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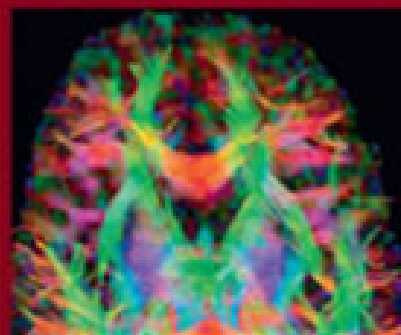
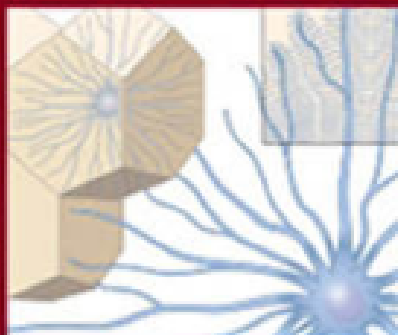
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DAVID L. FELTEN  
M. KERRY O'BANION  
MARY SUMMO MAIDA

# NETTER'S ATLAS OF NEUROSCIENCE

3<sup>RD</sup> EDITION

*F. Netter  
M.D.*



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# NETTER'S ATLAS OF NEUROSCIENCE

3rd Edition

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# ABOUT THE AUTHORS

**DAVID L. FELTEN, MD, PhD**, is currently Chairman of the Board and Chairman of the Scientific and Medical Advisory Board for Clerisy Corporation, a biotech firm located in Pittsford, New York. He was formerly Vice President for Research and Medical Director of the Research Institute at William Beaumont Health System in Royal Oak, Michigan and the Founding Associate Dean for Research at Oakland University William Beaumont School of Medicine. He previously served as Dean of the School of Graduate Medical Education at Seton Hall University in South Orange, New Jersey; the Founding Executive Director of the Susan Samuelli Center for Integrative Medicine and Professor of Anatomy and Neurobiology at the UC Irvine School of Medicine; the Founding Director of the Center for Neuroimmunology at Loma Linda School of Medicine; and the Kilian J. and Caroline F. Schmitt Professor and Chair of the Department of Neurobiology, and Director of the Markey Charitable Trust Institute for Neurobiology and Neurodegenerative Diseases and Aging at the University of Rochester School of Medicine in Rochester, New York. He received a bachelor of science degree from Massachusetts Institute of Technology and medical and doctoral degrees from the University of Pennsylvania School of Medicine. Dr. Felten carried out pioneering studies of autonomic innervation of lymphoid organs and neural-immune signaling that underlie the mechanistic foundations for psychoneuroimmunology and many aspects of integrative medicine.

Dr. Felten is the recipient of numerous honors and awards, including the prestigious John D. and Catherine T. MacArthur Foundation Prize Fellowship, two simultaneous NIH MERIT awards from the National Institutes of Mental Health and the National Institute on Aging, an Alfred P. Sloan Foundation Fellowship, an Andrew W. Mellon Foundation Fellowship, a Robert Wood Johnson Dean's Senior Teaching School Award, the Norman Cousins Award in Mind-Body Medicine, the Building Bridges of Integration Award from the Traditional Chinese Medicine World Foundation, and numerous teaching awards.

Dr. Felten co-authored the definitive scholarly text in the field of neural-immune interactions, *Psychoneuroimmunology* (Academic Press, 3rd edition, 2001) and was a founding co-editor of the major journal in the field, *Brain, Behavior and Immunity*, with Drs. Robert Ader and Nicholas Cohen of the University of Rochester School of Medicine. Dr. Felten is the author of more than 210 peer-reviewed journal articles and reviews, many on links between the nervous system and immune system. His work has been featured on Bill Moyer's PBS series and book, "Healing and the Mind," "20/20," and many other media venues. He served for over a decade on the National Board of Medical Examiners, including Chair of the Neurosciences Committee for the US Medical Licensure Examination.

**M. KERRY O'BANION, MD, PhD**, is Professor and Interim Chair of the Department of Neurobiology and Anatomy and Director of the Medical Scientist Training Program at the University of Rochester School of Medicine in Rochester, New York. He received a bachelor of science degree and medical and doctoral degrees from the University of Illinois at Champaign-Urbana. As a postdoctoral fellow at the University of Rochester, Dr. O'Banion cloned cyclooxygenase-2 and discovered its critical role in mediating inflammation.

Dr. O'Banion has worked for more than 20 years in the field of neuroinflammation, with particular interests in how cytokines mediate disease pathology. His current work, funded by NIH and NASA, focuses on possible beneficial effects of modulating inflammation in Alzheimer disease, the persistent effects elicited by brain irradiation, and the potential risk of neurodegenerative disease in individuals exposed to cosmic radiation.

Dr. O'Banion has authored nearly 120 peer-reviewed journal articles and reviews on these and other topics.

Since 1997, Dr. O'Banion has co-directed the Medical Neural Science course (now called Mind, Brain, and Behavior I) at the University of Rochester School of Medicine, a role he assumed from Dr. Felten. Dr. O'Banion also helped design and direct Mind, Brain, and Behavior II, a basic science course that accompanies medical clerkships in neurology and psychiatry for third-year medical students. He has been program director of the University of Rochester MSTP since 2000 and has served on multiple national committees related to medical and doctoral training.

**MARY E. MAIDA, PhD**, divides her time among research, teaching, mentoring future medical scientists, mentoring future entrepreneurs, and leading two companies focused on translational research. She is an adjunct faculty member of the Department of Neurobiology and Anatomy at the University of Rochester School of Medicine, as well as an annually invited Mentor for Entrepreneurship at the University of Rochester Simon School of Business. During her academic training she received bachelor of science degrees in microbiology/immunology and finance and operations management. She returned to academic medicine as a nontraditional student after having raised her children, commencing at the University of Miami School of Medicine and subsequently at the University of Rochester School of Medicine, where she completed a master of science degree in neurobiology and anatomy, and a doctoral degree in molecular neuroscience under the mentorship of Drs. M. Kerry O'Banion, John Olschowka, Richard Phipps, and Denise Figlewicz.

Because her return to medical and basic sciences training resumed after she raised her children, her interest turned from microbiology/immunology to the broader field of neuroimmunology, which seeks to pinpoint how the CNS and immune systems are intricately involved in a delicate and elaborate dance of connectivity, everyday cross-talk, more elaborate communication when pathogens or damage is involved, give-and-take vs. give-and-go between the two systems (and among other systems), and many more descriptions than words can adequately capture.

Dr. Maida has received several honors and awards across many disciplines, including Outstanding Alumni of Distinction Award from Excelsior College, New York State Hall of Distinction Award, Partners in Lifelong Learning Award, Greater Rochester Excellence in Achievement Technology Award, Winning Mentor for Mark Ain Business Competition, 43North Semifinalist distinction, and winning finalist in several open invitation awards.

A firm proponent of fostering and living the spirit-mind-body relationship that clearly underlies optimal neural-immune health, Dr. Maida is devoted to her family, her Catholic faith, and the privilege of being a Eucharistic Minister. She is honored to be a community volunteer and board member for agencies that support US military veterans and their families. She is a community volunteer and board of trustees member of agencies that care for medically fragile children and their families and has founded a scholarship fund at Excelsior College, named in honor of her parents. Dr. Maida is a fun-loving and enthusiastic competitor in tennis, running, golf, cross-fitness training, and equestrianism and a lover of the arts as a patron, musician, and active performer.

# DEDICATION

*In memory of Walle J.H. Nauta, MD, PhD, Institute Professor  
of Neuroscience at the Massachusetts Institute of Technology*

*A distinguished, brilliant, and pioneering neuroscientist  
An outstanding and inspirational teacher  
A kind, supportive, insightful, and gracious mentor  
An incredible role model and human being*

*and*

*To my wife, Mary E. Maida, PhD*

*A wonderful wife, partner, and friend  
My inspiration and motivation  
A superb researcher, teacher, scientific innovator, and CEO  
A woman who has it all—brains, beauty, kindness, and  
accomplishment*

**David L. Felten**

*In memory of Teresa Bellofatto, Nicholas Summo, and Robert  
Summo*

*Beloved family and friends who faced overwhelming health  
challenges with determination and a remarkably positive  
attitude.  
They showed the strength of the human spirit and the joy  
of human kindness in the face of daunting physiological  
odds.  
They taught us that it is possible to be healed in the absence  
of a cure.  
May their memory inspire us to continue to strive for a better  
understanding of the molecular, physiological, and sys-  
temic mechanisms that underlie health and disease.*

**David L. Felten  
Mary E. Maida**



*In memory of Fred Coyner and Nellie Rogers, sweet souls  
changed in old age, who turned my attention to brain dys-  
function and neuroscience research*

*and*

*To my parents, Terry O'Banion and Mary Rogers, who both  
served as educators, teaching me the values of service in the  
name of learning and inspiring me to pursue my love of  
nature despite the piles of fossils, the stench of chemistry  
experiments, and some small fires they may still not know  
about.*

*and*

*To my spouse, Dorothy Petrie, also an educator, for her love,  
her unconditional support through late nights and weekends  
of writing and looming deadlines, and her consistent reminder  
that the opportunity to do science is a gift to be shared  
with all*

**M. Kerry O'Banion**

*In honor of my mother, Mary D. Summo, MS, who endlessly  
gave her love, time, talent, intellect, and wise advice to the 6  
of us, her children, and her 10 grandchildren, and still does.  
Thank you, Mom.*

*and*

*In memory of my father, Dr. Anthony J. Summo, a true  
Renaissance man who embraced and promoted the reality of  
psychobiology, biopsychology, and PTSD well before they  
became accepted into mainstream medicine. And whose Ciba-  
Geigy Netter "green books" with the flip-over acetate pages  
sitting on our living room coffee table fascinated me and  
formed the basis of my love for science and medicine*

*and*

*To my husband, David L. Felten, MD, PhD, and my sons  
Michael and Matthew Maida, without whose love, encour-  
agement, and support I would never be the woman I am  
today. In the spirit and words of our ancestors' family motto:  
Avanti! Sempre Avanti!*

**Mary E. Maida**

# ACKNOWLEDGMENTS

For decades, Dr. Frank Netter's beautiful and informative artwork has provided the visual basis for understanding anatomy, physiology, and relationships of great importance in medicine. Generations of physicians and healthcare professionals have "learned from the master" and have carried Dr. Netter's legacy forward through their own knowledge and contributions to patient care. There is no way to compare Dr. Netter's artwork to anything else because it stands in a class of its own. For many decades, the *Netter Collection* volume on the nervous system has been a flagship for the medical profession and for students of neuroscience. It was a great honor to provide the framework, organization, and new information for the updated first and second editions, and now the third edition, of *Netter's Atlas of Neuroscience*. The opportunity to make a lasting contribution to the next generation of physicians and healthcare professionals is perhaps the greatest honor anyone could receive.

I also gratefully acknowledge Walle J.H. Nauta, MD, PhD, whose inspirational teaching of the nervous system at MIT contributed to the organizational framework for this atlas. Professor Nauta always emphasized the value of an overview; the plates in the beginning of Section II, Regional Neurosciences, on the conceptual organization of sensory, motor, and autonomic systems, especially reflect his approach. I am particularly honored to contribute to these updated editions of *Netter's Atlas of Neuroscience* because I first learned neurosciences as an undergraduate in Professor Nauta's laboratory at MIT through his personal mentorship, masterful insights, and explanations—using the first *Nervous System* "green book" volume by Dr. Frank Netter. It is my hope that continuing generations of students can benefit from the legacy of this wonderful teacher and great scientist.

I thank our outstanding artist and medical illustrator, James Perkins, MS, MFA, for his clear, creative, and beautiful contributions to this revised atlas. Jim is an excellent anatomist, with great insights for bringing otherwise complex systems and mechanisms into understandable illustrations.

We thank Gabrielle A. Yeane, MD, Assistant Professor of Pathology, Division of Neuropathology, Department of Pathology, University of Rochester School of Medicine, for her preparation of brain stem cross sections from neuropathological specimens. These sections allow us to directly compare the previous illustrations with actual cross-sectional preparations used in neuropathology evaluations.

I thank Sasha Kurumety, now a student at Northwestern University, for her evaluation and summary of axonal transport, contributing to the new figure in Chapter 1.

Special thanks go to the outstanding editors at Elsevier Clinical Solutions: Marybeth Thiel, Senior Content Development Specialist, Elyse O'Grady, Senior Content Strategist, and John Casey, Senior Project Manager. They helped guide the process of the third edition and gave us the latitude to introduce new components, such as the many new molecular plates (especially in Chapter 1), photomicrographs, spinal cord and brain stem histological cross sections, and new clinical correlations.

I also would like to acknowledge my friend, colleague, and co-author of this atlas, Kerry O'Banion. His insights, spanning from the molecular details to the systemic interactions of neural systems, are amazing. For close to 30 years we have had the privilege of working together, both in teaching and research arenas. As one of the premier experts on brain inflammation and a highly knowledgeable molecular biologist, his expertise in this third edition has been invaluable.

Continuing thanks also go to Ralph Jozefowicz, MD, the consummate neurology educator. It was a delight to work with him in the University of Rochester medical neurosciences course and to learn from him through his amazing insights into clinical

neurology, and his ability to make those insights come alive for the benefits of both his students and colleagues.

And finally, to my wife Mary (Mary E. Maida), I again thank you for your unwavering love and your support and encouragement to continue this challenging project, and for your patience with the long hours and seemingly endless clutter of papers and folders you tolerated along the way. I particularly appreciate your willingness to personally join this effort as a co-author of the third edition. Your expertise as a molecular neuroscientist and your outstanding ability to take complex plates and explanations and help to clarify and re-express them in understandable terms for the readers has been a valuable addition.

**David L. Felten**

First, I thank David Felten not only for the opportunity to contribute to this third edition but also for his long-standing support, encouragement, and friendship. Second, I thank Ralph Jozefowicz, MD, Professor of Neurology at the University of Rochester, who together with David Felten served as outstanding mentors for how to teach neuroscience. Finally, I am indebted to my professional colleagues and students, past and current, for the opportunity to learn new things as we pursue science together.

**M. Kerry O'Banion**

To this very day, I remember my fascination with the original Netter “green books” that sat prominently displayed on the coffee table in the living room of my childhood home. I would sit for hours turning each page, which added another colorful layer to the beauty and intricacy of the human body’s anatomy and physiology—and day after day trying to recall what I saw, let alone make sense of it all. These original tomes that contained the original illustrations of Dr. Frank Netter in part formed the basis of my interest in, and pursuit of, science and medicine. It is an honor to be invited to participate, five decades later, as a contributor to the third edition of *Netter’s Atlas of Neuroscience*.

I thank my parents, Dr. Anthony J. and Mary D. Summo, for having provided us with such an enriched environment at home and for encouraging and allowing us to pursue our dreams.

I thank the University of Rochester School of Medicine and Dentistry Graduate Program in Neuroscience for providing me the opportunity to pursue my dreams as a nontraditional student. I also extend my deepest gratitude to my mentors M. Kerry O'Banion, MD, PhD, John Olschowka, PhD, Richard Phipps, PhD, and Denise Figlewicz, PhD, whom I have the privilege to know as friends as well as research colleagues.

Finally, I express my deepest gratitude to my husband, David Felten, and to my sons Michael and Matthew Maida—my biggest cheerleaders in life—who help me achieve far more than I believe I am capable of achieving and who adeptly help to keep my immune system healthy with the daily dose of humor and laughter we share.

**Mary E. Maida**

# PREFACE

As in the first and second editions, *Netter's Atlas of Neuroscience*, 3rd edition, combines the richness and beauty of Dr. Frank Netter's illustrations with key information about the many regions and systems of the brain, spinal cord, and periphery. Jim Perkins and John Craig have contributed additional outstanding illustrations to complement the original Netter illustrations.

The first edition included cross-sectional illustrations through the spinal cord and brain stem, as well as coronal and axial (horizontal) sections. The second edition built on the first edition with several additional illustrations and extensive new imaging using computed tomography (CT), magnetic resonance imaging (MRI), both T1- and T2-weighted, positron emission tomography (PET) scanning, functional MRI (fMRI), and diffusion tensor imaging (DTI), which provides pseudocolor images of central axonal commissural, association, and projection pathways. Full-plate MRIs were included for direct side-by-side comparisons with Dr. John Craig's illustrations of the brain stem cross sections and axial and coronal sections. More than 200 "clinical boxes" were added to offer succinct clinical discussions of the functional importance of key topics. These clinical discussions were intended to assist the reader in bridging the anatomy and physiology depicted in each relevant plate to important related clinical issues.

This third edition has many new components. Chapter 1, in the Overview section, "Neurons and Their Properties," has been extensively revised and reorganized. Approximately 15 new plates on molecular and cellular topics such as astrocytes, microglia, oligodendrocytes, axonal transport, growth and trophic factors, nuclear transcription factors, neuronal stem cell biology, and others have been added. Almost 50 new plates have been added throughout the atlas. Many of these plates reflect Jim Perkins' outstanding ability to represent molecular and cellular concepts in lucid and beautiful form. We have added histological cross sections of the spinal cord and brain stem to match the previous illustrations. We also added brain stem sections illustrating the major vascular syndromes of the medulla, pons, and midbrain. Many new photomicrographs have been introduced to plates throughout the atlas to add clarity to the illustrations.

The third edition retains the organization of the first and second editions: (I) Overview, (II) Regional Neurosciences, and (III) Systemic Neurosciences. Further breaks in these sections into component chapters aides in ease of use. We have provided succinct figure legends to point out some of the major functional aspects of each illustration, particularly as they relate to problems that a clinician may encounter in the assessment of a patient with neurological symptoms. We believe that it is important for an atlas of the depth and clarity of *Netter's Atlas of Neuroscience* to let the illustrations provide the focal point for learning, not long and detailed written explanations that constitute a full textbook in itself. However, the figure legends, combined with the excellent illustrations and the clinical discussions, provide content for a thorough understanding of the basic components, organization, and functional aspects of the region or system under consideration.

*Netter's Atlas of Neuroscience* provides a comprehensive view of the entire nervous system, including the peripheral nerves and their target tissues, central nervous system, ventricular system, meninges, cerebral vascular system, developmental neuroscience, and neuroendocrine regulation. We have provided substantial but not exhaustive details and labels so that the reader can understand the basics of human neuroscience, including the nervous system information usually presented in medical neurosciences courses, the nervous system components of anatomy courses, and neural components of physiology courses in medical school.

We are confronted with an era of rapid changes in health-care and exploding knowledge in all fields of medicine, particularly with the continuing revolution in molecular biology. Medical school curricula are under enormous pressure to add more and more non-basic sciences components. It has become dangerously tempting to emphasize high-technology tests, readouts, and imaging as a substitute for the real foundations of medical practice—the history and the physical examination. Many medical schools strive to “decompress” the intensity of teaching and to incorporate more problem-based and small group teaching exercises (which we applaud), with a goal of hastening students into clinical experiences.

In the long run, much of the additional information crammed into the medical curriculum has come at the expense of the basic sciences, particularly anatomy, physiology, histology, and embryology. We believe that there is a fundamental core of knowledge that every physician must know. It is not sufficient for a medical student to learn only 3 of the 12 cranial nerves, their functional importance, and their clinical applications, as “representative examples,” in order to further reduce the length of basic sciences courses. Although medical students are always anxious to get into the clinics and see patients, they need a substantial fund of knowledge to be even marginally competent, particularly if they strive to apply evidence-based practice, instead of rote memory, to patient care.

## ORGANIZATION OF NETTER'S ATLAS OF NEUROSCIENCE

The Overview section of the atlas is a presentation of the basic components and organization of the nervous system, a “view from 30,000 feet”; this view is an essential foundation for understanding the details of regional and systemic neurosciences. The Overview includes chapters on neurons and their properties, an introduction to the forebrain, brain stem and cerebellum, spinal cord, meninges, ventricular system, cerebral vasculature, and developmental neuroscience.

The Regional Neurosciences section provides the structural components of the peripheral nervous system, the spinal cord, the brain stem and cerebellum, and the forebrain (diencephalon and telencephalon). We begin in the periphery and move from caudal to rostral. The peripheral nervous system section includes details about the somatic and autonomic innervation of peripheral nerves; we do not leave the learner at the boundary of CNS and PNS, and hope that they can find out about peripheral and autonomic nerves from a gross anatomy course. This detailed regional understanding

is necessary to diagnose and understand the consequences of a host of lesions whose localization depends on regional knowledge—this includes strokes, local effects of tumors, injuries, specific demyelinating lesions, inflammatory reactions, and many other localized problems. In this section many of the clinical correlations assist the reader in integrating a knowledge of the vascular supply with the consequences of infarcts (e.g., brain stem syndromes), which requires a detailed understanding of brain stem anatomy and relationships.

The Systemic Neurosciences section evaluates the sensory systems, motor systems (including cerebellum and basal ganglia, acknowledging that they also are involved in many other spheres of activity besides motor), autonomic-hypothalamic-limbic systems (including neuroendocrine), and higher cortical functions. We have organized each sensory system, when appropriate, with a sequential presentation of reflex channels, cerebellar channels, and lemniscal channels, reflecting Professor Nauta's conceptual organization of sensory systems. For the motor systems, we begin with lower motor neurons and then show the various systems of upper motor neurons followed by cerebellum and basal ganglia, whose major motor influences are ultimately exerted through regulation of upper motor neuronal systems. For the autonomic-hypothalamic-limbic system, we begin with the autonomic preganglionic and postganglionic organization and then show brain stem and hypothalamic regulation of autonomic outflow, and finally limbic and cortical regulation of the hypothalamus and autonomic outflow. The systemic neurosciences constitute the basis for carrying out and interpreting the neurological examination. We believe that it is necessary for a student of neuroscience to understand both regional organization and systemic organization. Without this dual understanding, clinical evaluation of a patient with a neurological problem would be incomplete.

In a discipline as complex as the neurosciences, the acquisition of a solid organization and understanding of the major regions and hierarchies of the nervous system is not just a “nice idea” or a luxury—it is essential. The fact that this approach has been stunningly successful for our students in a course organized and taught for 15 years by both authors of the first edition (David L. Felten, MD, PhD and Ralph F. Jozefowicz, MD), and by M. Kerry O'Banion, MD, PhD and Ralph F. Jozefowicz, MD, for more than 15 years is an added benefit but is not why we organized this *Atlas* as we have. A working competence for students in basic and clinical neuroscience, and its value for delivering outstanding patient care, are always the main focus of our efforts. We truly value success in this arena. Knowledgeable and highly competent students are the finest outcome of our teaching that we could ever achieve. We hope that our students will come to appreciate both the beauty and the complexity of the nervous system and be inspired to contribute to the knowledge and functional application to patients of this greatest biological and medical frontier, which constitutes the substrate for human behavior and our loftiest human aspirations and endeavors.

# ABOUT THE ARTISTS

**FRANK H. NETTER, MD** was born in 1906 in New York City. He studied art at the Art Students League and the National Academy of Design before entering medical school at New York University, where he received his medical degree in 1931. During his student years, Dr. Netter's notebook sketches attracted the attention of the medical faculty and other physicians, allowing him to augment his income by illustrating articles and textbooks. He continued illustrating as a sideline after establishing a surgical practice in 1933, but he ultimately opted to give up his practice in favor of a full-time commitment to art. After service in the United States Army during World War II, Dr. Netter began his long collaboration with the CIBA Pharmaceutical Company (now Novartis Pharmaceuticals). This 45-year partnership resulted in the production of the extraordinary collection of medical art so familiar to physicians and other medical professionals worldwide.

In 2005, Elsevier, Inc. purchased the Netter Collection and all publications from Icon Learning Systems. There are now more than 50 publications featuring the art of Dr. Netter available through Elsevier, Inc. (in the US: [www.us.elsevierhealth.com/Netter](http://www.us.elsevierhealth.com/Netter); outside the US: [www.elsevierhealth.com](http://www.elsevierhealth.com)).

Dr. Netter's works are among the finest examples of the use of illustration in the teaching of medical concepts. The 13-book *Netter Collection of Medical Illustrations*, which includes the greater part of the more than 20,000 paintings created by Dr. Netter, became and remain one of the most famous medical works ever published. Dr. Netter's *Atlas of Human Anatomy*, first published in 1989, presents the anatomical paintings from the *Netter Collection*. Now translated into 16 languages, it is the anatomy atlas of choice among medical and health professions students the world over.

The Netter illustrations are appreciated not only for their aesthetic qualities, but, more important, for their intellectual content. As Dr. Netter wrote in 1949, "... clarification of a subject is the aim and goal of illustration. No matter how beautifully painted, how delicately and subtly rendered a subject may be, it is of little value as a medical illustration if it does not serve to make clear some medical point." Dr. Netter's planning, conception, point of view, and approach are what inform his paintings and what makes them so intellectually valuable.

Frank H. Netter, MD, physician and artist, died in 1991.

Learn more about the physician-artist whose work has inspired the Netter Reference collection: <http://www.netterimages.com/artist/netter.htm>.

**CARLOS MACHADO, MD** was chosen by Novartis to be Dr. Netter's successor. He continues to be the main artist who contributes to the Netter Collection of medical illustrations.

Self-taught in medical illustration, cardiologist Carlos Machado has contributed meticulous updates to some of Dr. Netter's original plates and has created many paintings of his own in the style of Netter as an extension of the Netter collection. Dr. Machado's photorealistic expertise and his keen insight into the physician/patient relationship inform his vivid and unforgettable visual style. His dedication to researching each topic and subject he paints places him among the premier medical illustrators at work today.

Learn more about his background and see more of his art at: <http://www.netterimages.com/artist/machado.htm>.

**JAMES A. PERKINS, CMI, FAMI** is Professor of Medical Illustration at Rochester Institute of Technology (RIT) where he teaches courses in anatomy, digital illustration, and scientific visualization. He is a Board Certified Medical Illustrator and Fellow of the Association of Medical Illustrators.

An expert in visualizing biological processes, Professor Perkins has illustrated more than 40 medical textbooks, particularly in the areas of pathology, physiology, and molecular biology. For more than 20 years, he has been the sole illustrator of the “Robbins” series of pathology texts published by Elsevier, including the flagship of the series, *Robbins and Cotran Pathologic Basis of Disease*. He has been a contributor to the Netter Collection since 2001, creating most of the new art for *Netter’s Atlas of Human Physiology*, *Netter’s Illustrated Pharmacology*, and *Netter’s Atlas of Neuroscience* and contributing to many other titles.

Professor Perkins received a bachelor degree in biology and geology from Cornell University and studied vertebrate paleontology and anatomy at the University of Texas and University of Rochester. He received a Master of Fine Arts degree in medical illustration from RIT and spent several years working in medical publishing and the medical legal exhibit field before returning to RIT to join the faculty. Learn more about his background and see more of his art at: <http://www.netterimages.com/artist/perkins.htm>