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## Neuroanatomy through Clinical Cases



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# NEUROANATOMY

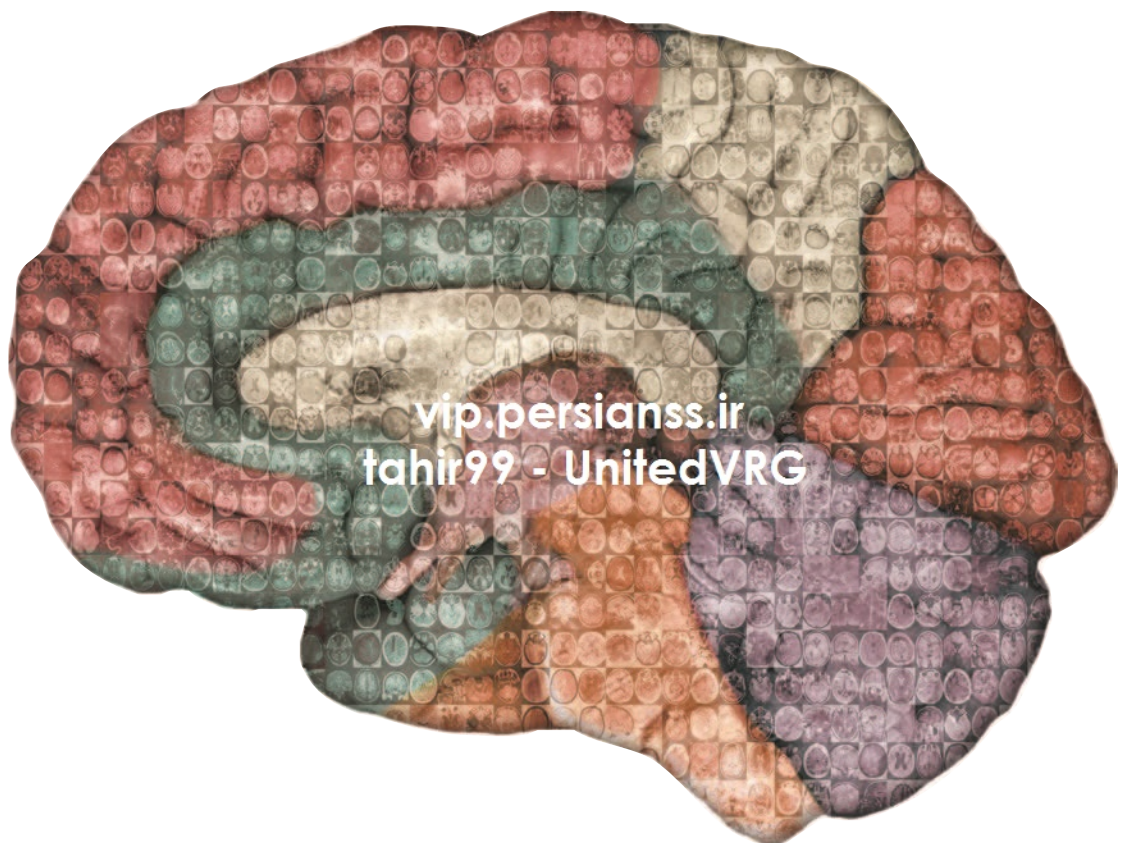
*through*

## Clinical Cases

SECOND EDITION

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*To Michelle*  
*And I think to myself... what a wonderful world.*

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# Preface

Neuroanatomy is a living, dynamic field that can bring both intellectual delight and aesthetic pleasure to students at all levels. However, by nature, it is also an exceedingly detailed subject, and herein lies the tragic pitfall of all too many neuroanatomy courses. Crushing amounts of memorization are often required of students of neuroanatomy, leaving them little time to step back and gain an appreciation of the structural and functional beauty of the nervous system and its relevance to clinical practice.

This book has a different point of view: instead of making the mastery of anatomical details the main goal and then searching for applications of this knowledge, actual clinical cases are used as both a teaching instrument and motivating force to encourage students to delve into further study of normal anatomy and function. Through this approach, structural details take on immediate relevance as they are being learned. In addition, each clinical case is an ideal way to integrate knowledge of disparate functional systems, since a single lesion may affect several different neural structures and pathways.

Over 100 clinical cases, accompanied by neuroradiological images, are presented in this text, and I am grateful to many neurologists, neurosurgeons, and neuroradiologists at the Columbia, Harvard, and Yale medical schools for helping me to amass enough material to present clinically relevant discussions of the entire nervous system. I have used this book's diagnostic method to teach neuroanatomy at these medical schools, and both students and faculty greeted the innovation enthusiastically. Through publication of *Neuroanatomy through Clinical Cases* I hope that students and faculty at many additional institutions will find this to be an enjoyable and effective way to learn neuroanatomy and its real-life applications.

## Acknowledgments for First Edition

First and foremost, I must thank my wife Michelle, and our children Eva and Jesse, for their enthusiasm and support throughout the writing and publication of this book.

This project has spanned a number of years, and stints at several academic centers, so there is a formidable list of people who I must thank for their important contributions. This book was conceived while I was teaching neuroanatomy as an M.D., Ph.D. student at Columbia Medical School, where I was inspired by my teachers Eric Kandel, Jack Martin, and Steven Siegelbaum. They have remained invaluable sources of inspiration and advice ever



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The focus and main strength of this book is its clinical cases. Therefore, I am very grateful to the many colleagues who suggested the clinical cases used in this book: Robert Ackerman, Claudia Baldassano, Tracy Batchelor, Flint Beal, Carsten Bonneman, Lawrence Borges, Robert Brown, Jeffrey Bruce, Brad Buchbinder, Ferdinando Buonanno, William Butler, Steve Cannon, David Caplan, Robert Carter, Verne Caviness, Jang-Ho Cha, Paul Chapman, Chinfei Chen, Keith Chiappa, In Sup Choi, Andrew Cole, Douglas Cole, G. Rees Cosgrove, Steven Cramer, Didier Cros, Merit Cudkowicz, Kenneth Davis, Rajiv Desai, Elizabeth Dooling, Brad Duckrow, Mitchell Elkind, Emad Eskandar, Stephen Fink, Seth Finkelstein, Alice Flaherty, Robert Friedlander, David Frim, Zoher Ghogawala, Michael Goldrich, Jonathan Goldstein, R. Gilberto Gonzalez, Kimberly Goslin, Steven Greenberg, John Growdon, Andrea Halliday, E. Tessa Hedley-Whyte, Martha Herbert, Daniel Hoch, Fred Hochberg, J. Maurice Hourihane, Brad Hyman, Michael Irizarry, David Jacoby, William Johnson, Raymond Kelleher, Philip Kistler, Walter Koroshetz, Sandra Kostyk, Kalpathy Krishnamoorthy, James Lehigh, Simmons Lessell, Michael Lev, Susan Levy, Michael Lin, Elan Louis, David Louis, Jean Lud-Cadet, David Margolin, Richard Mattson, Stephan Mayer, James Miller, Shawn Murphy, Brad Navia, Steven Novella, Edward Novotny, Christopher Ogilvy, Robert Ojemann, Michael Panzara, Dante Pappano, Stephen Parker, Marie Pasinski, John Penney, Bruce Price, Peter Riskind, Guy Rordorff, Diana Rosas, Tally Sagie, Pamela Schaefer, Jeremy Schmahmann, Lee Schwamm, Michael Schwarzschild, Saad Shafqat, Barbara Shapiro, Aneesh Singhal, Michael Sisti, Gerald So, Robert Solomon, Marcio Sotero, Dennis Spencer, Susan Spencer, John Stakes, Marion Stein, Divya Subramanian-Khurana, Brooke Swearingen, Max Takeoka, Thomas Tatemichi, Fran Testa, James Thompson, Mark Tramo, Jean Paul Vonsattel, Shirley Wray, Anne Young, and Nicholas Zervas.

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Finally, I thank the entire staff at Sinauer Associates for their tremendously helpful collaboration in all stages of producing this book. I have enjoyed working with, and am especially grateful to, Andrew D. Sinauer, Peter Farley, Kerry Falvey, Christopher Small, and Jefferson Johnson, but I extend my deep appreciation to all other members of the Sinauer staff as well. It is a pleasure to work with people who truly care about creating a fine book.

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# *How to Use This Book*

The goal of this book is to provide a treatment of neuroanatomy that is comprehensive, yet enables students to focus on the most important “take-home messages” for each topic. This goal is motivated by the recognition that, while access to detailed information is often useful in mastering neuroanatomy, certain selected pieces of information carry the most clinical relevance, or are most important for exam review.

## **General Outline**

The first four chapters of the book contain introductory material that will be especially useful to students who have little previous clinical background. Chapter 1 is an introduction to the standard format commonly used for presenting clinical cases, including an outline of the medical history, physical examination, neuroanatomical localization, and differential diagnosis. Chapter 2 is a brief overview of neuroanatomy which includes definitions and descriptions of basic structures that will be studied in greater detail in later chapters. Chapter 3 builds on this knowledge by describing the neurologic examination. It includes a summary of the structures and pathways tested in each part of the exam, which is essential for localizing the lesions presented in the clinical cases throughout the remainder of the book. Much of the material in this chapter is also covered on the [neuroexam.com](http://neuroexam.com) website described below, which provides video demonstrations for each part of the exam. For readers who are unfamiliar with neuroimaging techniques, Chapter 4 contains a concise introduction to CT, MRI, and other imaging methods. This chapter also includes a *Neuroradiological Atlas* showing normal CT, MRI, and angiographic images of the brain. Chapters 5–19 cover the major neuroanatomical systems and present relevant clinical cases.

## **Chapters 5–19**

Chapters 5–19 have a common structure. An “Anatomical and Clinical Review” at the beginning of the chapters presents relevant neuroanatomical structures and pathways, and generously sized, carefully labeled color illustrations are used to vividly depict spatial relationships. The first part of each chapter also includes numbered sections called “Key Clinical Concept,” or “KCC,” which cover common disorders of the system being discussed.

**CLINICAL CASES** The second part of each chapter is a “Clinical Cases” section that describes patients seen by the author and colleagues, each presented in a numbered color box. Full-length cases include complete findings from the neurologic examination, while “Minicases” have a briefer format. Each case begins with a narrative of how the patient’s symptoms developed and what deficits were found on neurologic examination. For example, one patient in Chapter 10 suddenly developed weakness in the right hand and lost the ability to speak. Another, in Chapter 14, experienced double vision and lapsed into a coma. Important symptoms and signs are indicated in boldface type. The reader is then challenged through a series of questions to deduce the neuroanatomical location of the patient’s lesion and the eventual diagnosis.

A discussion follows each case, beginning with a summary of the key symptoms and signs. Answers to the questions are provided which refer to anatomical and clinical material presented in the first half of the chapter that is demonstrated by the case. Continual improvements in imaging technology have allowed us to make clear and detailed radiographs of the nervous system *in vivo*, and one of the most exciting features of the book is the inclusion of large-format, labeled CT, MRI, or other scans that show the lesion for each patient, and serve as a central tool for teaching neuroanatomy. These images reveal, with striking clarity, both the lesion’s location and the anatomy of the system being studied. In addition, these radiographs help the reader develop skill in interpreting the kinds of diagnostic images employed on the wards. The neuroimaging studies for each case are provided in special boxes at least one page turn away from the case questions, so the answers to the questions are not “given away” by the imaging (see below).

The clinical course is also provided for each patient, and includes a discussion of how the patient was managed, and what outcome followed. Thus, by the end of each case, students learn the relevant material by application and diagnostic sleuthing rather than by rote memorization.

## Special Features for Focused Study and Review

Since one of the goals of this book is to enable students to either read the material in depth, or to distill it down to the most clinically relevant points or to material most commonly covered on the national boards or other examinations, several special features have been included to expedite focused study and review:

- **Boldface type** is used rather differently than in most texts. In addition to identifying the text for all important topics and definitions, boldface is also used to facilitate rapid or focused reading.
- **Review Exercises** appear in the margins throughout the text, highlighting the most important anatomical concepts in each chapter, and providing practice exam questions.
- Helpful **mnemonics** are provided throughout the text, and these are flagged in the margins by a special icon (shown at right) showing a section of the hippocampus (a structure important in memory formation).
- A **Brief Anatomical Study Guide** appears at the end of each chapter, which summarizes the most important neuroanatomical material, and refers to the appropriate figures and tables needed for focused exam review.
- The **Neuroradiological Atlas** in Chapter 4 also provides a useful review of neuroanatomical structures in three-dimensional space, and can be used for reference and comparison to lesions seen in clinical cases.

## REVIEW EXERCISE



**MNEMONIC**



Rapid hand movements

- The [neuroexam.com](http://neuroexam.com) website includes much of the text from Chapter 3 describing the neurologic exam and its anatomical interpretation, and also features video demonstrations of each part of the exam that are cited in the text (e.g., “see [neuroexam.com Video 37](#)”). Selected video frames are also shown in the book margins, as shown at right, to illustrate relevant portions of the neurologic exam. Students or instructors who prefer to view a full-length video of the neurologic exam can obtain *The NeuroExam Video* from Sinauer Associates ([www.sinauer.com](http://www.sinauer.com)).
- The **Key Clinical Concept (KCC)** sections provide a comprehensive introduction to clinical topics in neurology and neurosurgery, and enable an efficient review of these topics.
- Finally, the **Clinical Cases** can be used by themselves for study and review, since they consist of anatomical puzzles that reinforce the subject matter for each chapter in the most clinically relevant context. As noted above, the neuroimaging studies for each case are deliberately placed at least one page turn away from the case questions; the location of the images for each case are indicated by page numbers provided immediately after the images are cited in the text.
- The **Additional Cases** section at the end of each chapter, and the **Case Index** at the end of the book provide further cases relevant to the topics in each chapter.
- **Online review materials** will include many more clinical cases, images, and questions and answers for review.

## Suggested Course Use

*Neuroanatomy through Clinical Cases* is intended primarily for first- or second-year medical students enrolled in a course in neuroanatomy or neuroscience, but it is a versatile text that could be used in many settings.

The topics covered in the book include all neuroanatomical material required for the medical school board examinations. Although fundamental concepts are emphasized, some advanced subject matter is also provided. Because the book includes chapters on peripheral nerves, students will also find this book useful in their general gross anatomy course in which peripheral nerves are usually covered. The Key Clinical Concept sections in this book also cover the major neurologic and neurosurgical disorders at a level appropriate for medical school pathophysiology courses, clinical rotations, and residents early in their training.

Students of other health professions, especially physical therapy, occupational therapy, nursing, dentistry, speech therapy, and neuropsychology will find this textbook useful as well, and it may also be of interest to graduate students of neuroscience. In addition to those learning neuroanatomy, it is hoped that the cases in this book will serve as a resource for advanced medical students in their clinical rotations, and residents in neurology, neurosurgery, and neuroradiology seeking examples of “typical” cases of neurologic disorders. Because each case is a real patient, the clinical cases in this book are, in effect, a collection of case reports that can serve as a useful resource, especially for teaching purposes and board review. It should be noted, however, that the cases presented here are highly selected for their teaching value and do not constitute an unbiased sampling of the kinds of cases found in clinical practice.

Here are some suggestions for using *Neuroanatomy through Clinical Cases* in various courses and curricula:



- For a comprehensive course in **medical school neuroanatomy**, students should read Chapters 2 and 5–18, with selected topics from Chapters 1, 3, 4 and 19. Reading assignments and large class lectures could focus on the Anatomical and Clinical Review sections at the beginning of each chapter. The clinical cases are most effectively discussed in small groups of students, where instructors can help students puzzle through the anatomical localization and diagnosis, and then discuss the neuroradiology and clinical outcome. An **Instructor's Resource Library** is available which contains material that will be useful for lectures, and **additional clinical cases** not found in the book or in the student Online Review and Study Guide, ideal for use in small group teaching.
- For medical school courses covering neuroanatomy and other topics in **neuroscience**, additional readings from neuroscience texts such as *Neuroscience* by Purves et al. (2008, Sinauer Associates) or *Principles of Neural Science* by Kandel et al. (2000, McGraw-Hill) should be provided.
- For a comprehensive course in **clinical disorders of the nervous system**, students should read Chapters 3 and 4, and the Key Clinical Concept sections in Chapters 5–19. *The NeuroExam Video* should be viewed in class, and students referred to neuroexam.com for review. Clinical cases could then be presented in small groups, as described above.
- For a course focusing on **neuropsychological disorders** and anatomical correlations, students should read Chapters 2, 10, 18 and 19 and selected parts of Chapters 14 and 16.
- Finally, for a more **basic course in clinical neuroanatomy**, readings could be confined to selected topics in Chapters 2, 5–7, 10–16, and 18.





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