

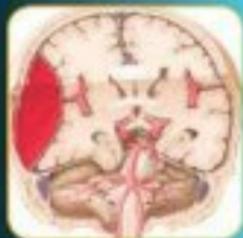
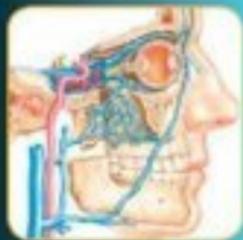
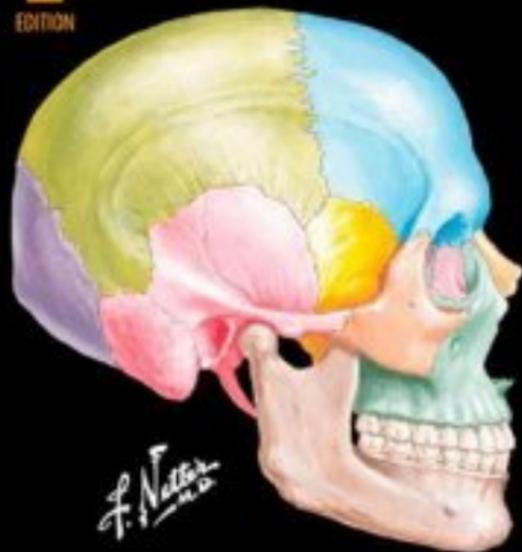
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JOHN T. HANSEN

Netter's Clinical Anatomy

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NETTER'S CLINICAL ANATOMY

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I dedicate this book to my wife

Paula,

and to my children

Amy and Sean,

and to my grandchildren

Abigail and Benjamin.

*Without their unconditional love, presence,
and encouragement, little would have been accomplished
either personally or professionally.*



About the Artists

Frank H. Netter, MD

Frank H. Netter was born in 1906 in New York City. He studied art at the Art Student's League and the National Academy of Design before entering medical school at New York University, where he received his MD 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 over 50 publications featuring the art of Dr. Netter available through Elsevier, Inc. (in the US: www.us.elsevierhealth.com/Netter and outside the US: 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 remains one of the most famous medical works ever published. The *Netter 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

Carlos Machado 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>.



About the Author

John T. Hansen, PhD, is Professor and Associate Chair for Education in Neurobiology and Anatomy, and Associate Dean for Admissions at the University of Rochester School of Medicine and Dentistry. Dr. Hansen served as Chair of the Department of Neurobiology and Anatomy before becoming Associate Dean. Dr. Hansen is the recipient of numerous teaching awards from students at three different medical schools. In 1999, he was the recipient of the Alpha Omega Alpha Robert J. Glaser Distinguished Teacher Award given annually by the Association of American Medical Colleges to nationally recognized medical educators. Dr. Hansen's investigative career encompassed the study of the peripheral and central dopaminergic systems, neural plasticity, and neural inflammation. In addition to about 100 research publications, he is coauthor of *Netter's Atlas of Human Physiology*; the lead consulting editor of the *Atlas of Human Anatomy*; author of *Netter's Anatomy Flash Cards*, *Essential Anatomy Dissector*, and *Netter's Anatomy Coloring Book*; coauthor of the *TNM Staging Atlas*; and consultant on the CD-ROM *Netter Presenter Human Anatomy Collection*.



Preface

Human anatomy is the foundation upon which the education of our medical, dental, and allied health science students is built. However, today's biomedical science curriculum must cover an ever-increasing body of scientific knowledge, often in fewer hours, as competing disciplines and new technologies emerge. Many of these same technologies, especially those in the imaging science fields, have made understanding the anatomy even more important and have moved the discipline into the realm of clinical medicine. It is fair to say that competent clinicians and allied health professionals can no longer simply view their anatomical training in isolation from the clinical implications related to that anatomy.

In this context, I am proud to introduce the second edition of *Netter's Clinical Anatomy*. Generations of students have used Dr. Frank H. Netter's elegant anatomical illustrations to learn anatomy, and this book combines his beautiful anatomical and embryological renderings with numerous clinical illustrations to help students bridge the gap between normal anatomy and its clinical implications.

This second edition provides succinct text, key bulleted points, and ample summary tables, which offer students a concise textbook description of normal human anatomy, as well as a quick reference and review guide for clinical practitioners. Additionally, some of the more commonly encountered clinical conditions seen in medical practice are integrated within the textbook as *Clinical Focus* sections. These clinical correlations are drawn from a wide variety of medical fields including emergency medicine, radiology, orthopedics, and surgery, but also include relevant clinical anatomy related to the fields of cardiology, endocrinology, infectious diseases, neurology, oncology, reproductive biology, and urology. Other features of this edition include:

- An introductory chapter designed to orient students to the body's organ systems
- A set of end-of-chapter short answer review questions to help reinforce student learning of key concepts
- Online access to Elsevier's www.NetterReference.com website, where students may access additional images related to the *Clinical Focus* sections, and find additional short-answer review and multiple choice questions

My intent in writing this updated second edition of *Netter's Clinical Anatomy* was to provide a concise and focused introduction to clinical anatomy as a viable alternative to the more comprehensive anatomy textbooks, which few students read and often find difficult to navigate when looking for essential anatomical details. Moreover, this textbook serves as an excellent essential review text for students beginning their clinical clerkships or elective programs, and as a reference text that clinicians will find useful for review and patient education. By meeting the needs of the beginning student and providing ample detail for subsequent review or handy reference, my hope is that *Netter's Clinical Anatomy* will be the anatomy textbook of choice that will actually be read and used by students throughout their careers in the health professions.

I hope that you, the health science student-in-training or the physician in practice, will find *Netter's Clinical Anatomy*, second edition, the valuable link you've searched for to enhance your understanding of clinical anatomy as only Frank Netter can present it.

JOHN T. HANSEN, PhD



Acknowledgments

Compiling the illustrations for, researching, and writing *Netter's Clinical Anatomy*, second edition, has been both enjoyable and educational, confirming again the importance of lifelong learning in the health professions.

Netter's Clinical Anatomy is for all my students, and I am indebted to all of them who, like many others, yearn for a better view to help them learn the relevant anatomy that informs the practice of medicine.

Thanks and appreciation also to my colleagues and reviewers who provided encouragement and constructive comments that clarified many aspects of the book. Especially, I wish to acknowledge Lawrence Rizzolo, PhD, Department of Surgery, Yale University School of Medicine, and John Mahoney, MD, Department of Emergency Medicine, University of Pittsburgh, for their review of the first edition. Additionally, a very special “thank you” to David Lambert, MD, in the Department of Medicine at Rochester and Senior Associate Dean for Undergraduate Medical Education, who co-authored the first edition with me and remains a treasured colleague and friend.

At Elsevier, it has been a distinct pleasure to work with dedicated, professional people who massaged, molded, and ultimately nourished the dream beyond even my wildest imagination. I owe much to the efforts of Marybeth Thiel, Senior Developmental Editor, and Linda Van Pelt, Publishing Services Manager, both of whom kept me organized, focused, and on time. Without them, little would have been accomplished. Thanks and appreciation also to Gene Harris, Design Direction; Karen Giacomucci, Illustration Manager; Jason Oberacker, Marketing Manager; and Julie Goolsby, Editorial Assistant. A very special thank you to Anne Lenehan, Director of Netter Products, and Elyse O’Grady, Netter Acquisitions Editor, for believing in the idea and always supporting my efforts. This competent team defines the word “professionalism,” and it has been an honor to work with all of them.

Special thanks to Jim Perkins, John Craig, and Carlos Machado for their beautiful artistic renderings. Their work nicely complemented, updated, and supplemented the original Netter illustrations.

Finally, we remain indebted to Frank H. Netter, MD, whose creative genius lives on in generations of biomedical professionals who have learned clinical anatomy from his rich collection of medical illustrations.

To all of these remarkable people, and others, “Thank you.”

JOHN T. HANSEN, PhD

1

INTRODUCTION TO THE HUMAN BODY

1. TERMINOLOGY
2. SKIN
3. SKELETAL SYSTEM
4. MUSCULAR SYSTEM
5. CARDIOVASCULAR SYSTEM
6. LYMPHATIC SYSTEM
7. RESPIRATORY SYSTEM
8. NERVOUS SYSTEM
9. ENDOCRINE SYSTEM
10. GASTROINTESTINAL SYSTEM
11. URINARY SYSTEM
12. REPRODUCTIVE SYSTEM
13. BODY CAVITIES
14. OVERVIEW OF EARLY DEVELOPMENT
15. IMAGING THE INTERNAL ANATOMY

REVIEW QUESTIONS

1. TERMINOLOGY

Anatomical Position

The study of anatomy requires a clinical vocabulary that defines position, movements, relationships, and planes of reference, as well as the systems of the human body. The study of anatomy can be by **body region** or by **body organ systems**. Generally, courses of anatomy in the United States approach anatomical study by regions, integrating all applicable body systems into the study of that region. Hence, this textbook is arranged regionally but, by way of introduction for someone studying anatomy for the first time, this initial chapter will briefly introduce you to the major body systems that you will encounter in your study of anatomy. You will find it extremely helpful to refer back to this introduction as you encounter various body systems in your study of regional anatomy.

By convention, anatomical descriptions of the human body are based on a person in the **anatomical position** (Fig. 1-1):

- Standing erect and facing forward
- Arms hanging at the sides with palms facing forward
- Legs placed together with feet facing forward

Terms of Relationship and Body Planes

Anatomical descriptions often are referenced to one or more of three distinct body planes (Fig. 1-2 and Table 1-1):

- **Sagittal plane:** vertical plane that divides the body into equal right and left halves (median or mid-sagittal plane) or a plane parallel to the

median sagittal plane that divides the body into unequal right and left portions

- **Frontal (coronal) plane:** a vertical plane that divides the body into anterior and posterior

TABLE 1-1 Terms of Relationship

TERM	DEFINITION
Anterior (ventral)	Near the front
Posterior (dorsal)	Near the back
Superior (cranial)	Upward or near the head
Inferior (caudal)	Downward or near the feet
Medial	Toward the midline or median plane
Lateral	Farther from the midline or median plane
Proximal	Near a reference point
Distal	Away from a reference point
Superficial	Closer to the surface
Deep	Farther from the surface
Median plane	Divides body into equal right and left parts
Mid-sagittal plane	Median plane
Sagittal plane	Divides body into unequal right and left parts
Frontal (coronal) plane	Divides body into equal or unequal anterior and posterior parts
Transverse plane	Divides body into equal or unequal superior and inferior parts (cross sections)

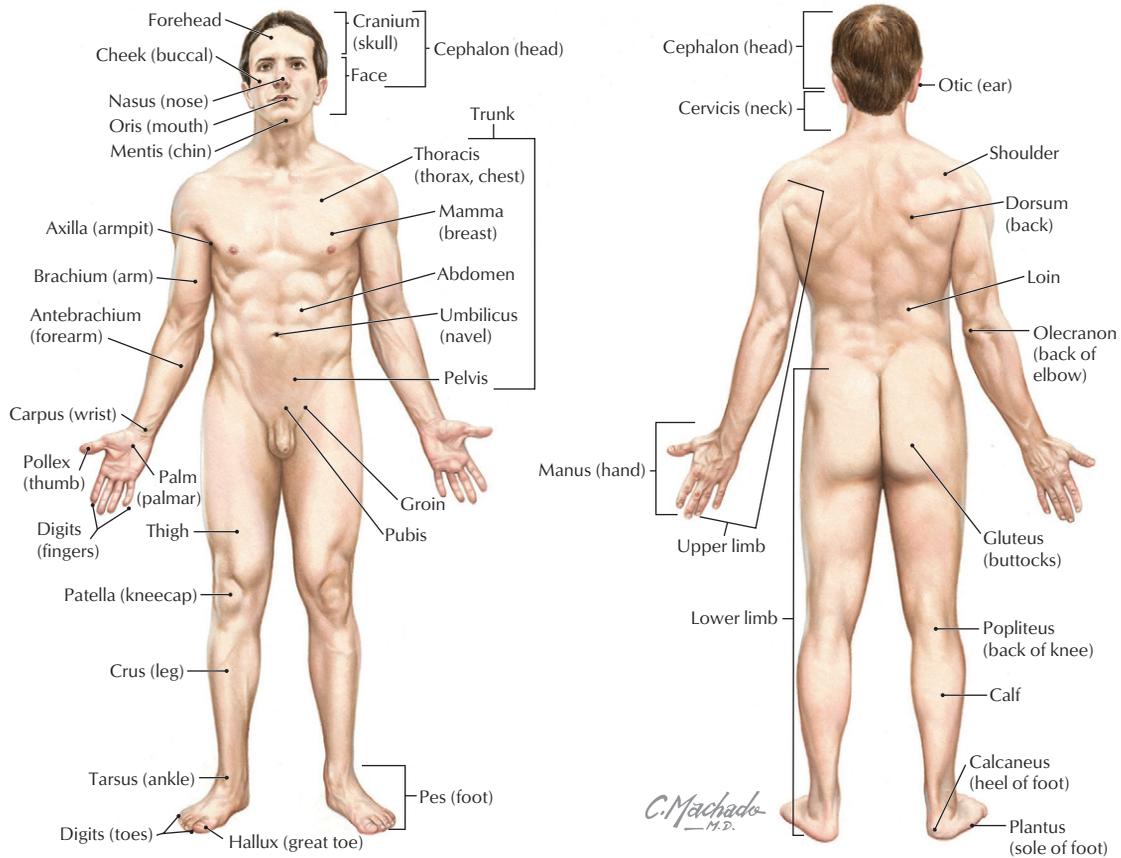


FIGURE 1-1 Anatomical Position and the Terminology Used to Describe Various Body Regions

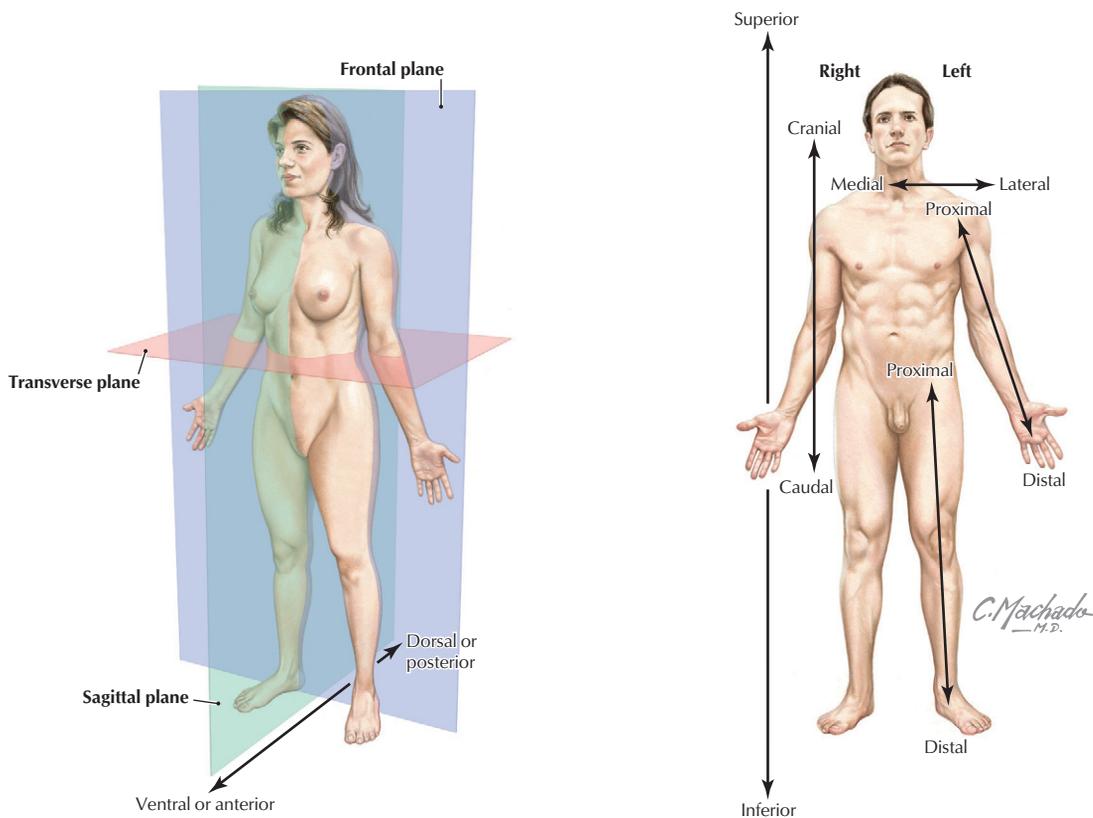


FIGURE 1-2 Body Planes and Terms of Relationship



FIGURE 1-3 Terms of Movement

portions (equal or unequal); this plane is at right angles to the median sagittal plane

- **Transverse (axial) plane:** horizontal plane that divides the body into superior and inferior portions (equal or unequal) and is at right angles to both the median sagittal and frontal planes (sometimes called *cross sections*)

Key terms of relationship used in anatomy and the clinic are summarized in Table 1-1. Sometimes these terms of relationship will be used in combination (e.g., superomedial, meaning closer to the head and nearer the median sagittal plane).

Movements

Body movements usually occur at the joints where two or more bones or cartilages articulate with one another. Muscles act on joints to accomplish these

movements and may be described as follows: “The biceps muscle flexes the forearm at the elbow.” Figure 1-3 summarizes the terms of movement.

Anatomical Variability

The human body is remarkably complex and remarkably consistent anatomically, but normal variations do exist, often related to size, gender, age, number, shape, and attachment. Variations are particularly common in the following structures:

- **Bones:** fine features of bones (processes, spines, articular surfaces) may be variable depending on the forces working on that bone
- **Muscles:** vary with size and fine details of their attachments (it is better to learn their actions and general attachments rather than focus on detailed exceptions)