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Fundamentals of Sleep TECHNOLOGY

SECOND EDITION

Cynthia **Mattice**

Rita **Brooks**

Teofilo **Lee-Chiong**

Wolters Kluwer Health | Lippincott Williams & Wilkins

American Association of Sleep Technologists
AAST

Fundamentals of
Sleep Technology

SECOND EDITION

Cynthia Mattice, MS, RPSGT, RST

Director of Sleep Operations
The Sleep Clinic
Oklahoma City, Oklahoma

Rita Brooks, MEd, R EEG/EP T, RPSGT, RST, CNIM

Director of Diagnostic Services and Clinical Informatics
Capital Health System
Trenton, New Jersey

Teofilo Lee-Chiong, MD

Professor of Medicine
Division of Sleep Medicine
National Jewish Health
Denver, Colorado
Professor of Medicine
University of Colorado Denver
Aurora, Colorado
Chief Medical Liaison
Philips Respironics
Murrysville, Pennsylvania

Wolters Kluwer | Lippincott Williams & Wilkins
Health

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Acquisitions Editor: Frances Destefano
Product Manager: Tom Gibbons
Vendor Manager: Bridgett Dougherty
Senior Manufacturing Manager: Benjamin Rivera
Marketing Manager: Alexander Burns
Design Coordinator: Steve Druding
Production Service: S4Carlisle

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PREFACE

The second edition of *Fundamentals of Sleep Technology* is designed as a comprehensive textbook for educators, students, and practitioners of sleep technology. This edition has been refined to focus on the practical and essential knowledge that educators need to impart to students entering the profession of sleep technology and to serve as a comprehensive reference for working sleep technologists.

Content has been updated to provide information relevant to recent changes in the profession that have emerged in the areas of technology and scoring. Updates include current information on the latest treatments for sleep disorders. The focus of this textbook is on development of knowledge related to testing processes and data analysis, basic anatomy and physiology, and normal sleep and sleep disorders in the adult and pediatric patient. This edition of the textbook includes information targeted toward assessment, care and education of the sleep disorders patient as well as methods for developing, tracking and maintaining treatment compliance. In addition, this edition includes a glossary, numerous algorithms outlining processes such as electrocardiographic arrhythmia recognition and the development of a patient education plan, and an accompanying website with slide sets developed to assist educators and enhance learning.

This textbook is written by and for sleep technologists with the collaboration of sleep medicine and behavioral sleep medicine specialists and includes contributions from international authorities in the field of sleep medicine who generously provided their expertise to this endeavor. The chapter on Preoperative Assessment and Perioperative Monitoring addresses a topic that is new to sleep technologists and was written by physician specialists at the invitation of the editors. Every effort has been made to provide a current, informative, and practical reference for educators, students, and practicing sleep technologists.

Even as the authors and editors are writing the various chapters of this book, ongoing changes in sleep-related definitions, regulations, scoring criteria, technology and practice guidelines continue to significantly transform the neuroscience of sleep as well as the clinical practice of sleep medicine. These changes will be posted on the textbook website. Future changes will be incorporated in slide presentations at the textbook website as well as in future editions of *Fundamentals of Sleep Technology*.

The editors extend their appreciation and thanks to all the authors of this textbook. In addition, we thank the many reviewers of the chapters as well as the volunteers who created the PowerPoint presentations for the website, namely Michael Garrison, Debbie Guerrero, Madelyn Hayden, Marcia Thompson and Rochelle Zozula. We also thank Christopher Waring, AAST Coordinator, Tom Gibbons, Product Manager at Lippincott Williams & Wilkins, and the Board of Directors of the American Association of Sleep Technologists for their untiring assistance and counsel throughout this process.

Finally, this textbook would not have been possible without the support of the following individuals—it is to them that we dedicate this second edition of *Fundamentals of Sleep Technology*:

Ed Mattice and Keely Mattice
Richard Brooks
Dolores Grace Zamudio and Zoe Lee-Chiong

CONTRIBUTORS

Debbie Akers, RPSGT, RRT
Program Manager
Department of Sleep Medicine
Eastern Virginia Medical School
Norfolk, Virginia

M. Cory Allnutt, BS, RPSGT
Polysomnography Supervisor
Olathe Medical Center Sleep Disorders Center
Olathe, Kansas

Edwina Ang, RPSGT
Staff Technologist
Department of Sleep Medicine
Eastern Virginia Medical School
Norfolk, Virginia

Jon W. Atkinson, BS, RPSGT
Consultant
Ohio Sleep Consulting and Recording Services, LLC
Sleep Health Management Resources, Inc.
Director, Sleep Center/Neurodiagnostics
Anderson Regional Medical Center
Meridian, Mississippi

Linda A. Bakos, RPSGT
Director, Ambulatory Services
Saint Mary's Health System
Waterbury, Connecticut

Matthew J. Balog, BS, RPSGT
RPSGT, Sleep Medicine Center
Ann & Robert H. Lurie Children's Hospital of Chicago
Chicago, Illinois

Philip M. Becker, MD
Clinical Professor of Psychiatry
University of Texas Southwestern Medical Center
President, Sleep Medicine Associates of Texas
Dallas, Texas

Eric A. Bell, PsyD, RPSGT, D,ABSM
Clinical Psychologist
Family Psychiatry of the Woodlands
The Woodlands, Texas

Richard B. Berry, MD
Professor of Medicine
Division of Pulmonary, Critical Care, and Sleep Medicine
University of Florida
Medical Director
University of Florida and Shands Sleep Disorders Center
Gainesville, Florida

Lee J. Brooks, MD
Clinical Professor of Pediatrics
University of Pennsylvania
Attending Physician, Division of Pediatric Pulmonology
Children's Hospital of Philadelphia
Philadelphia, Pennsylvania

W. David Brown, PhD
Instructor in Psychology
Sam Houston State University
Huntsville, Texas
Director, the Woodlands Sleep Evaluation Center
The Woodlands, Texas

Debra A. Campbell, RPSGT, R EEG T
Polysomnographic Technologist
Clinical Specialty Lab/Sleep Disorders
VA Eastern Kansas Health Care Services
Topeka, Kansas

Paul R. Carney, MD
Wilder Chair Professor
Professor of Pediatrics, Neurology, Neuroscience, and Biomedical Engineering
Chief, Division of Pediatric Neurology
Director, Comprehensive Epilepsy Program and Center of Excellence for Epilepsy Research
University of Florida College of Medicine
Gainesville, Florida

David A. Davis, MD
Medical Director
Siloam Springs Sleep Medicine Center
Siloam Springs, Arkansas
Johnson Regional Sleep Medicine Center
Clarksville, Arkansas

Jeremy Dozier, RPSGT, RST
Technical Director, Sleep Disorders Center
Houston Neurological Institute
Pasadena, Texas

William W. Eckhardt, BS, CRT, RPSGT, RST
Clinical Liaison
Genter Healthcare, Inc.
New London, New Hampshire

Todd Eiken, RPSGT
Chief Clinical Officer
Mays & Associates, Inc.
Brentwood, Tennessee

Lisa M. Endee, RRT, RPSGT, RST
Adjunct Faculty, Respiratory Care Program

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Stony Brook University
Stony Brook, New York
Clinical Coordinator, Sleep Apnea Center
Good Samaritan Hospital Medical Center
West Islip, New York

Lawrence Epstein, MD
Instructor in Medicine
Division of Sleep Medicine
Harvard Medical School
Boston, Massachusetts
Chief Medical Officer
Sleep HealthCenters
Brighton, Massachusetts

Carla A. Evans, BSc (Hons)
PhD Candidate, Faculty of Medicine
University of Sydney
Sydney, New South Wales, Australia
Scientific Officer, Department of Respiratory Medicine
Children's Hospital at Westmead
Westmead, New South Wales, Australia

Mario Fabiani, MD
Full Professor of Otolaryngology, Audiology and Phoniatrics
Università di Roma "Sapienza"
Chief, Sleep Study Unit
Institute of Otolaryngology
Policlinico Umberto I
Rome, Italy

Valerio Fabiani, MD
Postgraduate Fellow
Sense Organs Department
Università di Roma "Sapienza"
Rome, Italy

Mark D. Forester, BS, RPSGT
Director of CPAP Services
Sleep Medicine Associates of Texas
Dallas, Texas

Robin E. Foster, BA, BS, RPSGT
President
Sleep/Wake Health Care Solutions, Inc.
Cheyenne, Wyoming
Technical Director
Central Oregon Sleep Disorders Center
Bend, Oregon

Bhargavi Gali, MD
Anesthesiology
Mayo Clinic College of Medicine
Mayo Clinic
Rochester, Minnesota

Peter C. Gay, MD
Professor of Medicine
Pulmonary, Critical Care and Sleep Medicine
Mayo Clinic
Rochester, Minnesota

James D. Geyer, MD
Director of Sleep Medicine
Alabama Neurology and Sleep Medicine
Tuscaloosa, Alabama

Angela G. Giacomini, RPSGT, BA
San Francisco, California

Barys Greenberg, RPSGT
PSG Technologist Specialist
Center for Sleep Medicine at Capital Health
Hamilton, New Jersey

Nicholas S. Harris, RPSGT
Director of Clinical Operations, Sleep Laboratory
Sleepcare Diagnostics, Inc.
Cincinnati, Ohio

Monica M. Henderson, RN, RPSGT
Sleep Health Coordinator
Alabama Neurology and Sleep Medicine
Tuscaloosa, Alabama

Robert Hendrickson, RPSGT
Goddard, Kansas

Rebecca Hensley, RN, MN, Grad Dip Pead Sleep Science
Manager, Sleep Unit
Children's Hospital at Westmead
Sydney, New South Wales, Australia

Mary Kay Hobby, AS, AAS, RRT, RPSGT
President
Sleep Health Management Resources, Inc.
Stillman Valley, Illinois

Laura S. Hurmence, RPSGT, RRT, BA
Daytime Polysomnography Technologist
Olathe Medical Center Sleep Disorders Center
Olathe, Kansas

Nathan R. Hydes, PhD, RPSGT
Clinical Psychologist
United States Navy

Shahrokh Javaheri, MD
Emeritus Professor of Medicine
University of Cincinnati
Medical Director
Sleepcare Diagnostics, Inc.
Cincinnati, Ohio

Henry L. Johns, BS, RPSGT, CRT, CPFT
Supervisory Program Specialist, Clinical Specialty Labs
VA Eastern Kansas Health Care System
Topeka, Kansas

Joseph Kaplan, MD
Associate Professor of Medicine
Mayo Clinic College of Medicine
Rochester, Minnesota
Director, Mayo Sleep Disorders Center
Mayo Clinic
Jacksonville, Florida

Sharon A. Keenan, PhD, DABSM, RPSGT, REEGT
Director
The School of Sleep Medicine, Inc.
Palo Alto, California

Shawn Kimbro, RPSGT
Sleep Program Manager
The George Washington University Medical Faculty Associates
Washington, DC

Carole E. Kline, MS, CPNP
Senior Instructor in Pediatrics
University of Colorado
Denver, Colorado
Nurse Practitioner, Pulmonary Medicine
Children's Hospital Colorado
Aurora, Colorado

Iouri Kreinin, RPSGT
West Bloomfield, Michigan

Theresa A. Krupski, RPSGT, RRT
Lead Technologist
Sleep Medicine
National Jewish Health
Denver, Colorado

Su Jeong Lee, BS, RPSGT
Registered Polysomnographer, Sleep Lab
Children's Hospital Colorado
Aurora, Colorado
Registered Polysomnographer, Sleep Lab
National Jewish Health
Denver, Colorado

Eileen B. Leary, RPSGT
Special Projects Manager
Stanford Center for Sleep Sciences and Medicine
Stanford University
Palo Alto, California

Laura A. Linley, RST, RPSGT, CRTT
Vice President of Clinical Operations
Advanced Sleep Health, LLC
Rockford, Illinois

Darius A. Loghmanee, MD
Assistant Professor of Pediatrics
Northwestern University Feinberg School of Medicine
Attending Physician, Sleep Medicine Center
Ann & Robert H. Lurie Children's Hospital of Chicago
Chicago, Illinois

Elise Maher, BS, ALM, RPSGT
National Technical Director
Sleep HealthCenters
Wilmington, Massachusetts

Raman K. Malhotra, MD
Assistant Professor of Neurology and Psychiatry
Co-director, SLUC are Sleep Disorders Center
Saint Louis University School of Medicine
St. Louis, Missouri

Cynthia Mattice, MS, RPSGT, RST
Director of Sleep Operations
The Sleep Clinic
Oklahoma City, Oklahoma

Lisa J. Meltzer, PhD, CBSM
Assistant Professor of Pediatrics
National Jewish Health
Denver, Colorado

Sylvan S. Mintz, DDS
Bethesda, Maryland

David Moore, RPSGT
Chief Sleep Technologist
University of Alabama at Birmingham Hospital
Birmingham, Alabama

Jennifer Parr-Christmas, RPSGT
Chief Sleep Technologist,
Sleep Medicine Department
DCH Health System
Northport, Alabama

Regina Patrick, BA, RPSGT
Sleep Technologist
Wolverine Sleep Center
Tecumseh, Michigan

Christopher A. Potter, RPSGT, CRT
Lead Sleep Technologist
Sleep Disorder Center
Mayo Clinic
Jacksonville, Florida

Susan Purdy, RPSGT, RST
Research Coordinator
Sleep Disorders Center
Shands University of Florida
Gainesville, Florida

Andrea Rea
Specialist Register
Post-Graduate School of Audiology and Phoniatrics
Università di Roma "Sapienza"
Specialist Register

Sleep Respiratory Study Center
Rome, Italy

Christopher A. Richard, PhD, RPSGT
Polysomnographer, Sleep Disorders Center
St. Joseph Hospital
Orange, California

Richard Rosenberg, MD
Director of Professional Education and Training
American Academy of Sleep Medicine
Darien, Illinois

Thomas Russell, RPSGT, RRT
Supervisor, Sleep Laboratory
Royal Jubilee Hospital
Victoria, British Columbia, Canada

Brian J. Schultz, RPSGT
Supervisor, Sleep Lab
Children's Hospital of Philadelphia
Philadelphia, Pennsylvania

Kristine Bresnehan Servidio, BBA, RCP, RPSGT
Education Coordinator, Sleep Lab and Pulmonary Lab
Complete Sleep Solutions
Murrieta, California

Katherine M. Sharkey, MD, PhD, FAASM
Assistant Professor of Medicine and Psychiatry and Human Behavior
Warren Alpert Medical School of Brown University
Physician
Rhode Island Hospital
Providence, Rhode Island

Stephen H. Sheldon, DO, FAAP
Professor of Pediatrics
Northwestern University Feinberg School of Medicine
Director, Sleep Medicine Center
Ann & Robert H. Lurie Children's Hospital of Chicago
Chicago, Illinois

Connstance Shivers-Smith, BA, RPSGT
Polysomnographic Specialist
Sleep Disorders Center
Saint Luke's Hospital
Kansas City, Missouri

Mark R. Smith, PhD, RPSGT
Fort Collins, Colorado

Timothy A. Statza, BA, CRT, RPSGT, RST
Sleep Center Supervisor
Children's Hospital of Wisconsin
Milwaukee, Wisconsin

Stephen Tarnoczy, BS, RRT/SDS, RPSGT
Program Director, Respiratory Care
Carrington College
Las Vegas, Nevada

S. Justin Thomas, MA, RPSGT
Doctoral Student, Department of Psychology
University of Alabama
Tuscaloosa, Alabama

Robert L. Tognoli, MA, RPSGT
Stanford Hospitals and Clinics
Redwood City, California

Melinda O. Trimble, RST, RPSGT, LRCP
Director of Sleep Medicine
RPI
Russellville, Arkansas

Kimberly A. Trotter, MA, RPSGT
Administrative Director
Sleep Disorders Center
University of California San Francisco
San Francisco, California

Matthew Uhles, MS, RPSGT
Operational Director
Clayton Sleep Institute
Saint Louis University
St. Louis, Missouri

Robert D. Vorona, MD, ABSM, ABMS
Associate Professor of Sleep Medicine
Eastern Virginia Medical School
Norfolk, Virginia

Frank R. Walther, RPSGT, RST, BSChE
Williamsport, Pennsylvania

J. Catesby Ware, PhD, ABSM
Professor and Chief of Sleep Medicine
Eastern Virginia Medical School
Norfolk, Virginia

Karen A. Waters, MBBS, FRACP, PhD
Conjoint Professor of Paediatrics
University of Sydney
Camperdown, New South Wales, Australia
Head, Sleep Medicine (Respiratory Support)
Sydney Children's Hospital Network
Westmead, New South Wales, Australia

Harry R. Whitmore, RPSGT, RST
Chief Sleep Research Technologist
Sleep, Metabolism and Health Center
University of Chicago
Chicago, Illinois

Chad Whittlef, BS, RPSGT
Lead Instructor
Polysomnographic Technology Program
Minneapolis Community and Technical College
Minneapolis, Minnesota

Robyn Woidtke, RN, BS, RPSGT
RVW Clinical Consulting

Sleep and Medical Device
Castro Valley, California

Cheryl Yvanauskas, RPSGT, RRT
Manager
Institute of Sleep Medicine
DuPage Medical Group
Naperville, Illinois

Rose Ann Zumstein, RPSGT
Administrator
Alaska Sleep Clinic, Inc.
Anchorage, Alaska

REVIEWERS

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Karen Y. Allen, CRT, RPSGT
Sleep Technologist
St. Vincent Physician Network Sleep Center
St. Vincent Healthcare
Billings, Montana

Allen Boone, AS, RPSGT, RST
Associate Clinical Director, Sleep Services Department
SleepMed, Inc.
Columbia, South Carolina

Lata R. Casturi, MA, RPSGT, RST
Adjunct Faculty in Polysomnography
Alvin Community College
Alvin, Texas
Senior Sleep Technologist
Pulmonary, Critical Care and Sleep Department
Baylor College of Medicine
Houston, Texas

Claudia Cleveland, RRT, RPSGT
Coordinator, Sleep Diagnostic Service
St. Louis Children's Hospital
St. Louis, Missouri

Michael E. Garrison, BS, RPSGT
Adjunct Professor of Health Care Professions and Wellness
Johnson County Community College
Overland Park, Kansas
Polysomnographer, Sleep Disorders Center
Olathe Health Systems
Olathe, Kansas

Joel R. Glass, RPSGT
Program Manager
Pacific Sleep Program
Portland, Oregon

Georgette Goodwill, RPSGT, R EEG T, RDCS, RVT
Program Director, PSGT Program
Department of Polysomnography
Alvin Community College
Alvin, Texas

Scott C. Gray, RPSGT
Chief Technologist
Central Ohio Sleep Medicine
Gahanna, Ohio

Debra A. Guerrero, MS
Program Director, Polysomnography
Moraine Valley Community College
Palos Hills, Illinois

Madeleine Hayden, MHS, RPSGT, RST
Clinical Coordinator
Polysomnography Department
Sanford-Brown College
Fenton, Missouri

Joanne Hebding, RPSGT
Manager
Tallahassee Memorial Sleep Center
Tallahassee Memorial Hospital
Tallahassee, Florida

Henry L. Johns, BS, RPSGT, CRT, CPFT
Supervisory Program Specialist, Clinical Specialty Labs
VA Eastern Kansas Health Care System
Topeka, Kansas

Cindy Kistner, BS, RST, RPSGT, R EEG T
Tampa General Hospital
Tampa, Florida

Ryan O. Lindo, RPSGT, RST
Chief Technical Officer
New York Sleep Institute
Nocturnal Sleep Diagnostics
New York, New York

Michael McLeland, MEd, RPSGT, RST
Department Chair, Polysomnography
Sanford-Brown College
Fenton, Missouri

Karen Monarchy-Rowe, BS, AAS, RPSGT
North Carolina Academy of Sleep Medicine, Past President
Raleigh, North Carolina

Robert W. Moulden, BS, RPSGT
Adjunct Faculty in Polysomnography
Alvin Community College
Alvin, Texas
Neurophysiology Team Leader
Texas Children's Hospital
Houston, Texas

Angela P. Neal, RPSGT, RST
Scoring Technologist
The Sleep Clinic
Edmond, Oklahoma

Shari Angel Newman, RPSGT, RST
Clinical Manager
Spartanburg Regional Sleep Services
Spartanburg, South Carolina

Auburne Overton, MHA, RPSGT
Chair, Polysomnographic Technology
Mercy College of Health Sciences
Des Moines, Iowa

Jennifer H. Pierce-Daube, RPSGT
Clinical Coordinator, Polysomnography Department
Alvin Community College
Alvin, Texas

Christine Robinson, BA, RRT, RPSGT
Program Coordinator, Health Science Department
Baker College
Flint, Michigan

Thomas Russell, RPSGT, RRT
Supervisor, Sleep Laboratory
Royal Jubilee Hospital
Victoria, British Columbia, Canada

Jessica Schmidt, RPSGT, MA
Adjunct Faculty and former Program Director
Continuing Education and Academic Development
Community College of Baltimore County
Area Operations Manager
Sleep Services of America
Baltimore, Maryland

Connstance Shivers-Smith, BA, RPSGT
Polysomnographic Specialist
Sleep Disorders Center
Saint Luke's Hospital
Kansas City, Missouri

Karen I. Smith, BA, RPSGT
Vice-President of Education and Training
Timely Sleep Testing, Inc.
Soquel, California

Richard Swanson, RPSGT
OEM Product Manager
Home Healthcare Solutions
Philips Healthcare
Pittsburgh, Pennsylvania

Stephen Tarnoczy, BS, RRT/SDS, RPSGT
Program Director, Respiratory Care
Carrington College
Las Vegas, Nevada

Marcia L. Thompson, RN, RPSGT/RST
Board of Directors
Kentucky State Sleep Society
Sleep Lab Manager/Marketing Director
Sleep Elite, LLC
Paul B. Hall Regional Medical Center
Paintsville, Kentucky

Kimberly A. Trotter, MA, RPSGT
Administrative Director
Sleep Disorders Center
University of California San Francisco
San Francisco, California

Robert N. Turner, MS, RPSGT, LPC
Clinical Supervisor
Sleep Disorders Center
Rose Medical Center
Denver, Colorado

David F. Wolfe, MSed, RRT-SDS, RST, RPSGT, AE-C
Adjunct Assistant Professor of Respiratory Therapy Education
SUNY Upstate Medical University
Education Coordinator, Educational Services
Crouse Hospital
Syracuse, New York

In addition, the editors gratefully acknowledge the specialty reviewers who gave their time, knowledge, and expertise.

Dennis R. Bailey, DDS
Clinical Instructor in Orofacial Pain and Sleep Medicine
UCLA School of Dentistry
Los Angeles, California

Lee J. Brooks, MD
Clinical Professor of Pediatrics
University of Pennsylvania
Attending Physician, Division of Pediatric Pulmonology
Children's Hospital of Philadelphia
Philadelphia, Pennsylvania

Rochelle Zozula, PhD, DABSM
Clinical Associate Professor of Neuroscience
Seton Hall University, School of Graduate Medical Education
South Orange, New Jersey
Coordinator, Behavioral Sleep Medicine
Center for Sleep Medicine
Capital Health
Hamilton, New Jersey

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Appendix

CHAPTER 1

Sleep Technology: Past, Present, and Future

JON W. ATKINSON

LEARNING OBJECTIVES

The purpose of this chapter is to provide the reader with

1. An overview of the key people involved in the development of sleep medicine and technology.
2. A list of some of the hallmark publications related to sleep medicine and technology.
3. A review of technologic advances in recording and treating sleep disorders.
4. A history of the sleep technology professional organizations (AAST and BRPT).
5. An overview of legislative and licensure status.
6. A review of the evolving role of the sleep technologist.

KEY TERMS

Analog (paper) polysomnography
Association of Polysomnographic Technologists (APT)
American Association of Sleep Technologists (AAST)
Continuous positive airway pressure (CPAP)
Digital polysomnography
Hallmark publications
Technologic advances

HISTORY

The seed of polysomnographic technology was sown during the late 1920s and 1930s in research studies in physiology and psychology/psychiatry. William Dement's chronicle of the history of sleep physiology and medicine provides an insight from the perspective of one of the pioneers of sleep medicine (1). Since the first recording of the EEG in humans by Hans Berger (2) in the late 1920s, the following five decades provided the substrate upon which the current level of sleep medicine and polysomnographic technology was built. Much of the information came out of efforts to determine the state of sleep in which dreaming was most likely to occur (3–6). It was not until the 1950s when papers by Eugene Aserinsky and Nathaniel Kleitman (7, 8) describing the electrographic characteristics of rapid eye movement (REM) sleep and the association of REM sleep and dream report, as well as the work by Dement and Kleitman (9) describing the cyclical variation of sleep depth in normal subjects, that the root system really began to be established.

One of the following events that shaped the evolution of sleep medicine and technology was the development of a standardized manual for terminology and scoring by Alan Rechtschaffen and Anthony Kales in 1968 (10). This hallmark publication, likely the most quoted and referenced source in sleep medicine, provided a nomenclature, technical methodology recommendations, and sleep scoring method needed to provide a common reference point for future development of the science. This reference has been replaced by a comprehensive guide for scoring sleep stages and related events published in 2007 by the American Academy of Sleep Medicine (AASM) (11). This manual also outlines technical specifications for performance of polysomnography. AASM sleep center accreditation standards require that accredited sleep facilities follow these standards (12).

Before the publication of the Rechtschaffen and Kales manual, sleep medicine and polysomnography were yet obscure. In the early to mid-1960s, the electrographic description of sleep onset REM periods was established, (13-15) interest in sleep problems from a clinical perspective developed in Europe (16), and the discovery of sleep apnea (17, 18) entrenched sleep as a clinical, medical entity. In 1974, the term polysomnography was coined by Jerome Holland at Stanford University following the routine employment of multiple physiologic parameters, adding respiratory and cardiac sensors to the routine EEG, EOG, and chin EMG sensors to sleep studies. The addition of these derivations was instituted following the arrival of Christian Guilleminault at Stanford, based on his experience with sleep apnea in Europe (1, 19).

The body of knowledge of sleep disorders and sleep medicine advanced, and several key resources were published, including the Peter Hauri and William C. Orr classic monograph, *The Sleep Disorders* (20), the Guilleminault-edited *Sleeping and Waking Disorders: Indications and Techniques* (21), the first edition of *Principles and Practice of Sleep Medicine*, edited by Meir Kryger, Thomas Roth, and William Dement (22), and the *Atlas of Clinical Polysomnography* (23) by Nic Butkov.

TECHNOLOGIC ADVANCES

The development of sleep science, sleep medicine, and sleep technology has been codependent on advances in both recording and treatment technology.

It is fascinating to read some of the early information on methodology for recording sleep studies. These recordings were performed on analog equipment, using paper and ink EEG machines with direct current (DC) capabilities and limited channel availability. Because of the limitations in the number of recording channels, montages had to be well devised to provide adequate information for proper diagnosis, often sacrificing a recording derivation for one that may be more important, based on the presentation of a particular patient. Recording devices with 8, 10, or 12 channels were commonplace; 16, 18, or 21 channels were a luxury. Sleep technologists had to possess a good understanding of amplifiers and filters as well as expected frequency ranges of the physiologic parameters recorded. Improper utilization of filters or sensitivity controls could make stage N3 sleep look like wakefulness or make normal breathing appear to be apnea ... and there was no return. Once on paper, it was there for good. Sleep technologists had to unclog polygraph pens, change broken galvanometers, fill ink wells, and carefully align and tape together two boxes of folded paper to ensure that a single overnight recording was properly acquired. It was extremely awkward to go back and review previous portions of the recording. Scoring was performed manually and data tabulation was done with pencil and paper, sometimes with the assistance of a calculator. It often took longer to generate the requisite sleep report statistics than to identify sleep stages and abnormal events. The recording technologist could hear the sound of sleep spindles, REM sleep, slow-wave sleep, arousals, cardiac dysrhythmias, and periodic limb movements. Each had its own distinct sound generated by the scratching of the pens on the moving paper chart. This was actually quite helpful, as it drew the attention of the attending technologist to a particular patient, when concentration may have been focused elsewhere.

The polygraphs were massive, veritable monoliths, with approximate dimensions of 5′ to 6′ height, 4′ width, and 2.5′ to 3′ depth, each weighing several hundred pounds (see Fig. 1-1). Storage and archival of recorded data was an enormous and expensive problem. The cost of the paper alone for four recordings was over $200 and required about 2.3 ft^3 of storage space for a minimum of 7 years (see Fig. 1-2). This is not to say that these behemoths were not wonderful, highly reliable workhorses. They seldom failed in such a way that a recording needed to be rescheduled. Fairly simple pen or galvanometer replacement, or occasional swapping of an amplifier board "on the fly," that is, while the recording was still being performed, put you back in business. There are times when many of "the old guard" may long for the days of analog

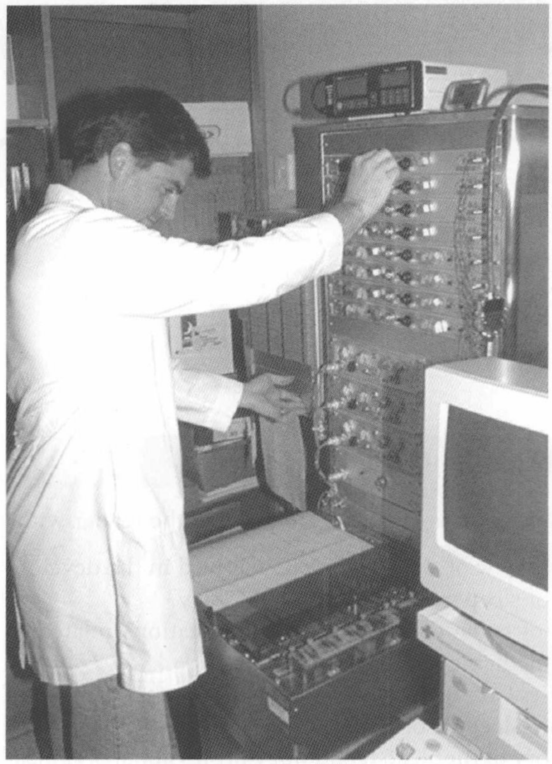

Figure 1-1 Grass Model 78 polygraph.

Figure 1-2 Technologist reviewing a single night recording.

recorders with stable amplifiers and filters, in place of nebulous software glitches and corruptions, or the whims and fancies of computer hardware, networks, and interfaces that can put one out of commission for days. Days when a couple more beds added did not mean several months of troubleshooting, as often seen today, even when using the same brand of equipment and software.

Many of the sensors for peripheral devices were constructed in the laboratory. Snore sensors, flow sensors, and mercury strain gauges were often home made, and chasing down spilled mercury balls with a syringe or pipette was a challenge. Burns and blisters from dropped or mishandled soldering irons were painful.

Ear oximeters were bulky and cumbersome, even painful, and performed poorly or not at all on patients with highly pigmented skin.

Huge technologic strides have been made in the past 25 to 30 years. In the late 1980s and early 1990s, computer technology had advanced sufficiently for the introduction of digital polysomnography. As with any new technology, digital recordings were not without problems. Hard drive capacities were insufficient to run the acquisition program and store the raw data. Thirty to fifty MB hard drives were the standard. Raw data had to be stored on optical media at a cost of about $100 per optical disc. Processor speeds were slow (<100 MHz per second) and frequent computer crashes because of data overload were a common occurrence. Waveform definition on the computer screen was mediocre at best. Automated sleep staging and scoring algorithms were very inaccurate. However, by the late 1990s, computer technology had advanced far enough to make digital polysomnography the rule rather than the exception. With current technology, massive several terabyte hard drives are available, processor speeds have increased to several GHz per second, archival media storage is very inexpensive (<$1 per patient), and several years of recording data can be stored in the space required for one or two nights of paper studies. Resolution of the monitors can produce paper-like, crisp appearing records (see Fig. 1-3). Although automated sleep staging is still not accurate, computer recognition of abnormal events has improved dramatically but still requires technologists' review and editing.

Despite all these advances, the technologist must still possess a good working understanding of the basics of polysomnographic technology, including amplifiers, filters, sensitivities, expected frequency ranges of physiologic parameters, and troubleshooting. Now, in addition, the technologist must understand the Nyquist theorem, sampling rates, signal resolution, hardware versus software filters, common referencing, basic networking, and data file management. Indeed, there are more potential recording and troubleshooting issues now than ever before. There are currently more than twenty manufacturers and suppliers of digital polysomnography systems.

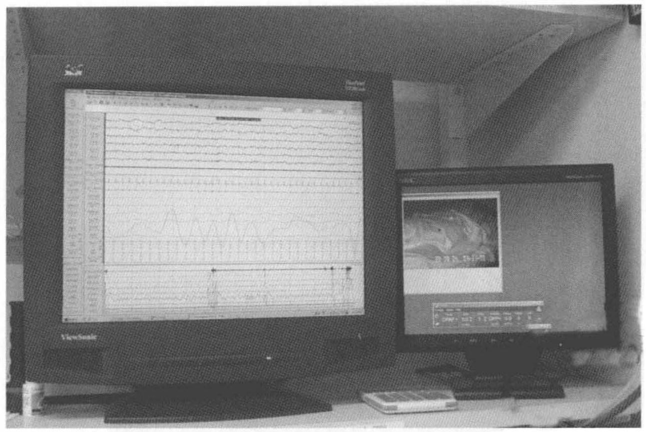

Figure 1-3 Contemporary work station with dual high-resolution monitors.

Today's recording technologist has high-quality snore sensors, pressure transducers, thermocouples and thermistors, respiratory effort sensors, and so on available from multiple commercial companies. There are also multiple vendors supplying a variety of preparation materials and supplies needed for polysomnographic recordings. Pulse oximetry devices placed on the finger have replaced the ear oximeter.

In the past, patients with obstructive sleep apnea that could not be ameliorated significantly by weight loss, by maintaining a side sleeping position, or by changing bed elevation, were often subjected to a tracheotomy. It was not uncommon, even in a modest-sized laboratory, to encounter one or two such cases per week. This provided the impetus for the massive growth in sleep medicine and technology, such as the demonstration of treating obstructive sleep apnea through nasal continuous positive airway pressure (CPAP) by Colin Sullivan and colleagues in 1981 (24).

An effective, nonsurgical treatment for a debilitating, potentially life-threatening disorder had been discovered. In the early years, CPAP masks were individually molded to the patient and adhesive was used to apply the mask. The flow generators were noisy and cumbersome, weighing close to 16 lb (7.25 kg). Early commercial CPAP devices became available in the mid-1980s (Fig. 1-4). Competition among manufacturers continues to lead to increasingly smaller and less noisy flow generators and more comfortable interfaces. Some of the newer flow generators are less than a tenth the size and weight of the early models and very quiet during operation. Advances in positive airway pressure device technology with the availability of flow generators that can provide pressure reduction on exhalation (Cflex and CFlex +, EPR), auto adjusting CPAP, and BiLevel pressure devices are in common usage. Other advances include servo controlled respiratory assist devices (AdaptSV, AutoSV, and AVAPS) produced by several manufacturers.

Figure 1-4 Respironics SleepEasy, circa 1985.

ASSOCIATION OF POLYSOMNOGRAPHIC TECHNOLOGISTS/AMERICAN ASSOCIATION OF SLEEP TECHNOLOGISTS

The Association of Polysomnographic Technologists (APT) was formed in 1978, spurred by the vision of Peter McGregor, the organization's first president and the first registered polysomnographic technologist. Peter died on January 23, 2010, and will be greatly missed by those who knew him.

The early years were those of a closely knit group of individuals gathering for the purpose of promoting the field, sharing ideas about a burgeoning technology, and administering the registration exam. The following individuals served as presidents of the APT: Peter McGregor, 1978 to 1983; Sharon Keenan, 1983 to 1991; Cameron Harris, 1991 to 1993; Todd Eiken, 1993 to 1996; Pamela Minkley, 1996 to 1998; Robert Turner, 1998 to 2000; Kelly Million, 2000 to 2002; Rose Ann Zumstein, 2002 to 2005; Cynthia Mattice, 2005 to 2007; Jon Atkinson, 2007 to 2009; Cindy Kistner, 2009 to 2011; and Melinda Trimble, 2011 to 2013.

Working through the years, the APT leadership has successfully advanced the profession, culminating in April 2003 when the profession of polysomnographic technology was recognized by the Commission on Accreditation of Allied Health Education Programs (CAAHEP) and the Committee on Accreditation for Polysomnographic Technologist Education (CoA PSG) was formed. The CoA PSG comprised three sponsoring organizations: the American Association of Sleep Technologists (AAST), the AASM, and the Board of Registered Polysomnographic Technologists (BRPT). The CoA PSG established standards and guidelines for the accreditation of educational programs in sleep technology. The CoA PSG recommended the first community college educational programs in polysomnographic technology to CAAHEP for accreditation in 2006.

To encompass the expansion of the sleep technologist's role in the growing field of sleep medicine, in 2007 the APT changed its name to the AAST. Within the last few years, the AAST has experienced a tremendous growth, leading to development of numerous educational programs and continuing education credits (CECs) for members of the association and those interested in sleep technology. The AAST offers comprehensive review courses to technicians preparing for certification exams, scientific sessions, courses and workshops at its annual meetings, position papers, and career opportunities listed on the association's Web site, and other valuable resources. The association's goal is to prepare individuals for a rewarding career in the field of sleep technology and to enhance their skills and knowledge as the profession continues to expand. The AAST continues to engage new initiatives that promote sleep technology as a separate and distinct profession and that direct the advancement of the profession by increasing recognition in many venues, including the medical community, educational institutions, and the public. New technologies are continually being developed that provide state-of-the-art methods that are used in the evaluation and diagnosis of sleep disorders. The future is certainly difficult to predict, but given the recent developments on multiple fronts, the field will provide sleep technologists with opportunities for continued career growth and development for years to come.

BRPT, THE RPSGT, AND OTHER CREDENTIALS

Initially a standing committee of the APT, the BRPT is now an independent corporation established in the year 2000. While a standing committee of the APT, chairpersons included Moshe Reitman, Cynthia Mattice, David Franklin, Jan McAninch, Robin Foster, Andrea Patterson, Gregory Landholt, Gary Hansen, Dan Herold, Bonnie Robertson, and Cameron Harris. The following people have served as President of the BRPT board of directors: Cameron Harris, Marietta Bellamy-Bibbs, Mark DiPhillipo, Bonnie Robertson, Becky Appenzeller, Janice East, and Cindy Altman.

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