Arrhythmias

David M. Mirvis, MD

Professor of Preventive Medicine, University of Tennessee Health Science Center, Memphis, Tennessee Electrocardiography

David A. Morrow, MD

Assistant Professor of Medicine, Harvard Medical School; Brigham and Women's Hospital, Boston, Massachusetts Chronic Coronary Artery Disease; Guidelines: Chronic Stable Angina

Robert J. Myerburg, MD

Professor of Medicine, Division of Cardiology, University of Miami School of Medicine; Jackson Memorial Hospital, Miami, Florida Cardiac Arrest and Sudden Cardiac Death Elizabeth G. Nabel, MD

Director, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland Principles of Cardiovascular Molecular Biology and Genetics

Yoshifumi Naka, MD, PhD

Associate Professor of Surgery, Columbia University
College of Physicians and Surgeons; Director, Cardiac
Transplantation and Mechanical Circulatory Support
Program, New York–Presbyterian Hospital, Columbia
University Medical Center, New York, New York
Assisted Circulation in the Treatment of Heart Failure

Carlo Napolitano, MD, PhD

Senior Scientist, Molecular Cardiology Laboratories, IRCCS Fondazione Salvatore Maugeri, Pavia, Italy Genetics of Cardiac Arrhythmias

Richard W. Nesto, MD

Associate Professor of Medicine, Harvard Medical School, Boston; Chair, Department of Cardiovascular Medicine, Lahey Clinic Medical Center, Burlington, Massachusetts Diabetes and Heart Disease

L. Kristin Newby, MD, MHS

Associate Professor of Medicine, Division of Cardiovascular Medicine, Duke University School of Medicine; Duke University Medical Center, Durham, North Carolina

Cardiovascular Disease in Women

Patrick T. O'Gara, MD

Associate Professor of Medicine, Harvard Medical School; Director of Clinical Cardiology and Vice Chair of Medicine, Brigham and Women's Hospital, Boston, Massachusetts

The History and Physical Examination: An Evidence-Based Approach

Jae K. Oh, MD

Professor of Medicine, Mayo Clinic College of Medicine; Consultant of Cardiovascular Diseases, Co-Director of Echocardiography Laboratory, Director of Echocardiography Core Laboratory, Mayo Clinic, Rochester, Minnesota Echocardiography

Jeffrey E. Olgin, MD

Associate Professor in Residence, Chief of Cardiac Electrophysiology, and Melvin M. Schienman Chair in Electrophysiology, University of California, San Francisco, School of Medicine, San Francisco, California

Specific Arrhythmias: Diagnosis and Treatment

Lionel H. Opie, MD, DPhil

Professor of Medicine, Faculty of Health Sciences, The Hatter Institute for Cardiology Research, University of Cape Town, Cape Town, South Africa Mechanisms of Cardiac Contraction and Relaxation

Catherine M. Otto, MD

J. Ward Kennedy-Hamilton Endowed Professor of Cardiology, Director of Cardiology Fellowship Programs, and Associate Director of Echocardiography, University of Washington School of Medicine, Seattle, Washington Valvular Heart Disease Contributors

#### xii Dudley Pennell, MD



Professor of Cardiology, Imperial College London; Director, Cardiovascular Magnetic Resonance Unit, Royal Brompton Hospital, London, United Kingdom Cardiovascular Magnetic Resonance

Jeffrey J. Popma, MD

Associate Professor of Medicine, Harvard Medical School; Director, Interventional Cardiology, Brigham and Women's Hospital, Boston, Massachusetts Coronary Arteriography and Intravascular Imaging; Percutaneous Coronary and Valvular Intervention

#### Silvia G. Priori, MD, PhD

Associate Professor of Cardiology, University of Pavia; Director, Molecular Cardiology, IRCCS Fondazione Salvatore Maugeri, Pavia, Italy Genetics of Cardiac Arrhythmias

Reed E. Pyeritz, MD, PhD

Professor of Medicine and Genetics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

General Principles of Genetic Factors in Cardiovascular Disease; Genetic Factors in Myocardial Disease

B. Soma Raju, MD

Professor of Cardiology, Care Institute of Medical Sciences; Chair, Division of Cardiology, Care Hospital, Hyderabad, India Rheumatic Fever

Margaret M. Redfield, MD

Professor of Medicine, Mayo Clinic College of Medicine; Director, Mayo Heart Failure Clinic, Rochester, Minnesota

Heart Failure with Normal Ejection Fraction

Andrew N. Redington, MD

Professor of Pediatrics, University of Toronto Faculty of Medicine; Head of Cardiology, Hospital for Sick Children, Toronto, Ontario, Canada Congenital Heart Disease

#### Frederic S. Resnic, MD

Assistant Professor of Medicine, Harvard Medical School; Director, Cardiac Catheterization Laboratory, Brigham and Women's Hospital, Boston, Massachusetts Percutaneous Coronary and Valvular Intervention

#### Stuart Rich, MD

Professor of Medicine, University of Chicago Pritzker School of Medicine; Center for Pulmonary Hypertension, University of Chicago Medical Center, Chicago, Illinois Pulmonary Hypertension

#### Paul M. Ridker, MD, MPH

Eugene Braunwald Professor of Medicine, Harvard Medical School; Director, Center for Cardiovascular Disease Prevention, Brigham and Women's Hospital, Boston, Massachusetts

Risk Factors for Atherothrombotic Disease; Primary and Secondary Prevention of Coronary Heart Disease

#### Dan M. Roden, MD

Professor of Medicine and Pharmacology; Director, Oates Institute for Experimental Therapeutics; Assistant Vice-Chancellor for Personalized Medicine, Vanderbilt University School of Medicine, Nashville, Tennessee The Principles of Drug Therapy

#### Eric A. Rose, MD

Professor of Surgery, Columbia University College of Physicians and Surgeons; Director of Surgical Service and Surgeon-in-Chief, New York–Presbyterian Hospital, Columbia University Medical Center, New York, New York

Assisted Circulation in the Treatment of Heart Failure

#### Michael Rubart, MD

Assistant Professor of Pediatrics, Herman B. Wells Center for Pediatric Research, Indiana University School of Medicine, Indianapolis, Indiana Genesis of Cardiac Arrhythmias: Electrophysiological Considerations

#### Andrew I. Schafer, MD

E. Hugh Luckey Distinguished Professor of Medicine and Chair, Department of Medicine, Weill Medical College of Cornell University; Physician-in-Chief, New York-Presbyterian Hospital, Weill Cornell Medical Center, New York, New York

Hemostasis, Thrombosis, Fibrinolysis, and Cardiovascular Disease

#### Heinz-Peter Schultheiss, MD

Department of Cardiology and Pneumology, Charité— University Medicine Berlin, Campus Benjamin Franklin, Berlin, Germany Myocarditis

#### Janice B. Schwartz, MD

Clinical Professor of Medicine, University of California, San Francisco, School of Medicine; Director of Research, Jewish Home, San Francisco, California Cardiovascular Disease in the Elderly

#### Peter J. Schwartz, MD

Professor and Chair, Department of Cardiology, University of Pavia; Chief, Coronary Care Unit, IRCCS Fondazione Policlinico S. Matteo, Pavia, Italy Genetics of Cardiac Arrhythmias

#### Christine E. Seidman, MD

Thomas W. Smith Professor of Medicine and Genetics, Harvard Medical School; Director, Cardiovascular Genetics Center, Brigham and Women's Hospital, Boston, Massachusetts

General Principles of Genetic Factors in Cardiovascular Disease; Genetic Factors in Myocardial Disease

#### Jonathan G. Seidman, PhD

Henrietta B. and Frederick H. Bugher Professor of Cardiovascular Genetics, Department of Genetics, Harvard Medical School, Boston, Massachusetts Genetic Factors in Myocardial Disease

#### Dhun H. Sethna, MD

Associate Director of Cardiology, Almeda County Medical Center, Oakland, California

Medical Management of the Patient Undergoing Cardiac Surgery

Daniel Simon, MD

Herman K. Hellerstein Professor of Medicine, Case
Western Reserve University School of Medicine; Chief of
Cardiovascular Medicine, Director of the Heart and
Vascular Institute, University Hospitals of Cleveland/
Case Medical Center, Cleveland, Ohio
Hemostasis, Thrombosis, Fibrinolysis, and
Cardiovascular Disease

Jeffrey F. Smallhorn, MBBS

Professor of Pediatrics, University of Alberta Faculty of Medicine and Dentistry; Head, Section of Echocardiography Laboratory, Stollery Children's Hospital, Edmonton, Alberta, Canada Congenital Heart Disease

Virend K. Somers, MD, DPhil

Professor of Medicine, Division of Cardiovascular Diseases, Mayo Clinic College of Medicine; Consultant, Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota

Sleep Apnea and Cardiovascular Disease; Cardiovascular Manifestations of Autonomic Disorders

John R. Teerlink, MD

Associate Professor of Medicine, University of California, San Francisco, School of Medicine; Director of Heart Failure, Director of Clinical Echocardiography, San Francisco Veterans Affairs Medical Center, San Francisco, California Diagnosis and Management of Acute Heart Failure

Judith Therrien, MD

Assistant Professor of Medicine, McGill University Faculty of Medicine; Cardiologist, Sir Mortimer B. Davis Jewish General Hospital, Montreal, Quebec, Canada Congenital Heart Disease

Paul D. Thompson, MD

Professor of Medicine, University of Connecticut School of Medicine; Director of Cardiology, Henry Low Heart Center, Hartford Hospital, Hartford, Connecticut Exercise-Based, Comprehensive Cardiac Rehabilitation

Zoltan G. Turi, MD

Professor of Medicine, Robert Wood Johnson Medical School, University of Medicine and Dentistry of New Jersey; Director of the Structural Heart Disease Program, Director of the Cooper Vascular Center, Cooper University Hospital, Camden, New Jersey Rheumatic Fever

James E. Udelson, MD

Associate Professor of Medicine and Radiology, Tufts University School of Medicine; Associate Chief of Cardiology, Director of Nuclear Cardiology, and Co-Director of the Heart Failure Service, Tufts-New England Medical Center, Boston, Massachusetts Nuclear Cardiology; Guidelines: Nuclear Cardiology

Ronald G. Victor, MD

Clinical Professor of Medicine, University of Texas Southwestern Medical School; Chief of Hypertension, Norman and Audrey Kaplan Chair in Hypertension, University of Texas Southwestern Medical Center, Dallas, Texas

Systemic Hypertension: Mechanisms and Diagnosis

John H. K. Vogel, MD

Former Chair, Cardiology, Santa Barbara Cottage Hospital; Former President, American Heart Association, Santa Barbara County, Santa Barbara, California Complementary and Alternative Approaches to Management of Patients with Heart Disease

Matthew J. Wall, Jr., MD

Professor, Michael E. DeBakey Department of Surgery, Baylor College of Medicine; Deputy Chief of Surgery and Chief of Cardiothoracic Surgery, Ben Taub General Hospital, Houston, Texas Traumatic Heart Disease

Carole A. Warnes, MD

Professor of Medicine, Mayo Clinic College of Medicine; Consultant in Cardiovascular Diseases and Internal Medicine, Pediatric Cardiology; Director, Adult Congenital Heart Disease Clinic; Dean, Mayo School of Continuing Medical Education, Mayo Clinic, Rochester, Minnesota

Pregnancy and Heart Disease

Gary D. Webb, MD

Professor of Medicine, University of Pennsylvania School of Medicine; Director, Philadelphia Adult Congenital Heart Center, University of Pennsylvania Health System, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

Congenital Heart Disease

Christopher J. White, MD

Chairman, Department of Cardiology, Ochsner Clinic Foundation, New Orleans, Louisiana Endovascular Treatment of Noncoronary Obstructive Vascular Disease

Lawson R. Wulsin, MD

Professor of Psychiatry and Family Medicine, University of Cincinnati College of Medicine; Director, Family Medicine Psychiatry Training Program, University Hospital, Cincinnati, Ohio Psychiatric and Behavioral Aspects of Cardiovascular Disease

Clyde W. Yancy, MD

Medical Director, Baylor Heart and Vascular Institute; Chief, Cardiothoracic Transplantation, Baylor University Medical Center at Dallas, Dallas, Texas Heart Disease in Varied Populations

Andreas M. Zeiher, MD

Professor of Cardiology and Chair, Department of Medicine, University of Frankfurt, Frankfurt, Germany Emerging Therapies and Strategies in the Treatment of Heart Failure

Douglas P. Zipes, MD

Distinguished Professor; Professor Emeritus of Medicine, Pharmacology, and Toxicology; and Director Emeritus, Division of Cardiology and the Krannert Institute of Cardiology, Indiana University School of Medicine, Indianapolis, Indiana

Genesis of Cardiac Arrhythmias: Electrophysiological Considerations; Diagnosis of Cardiac Arrhythmias; Therapy for Cardiac Arrhythmias; Cardiac Pacemakers and Cardioverter-Defibrillators; Specific Arrhythmias: Diagnosis and Treatment; Hypotension and Syncope; Cardiovascular Disease in the Elderly; Neurological Disorders and Cardiovascular Disease

## Preface 👸

The currents of contemporary cardiovascular disease run swiftly, broadly, and deeply. The Eighth Edition of Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine, presented here, serves as the hub of a learning system designed to help physicians and students at all levels, from trainees to highly specialized practitioners, confront the challenge of staying abreast of this rapidly evolving field.

We intend *Heart Disease* to constitute the "core curriculum," an up-to-date, comprehensive, and authoritative ready reference for all practitioners. We strove to make this Eighth Edition an information source of practical clinical utility, grounded in the rapidly expanding evidence base that informs our practice. As in the previous editions of *Heart Disease*, we present the scientific underpinnings that govern cardiovascular pathophysiology and provide a rational basis for understanding therapeutics and management of cardiovascular diseases encountered in clinical practice.

Since the preparation of the last edition of *Heart Disease* much has changed, a reflection of the rapid pace of progress in our specialty. The results of manifold new clinical trials have become available in ways that in many cases profoundly affect our management strategies and practice. Novel therapeutics, both pharmacological and device-based, provide new management options. In the last few years we have not only witnessed striking advances in therapeutics but encountered challenges in the application of drug therapies and cardiovascular devices ranging from drug-eluting stents to implantable devices. The constant change and complexities in therapeutics and management strategies render obsolete textbooks published only a few years ago.

Other rapid shifts are under way in the prevalence of cardiovascular disease. In recent years cardiovascular specialists could congratulate themselves that the epidemic of cardiovascular disease had declined, based on the progress in our specialty. Current demographic trends suggest, however, that the scourge of cardiovascular disease, rather than waning, may indeed be increasing in the years to come. The aging of the population will increase the overall burden of cardiovascular disease in society, even as age-adjusted rates of cardiovascular mortality plateau or decline. We also need to confront a renewed upswing of cardiovascular risk linked to the worldwide epidemic of obesity, insulin resistance, and diabetes rooted in over-nutrition and declining physical activity. This gathering of cardiovascular risk increasingly threatens to extend the burden of cardiovascular disease to developing as well as Western societies. Thus, we cannot presume that the toll of cardiovascular disease will continue to ebb, highlighting the urgency of tools such as the Heart Disease Learning System that aim to help the clinician remain abreast of the constantly changing landscape of cardiovascular disease.

We have thoroughly revised this new edition to reflect these multiple changes. Thirty of eighty-nine chapters are entirely new. Thus, more than one third of the Eighth Edition represents completely new material. There are 43 new authors, comparing the Eighth to the Seventh Edition of Heart Disease. All of the chapters carried over from the Seventh Edition have undergone extensive revision to update them and heighten their utility. A full description of the changes introduced in this Eighth Edition exceeds the

scope of this Preface. Among the major changes, Douglas L. Mann, MD, has joined the editorial team and overseen a recasting of the entire section devoted to heart failure and chapters relating to myocardial disease. As heart failure represents the leading cause of admissions of patients covered by Medicare to hospitals, and comprises an everincreasing fraction of our patient population given the success of acute interventions, the fresh approach to this important topic should be welcome to readers. In particular, new chapters focus on acute heart failure and heart failure with preserved systolic function, two timely and challenging issues in clinical practice.

Given the growing potential of genetics and expanding knowledge of cardiovascular genetics, Christine E. Seidman, MD, and Jonathan G. Seidman, PhD, have joined the author list of Heart Disease and provide a thorough revision with Reed E. Pyeritz, MD, PhD, of the chapter on cardiovascular genetics and an entirely new chapter on the genetics of myocardial disease, complemented by online supplements. A new chapter on evidence-based physical examination has replaced the traditional recitation and cataloguing of signs and symptoms of cardiovascular disease. We are grateful to James C. Fang, MD, and Patrick T. O'Gara, MD, for taking on the assignment of preparing this entirely new approach to the foundation of clinical evaluation, the physical examination. Heidi M. Connolly, MD, and Jae K. Oh, MD, have prepared a new chapter on echocardiography that provides in-depth discussion of the current state-of-the-art applications of this versatile imaging modality for virtually all forms of cardiac disease. A new chapter on stroke by Larry B. Goldstein, MD, highlights what a cardiovascular practitioner needs to know about prevention and treatment of stroke and illustrates the extra-cardiac extensions of contemporary cardiology practice. A new chapter on sleep disorders likewise acknowledges the importance of an integrated multi-system approach to the management of our patients with cardiovascular disease. A new chapter on complementary and alternative approaches to cardiovascular disease reflects the growing interest in this area in patients and doctors alike. For similar reasons, we have added a new chapter on sports cardiology.

The Eighth Edition of *Heart Disease* contains 2275 illustrations, in full color where appropriate, as well as 600 tables. The CD-ROM packaged with the book contains all the figures and tables from the book, available to download to PowerPoint® to facilitate the use of these abundant materials for teaching. We hope thus to multiply the communication value of the content offered by the experts who contributed to *Heart Disease*.

As noted above, we conceive of *Heart Disease* as a family of learning tools intended to help the reader surmount the swift change in cardiovascular knowledge. To keep pace with the rapid evolution of our specialty between editions, we have approached *Heart Disease* as a living book. The *Heart Disease* website personally edited and updated by Eugene Braunwald, MD, on a weekly basis provides the readers of *Heart Disease* with a pulse of progress in cardiovascular medicine on an ongoing and contemporaneous basis. The many special features of the website, such as weekly updates, late-breaking clinical trials, hot-off-the-

xvi press topics, abstracts, and focused reviews, in addition to the searchability and functionality of the online medium, offer the interested reader the wealth and breadth of current information that no other online resource in cardiology can

We intend the growing family of *Heart Disease* companion volumes to address the breadth and depth of cardiovascular medicine. Several companions are currently in print, many published or revised in the last few years. Other companions in production or the planning stages include topics such as arrhythmology and lipidology, and mechanical circulatory support will emerge in the coming years. Noteworthy additions to the family of Heart Disease companions include a new volume on hypertension edited by Henry R. Black, MD, and William J. Elliott, MD, PhD; an entirely revised and updated version of Cardiovascular Therapeutics edited by Elliott M. Antman, MD; a comprehensive volume on vascular medicine edited by Mark A. Creager, MD, Victor J. Dzau, MD, and Joseph Loscalzo, MD, PhD; and a volume on cardiac nursing edited by Debra K. Moser, DNSc, RN, and Barbara Riegel, DNSc, RN. Readers of Heart Disease who wish to deepen their knowledge of specific areas can turn to the companion volumes as a convenient source, bearing the hallmark of clinical utility with a clinical evidence

foundation and scientific basis common to the Heart Disease mission. The companions are intended to complement the core curriculum of this *Heart Disease* volume. In response to the growing importance of imaging in cardiovascular practice, atlases of the emerging and established imaging technologies are currently in preparation under editorial direction of Robert O. Bonow, MD. Finally, a new edition of the Heart Disease Review and Assessment book is under way, to help trainees prepare for the certification examinations in the specialty of cardiovascular diseases.

These various key components of the Heart Disease Learning System, assembled in a personalized way to meet the needs of each practitioner, should help one navigate the rapidly flowing stream of cardiovascular knowledge. We hope that the readers will find Heart Disease and its associated learning tools useful in their quest to stay abreast of this ever-evolving field.

> PETER LIBBY ROBERT O. BONOW DOUGLAS L. MANN DOUGLAS P. ZIPES 2007

Adapted from the First Edition



Cardiovascular disease is the greatest scourge affecting the industrialized nations. As with previous scourges—bubonic plague, yellow fever, and smallpox—cardiovascular disease not only strikes down a significant fraction of the population without warning but also causes prolonged suffering and disability in an even larger number. In the United States alone, despite recent encouraging declines, cardiovascular disease is still responsible for almost 1 million fatalities each year and more than half of all deaths; almost 5 million persons afflicted with cardiovascular disease are hospitalized each year. The cost of these diseases in terms of human suffering and of material resources is almost incalculable. Fortunately, research focusing on the causes, diagnosis, treatment, and prevention of heart disease is moving ahead rapidly.

In order to provide a comprehensive, authoritative text in a field that has become as broad and deep as cardiovascular medicine, I chose to enlist the aid of a number of able colleagues. However, I hoped that my personal involvement in the writing of about half of the book would make it possible to minimize the fragmentation, gaps, inconsistencies, organizational difficulties, and impersonal tone that sometimes plague multiauthored texts.

Since the early part of the 20th century, clinical cardiology has had a particularly strong foundation in the basic sciences of physiology and pharmacology. More recently, the disciplines of molecular biology, genetics, developmental biology, biophysics, biochemistry, experimental pathology, and bioengineering have also begun to provide critically important information about cardiac function and malfunction. Although Heart Disease: A Textbook of Cardiovascular Medicine is primarily a clinical treatise and not a textbook of fundamental cardiovascular science, an effort has been made to explain, in some detail, the scientific bases of cardiovascular diseases.

> **EUGENE BRAUNWALD** 1980

## Look for these other titles in the Braunwald's Heart Disease family!

### ANTMAN Cardiovascular Therapeutics Third Edition

### BLACK and ELLIOTT Hypertension

CHIEN
Molecular Basis of Cardiovascular Disease
Second Edition

CREAGER, LOSCALZO, and DZAU

Vascular Medicine

LILLY Heart Disease Review and Assessment

> MANN Heart Failure

MANSON, BURING, RIDKER, and GAZIANO
Clinical Trials in Heart Disease
Second Edition

MOSER and RIEGEL Cardiac Nursing

ST. JOHN SUTTON and RUTHERFORD Clinical Cardiovascular Imaging

Part I	<b>Fundamentals</b>	of Cardiovascular
Disease	1	

#### CHAPTER 1

Global Burden of Cardiovascular

Disease 1

J. Michael Gaziano

#### CHAPTER 2

Heart Disease in Varied Populations 23 Clyde W. Yancy

#### **CHAPTER 3**

Economics and Cardiovascular Disease 35 Mark A. Hlatky • Daniel B. Mark

#### CHAPTER 4

Clinical Decision-Making in Cardiology 41 Harlan M. Krumholz

#### CHAPTER 5

Measurement and Improvement of Quality of Cardiovascular Care 49

Thomas H. Lee

#### CHAPTER 6

The Principles of Drug Therapy 57
Dan M. Roden

### Part II Molecular Biology and Genetics 67

#### CHAPTER 7

Principles of Cardiovascular Molecular Biology and Genetics 67

Elizabeth G. Nabel

#### CHAPTER 8

General Principles of Genetic Factors in Cardiovascular Disease 85

Reed E. Pyeritz • Christine E. Seidman

#### **CHAPTER 9**

Genetics of Cardiac Arrhythmias
Silvia G. Priori • Carlo Napolitano •
Peter J. Schwartz

#### **CHAPTER 10**

Genetic Factors in Myocardial Disease
Jonathan G. Seidman • Reed E. Pyeritz •
Christine E. Seidman

#### Part III Evaluation of the Patient 125

#### **CHAPTER 11**

The History and Physical Examination: An Evidence-Based Approach 125

James C. Fang • Patrick T. O'Gara

#### **CHAPTER 12**

Electrocardiography 149
David M. Mirvis • Ary L. Goldberger

GUIDELINES: Electrocardiography 190
Thomas H. Lee

#### **CHAPTER 13**

Exercise Stress Testing 195

Bernard R. Chaitman

GUIDELINES: Exercise Stress Testing 220
Thomas H. Lee

#### **CHAPTER 14**

Echocardiography 227 Heidi M. Connolly • Jae K. Oh

GUIDELINES: Use of Echocardiography 314 Thomas H. Lee

#### **CHAPTER 15**

The Chest Radiograph in Cardiovascular Disease 327

Michael A. Bettmann

#### **CHAPTER 16**

Nuclear Cardiology 345

James E. Udelson • Vasken Dilsizian • Robert O. Bonow

GUIDELINES: Nuclear Cardiology 389
Thomas H. Lee • James E. Udelson

#### CHAPTER 17

Cardiovascular Magnetic Resonance 393
Dudley Pennell

GUIDELINES: Appropriateness Guidelines: Cardiovascular Magnetic Resonance 412 Thomas H. Lee

#### **CHAPTER 18**



#### Computed Tomography of the Heart 415

Stephan Achenbach • Werner G. Daniel

GUIDELINES: Appropriateness Guidelines: Cardiac Computed Tomography 436 Thomas H. Lee

#### **CHAPTER 19**

#### Cardiac Catheterization 439

Charles J. Davidson • Robert O. Bonow

#### **CHAPTER 20**

#### Coronary Arteriography and Intravascular Imaging 465

Jeffrey J. Popma

GUIDELINES: Coronary Arteriography 501 Thomas H. Lee

#### Part IV Heart Failure 509

#### **CHAPTER 21**

Mechanisms of Cardiac Contraction and Relaxation 509

Lionel H. Opie

#### **CHAPTER 22**

Pathophysiology of Heart Failure 541

Douglas L. Mann

#### **CHAPTER 23**

Clinical Assessment of Heart Failure 561

Otto M. Hess • John D. Carroll

#### **CHAPTER 24**

Diagnosis and Management of Acute Heart

Failure 583

John R. Teerlink

#### CHAPTER 25

Management of Heart Failure Patients with Reduced Ejection Fraction 611

Douglas L. Mann

#### **CHAPTER 26**

Heart Failure with Normal Ejection

Fraction 641

Margaret M. Redfield

GUIDELINES: Management of Heart Failure 657 Thomas H. Lee

#### CHAPTER 27

Surgical Management of Heart Failure 665

Patrick M. McCarthy

#### **CHAPTER 28**

Assisted Circulation in the Treatment of Heart Failure 685

Yoshifumi Naka • Eric A. Rose

#### CHAPTER 29

Emerging Therapies and Strategies in the Treatment of Heart Failure 697

Stefanie Dimmeler • Douglas L. Mann • Andreas M. Zeiher

#### **CHAPTER 30**

Care of Patients with End-Stage Heart Disease 717

Linda L. Emanuel • Robert O. Bonow

### Part V Arrhythmias, Sudden Death, and Syncope 727

#### **CHAPTER 31**

Genesis of Cardiac Arrhythmias:

Electrophysiological Considerations 727

Michael Rubart • Douglas P. Zipes

#### **CHAPTER 32**

Diagnosis of Cardiac Arrhythmias 763

John M. Miller • Douglas P. Zipes

#### **CHAPTER 33**

Therapy for Cardiac Arrhythmias 779
John M. Miller • Douglas P. Zipes

GUIDELINES: Ambulatory Electrocardiographic and Electrophysiological Testing 823

Thomas H. Lee

#### **CHAPTER 34**

Cardiac Pacemakers and
Cardioverter-Defibrillators 831

David L. Hayes • Douglas P. Zipes

GUIDELINES: Cardiac Pacemakers and Cardioverter-Defibrillators 854

#### **CHAPTER 35**

Specific Arrhythmias: Diagnosis and

Treatment 863

Jeffrey E. Olgin • Douglas P. Zipes

GUIDELINES: Atrial Fibrillation 923
Thomas H. Lee

#### **CHAPTER 36**

Cardiac Arrest and Sudden Cardiac

Death 933

Robert J. Myerburg • Agustin Castellanos

#### **CHAPTER 37**

Hypotension and Syncope 975 Hugh Calkins • Douglas P. Zipes

#### Part VI Preventive Cardiology 985

#### **CHAPTER 38**

The Vascular Biology of Atherosclerosis 985
Peter Libby

#### **CHAPTER 39**

Risk Factors for Atherothrombotic Disease 1003 Paul M. Ridker • Peter Libby

#### **CHAPTER 40**

Systemic Hypertension: Mechanisms and Diagnosis 1027
Ronald G. Victor • Norman M. Kaplan

#### **CHAPTER 41**

Systemic Hypertension: Therapy 1049 Norman M. Kaplan

GUIDELINES: Treatment of Hypertension 1068 Thomas H. Lee

#### **CHAPTER 42**

Lipoprotein Disorders and Cardiovascular

Disease 1071

Jacques Genest • Peter Libby

#### **CHAPTER 43**

Diabetes Mellitus, the Metabolic Syndrome, and Atherosclerotic Vascular Disease 1093 Joshua A. Beckman • Peter Libby • Mark A. Creager

#### CHAPTER 44

Nutrition and Cardiovascular Disease 1107 Ronald M. Krauss

#### **CHAPTER 45**

Primary and Secondary Prevention of Coronary Heart Disease 1119 J. Michael Gaziano • JoAnn E. Manson •

#### **CHAPTER 46**

Paul M. Ridker

Exercise-Based, Comprehensive Cardiac Rehabilitation 1149 Paul D. Thompson

#### CHAPTER 47

Complementary and Alternative Approaches to Management of Patients with Heart Disease 1157

John H. K. Vogel • Rebecca B. Costello • Mitchell W. Krucoff

### Part VII Atherosclerotic Cardiovascular Disease 1167

#### CHAPTER 48

Coronary Blood Flow and Myocardial Ischemia 1167 John M. Canty, Jr.

#### **CHAPTER 49**

Approach to the Patient with Chest Pain 1195 Christopher P. Cannon • Thomas H. Lee

#### **CHAPTER 50**

ST-Elevation Myocardial Infarction: Pathology, Pathophysiology, and Clinical Features 1207
Elliott M. Antman • Eugene Braunwald

#### **CHAPTER 51**

ST-Elevation Myocardial Infarction: Management 1233 Elliott M. Antman

#### CHAPTER 52

Primary Percutaneous Coronary Intervention in the Management of Acute Myocardial Infarction 1301

Gary E. Lane • David R. Holmes, Jr.

GUIDELINES: Primary Percutaneous Coronary Intervention in Acute Myocardial Infarction 1314 Thomas H. Lee

#### CHAPTER 53

Unstable Angina and Non-ST Elevation Myocardial Infarction 1319

Christopher P. Cannon • Eugene Braunwald

GUIDELINES: Unstable Angina and Non-ST Elevation Myocardial Infarction 1344 Thomas H. Lee

#### CHAPTER 54

Chronic Coronary Artery Disease 1353
David A. Morrow • Bernard J. Gersh

GUIDELINES: Chronic Stable Angina 1405
Thomas H. Lee • David A. Morrow