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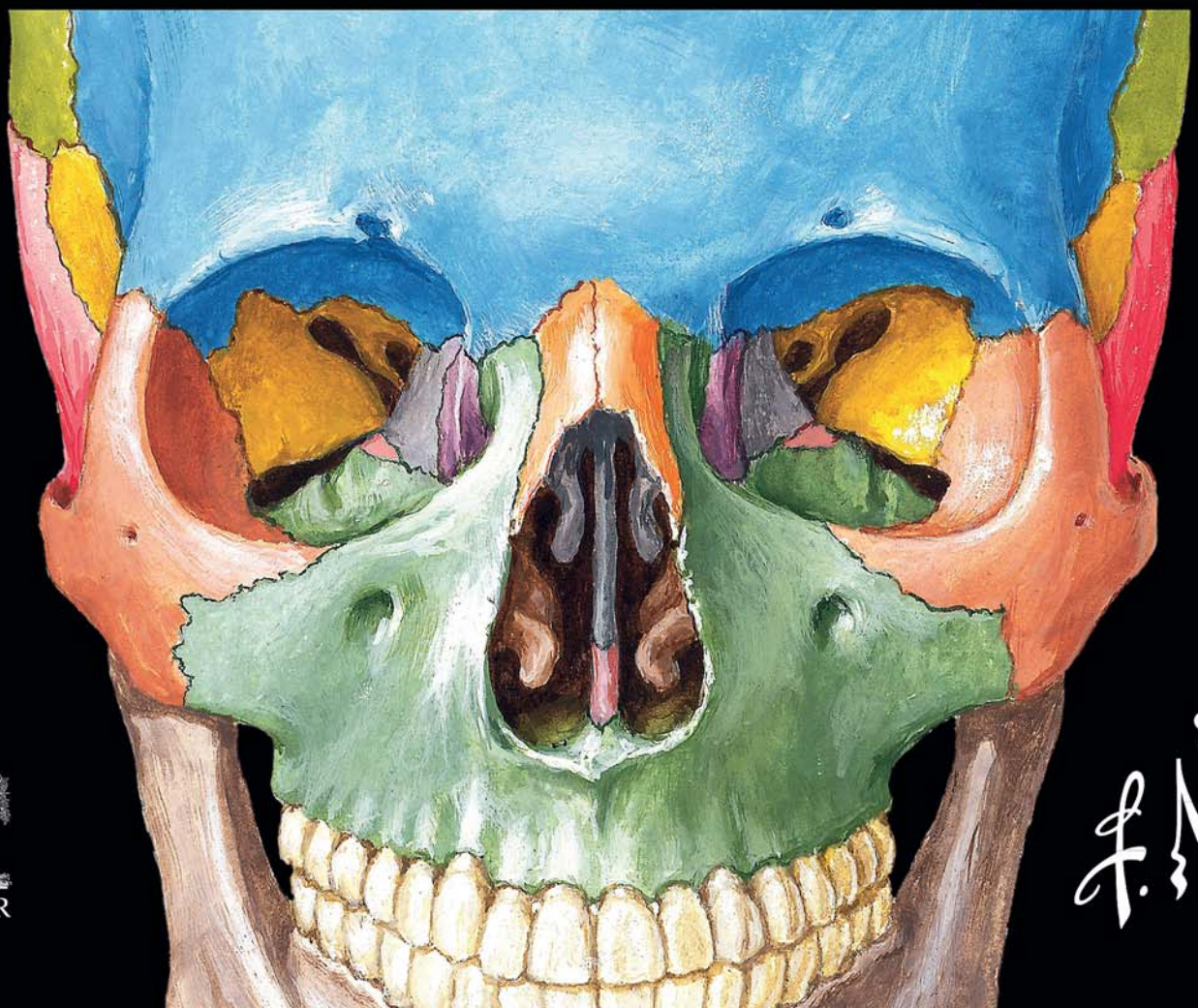
NETTER ATLAS of HUMAN ANATOMY 8

A Systems Approach

EIGHTH EDITION



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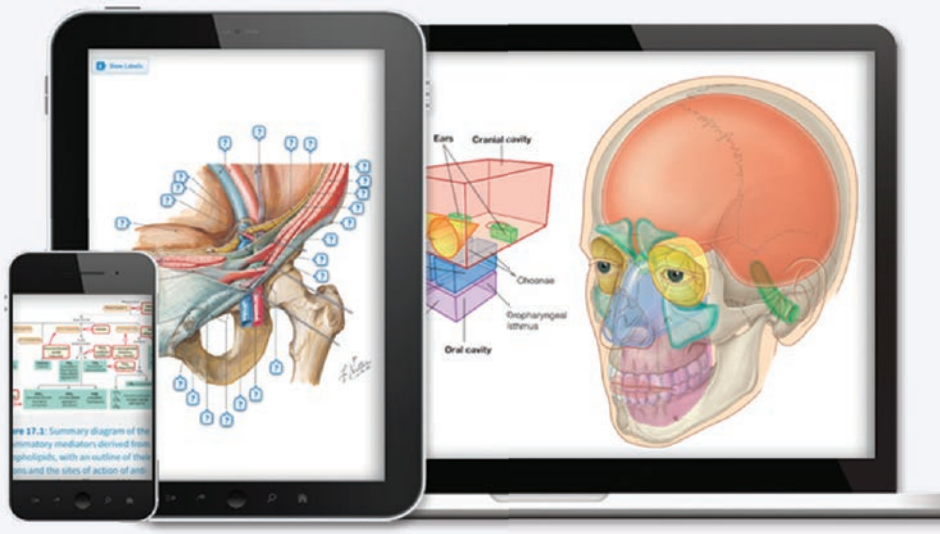

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A Systems Approach

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F. Netter M.D.

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ATLAS OF HUMAN ANATOMY : A SYSTEMS APPROACH, EIGHTH EDITION

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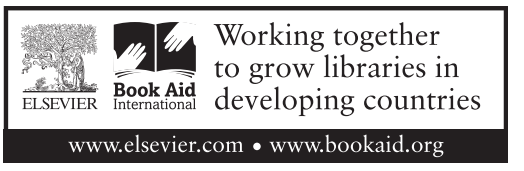

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PREFACE

The illustrations comprising the *Netter Atlas of Human Anatomy* were painted by physician-artists, Frank H. Netter, MD, and Carlos Machado, MD. Dr. Netter was a surgeon and Dr. Machado is a cardiologist. Their clinical insights and perspectives have informed their approaches to these works of art. The collective expertise of the anatomists, educators, and clinicians guiding the selection, arrangement, labeling, and creation of the illustrations ensures the accuracy, relevancy, and educational power of this outstanding collection.

You have a copy of the **Systems Approach 8th edition** with English-language terminology. This is a new organization, available for the first time. Traditionally, the Netter Atlas has only been offered as a regionally organized Atlas. This arrangement is still available (with English or Latin terminology options), but this new systems organization reflects the needs of a growing number of programs that approach anatomy within a body systems context. In all cases, the same beautiful and instructive Art Plates and Table information are included.

New to this Edition

New Art

More than 20 new illustrations have been added and over 30 art modifications have been made throughout this edition. Highlights include new views of the temporal and infratemporal fossa, pelvic fascia, nasal cavity and paranasal sinuses, plus multiple new perspectives of the heart, a cross-section of the foot, enhanced surface anatomy plates, and overviews of many body systems. In these pages you will find the most robust illustrated coverage to date for modern clinical anatomy courses.

Terminology and Label Updates

This 8th edition incorporates terms of the *Terminologia Anatomica* (2nd edition), as published by the Federative International Programme on Anatomical Terminology in 2019 (https://fipat.library.dal.ca/ta2) and adopted by the International Federation of Associations of Anatomy in 2020. A fully searchable database of the updated *Terminologia Anatomica* can be accessed at https://ta2viewer.openanatomy.org. Common clinical eponyms and former terminologies are selectively included, parenthetically, for clarity. In addition, a strong effort has been made to reduce label text on the page while maximizing label information through the use of abbreviations (muscle/s = m/mm.; artery/ies = a./aa.; vein/s = v./vv.; and nerve/s = n./nn.) and focusing on the labels most relevant to the subject of each Plate.

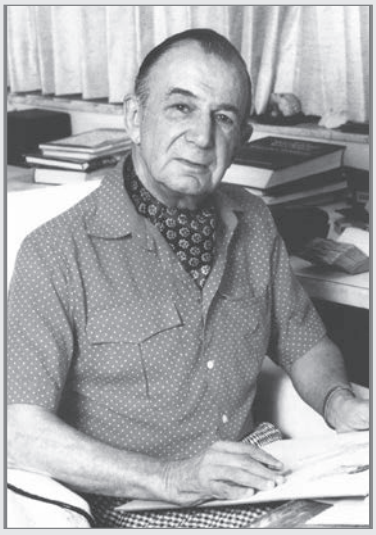
Nerve Tables

The muscle tables and clinical tables of previous editions have been so positively received that new tables have been added to cover four major nerve groups: cranial nerves and the nerves of the cervical, brachial, and lumbosacral plexuses.

The Future of the Netter Anatomy Atlas

As the Netter Atlas continues to evolve to meet the needs of students, educators, and clinicians, we welcome suggestions! Please use the following form to provide your feedback:

https://tinyurl.com/NetterAtlas8



To my dear wife, Vera

PREFACE TO THE FIRST EDITION

I have often said that my career as a medical artist for almost 50 years has been a sort of "command performance" in the sense that it has grown in response to the desires and requests of the medical profession. Over these many years, I have produced almost 4,000 illustrations, mostly for *The CIBA* (now *Netter*) *Collection of Medical Illustrations* but also for *Clinical Symposia.* These pictures have been concerned with the varied subdivisions of medical knowledge such as gross anatomy, histology, embryology, physiology, pathology, diagnostic modalities, surgical and therapeutic techniques, and clinical manifestations of a multitude of diseases. As the years went by, however, there were more and more requests from physicians and students for me to produce an atlas purely of gross anatomy. Thus, this atlas has come about, not through any inspiration on my part but rather, like most of my previous works, as a fulfillment of the desires of the medical profession.

It involved going back over all the illustrations I had made over so many years, selecting those pertinent to gross anatomy, classifying them and organizing them by system and region, adapting them to page size and space, and arranging them in logical sequence. Anatomy of course does not change, but our understanding of anatomy and its clinical significance does change, as do anatomical terminology and nomenclature. This therefore required much updating of many of the older pictures and even revision of a number of them in order to make them more pertinent to today's ever-expanding scope of medical and surgical practice. In addition, I found that there were gaps in the portrayal of medical knowledge as pictorialized in the illustrations I had previously done, and this necessitated my making a number of new pictures that are included in this volume.

In creating an atlas such as this, it is important to achieve a happy medium between complexity and simplification. If the pictures are too complex, they may be difficult and confusing to read; if oversimplified, they may not be adequately definitive or may even be misleading. I have therefore striven for a middle course of realism without the clutter of confusing minutiae. I hope that the students and members of the medical and allied professions will find the illustrations readily understandable, yet instructive and useful.

At one point, the publisher and I thought it might be nice to include a foreword by a truly outstanding and renowned anatomist, but there are so many in that category that we could not make a choice. We did think of men like Vesalius, Leonardo da Vinci, William Hunter, and Henry Gray, who of course are unfortunately unavailable, but I do wonder what their comments might have been about this atlas.

Frank H. Netter, MD
(1906–1991)

FRANK H. NETTER, MD

Frank H. Netter was born in New York City in 1906. 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 Doctor of Medicine 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.

Icon Learning Systems acquired the Netter Collection in July 2000 and continued to update Dr. Netter's original paintings and to add newly commissioned paintings by artists trained in the style of Dr. Netter. 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.

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 anatomic 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 importantly, 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 make them so intellectually valuable.

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

ABOUT THE EDITORS

Carlos A.G. 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: https://netterimages.com/artist-carlos-a-g-machado.html

Paul E. Neumann, MD was clinically trained in anatomical pathology and neuropathology. Most of his research publications have been in mouse neurogenetics and molecular human genetics. In the past several years, he has concentrated on the anatomical sciences, and has frequently written about anatomical terminology and anatomical ontology in the journal *Clinical Anatomy*. As an officer of the Federative International Programme for Anatomical Terminology (FIPAT), he participated in the production of Terminologia Anatomica (2nd edition), Terminologia Embryologica (2nd edition), and Terminologia Neuroanatomica. In addition to serving as the lead Latin editor of the 8th edition of Netter's Atlas, he was a contributor to the 33rd edition of *Dorland's Illustrated Medical Dictionary*.

R. Shane Tubbs, MS, PA-C, PhD is a native of Birmingham, Alabama and a clinical anatomist. His research interests are centered around clinical/surgical problems that are identified and solved with anatomical studies. This investigative paradigm in anatomy as resulted in over 1,700 peer reviewed publications. Dr. Tubbs' laboratory has made novel discoveries in human anatomy including a new nerve to the skin of the lower eyelid, a new space of the face, a new venous sinus over the spinal cord, new connections between the parts of the sciatic nerve, new ligaments of the neck, a previously undescribed cutaneous branch of the inferior gluteal nerve, and an etiology for postoperative C5 nerve palsies. Moreover, many anatomical feasibility studies from Dr. Tubbs' laboratory have gone on to be used by surgeons from around the world and have thus resulted in new surgical/clinical procedures such as treating hydrocephalus by shunting cerebrospinal fluid into various bones, restoration of upper limb function in paralyzed patients with neurotization procedures using the contralateral spinal accessory nerve, and harvesting of clavicle for anterior cervical discectomy and fusion procedures in patients with cervical instability or degenerative spine disease.

Dr. Tubbs sits on the editorial board of over 15 anatomical journals and has reviewed for over 150 scientific journals. He has been a visiting professor to major institutions in the United States and worldwide. Dr. Tubbs has authored over 40 books and over 75 book chapters. His published books by Elsevier include *Gray's Anatomy Review*, *Gray's Clinical Photographic Dissector of the Human Body*, *Netter's Introduction to Clinical Procedures*, and *Nerves and Nerve Injuries* volumes I and II. He is an editor for the 41st and 42nd editions of the over 150-year-old *Gray's Anatomy*, the 5th through 8th editions of *Netter's Atlas of Anatomy,* and is the editor-in-chief of the journal *Clinical Anatomy*. He is the Chair of the Federative International Programme on Anatomical Terminologies (FIPAT).

Jennifer K. Brueckner-Collins, PhD is a proud Kentucky native. She pursued her undergraduate and graduate training at the University of Kentucky. During her second year of graduate school there, she realized that her professional calling was not basic science research in skeletal muscle biology, but was instead helping medical students master the anatomical sciences. She discovered this during a required teaching assistantship in medical histology, where working with students at the 10-headed microscope changed her career path.

The next semester of graduate school, she assisted in teaching dissection-based gross anatomy, although she had taken anatomy when the lab component was prosection based. After teaching in the first lab, she knew that she needed to learn anatomy more thoroughly through dissection on her own, so she dissected one to two labs ahead of the students that semester; that was when she really learned anatomy and was inspired to teach this discipline as a profession. All of this occurred in the early 1990s, when pursuing a teaching career was frowned upon by many; it was thought that you only pursued this track if you were unsuccessful in research. She taught anatomy part-time during the rest of her graduate training, on her own time, to gain requisite experience to ultimately secure a faculty position.

Dr. Brueckner-Collins spent 10 years at the University of Kentucky as a full-time faculty member teaching dissection-based gross anatomy to medical, dental, and allied health students. Then, after meeting the love of her life, she moved to the University of Louisville and has taught medical and dental students there for more than a decade. Over 20 years of teaching full time at two medical schools in the state, her teaching efforts have been recognized through receipt of the highest teaching honor at each medical school in the state, the Provost's Teaching Award at University of Kentucky, and the Distinguished Teaching Professorship at University of Louisville.

Martha Johnson Gdowski, PhD earned her BS in Biology cum laude from Gannon University in 1990, followed by a PhD in Anatomy from the Pennsylvania State University College of Medicine in 1995. She completed postdoctoral fellowships at the Cleveland Clinic and Northwestern University School of Medicine prior to accepting a faculty position in the Department of Neuroscience at

the University of Rochester School of Medicine and Dentistry in 2001. Previous research interests include the development of an adult model of hydrocephalus, sensorimotor integration in the basal ganglia, and sensorimotor integration in normal and pathological aging.

Her passion throughout her career has been in her service as an educator. Her teaching has encompassed a variety of learning formats, including didactic lecture, laboratory, journal club, and problem-based learning. She has taught for four academic institutions in different capacities (The Pennsylvania State University School of Medicine, Northwestern University School of Medicine, Ithaca College, and The University of Rochester School of Medicine and Dentistry). She has taught in the following curricula: Undergraduate and Graduate Neuroscience, Graduate Neuroanatomy, Graduate Human Anatomy and Physiology for Physical Therapists, Undergraduate Medical Human Anatomy and Histology, and Undergraduate and Graduate Human Anatomy. These experiences have provided an opportunity to instruct students that vary in age, life experience, race, ethnicity, and economic background, revealing how diversity in student populations enriches learning environments in ways that benefit everyone. She has been honored to be the recipient of numerous awards for her teaching and mentoring of students during their undergraduate medical education. Martha enjoys gardening, hiking, and swimming with her husband, Greg Gdowski, PhD, and their dogs, Sophie and Ivy.

Virginia T. Lyons, PhD is an Associate Professor of Medical Education and the Associate Dean for Preclinical Education at the Geisel School of Medicine at Dartmouth. She received her BS in Biology from Rochester Institute of Technology and her PhD in Cell Biology and Anatomy from the University of North Carolina at Chapel Hill. Dr. Lyons has devoted her career to education in the anatomical sciences, teaching gross anatomy, histology, embryology, and neuroanatomy to medical students and other health professions students. She has led courses and curricula in human gross anatomy and embryology for more than 20 years and is a strong advocate for incorporating engaged pedagogies into preclinical medical education. Dr. Lyons has been recognized with numerous awards for teaching and mentoring students and was elected to the Dartmouth chapter of the Alpha Omega Alpha Honor Medical Society. She is the author of *Netter's Essential Systems-Based Anatomy* and co-author of the Human Anatomy Learning Modules website accessed by students worldwide. Dr. Lyons also serves as the Discipline Editor for Anatomy on the Aquifer Sciences Curriculum Editorial Board, working to integrate anatomical concepts into virtual patient cases that are used in multiple settings including clerkships and residency training.

Peter J. Ward, PhD grew up in Casper, Wyoming, graduating from Kelly Walsh High School and then attending Carnegie Mellon University in Pittsburgh, Pennsylvania. He began graduate school at Purdue University, where he first encountered gross anatomy, histology, embryology, and neuroanatomy. Having found a course of study that engrossed him, he helped teach those courses in the veterinary and medical programs at Purdue. Dr. Ward completed a PhD program in anatomy education and, in 2005, he joined the faculty at the West Virginia School of Osteopathic Medicine (WVSOM) in Lewisburg, West Virginia. There he has taught gross anatomy, embryology, neuroscience, histology, and the history of medicine. Dr. Ward has received numerous teaching awards, including the WVSOM Golden Key Award, the Basmajian Award from the American Association of Anatomists, and has been a two-time finalist in the West Virginia Merit Foundation's Professor of the Year selection. Dr. Ward has also been director of the WVSOM plastination facility, coordinator of the anatomy graduate teaching assistants, chair of the curriculum committee, chair of the faculty council, creator and director of a clinical anatomy elective course, and host of many anatomy-centered events between WVSOM and two Japanese Colleges of Osteopathy. Dr. Ward has also served as council member and association secretary for the American Association of Clinical Anatomists. In conjunction with Bone Clones, Inc., Dr. Ward has produced tactile models that mimic the feel of anatomical structures when intact and when ruptured during the physical examination. He created the YouTube channel Clinical Anatomy Explained! and continues to pursue interesting ways to present the anatomical sciences to the public. Dr. Ward was the Senior Associate Editor for the three volumes of *The Netter Collection: The Digestive System*, 2nd Edition, a contributor to *Gray's Anatomy,* 42nd Edition, and is author of *Netter's Integrated Musculoskeletal System: Clinical Anatomy Explained*.

Brion Benninger, MD, MBChB, MSc currently teaches surgical, imaging, and dynamic anatomy to medical students and residents in several countries (United States, New Zealand, China, Japan, Korea, Taiwan, The Caribbean, Mexico). He develops, invents, and assesses ultrasound probes, medical equipment, simulations, and software while identifying dynamic anatomy. He enjoys mixing educational techniques integrating macro imaging and surgical anatomy. Dr. Benninger developed the teaching theory of anatomy deconstruction/reconstruction and was the first to combine ultrasound with Google Glass during physical examination, coining the term "triple feedback examination." An early user of ultrasound, he continues to develop eFAST teaching and training techniques, has developed and shares a patent on a novel ultrasound finger probe, and is currently developing a new revolutionary ultrasound probe for breast screening. He is a reviewer for several ultrasound, clinical anatomy, surgical, and radiology journals and edits and writes medical textbooks. His research interests integrate clinical anatomy with conventional and emerging technologies to improve training techniques in situ and simulation. Dr. Benninger pioneered and coined the term "dynamic anatomy," developed a technique to deliver novel contrast medium to humans, and was the first to reveal vessels and nerves not previously seen using CT and MRI imaging. He has mentored more than 200 students on over 350 research projects presented at national and international

conferences and has received numerous awards for projects related to emergency procedures, ultrasound, sports medicine, clinical anatomy, medical simulation, reverse translational research, medical education, and technology. He is proud to have received medical teaching awards from several countries and institutions, including being the first recipient in more than 25 years to receive the Commendation Medal Award from the Commission of Osteopathic Accreditation for innovative clinical anatomy teaching that he designed and facilitated in Lebanon, Oregon. Dr. Benninger has received sports medicine accolades from Sir Roger Bannister regarding his medical invention on shoulder proprioception. He is also Executive Director of the Medical Anatomy Center and collaborates with colleagues globally from surgical and nonsurgical specialties. He is also an invited course speaker for surgical anatomy in New Zealand. Dr. Benninger collects medical history books, loves mountains and sports, and is an anonymous restaurant critic. British mentors directly responsible for his training include Prof. Peter Bell (surgery), Prof. Sir Alec Jeffreys (genetic fingerprinting), Profs. David deBono and Tony Gershlick (cardiology), Prof. Roger Greenhalgh (vascular surgery), Profs. Chris Colton, John Webb, and Angus Wallace (orthopaedics), Prof. Harold Ellis CBE (surgery and clinical anatomy), and Prof. Susan Standring (Guys Hospital/Kings College).

Todd M. Hoagland, PhD is Clinical Professor of Biomedical Sciences and Occupational Therapy at Marquette University in the College of Health Sciences. Previously he was Professor of Anatomy at the Medical College of Wisconsin (MCW). Prior to MCW, Dr. Hoagland was at Boston University School of Medicine (BUSM) and he still holds an adjunct faculty position at Boston University Goldman School of Dental Medicine. Dr. Hoagland is a passionate teacher and is dedicated to helping students achieve their goals. He believes in being a strong steward of the anatomical sciences, which involves teaching it to students while contemporaneously developing resources to improve the transfer of knowledge and preparing the next generation to be even better teachers. While at BUSM, Dr. Hoagland was a leader for the Carnegie Initiative on the Doctorate in Neuroscience and helped develop the Vesalius Program (teacher training) for graduate students. The program ensures that graduate students learn about effective teaching, receive authentic experiences in the classroom, and understand how to share what they learn via scholarship.

Dr. Hoagland's dedication to health professions education has been richly rewarded by numerous teaching awards from the University of Notre Dame, BUSM, and MCW. Dr. Hoagland received the Award for Outstanding Ethical Leadership in 2009, was inducted into the Alpha Omega Alpha Honor Medical Society in 2010, received the American Association of Anatomists Basmajian Award in 2012, and was inducted into the Society of Teaching Scholars in 2012 and was their director from 2016–2020.

Dr. Hoagland's scholarly activity centers on (1) evaluating content and instructional/learning methodology in Clinical Human Anatomy and Neuroanatomy courses, especially as relevant to clinical practice, (2) translating basic anatomical science research findings into clinically meaningful information, and (3) evaluating professionalism in students to enhance their self-awareness and improve patient care outcomes. Dr. Hoagland is also consulting editor for *Netter's Atlas of Human Anatomy,* co-author for the digital anatomy textbook *AnatomyOne,* and lead author for *Clinical Human Anatomy Dissection Guide*.

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Carlos A. G. Machado, MD

With the completion of this 8th edition, I celebrate 27 years contributing to the Netter brand of educational products, 25 years of which have been dedicated to the update—seven editions—of this highly prestigious, from birth, *Atlas of Human Anatomy*. For these 25 years I have had the privilege and honor of working with some of the most knowledgeable anatomists, educators, and consulting editors—my treasured friends—from whom I have learned considerably.

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CONTENTS

7th Edition to 8th Edition Plate Number Conversion Chart Available Online at https://tinyurl.com/Netter7to8conversion

SECTION 1 INTRODUCTION • Plates S–1 to S–14

General Anatomy • Plates S–1 to S–4

S–1 Body Planes and Terms of Relationship
S–2 Body Parts: Anterior View of Female
S–3 Body Parts: Posterior View of Male
S–4 Cross Section of Skin

Surface Anatomy • Plates S–5 to S–14

S–5 Surface Anatomy of Head and Neck
S–6 Surface Anatomy of Back
S–7 Surface Anatomy of Thorax
S–8 Surface Anatomy of Abdomen
S–9 Surface Anatomy of Pelvis
S–10 Surface Anatomy of Upper Limb
S–11 Surface Anatomy of Lower Limb
S–12 Dermatomes of Upper and Lower Limbs
S–13 Cutaneous Innervation of Upper Limb
S–14 Cutaneous Innervation of Wrist and Hand

Electronic Bonus Plates • Plates S–BP 1 to S–BP 2

S–BP 1 Pilosebaceous Apparatus
S–BP 2 Major Body Cavities

SECTION 2 NERVOUS SYSTEM AND SENSE ORGANS • Plates S–15 to S–119

Overview • Plate S–15

S–15 Overview of Nervous System

Spinal Cord • Plates S–16 to S–25

S–16 Spinal Cord and Spinal Nerves
S–17 Spinal Meninges and Nerve Roots
S–18 Spinal Nerve Roots and Vertebrae
S–19 Dermatomes
S–20 Sympathetic Nervous System: Schema
S–21 Parasympathetic Nervous System: Schema
S–22 Spinal Nerve, Roots, and Rami
S–23 Arteries of Spinal Cord: Schema
S–24 Arteries of Spinal Cord: Intrinsic Distribution
S–25 Veins of Spinal Cord and Vertebral Column

Brain • Plates S–26 to S–42

S–26 Meninges and Diploic Veins
S–27 Meningeal Arteries
S–28 Meninges and Superficial Cerebral Veins
S–29 Dural Venous Sinuses: Sagittal Section
S–30 Dural Venous Sinuses: Cranial Base
S–31 Brain: Lateral Views
S–32 Brain: Medial Views
S–33 Brain: Inferior View
S–34 Ventricles of Brain
S–35 Circulation of Cerebrospinal Fluid
S–36 Basal Nuclei
S–37 Thalamus and Related Structures
S–38 Hippocampus and Fornix
S–39 Cranial Imaging (MRI)
S–40 Brain Stem
S–41 Ventricles and Cerebellum
S–42 Cerebellum

Cerebral Vasculature • Plates S–43 to S–52

S–43 Arteries to Brain: Schema
S–44 Arteries of Brain: Inferior Views
S–45 Cerebral Arterial Circle (of Willis)
S–46 Arteries of Brain: Frontal View and Section
S–47 Arteries of Brain: Lateral and Medial Views
S–48 Arteries of Brain: Branches of Vertebral and Basilar Arteries
S–49 Veins of Posterior Cranial Fossa
S–50 Deep Veins of Brain
S–51 Subependymal Veins of Brain
S–52 Cranial Imaging (MRA and MRV)

Cranial and Cervical Nerves • Plates S–53 to S–81

S–53 Cranial Nerves: Schema of Motor and Sensory Distribution
S–54 Cranial Nerve Nuclei in Brain Stem: Schema (Posterior View)
S–55 Cranial Nerve Nuclei in Brain Stem: Schema (Medial View)
S–56 Olfactory Nerve (CN I) and Olfactory Pathways: Schema
S–57 Optic Nerve (CN II) and Visual Pathway: Schema
S–58 Oculomotor (CN III), Trochlear (CN IV), and Abducens (CN VI) Nerves: Schema
S–59 Trigeminal Nerve (CN V): Schema
S–60 Muscles, Nerves and Arteries of Face
S–61 Ophthalmic and Maxillary Nerves
S–62 Mandibular Nerve (CN V_3)
S–63 Infratemporal Fossa
S–64 Facial Nerve Branches and Parotid Gland
S–65 Facial Nerve (CN VII): Schema
S–66 Vestibulocochlear Nerve (CN VIII): Schema

S–67 Glossopharyngeal Nerve (CN IX): Schema
S–68 Vagus Nerve (CN X): Schema
S–69 Accessory Nerve (CN XI): Schema
S–70 Hypoglossal Nerve (CN XII): Schema
S–71 Orientation of Nerves and Vessels of the Cranial Base
S–72 Posterior View of Pharynx: Nerves and Vessels
S–73 Nerves of Oral and Pharyngeal Regions
S–74 Cervical Plexus: Schema
S–75 Phrenic Nerve and Relationship to Pericardium
S–76 Autonomic Nerves in Neck
S–77 Autonomic Nerves in Head
S–78 Ciliary Ganglion: Schema
S–79 Pterygopalatine and Submandibular Ganglia: Schema
S–80 Otic Ganglion: Schema
S–81 Taste Pathways: Schema

Eye • Plates S–82 to S–92

S–82 Eyelids
S–83 Lacrimal Apparatus
S–84 Extrinsic Eye Muscles
S–85 Nerves of Orbit
S–86 Superior and Anterior Views of Orbit
S–87 Arteries and Veins of Orbit and Eyelids
S–88 Eyeball: Transverse Section
S–89 Anterior and Posterior Chambers of Eyeball
S–90 Lens and Supporting Structures
S–91 Intrinsic Arteries and Veins of Eye
S–92 Vascular Supply of Eye

Ear • Plates S–93 to S–98

S–93 Ear and Course of Sound in Cochlea
S–94 External Ear and Tympanic Cavity
S–95 Tympanic Cavity
S–96 Bony and Membranous Labyrinths
S–97 Bony and Membranous Labyrinths: Schema and Section
S–98 Orientation of Labyrinths in Cranium

Nerves of Thorax • Plates S–99 to S–101

S–99 Nerves of Thorax
S–100 Typical Thoracic Spinal Nerve
S–101 Autonomic Nerves of Thorax

Nerves of Abdomen • Plates S–102 to S–105

S–102 Nerves of Anterior Abdominal Wall
S–103 Nerves of Posterior Abdominal Wall
S–104 Lumbosacral Plexus
S–105 Autonomic Nerves and Ganglia of Abdomen

Nerves of Upper Limb • Plates S–106 to S–112

S–106 Brachial Plexus: Schema
S–107 Nerves of Upper Limb
S–108 Musculocutaneous Nerve
S–109 Median Nerve
S–110 Ulnar Nerve
S–111 Radial Nerve in Arm and Nerves of Posterior Shoulder
S–112 Radial Nerve in Forearm and Hand

Nerves of Lower Limb • Plates S–113 to S–119

S–113 Lumbar Plexus
S–114 Sacral and Coccygeal Plexuses
S–115 Femoral Nerve and Lateral Femoral Cutaneous Nerve
S–116 Obturator Nerve
S–117 Sciatic Nerve and Posterior Femoral Cutaneous Nerve
S–118 Tibial Nerve
S–119 Common Fibular Nerve

Structures with High Clinical Significance • Tables 2.1–2.3

Cranial Nerves • Tables 2.4– 2.7

Branches of Cervical Plexus • Table 2.8

Nerves of Brachial Plexus • Tables 2.9–2.11

Nerves of Lumbosacral Plexus • Tables 2.12–2.14

Electronic Bonus Plates • S–BP 3 to S–BP 18

S–BP 3 Neurons and Synapses
S–BP 4 Features of a Typical Peripheral Nerve
S–BP 5 Sites of Visceral Referred Pain
S–BP 6 Afferent Innervation of Oral Cavity and Pharynx
S–BP 7 Fasciae of Orbit and Eyeball
S–BP 8 Tympanic Cavity: Medial and Lateral Views
S–BP 9 Anatomy of the Pediatric Ear
S–BP 10 Auditory Tube (Eustachian)
S–BP 11 Cranial Imaging (MRV and MRA)
S–BP 12 Axial and Coronal MRIs of Brain
S–BP 13 Sympathetic Nervous System: General Topography
S–BP 14 Parasympathetic Nervous System: General Topography
S–BP 15 Cholinergic and Adrenergic Synapses: Schema
S–BP 16 Spinal Cord Cross Sections: Fiber Tracts
S–BP 17 Somatosensory System: Trunk and Limbs
S–BP 18 Pyramidal System

Section 3 Skeletal System • Plates S–120 to S–182

Overview • Plates S–120 to S–121

S–120 Overview of Skeletal System
S–121 Types of Synovial Joints

Cranium, Mandible, and Temporomandibular Joint • Plates S–122 to S–136

S–122 Skeleton of Nose
S–123 Skull: Anterior View
S–124 Skull: Radiographs
S–125 Skull: Lateral View
S–126 Skull: Lateral Radiograph
S–127 Cranium of Newborn
S–128 Calvaria
S–129 Skull: Midsagittal Section
S–130 Cranium: Posterior and Lateral Views
S–131 Cranial Base: Inferior View
S–132 Cranial Base: Superior View
S–133 Foramina and Canals of Cranial Base: Inferior View
S–134 Foramina and Canals of Cranial Base: Superior View
S–135 Mandible
S–136 Temporomandibular Joint

Vertebral Column • Plates S–137 to S–148

S–137 Vertebral Column
S–138 Vertebrae: Radiograph and MRI
S–139 Cervical Part of Spinal Column
S–140 Cervical Vertebrae: Atlas and Axis
S–141 External Craniocervical Ligaments
S–142 Internal Craniocervical Ligaments
S–143 Cervical Vertebrae
S–144 Thoracic Vertebrae
S–145 Lumbar Vertebrae
S–146 Sacrum and Coccyx
S–147 Ligaments of Vertebral Column: Lumbosacral Region
S–148 Joints of Vertebral Column: Lumbar Region

Thoracic Skeleton • Plates S–149 to S–150

S–149 Bony Framework of Thorax
S–150 Ribs and Associated Joints

Bony Pelvis • Plates S–151 to S–154

S–151 Bony Framework of Abdomen
S–152 Ligaments of Bony Pelvis
S–153 Hip Bone
S–154 Ligaments of Hip Bone

Upper Limb • Plates S–155 to S–169

S–155 Humerus and Scapula
S–156 Clavicle and Sternoclavicular Joint
S–157 Joints of Shoulder
S–158 Shoulder: Anteroposterior Radiograph
S–159 Bones of Elbow
S–160 Elbow: Radiographs
S–161 Ligaments of Elbow
S–162 Bones of Forearm
S–163 Carpal Bones
S–164 Movements of Wrist
S–165 Ligaments of Wrist: Anterior View
S–166 Ligaments of Wrist: Posterior View
S–167 Bones of Hand
S–168 Wrist and Hand: Radiographs
S–169 Metacarpophalangeal and Interphalangeal Ligaments

Lower Limb • Plates S–170 to S–182

S–170 Hip Joint
S–171 Hip Joint: Anteroposterior Radiograph
S–172 Femur
S–173 Knee: Cruciate and Collateral Ligaments
S–174 Tibia and Fibula: Anterior and Posterior Views
S–175 Tibia and Fibula: Additional Views and Cross Section
S–176 Bones of Foot: Superior and Inferior Views
S–177 Bones of Foot: Lateral View
S–178 Calcaneus
S–179 Ankle: Radiographs
S–180 Ligaments of Ankle and Foot
S–181 Ligaments of Foot: Plantar View
S–182 Hip: MRI and 3D CT

Structures with High Clinical Significance • Tables 3.1–3.3

Electronic Bonus Plates • Plates S–BP 19 to S–BP 33

S–BP 19 3D Skull Reconstruction CTs
S–BP 20 Degenerative Changes in Cervical Vertebrae
S–BP 21 Atlantooccipital Junction
S–BP 22 Cervical Spine: Radiographs
S–BP 23 Cervical Spine: MRI and Radiograph
S–BP 24 Lumbar Vertebrae: Radiographs
S–BP 25 Lumbar Spine: MRIs
S–BP 26 Ligaments of Vertebral Column
S–BP 27 Vertebral Veins: Detail Showing Venous Communications
S–BP 28 Thoracolumbar Spine: Lateral Radiograph
S–BP 29 Ligaments of Wrist: Posterior and Anterior Views
S–BP 30 Joints: Connective Tissues and Articular Cartilage

S–BP 31 Architecture of Bone
S–BP 32 Osteology of Knee
S–BP 33 Knee Radiograph: Lateral View

SECTION 4 MUSCULAR SYSTEM • Plates S–183 to S–301

Overview • Plate S–183

S–183 Overview of Muscular System

Head and Neck • Plates S–184 to S–197

S–184 Muscles of Facial Expression: Lateral View
S–185 Cutaneous Nerves of Head and Neck
S–186 Muscles of Mastication: Masseter and Temporalis Muscle
S–187 Muscles of Mastication: Pterygoid Muscles
S–188 Temporal and Infratemporal Fossa
S–189 Maxillary Artery
S–190 Muscles of Neck: Anterior View
S–191 Infrahyoid and Suprahyoid Muscles
S–192 Muscles of Neck: Lateral View
S–193 Anterior and Lateral Cervical Muscles
S–194 Nerves of Neck
S–195 Nerves of Neck and Cervical Plexus
S–196 Fascial Layers of Neck
S–197 Cervical Fasciae

Back • Plates S–198 to S–202

S–198 Nerves of Back
S–199 Muscles of Back: Superficial Layer
S–200 Muscles of Back: Intermediate Layer
S–201 Muscles of Back: Deep Layer
S–202 Nerves of Back of Neck

Thorax • Plates S–203 to S–208

S–203 Anterior Thoracic Wall: Superficial Dissection
S–204 Anterior Thoracic Wall: Deeper Dissection
S–205 Anterior Thoracic Wall: Internal View
S–206 Intercostal Nerves and Arteries
S–207 Diaphragm: Thoracic Surface
S–208 Diaphragm: Abdominal Surface

Abdomen and Pelvis • Plates S–209 to S–226

S–209 Intercostal Nerves
S–210 Posterolateral Abdominal Wall
S–211 Anterior Abdominal Wall: Superficial Dissection
S–212 Anterior Abdominal Wall: Intermediate Dissection

S–213 Anterior Abdominal Wall: Deep Dissection
S–214 Rectus Sheath: Cross Section
S–215 Inguinal Canal and Spermatic Cord
S–216 Inguinal Region: Dissections
S–217 Anterior Abdominal Wall: Internal View
S–218 Femoral Sheath and Inguinal Canal
S–219 Posterior Abdominal Wall: Internal View
S–220 Pelvic Diaphragm: Female
S–221 Rectum in Situ: Female and Male
S–222 Perineal and Pelvic Extraperitoneal Spaces: Actual and Potential
S–223 Anorectal Musculature
S–224 External Anal Sphincter: Perineal Views
S–225 Ischioanal Fossae
S–226 Rectum and Anal Canal

Upper Limb • Plates S–227 to S–264

S–227 Arteries and Nerves of Upper Limb: Anterior View
S–228 Superficial Veins of Proximal Upper Limb
S–229 Superficial Veins of Forearm and Hand
S–230 Muscles of Shoulder
S–231 Pectoral, Clavipectoral, and Axillary Fasciae
S–232 Rotator Cuff Muscles
S–233 Shoulder MRI and CT
S–234 Axillary Artery and Anastomoses Around Scapula
S–235 Shoulder Region
S–236 Axilla: Posterior Wall
S–237 Axilla: Anterior View
S–238 Brachial Artery in Situ
S–239 Muscles of Arm: Anterior Compartment
S–240 Muscles of Arm: Posterior Compartment
S–241 Muscles of Forearm: Deep Part of Posterior Compartment
S–242 Muscles of Forearm: Superficial Part of Posterior Compartment
S–243 Muscles of Forearm: Extensors of Wrist and Digits
S–244 Muscles of Forearm: Superficial Part of Anterior Compartment
S–245 Muscles of Forearm: Flexors of Wrist
S–246 Muscles of Forearm: Flexors of Digits
S–247 Muscles of Forearm: Anterior Compartment
S–248 Muscles of Forearm: Pronators and Supinator
S–249 Muscles of Forearm: Deep Part of Anterior Compartment
S–250 Wrist and Hand: Superficial Palmar Dissections
S–251 Wrist and Hand: Deeper Palmar Dissections
S–252 Lumbrical Muscles, Midpalmar and Thenar Spaces, and Tendon Sheaths
S–253 Flexor Tendons, Arteries, and Nerves at Wrist

S–254 Spaces and Tendon Sheaths of Hand
S–255 Flexor and Extensor Tendons in Fingers
S–256 Muscles of Hand
S–257 Arteries of Hand: Palmar Views
S–258 Wrist and Hand: Superficial Dorsal Dissection
S–259 Wrist and Hand: Superficial Lateral Dissection
S–260 Extensor Tendons at Wrist
S–261 Nerves and Arteries of Dorsal Hand and Wrist
S–262 Attachments of Muscles of Forearm: Anterior View
S–263 Attachments of Muscles of Forearm: Posterior View
S–264 Muscle Attachment Sites of Humerus, Scapula, and Clavicle

Lower Limb • Plates S–265 to S–301

S–265 Segmental Motor Nerve Function
S–266 Superficial Veins of Lower Limb: Anterior View
S–267 Superficial Veins of Lower Limb: Posterior View
S–268 Muscles of Thigh: Anterior Compartment
S–269 Muscles of Thigh: Medial Compartment
S–270 Arteries of Thigh: Anterior Views
S–271 Arteries of Thigh: Anterior Views of Deeper Dissection
S–272 Muscles of Hip and Thigh: Lateral View
S–273 Muscles of Hip and Thigh: Posterior Views
S–274 Arteries of Thigh: Posterior View
S–275 Nerves of Buttock
S–276 Hip Bursae: Posterior and Anterolateral Views
S–277 Psoas and Iliacus Muscle
S–278 Arteries of Femoral Head and Neck
S–279 Knee: Medial and Lateral Views
S–280 Knee: Anterior Views
S–281 Knee: Interior Views
S–282 Knee: Posterior and Sagittal Views
S–283 Knee: Anteroposterior Radiograph and Posterior View
S–284 Muscles of Leg: Superficial Part of Posterior Compartment
S–285 Muscles of Leg: Superficial Part of Posterior Compartment (Partial Dissection)
S–286 Muscles of Leg: Deep Part of Posterior Compartment
S–287 Muscles of Leg: Lateral Compartment
S–288 Muscles of Leg: Anterior Compartment
S–289 Muscles of Leg: Anterior Compartment (Continued)
S–290 Tendon Sheaths of Ankle
S–291 Muscles of Dorsum of Foot: Superficial Dissection
S–292 Muscles of Dorsum of Foot: Deep Dissection
S–293 Sole of Foot: Superficial Dissection
S–294 Muscles of Sole of Foot: First Layer
S–295 Muscles of Sole of Foot: Second Layer
S–296 Muscles of Sole of Foot: Third Layer
S–297 Interosseous Muscles and Deep Arteries of Foot

S–298 Interosseous Muscles of Foot
S–299 Attachments of Muscles of Leg
S–300 Attachments of Muscles of Hip and Thigh: Anterior View
S–301 Attachments of Muscles of Hip and Thigh: Posterior View

Structures with High Clinical Significance • Tables 4.1–4.3

Electronic Bonus Plates • Plates S–BP 34 to S–BP 43

S–BP 34 Muscle Structure
S–BP 35 Muscles of Facial Expression: Anterior View
S–BP 36 Musculature of Face
S–BP 37 Opening of the Mandible
S–BP 38 Cervical Ribs and Related Variations
S–BP 39 Muscle Attachments of Ribs
S–BP 40 Inguinal and Femoral Regions
S–BP 41 Indirect Inguinal Hernia
S–BP 42 Flexor and Extensor Zones of Hand
S–BP 43 Foot: Nerves and Arteries

Section 5 Cardiovascular System • Plates S–302 to S–342

Overview • Plates S–302 to S–306

S–302 Overview of Cardiovascular System
S–303 Major Arteries and Pulse Points
S–304 Major Systemic Veins of the Cardiovascular System
S–305 Prenatal and Postnatal Circulation
S–306 Heart and Precordial Areas of Auscultation

Pericardium • Plates S–307 to S–308

S–307 Heart in Situ
S–308 Pericardial Sac and Pericardial Cavity

Heart • Plates S–309 to S–321

S–309 Heart: Anterior Exposure
S–310 Heart: Base and Diaphragmatic Surface
S–311 Right Atrium and Ventricle
S–312 Left Atrium and Ventricle
S–313 Heart Valves
S–314 Valvular Complex of Heart
S–315 Valvular Complex of Heart (Continued)
S–316 Atria, Ventricles, and Interventricular Septum
S–317 Coronary Arteries and Cardiac Veins
S–318 Coronary Arteries: Imaging

S–319 Conducting System of Heart
S–320 Innervation of Heart: Schema
S–321 Heart: Radiographs and CT Angiogram

Blood Vessels of the Head and Neck • Plates S–322 to S–330

S–322 Superficial Arteries and Veins of Face and Scalp
S–323 Arteries of Head and Neck
S–324 Carotid Arteries
S–325 Superficial Temporal and Maxillary Arteries
S–326 Arteries to Brain and Meninges
S–327 Internal Carotid Artery in Petrous Part of Temporal Bone
S–328 Veins of Head and Neck
S–329 Superficial Veins of Neck
S–330 Veins of Vertebral Column: Vertebral Veins

Blood Vessels of the Limbs • Plates S–331 to S–335

S–331 Arteries of Upper Limb
S–332 Veins of Upper Limb
S–333 Arteries of Lower Limb
S–334 Veins of Lower Limb
S–335 Veins of Leg

Blood Vessels of the Trunk • Plates S–336 to S–342

S–336 Arteries of Anterior Abdominal Wall
S–337 Veins of Anterior Abdominal Wall
S–338 Veins of Thoracic Wall
S–339 Arteries of Esophagus
S–340 Veins of Esophagus
S–341 Arteries of Posterior Abdominal Wall
S–342 Veins of Posterior Abdominal Wall

Structures with High Clinical Significance • Tables 5.1–5.5

Electronic Bonus Plates • Plates S–BP 44 to S–BP 53

S–BP 44 Cardiovascular System: Composition of Blood
S–BP 45 Arterial Wall
S–BP 46 Innervation of Blood Vessels: Schema
S–BP 47 Coronary Arteries: Right Anterolateral Views with Arteriograms
S–BP 48 Coronary Arteries and Cardiac Veins: Variations
S–BP 49 Subclavian Artery
S–BP 50 Arteries of Arm and Proximal Forearm
S–BP 51 Arteries of Forearm and Hand
S–BP 52 Arteries of Knee and Foot
S–BP 53 Arteries of Thigh and Knee

Section 6 Lymph Vessels and Lymphoid Organs • Plates S–343 to S–357

Overview • Plate S–343

S–343 Overview of Lymph Vessels and Lymphoid Organs

Head and Neck • Plates S–344 to S–345

S–344 Lymph Nodes of Head and Neck
S–345 Lymph Nodes of Pharynx and Tongue

Limbs • Plates S–346 to S–347

S–346 Lymph Vessels and Lymph Nodes of Upper Limb
S–347 Lymph Vessels and Lymph Nodes of Lower Limb

Trunk • Plates S–348 to S–357

S–348 Lymph Vessels and Lymph Nodes of Breast
S–349 Lymphatic Drainage of Breast
S–350 Lymph Vessels of Thorax and Pulmonary and Mediastinal Lymph Nodes
S–351 Lymph Vessels and Lymph Nodes of Esophagus
S–352 Lymph Vessels and Lymph Nodes of Posterior Abdominal Wall
S–353 Lymphatic Drainage of Abdomen and Pelvis: Schema
S–354 Lymph Vessels and Lymph Nodes of Kidneys and Urinary Bladder
S–355 Lymph Vessels and Lymph Nodes of Pelvis and Genitalia: Female
S–356 Inguinal Nodes and Lymph Vessels of Perineum: Female
S–357 Lymph Vessels and Lymph Nodes of Pelvis and Genitalia: Male

Structures with High Clinical Significance • Table 6.1

Electronic Bonus Plates • Plates S–BP 54 to S–BP 58

S–BP 54 Lymph Vessels and Lymph Nodes of Stomach
S–BP 55 Lymph Vessels and Lymph Nodes of Pancreas
S–BP 56 Lymph Vessels and Lymph Nodes of Small Intestine
S–BP 57 Lymph Vessels and Lymph Nodes of Large Intestine
S–BP 58 Lymph Vessels and Lymph Nodes of Liver

Section 7 Respiratory System • Plates S–358 to S–393

Overview • Plates S–358 to S–359

S–358 Overview of Respiratory System
S–359 Bony Framework of Head and Neck

Nasal Cavity • Plates S–360 to S–362

S–360 Medial Wall of Nasal Cavity (Nasal Septum)
S–361 Lateral Wall of Nasal Cavity
S–362 Lateral Wall of Nasal Cavity of Cranium

Vasculature and Innervation of Nasal Cavity • Plates S–363 to S–366

S–363 Vasculature of Nasal Cavity
S–364 Nerves of Nasal Cavity
S–365 Nerves of Nasal Cavity: Bony Nasal Septum Turned Up
S–366 Autonomic Innervation of Nasal Cavity

Paranasal Sinuses • Plates S–367 to S–371

S–367 Nasal Skeleton and Paranasal Sinuses
S–368 Paranasal Sinuses: Coronal and Transverse Sections
S–369 Paranasal Sinuses: Paramedian Views
S–370 Paranasal Sinuses: Changes with Age
S–371 Nerves and Arteries of the Midface

Pharynx • Plates S–372 to S–374

S–372 Pharynx: Medial View
S–373 Pharynx: Opened Posterior View
S–374 Pharyngoesophageal Junction

Larynx • Plates S–375 to S–378

S–375 Cartilages of Larynx
S–376 Intrinsic Muscles of Larynx
S–377 Action of Intrinsic Muscles of Larynx
S–378 Nerves and Coronal Section of Larynx

Trachea and Bronchi • Plates S–379 to S–382

S–379 Trachea and Major Bronchi
S–380 Bronchi and Intrapulmonary Airways
S–381 Bronchopulmonary Segments: Anterior and Posterior Views
S–382 Bronchopulmonary Segments: Medial and Lateral Views

Vasculature and Innervation of Tracheobronchial Tree • Plates S–383 to S–384

S–383 Bronchial Arteries and Veins
S–384 Innervation of Tracheobronchial Tree: Schema

Lungs • Plates S–385 to S–388

S–385 Lungs in Thorax: Anterior View
S–386 Lungs in Thorax: Posterior View
S–387 Lungs in Situ: Anterior View
S–388 Lungs: Medial Views

Vasculature and Innervation of Mediastinum • Plates S–389 to S–393

S–389 Great Vessels of Mediastinum
S–390 Mediastinum: Right Lateral View
S–391 Mediastinum: Left Lateral View
S–392 Intrapulmonary Blood Circulation: Schema
S–393 Phrenic Nerve

Structures with High Clinical Significance • Table 7.1

Electronic Bonus Plates • Plates S–BP 59 to S–BP 64

S–BP 59 Arteries of Nasal Cavity: Bony Nasal Septum Turned Up
S–BP 60 Nose and Maxillary Sinus: Transverse Section
S–BP 61 Paranasal Sinuses
S–BP 62 Intrapulmonary Airways: Schema
S–BP 63 Anatomy of Ventilation and Respiration
S–BP 64 Muscles of Respiration

Section 8 Digestive System • Plates S–394 to S–457

Overview • Plates S–394 to S–395

S–394 Overview of Digestive System
S–395 Regions and Planes of Abdomen

Mouth • Plates S–396 to S–406

S–396 Salivary Glands
S–397 Inspection of Oral Cavity
S–398 Roof of Oral Cavity
S–399 Suprahyoid Muscles
S–400 Tongue and Salivary Glands: Sections
S–401 Tongue
S–402 Dorsum of Tongue
S–403 Fauces
S–404 Teeth
S–405 Tooth
S–406 Afferent Innervation of Oral Cavity and Tongue

Pharynx • Plates S–407 to S–409

S–407 Muscles of Pharynx: Lateral View
S–408 Muscles of Pharynx: Medial View
S–409 Muscles of Pharynx: Partially Opened Posterior View

Viscera (Esophagus, Stomach, Intestines, Liver, Pancreas) • Plates S–410 to S–434

S–410 Esophagus in Situ
S–411 Esophagus: Constrictions and Relations
S–412 Musculature of Esophagus

S–413 Esophagogastric Junction
S–414 Mucosa of Stomach
S–415 Stomach in Situ
S–416 Omental Bursa: Stomach Reflected
S–417 Omental Bursa: Cross Section
S–418 Abdominal Wall and Viscera: Paramedian Section
S–419 Peritoneum of Posterior Abdominal Wall
S–420 Duodenum in Situ
S–421 Mucosa and Musculature of Small Intestine
S–422 Mesenteries and Suspensory Muscle of Duodenum
S–423 Greater Omentum and Abdominal Viscera
S–424 Mesocolons and Root of Mesentery
S–425 Ileocecal Junction
S–426 Cecum and Ileal Orifice
S–427 Vermiform Appendix
S–428 Mucosa and Musculature of Large Intestine
S–429 Surfaces and Bed of Liver
S–430 Liver in Situ: Vascular and Duct Systems
S–431 Liver Structure: Schema
S–432 Gallbladder, Extrahepatic Bile Ducts, and Pancreatic Duct
S–433 Pancreas in Situ
S–434 Spleen

Visceral Vasculature • Plates S–435 to S–446

S–435 Arteries of Stomach, Liver, and Spleen
S–436 Arteries of Liver, Pancreas, Duodenum, and Spleen
S–437 Celiac Arteriogram and CT Angiogram
S–438 Arteries of Duodenum and Head of Pancreas
S–439 Arteries of Small Intestine
S–440 Arteries of Large Intestine
S–441 Arteries of Rectum and Anal Canal: Male Posterior View
S–442 Veins of Stomach, Duodenum, Pancreas, and Spleen
S–443 Veins of Small Intestine
S–444 Veins of Large Intestine
S–445 Veins of Rectum and Anal Canal: Female Anterior View
S–446 Hepatic Portal Vein, Tributaries and Portacaval Anastomoses

Visceral Innervation • Plates S–447 to S–457

S–447 Nerves of Esophagus
S–448 Autonomic Innervation of Stomach and Duodenum
S–449 Autonomic Innervation of Stomach and Duodenum (Continued)
S–450 Autonomic Innervation of Esophagus, Stomach, and Duodenum: Schema
S–451 Autonomic Innervation of Small Intestine
S–452 Autonomic Innervation of Large Intestine
S–453 Autonomic Innervation of Intestine: Schema

S–454 Autonomic Reflex Pathways: Schema
S–455 Enteric Plexuses of Intestine
S–456 Autonomic Innervation of Liver: Schema
S–457 Autonomic Innervation of Pancreas: Schema

Structures with High Clinical Significance • Table 8.1

Electronic Bonus Plates • Plates S–BP 65 to S–BP 82

S–BP 65 Intrinsic Nerves and Variations in Nerves of Esophagus
S–BP 66 Arteries of Esophagus: Variations
S–BP 67 Variations in Position and Contour of Stomach in Relation to Body Habitus
S–BP 68 Layers of Duodenal Wall
S–BP 69 CT and MRCP Showing Vermiform Appendix, Gallbladder, and Ducts; Nerve Branches on Hepatic Artery
S–BP 70 Topography of Liver
S–BP 71 Variations in Form of Liver
S–BP 72 Sigmoid Colon: Variations in Position
S–BP 73 Variations in Pancreatic Duct
S–BP 74 Variations in Cystic, Hepatic, and Pancreatic Ducts
S–BP 75 Variations in Cystic Arteries
S–BP 76 Variations in Hepatic Arteries
S–BP 77 Arterial Variations and Collateral Supply of Liver and Gallbladder
S–BP 78 Variations and Anomalies of Hepatic Portal Vein
S–BP 79 Variations in Celiac Trunk
S–BP 80 Variations in Arterial Supply to Cecum and Posterior Peritoneal Attachment of Cecum
S–BP 81 Variations in Colic Arteries
S–BP 82 Variations in Colic Arteries (Continued)

SECTION 9 URINARY SYSTEM • Plates S–458 to S–471

Overview • Plate S–458

S–458 Overview of Urinary System

Kidneys and Ureter • Plates S–459 to S–463

S–459 Kidneys in Situ: Anterior Views
S–460 Kidneys in Situ: Posterior Views
S–461 Renal Fascia
S–462 Gross Structure of Kidney
S–463 Ureters in Abdomen and Pelvis

Urinary Bladder and Urethra • Plates S–464 to S–466

S–464 Urinary Bladder: Orientation and Supports
S–465 Urinary Bladder: Female and Male
S–466 Female Urethral Sphincters

Vasculature and Innervation • Plates S–467 to S–471

S–467 Intrarenal Arteries and Renal Segments
S–468 Arteries of Ureters and Urinary Bladder
S–469 Autonomic Nerves of Kidneys, Ureters, and Urinary Bladder
S–470 Autonomic Innervation of Kidneys and Abdominal Part of Ureters: Schema
S–471 Innervation of Urinary Bladder and Lower Ureter: Schema

Structures with High Clinical Significance • Table 9.1

Electronic Bonus Plates • Plates S–BP 83 to S–BP 88

S–BP 83 Histology of Renal Corpuscle
S–BP 84 Nephron and Collecting Tubule: Schema
S–BP 85 Blood Vessels in Parenchyma of Kidney: Schema
S–BP 86 Female Urethra
S–BP 87 Cystourethrograms: Male and Female
S–BP 88 Variations in Renal Artery and Vein

Section 10 Reproductive System • Plates S–472 to S–521

Overview • Plate S–472

S–472 Overview of Reproductive System

Mammary Glands • Plates S–473 to S–474

S–473 Mammary Glands
S–474 Arteries of Breast

Bony Pelvis • Plates S–475 to S–478

S–475 Bony Framework of Pelvis
S–476 Male and Female Pelvis: Radiographs
S–477 Sex Differences of Bony Pelvis: Measurements
S–478 Uterus: Fascial Ligaments

Pelvic Diaphragm and Pelvic Cavity • Plates S–479 to S–484

S–479 Pelvic Diaphragm (Female): Medial and Superior Views
S–480 Pelvic Diaphragm (Female): Inferior Views
S–481 Pelvic Diaphragm (Male): Superior View
S–482 Pelvic Diaphragm (Male): Inferior View
S–483 Pelvic Cavity: Female
S–484 Pelvic Cavity: Male

Female Internal Genitalia • Plates S–485 to S–490

S–485 Pelvic Viscera and Perineum: Female

S–486 Pelvic Viscera: Female
S–487 Uterus and Adnexa
S–488 Uterus, Vagina, and Supporting Structures
S–489 Pelvic Ligaments
S–490 Endopelvic Fascia

Female Perineum and External Genitalia • Plates S–491 to S–494

S–491 Female Perineum and External Genitalia
S–492 Female Perineum (Superficial Dissection)
S–493 Female Perineum (Deeper Dissection)
S–494 Female Perineal Spaces

Male Internal Genitalia • Plates S–495 to S–499

S–495 Pelvic Viscera and Perineum: Male
S–496 Prostate and Seminal Gland
S–497 Scrotum and Contents
S–498 Testis, Epididymis, and Ductus Deferens
S–499 Descent of Testis

Male Perineum and External Genitalia • Plates S–500 to S–504

S–500 Male Perineum and External Genitalia (Superficial Dissection)
S–501 Male Perineum and External Genitalia (Deeper Dissection)
S–502 Penis
S–503 Urethra
S–504 Male Perineal Spaces

Homologies of Male and Female Genitalia • Plates S–505 to S–506

S–505 Homologues of Internal Genitalia
S–506 Homologues of External Genitalia

Vasculature • Plates S–507 to S–512

S–507 Arteries of Pelvis: Female
S–508 Arteries and Veins of Pelvic Viscera: Female Anterior View
S–509 Arteries and Veins of Pelvis: Male
S–510 Arteries and Veins of Testis: Anterior View
S–511 Arteries and Veins of Perineum and Uterus
S–512 Arteries and Veins of Perineum: Male

Innervation • Plates S–513 to S–520

S–513 Nerves of Pelvic Viscera: Female
S–514 Neuropathways in Parturition
S–515 Innervation of Female Reproductive Organs: Schema
S–516 Nerves of Perineum and External Genitalia: Female
S–517 Nerves of Pelvic Viscera: Male
S–518 Nerves of External Genitalia: Male

S–519 Innervation of Male Reproductive Organs: Schema
S–520 Nerves of Perineum: Male

Imaging of Pelvic Viscera • Plate S–521

S–521 Pelvic Scans: Sagittal T2-Weighted MRIs

Structures with High Clinical Significance • Table 10.1

Electronic Bonus Plates • Plates S–BP 89 to S–BP 94

S–BP 89 Genetics of Reproduction
S–BP 90 Fasciae of Pelvis and Perineum: Male and Female
S–BP 91 Uterine Development
S–BP 92 Variations in Hymen
S–BP 93 Cross Section of Pelvis Through Prostate
S–BP 94 Arteries and Veins of Pelvis: Male (Featuring Prostate)

Section 11 Endocrine System • Plates S–522 to S–533

Overview • Plate S–522

S–522 Overview of Endocrine System

Hypothalamus and Pituitary Gland • Plates S–523 to S–524

S–523 Vasculature of Hypothalamus and Hypophysis
S–524 Hypothalamus and Hypophysis

Thyroid and Parathyroid Glands • Plates S–525 to S–527

S–525 Thyroid Gland: Anterior View
S–526 Thyroid Gland: Posterior View
S–527 Thyroid and Parathyroid Glands

Pancreas • Plate S–528

S–528 Celiac Trunk and Branches

Ovary and Testis • Plates S–529 to S–530

S–529 Female Internal Genital Organs
S–530 Testes

Suprarenal Gland • Plates S–531 to S–533

S–531 Suprarenal Glands
S–532 Arteries and Veins of Suprarenal Glands in Situ
S–533 Autonomic Nerves of Suprarenal Glands: Dissection and Schema

Structures with High Clinical Significance • Table 11.1

Electronic Bonus Plates • Plates S–BP 95 to S–BP 97

S–BP 95 Menstrual Cycle
S–BP 96 Ovary, Oocytes, and Follicles
S–BP 97 Endocrine Glands, Hormones, and Puberty

Section 12 Cross-Sectional Anatomy and Imaging • Plates S–534 to S–556

Thorax • Plates S–534 to S–540

S–534 Thorax: Coronal Section of Heart and Ascending Aorta
S–535 Cross Section of Thorax at T3 Vertebral Level
S–536 Cross Section of Thorax at T3/T4 Disc Level
S–537 Cross Section of Thorax at T4/T5 Disc Level
S–538 Cross Section of Thorax at T7 Vertebral Level
S–539 Mediastinum: Cross Section
S–540 Thorax: Axial CT Images

Abdomen • Plates S–541 to S–548

S–541 Cross Section at T10 Vertebral Level, Through Esophagogastric Junction
S–542 Cross Section at T12 Vertebral Level, Inferior to Xiphoid Process
S–543 Cross Section at T12/L1 Disc Level
S–544 Cross Section at L1/L2 Disc Level
S–545 Lumbar Region of Back: Cross Section
S–546 Cross Section at L3/L4 Disc Level
S–547 Abdominal Scans: Axial CT Images
S–548 Abdominal Scans: Axial CT Images (Continued)

Pelvis • Plates S–549 to S–550

S–549 Male Pelvis: Cross Section of Bladder–Prostate Junction
S–550 Female Pelvis: Cross Section of Vagina and Urethra

Upper Limb • Plates S–551 to S–553

S–551 Arm: Serial Cross Sections
S–552 Forearm: Serial Cross Sections
S–553 Fingers

Lower Limb • Plates S–554 to S–556

S–554 Thigh: Serial Cross Sections
S–555 Leg: Cross Sections and Compartments
S–556 Cross Section of Foot

Electronic Bonus Plates • Plates S–BP 98 to S–BP 112

S–BP 98 Thorax: Coronal Section
S–BP 99 Thorax: Coronal CTs
S–BP 100 Schematic Cross Section of Abdomen at T12 Vertebral Level
S–BP 101 Axial CT Image of Upper Abdomen
S–BP 102 Transverse Section of Abdomen: L5 Vertebral Level, Near Transtubercular Plane
S–BP 103 Transverse Section of Abdomen: S1 Vertebral Level, Anterior Superior Iliac Spine
S–BP 104 Cross Section of Lower Pelvis
S–BP 105 Cross Sections Through Metacarpal and Distal Carpal Bones
S–BP 106 Cross Section of Hand: Axial View
S–BP 107 Cross Section of Hand: Axial View (Continued)
S–BP 108 Cross-Sectional Anatomy of Hip: Axial View
S–BP 109 Leg: Serial Cross Sections
S–BP 110 Cross-Sectional Anatomy of Ankle and Foot
S–BP 111 Cross-Sectional Anatomy of Ankle and Foot (Continued)
S–BP 112 Anatomy of the Toenail

Appendix

Appendix A Muscles Tables A.1 to A.18

References

Index

Available Online (see inside front cover)

Bonus Plates
Study Guides
Self-Assessments

e–Appendix B Plate Pearls

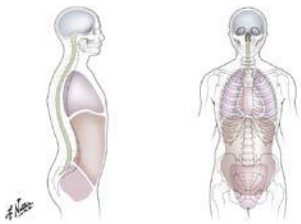
e–Appendix C Study Guides

INTRODUCTION 1

General Anatomy S–1 to S–4
Surface Anatomy S–5 to S–14
Electronic Bonus Plates S–BP 1 to S–BP 2

ELECTRONIC BONUS PLATES

S–BP 1 Pilosebaceous Apparatus



S–BP 2 Major Body Cavities

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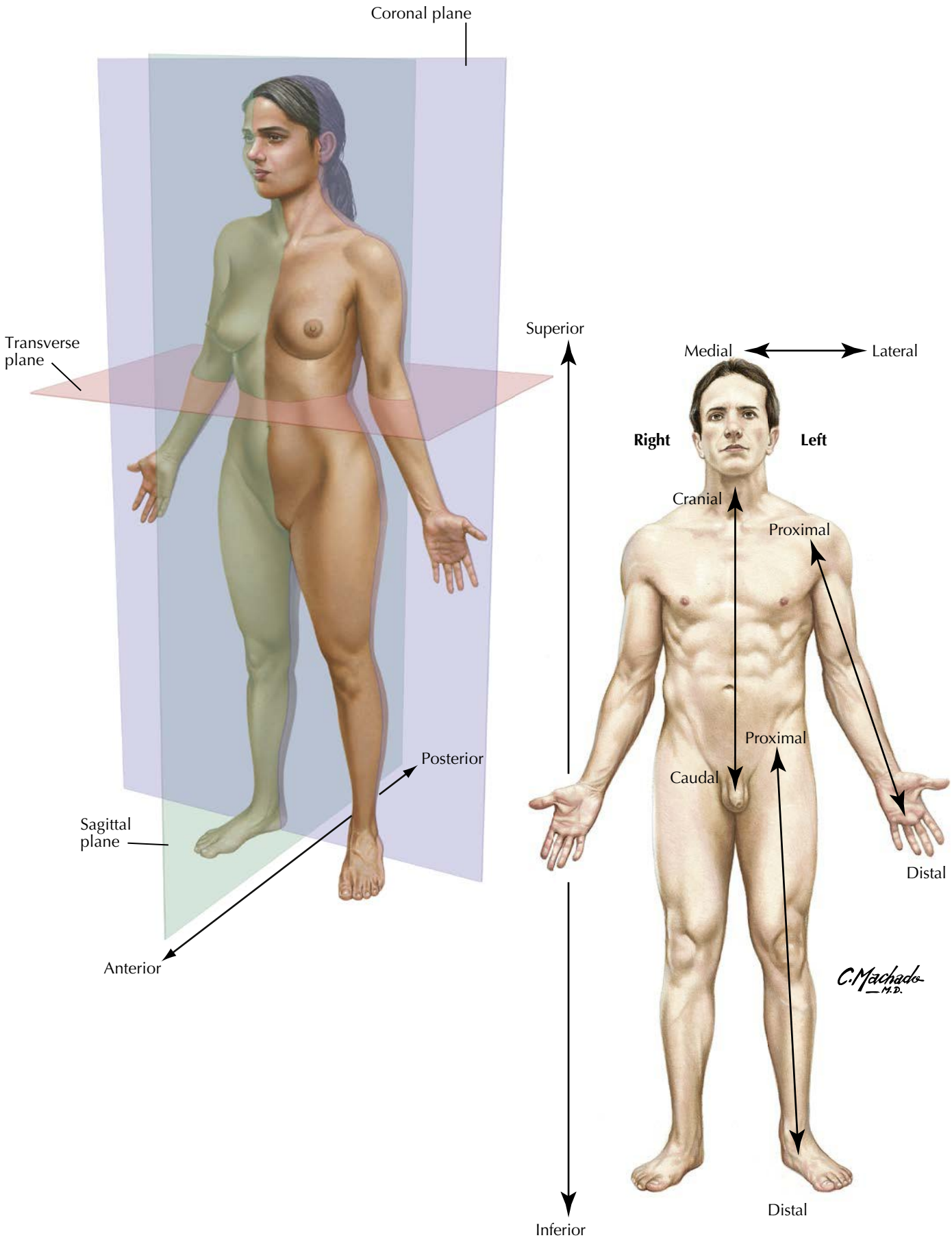
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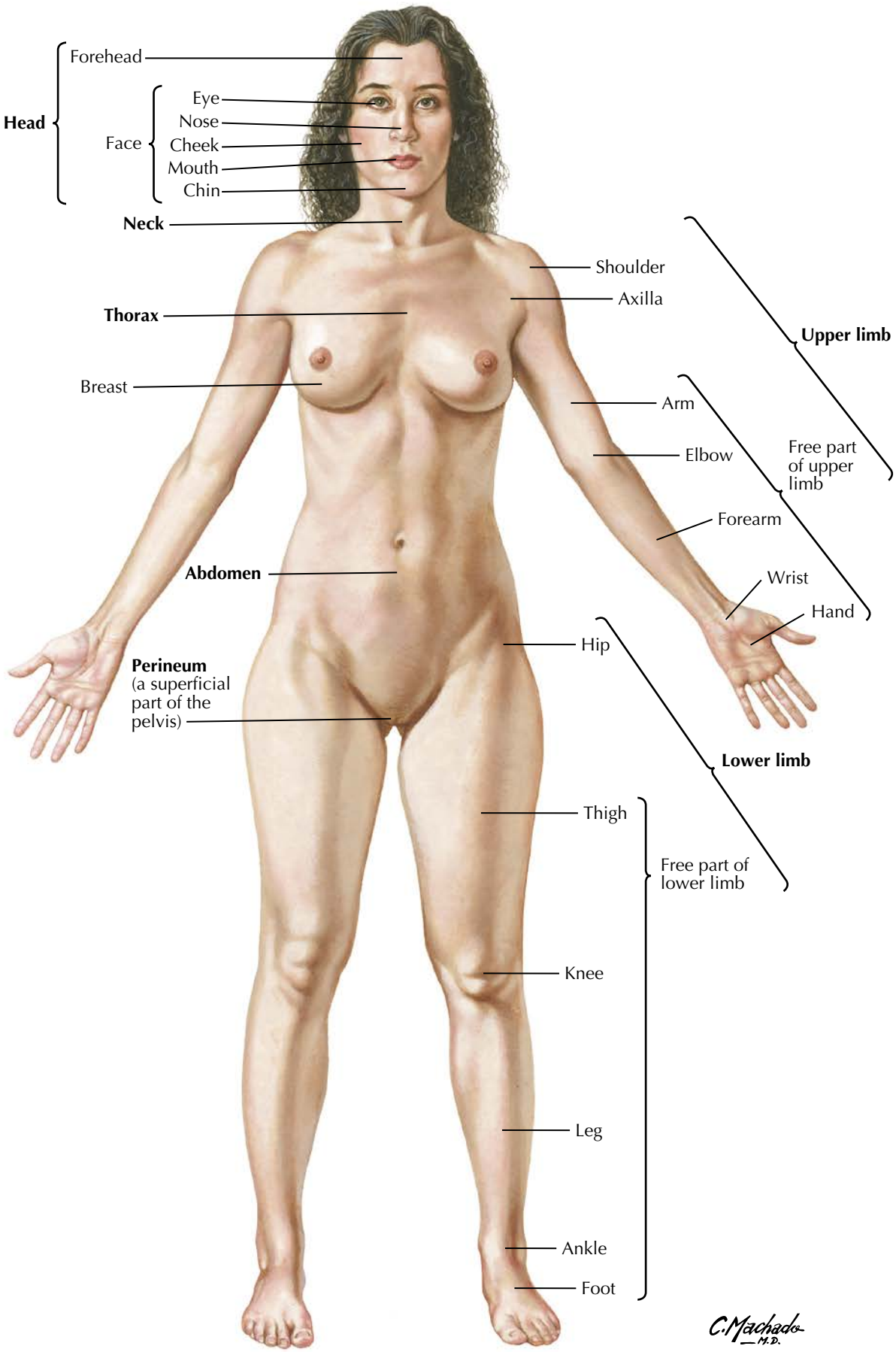
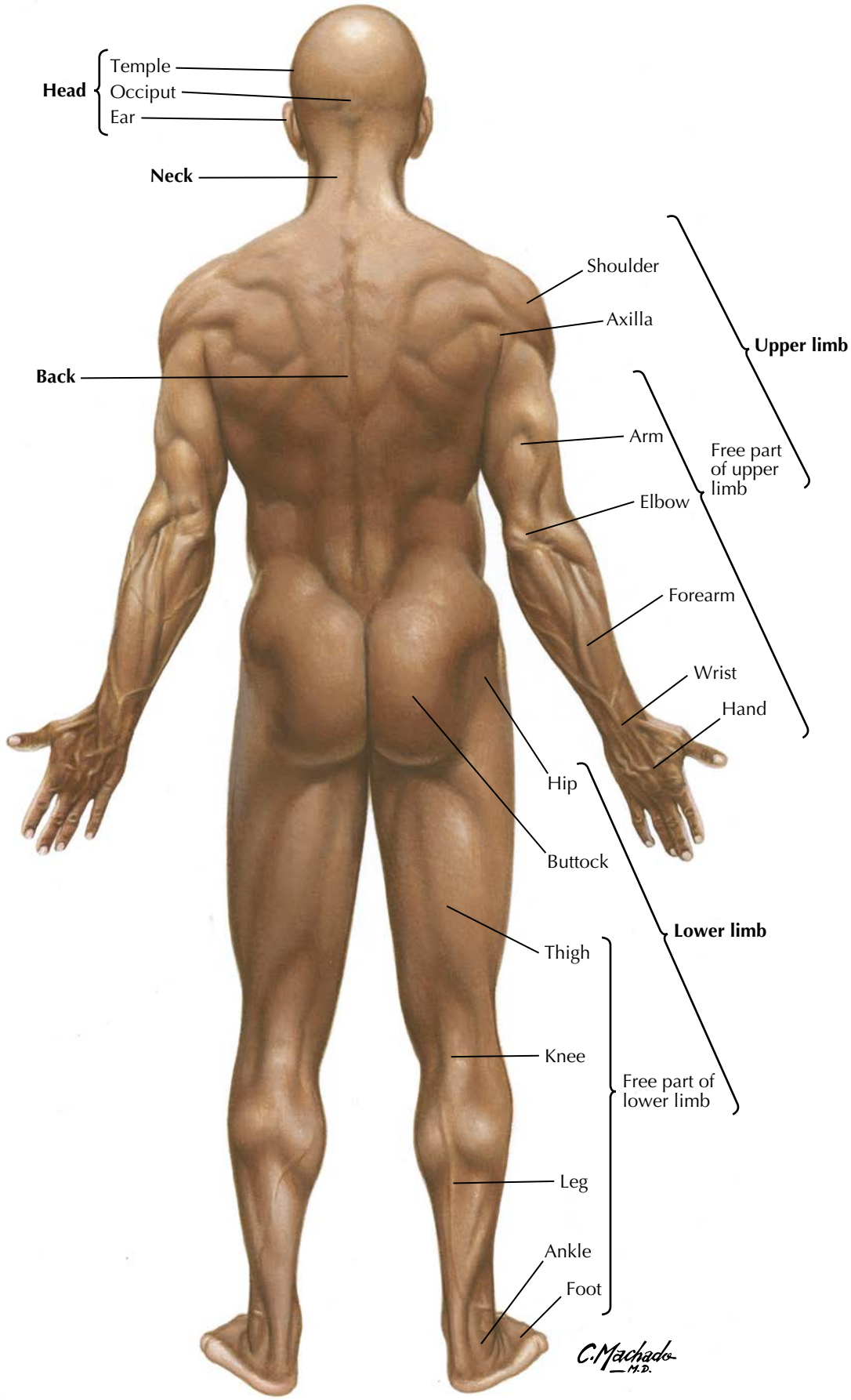
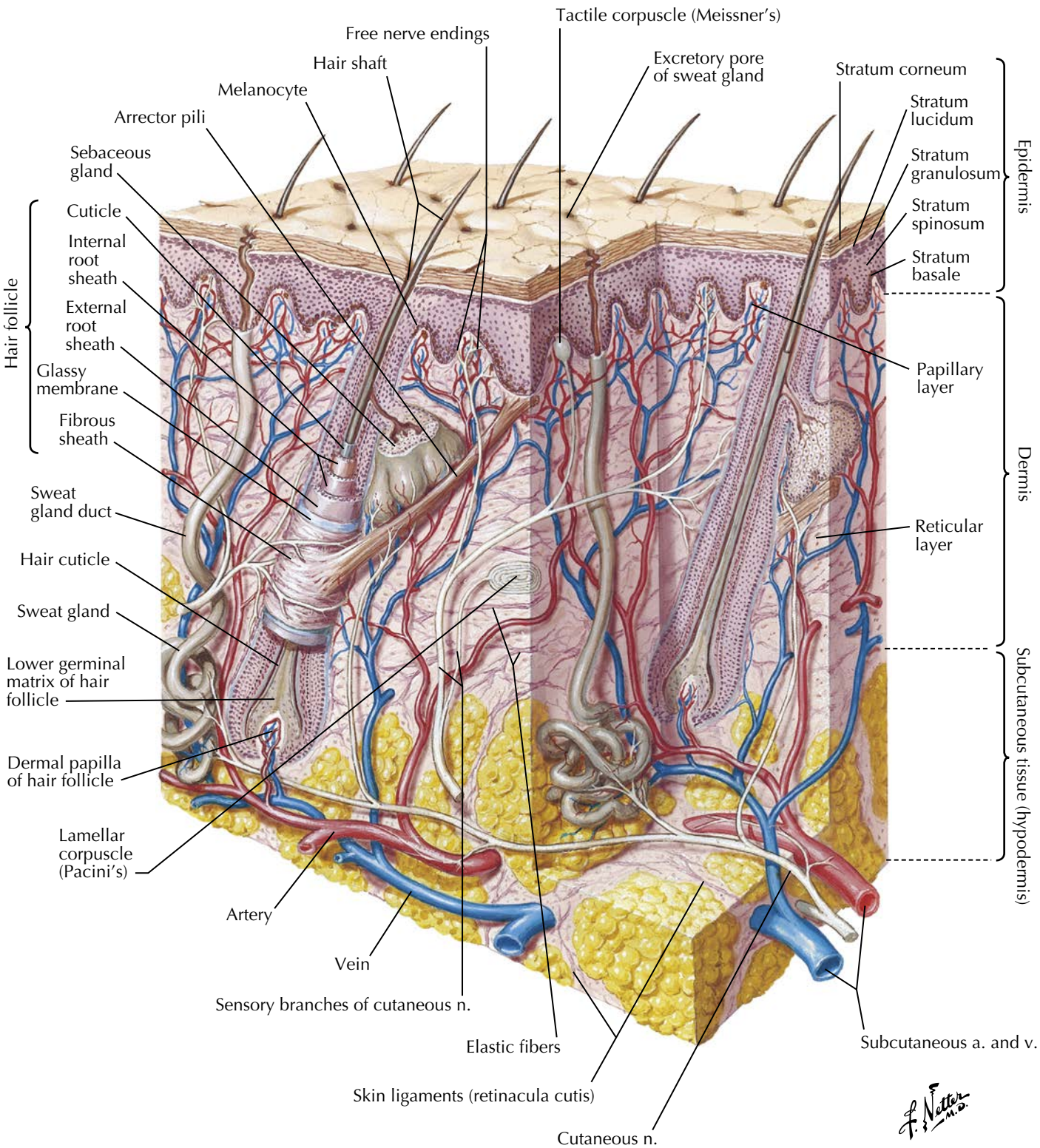
Transverse plane
Sagittal plane
Posterior
Anterior
Superior
Inferior
Medial
Lateral
Right
Left
Cranial
Caudal
Proximal
Proximal
Distal
Distal
C. Machado M.D.


Forehead
Head
Eye
Nose
Face
Cheek
Mouth
Chin
Neck
Shoulder
Axilla
Upper limb
Thorax
Breast
Arm
Elbow
Free part of upper limb
Forearm
Abdomen
Wrist
Hand
Hip
Perineum (a superficial part of the pelvis)
Lower limb
Thigh
Free part of lower limb
Knee
Leg
Ankle
Foot
C. Machado, M.D.

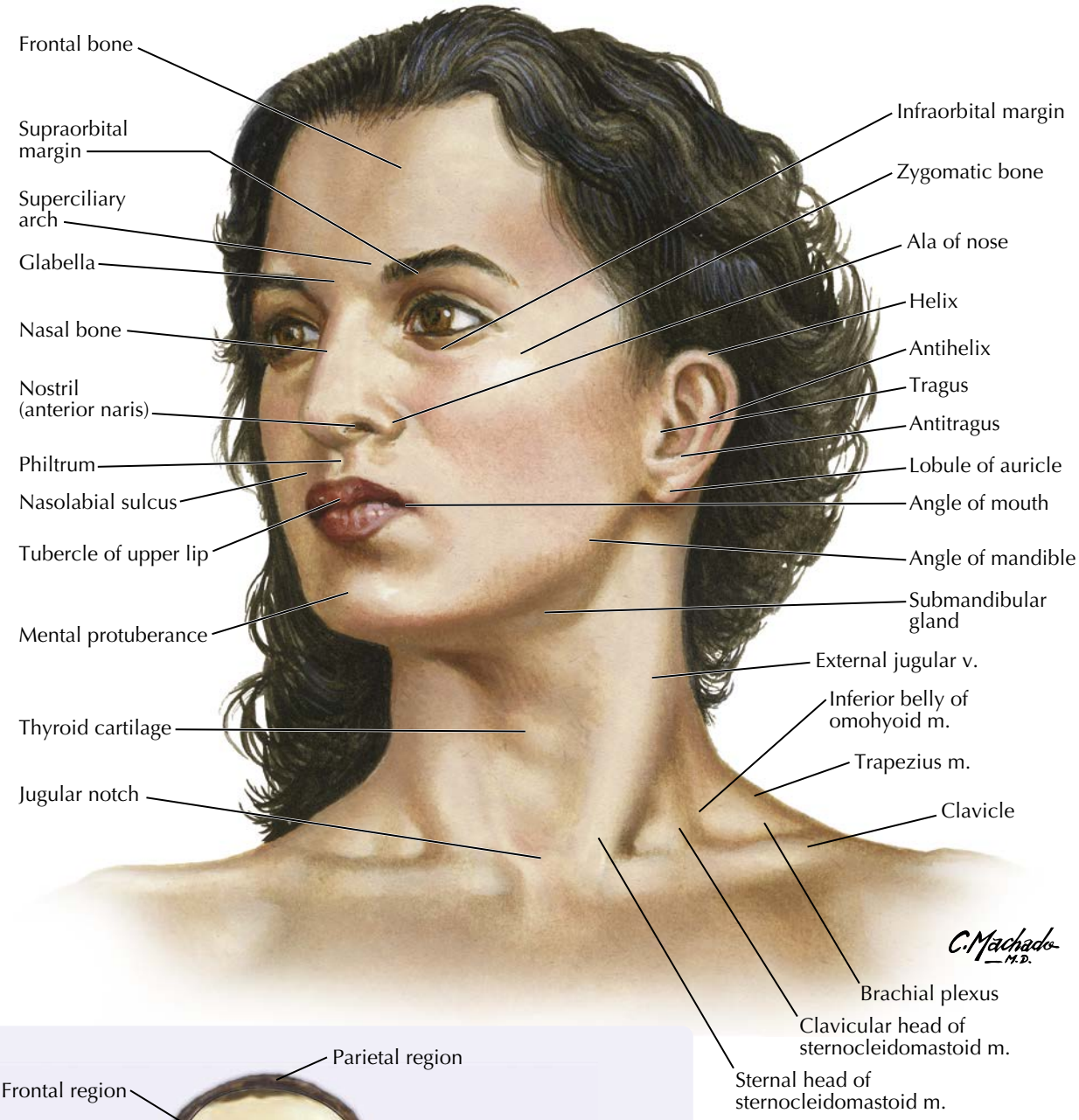

Head
Temple
Occiput
Ear
Neck
Back
Shoulder
Axilla
Upper limb
Arm
Free part of upper limb
Elbow
Forearm
Wrist
Hand
Hip
Buttock
Lower limb
Thigh
Knee
Free part of lower limb
Leg
Ankle
Foot
C. Machado M.D.

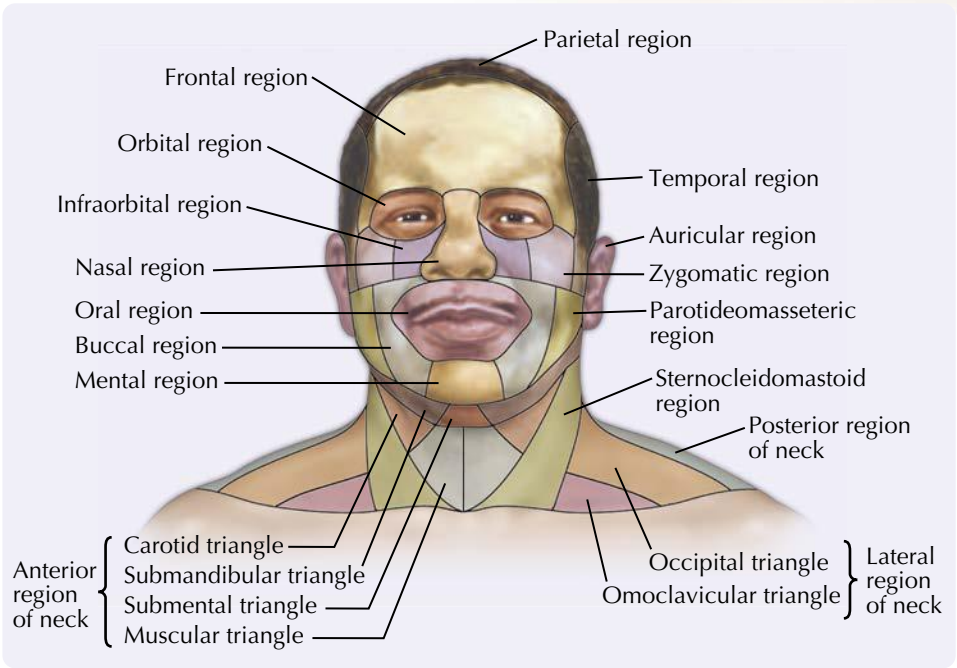
Cross Section of Skin

See also **Plate S–BP 1**

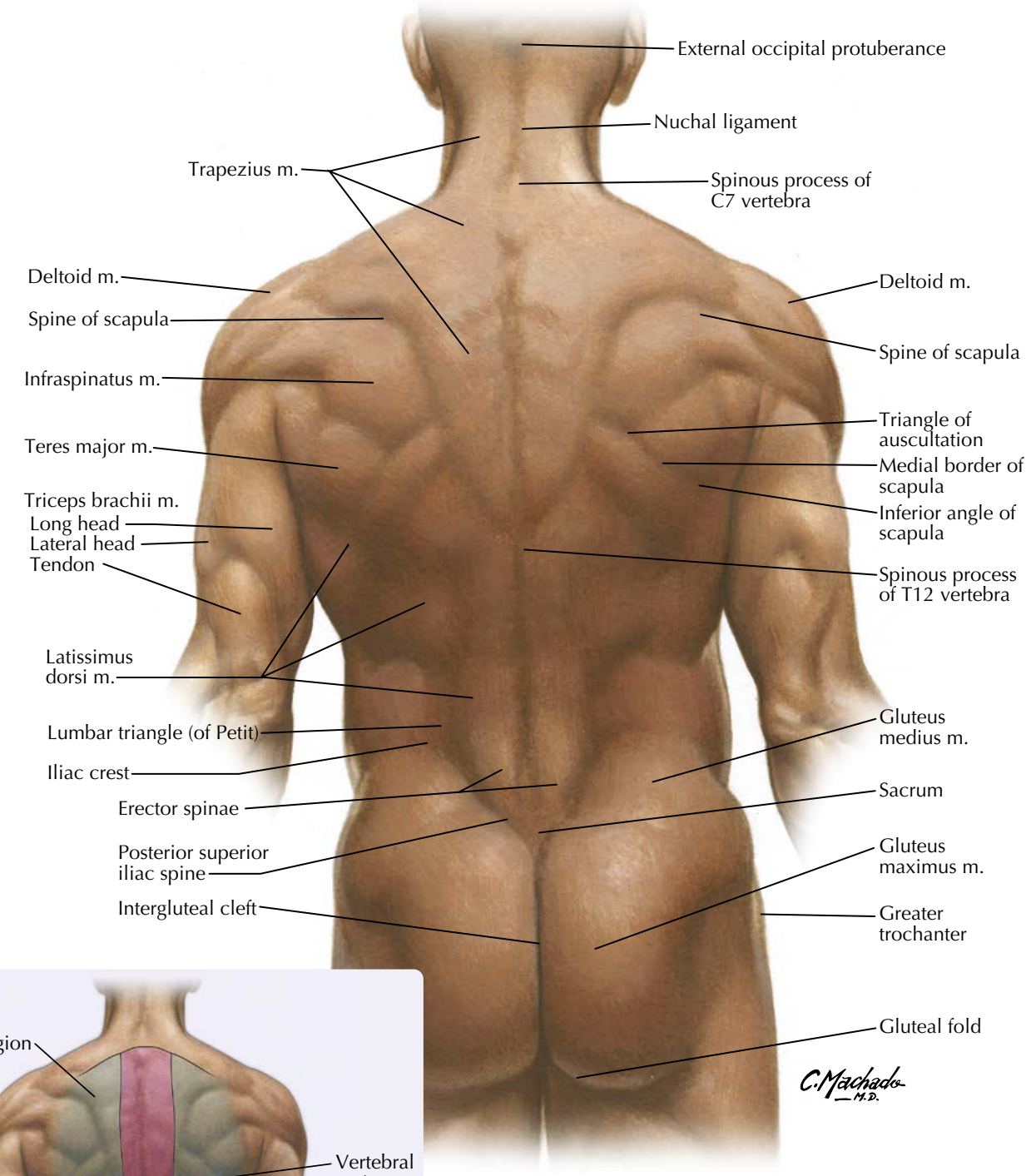


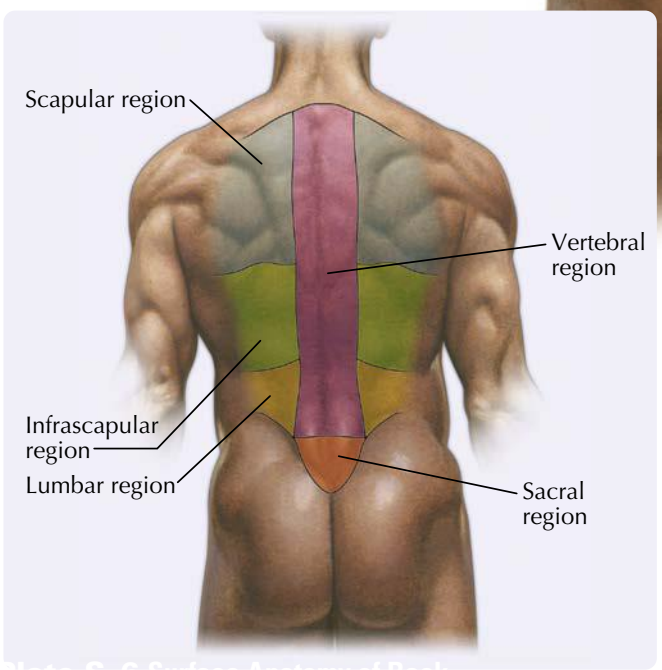
See also **Plate S–19**



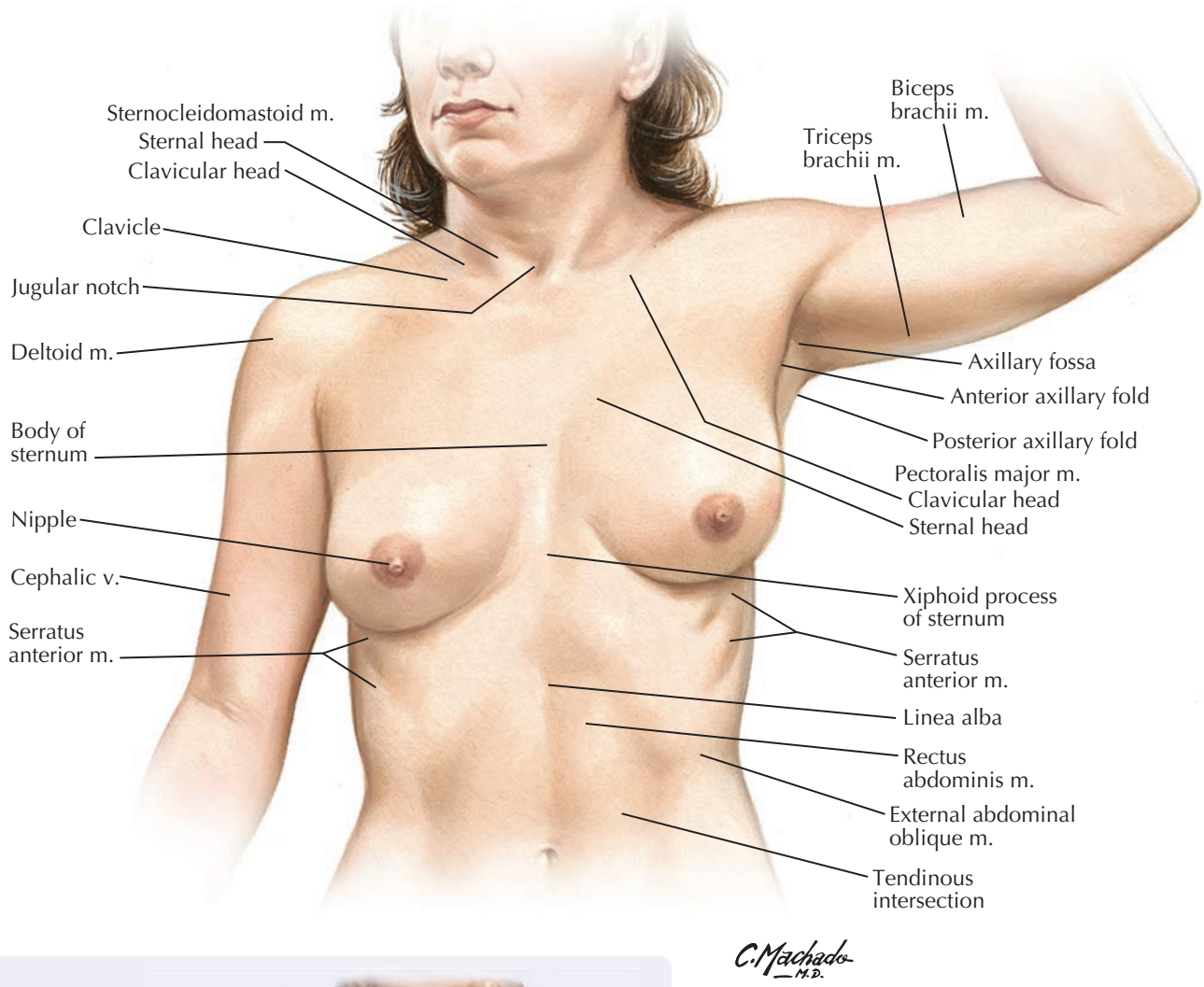


See also **Plates S–19, S–137, S–199**





See also **Plates S–19, S–149, S–203**



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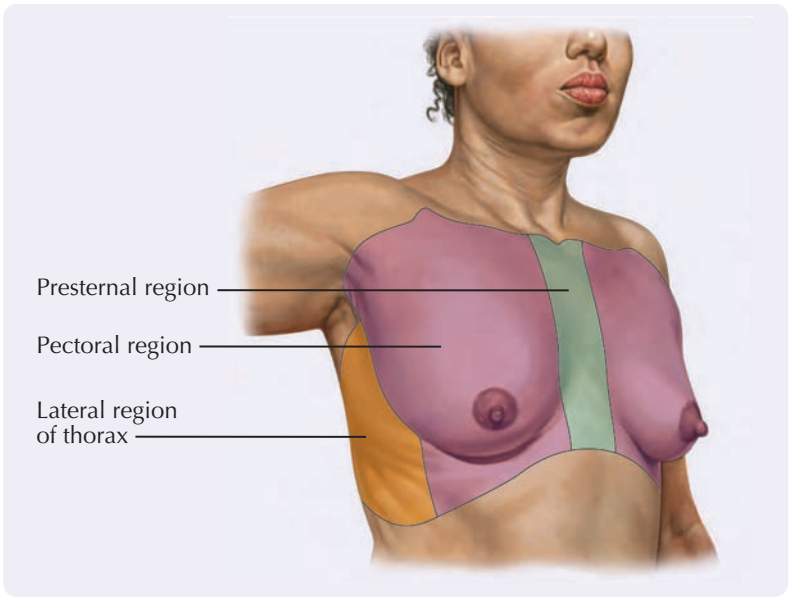
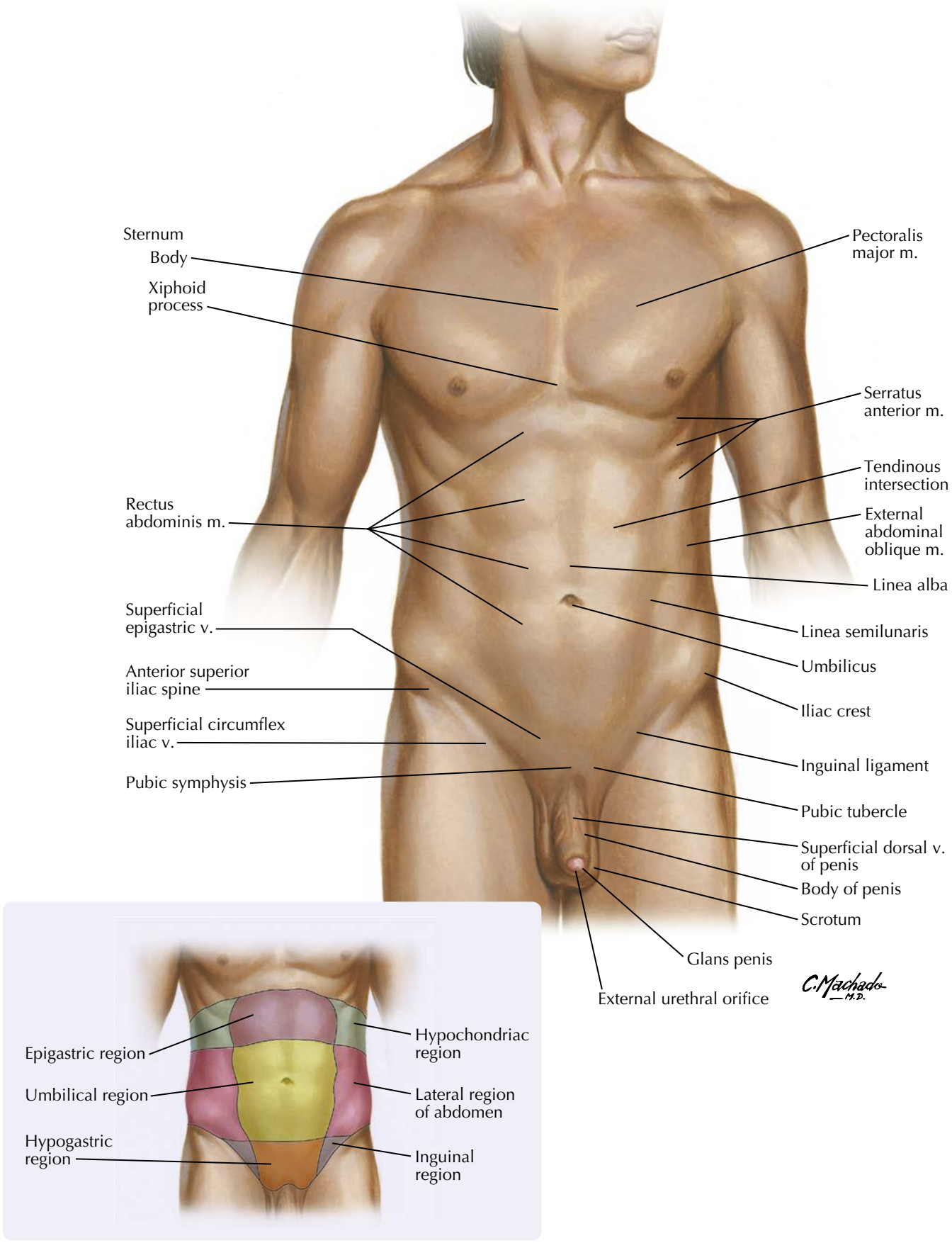
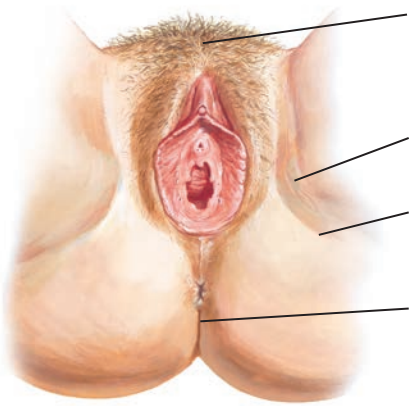
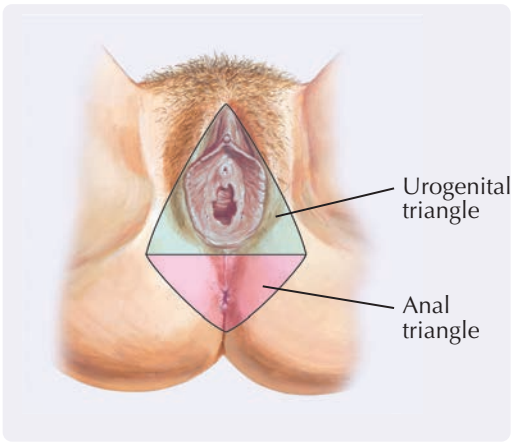


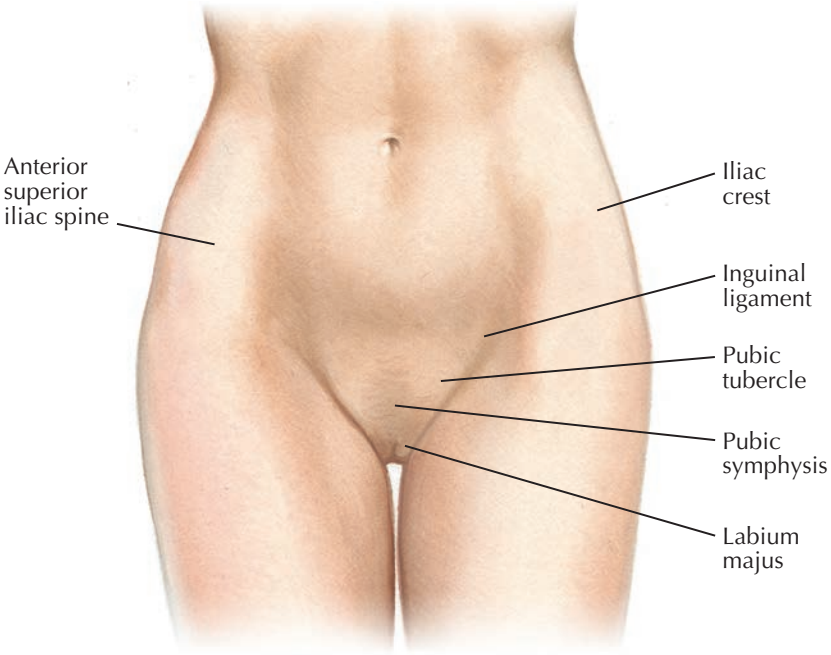
See also **Plates S–19, S–151, S–211**

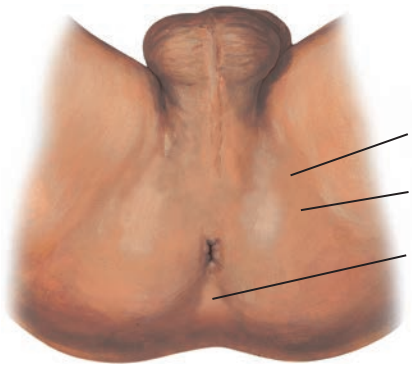


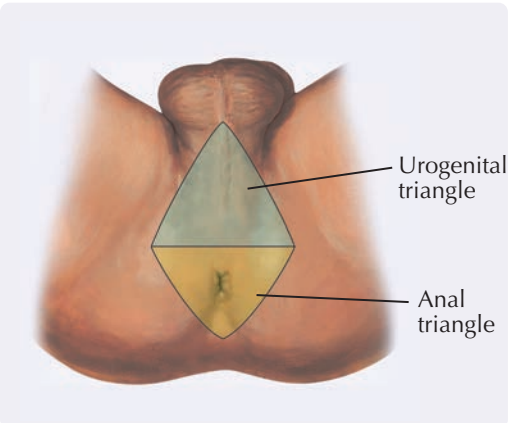
See also **Plates S–19, S–151, S–211, S–491, S–500, S–543**

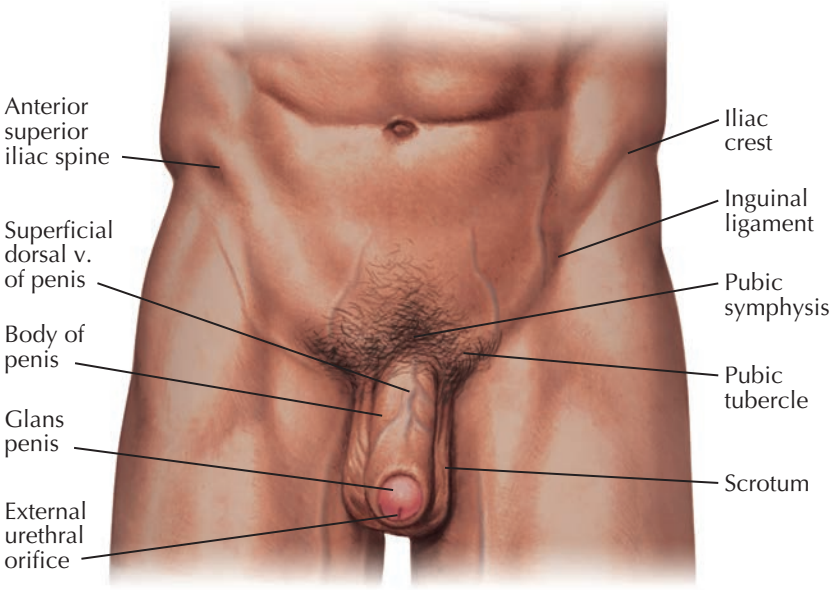






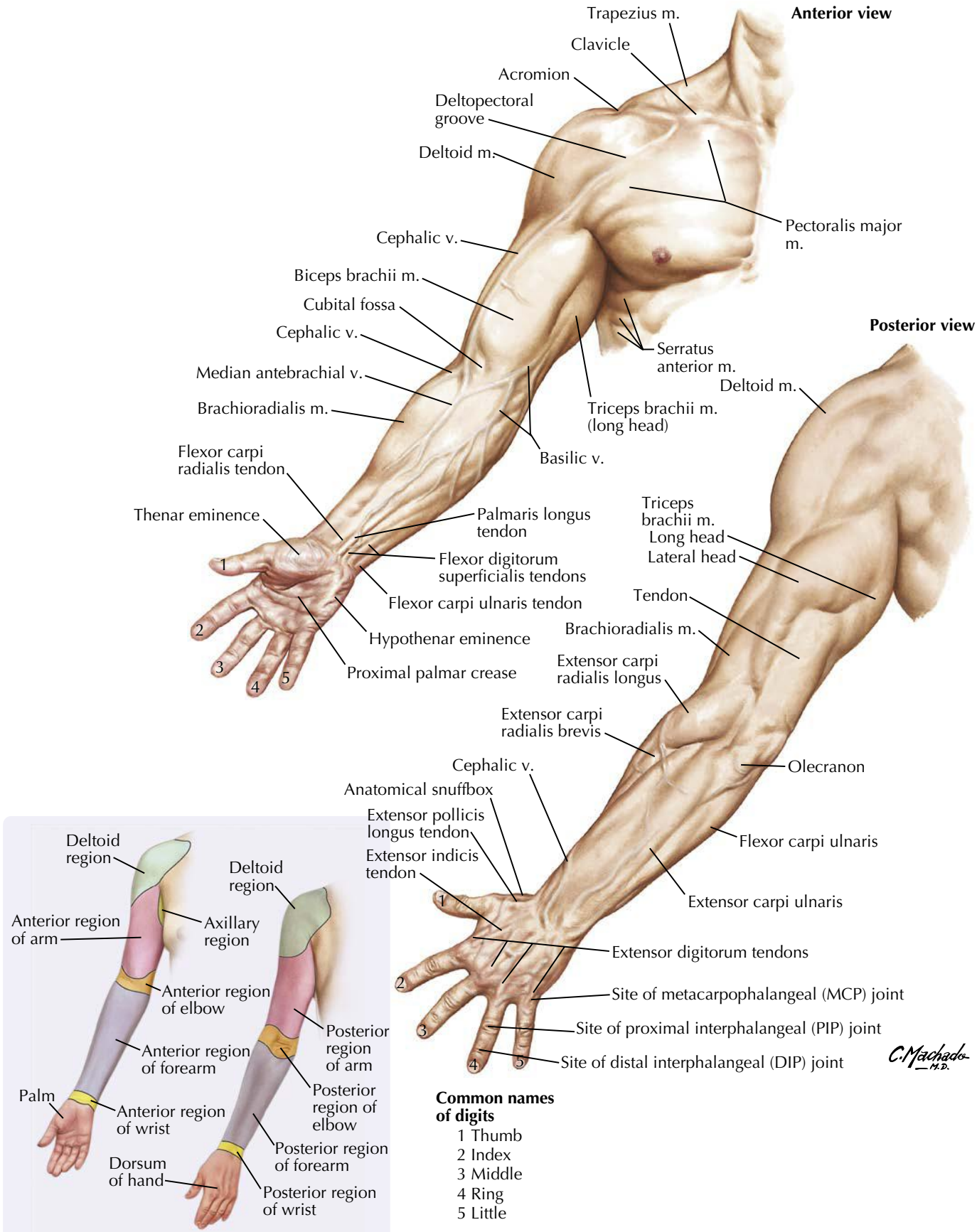




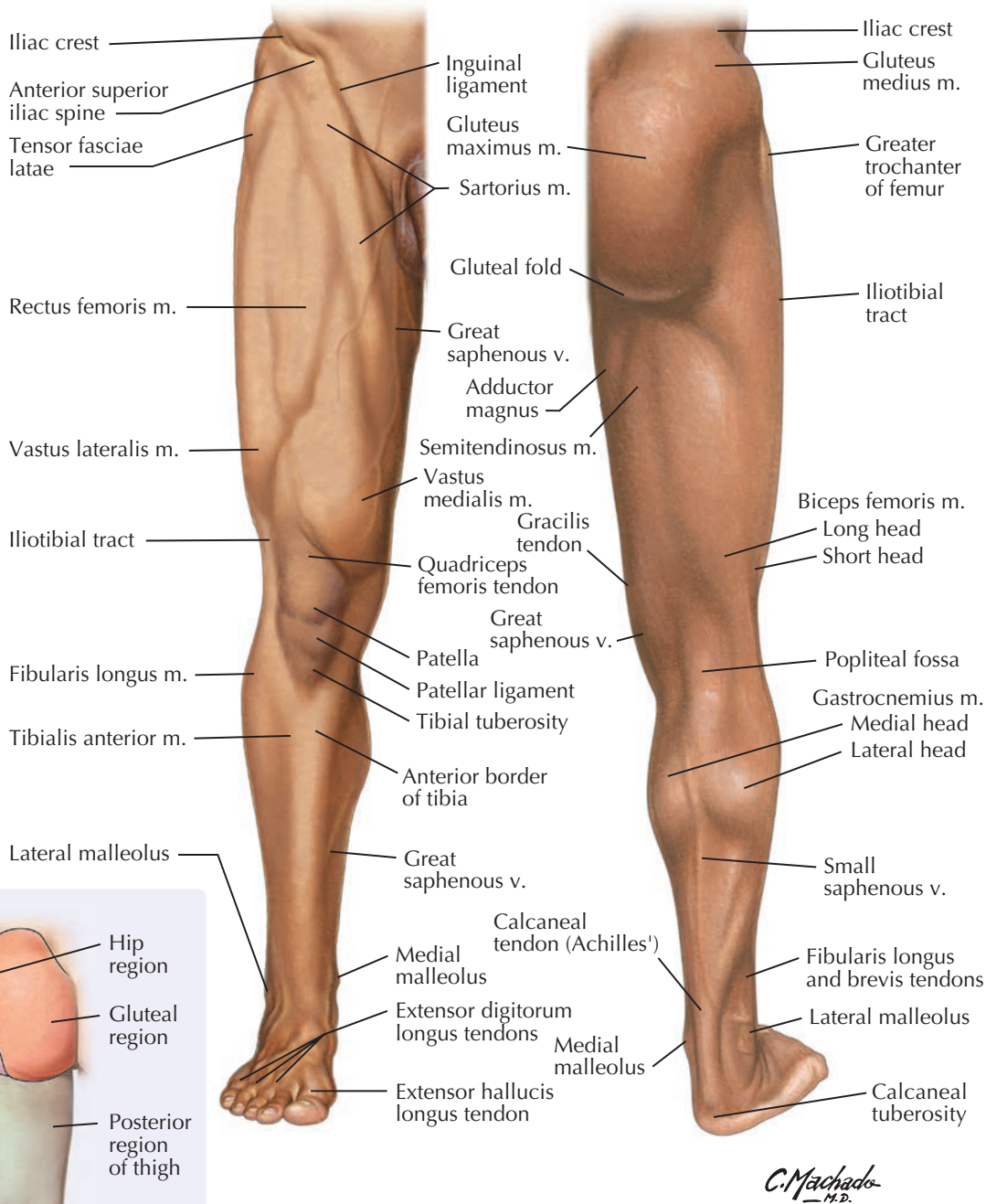


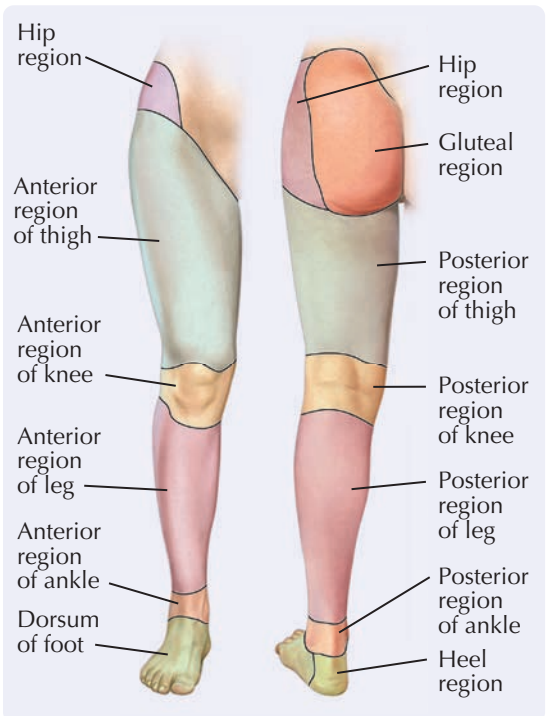
F. Netter M.D. C. Machado M.D.

See also **Plates S–6, S–8, S–13, S–19, S–12, S–265**

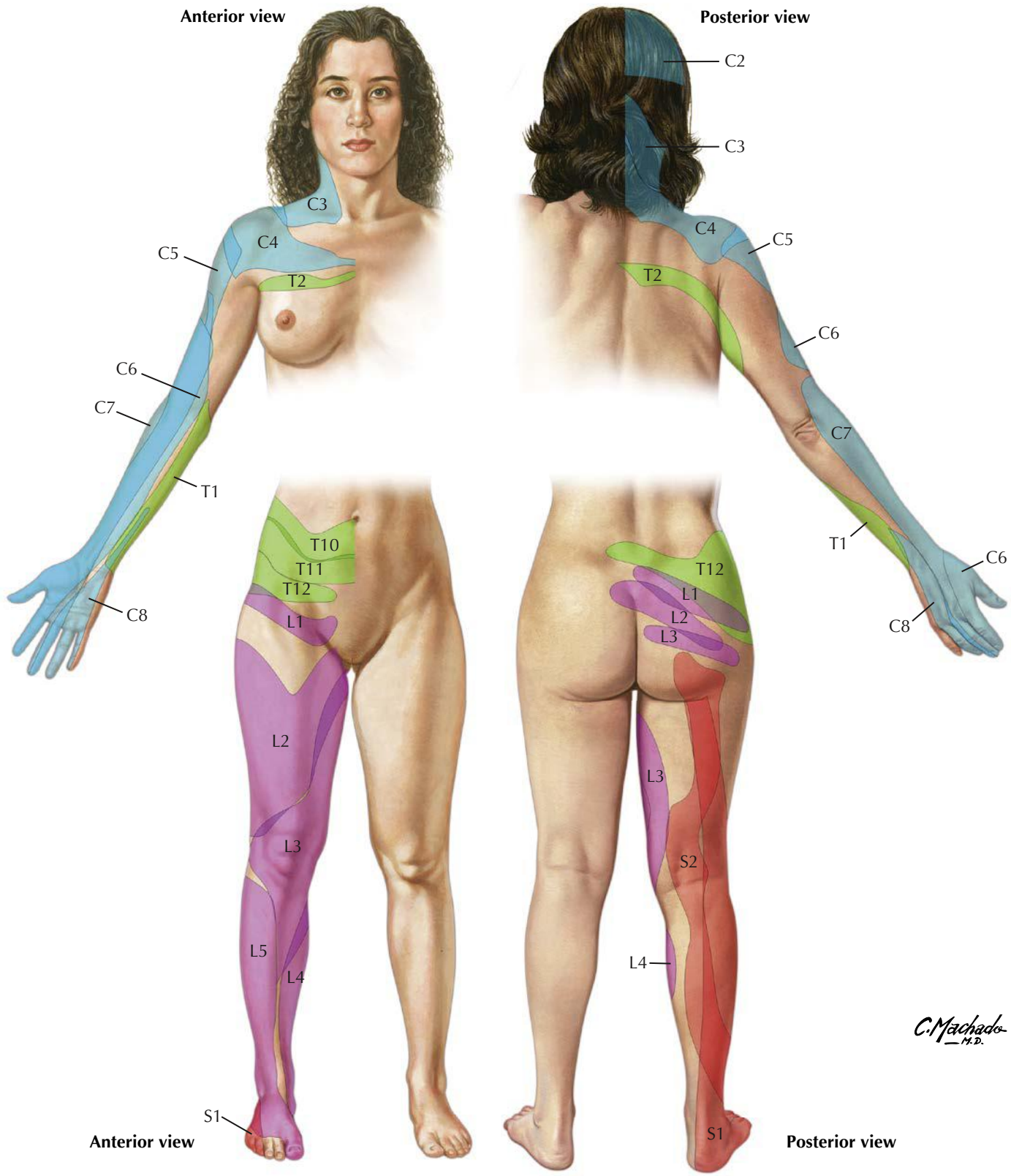


See also **Plates S–12, S–265, S–266, S–267**



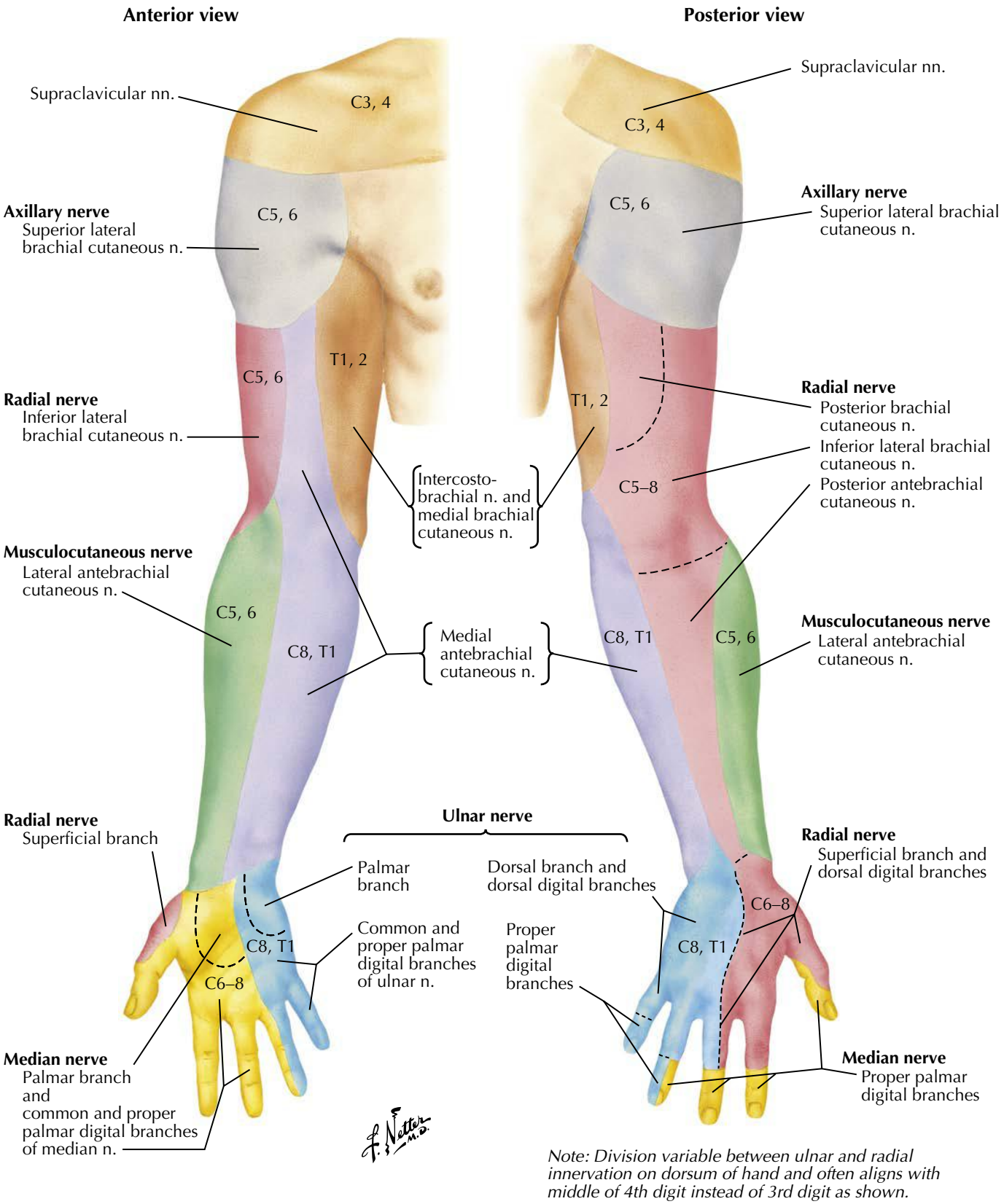


See also **Plate S–19**



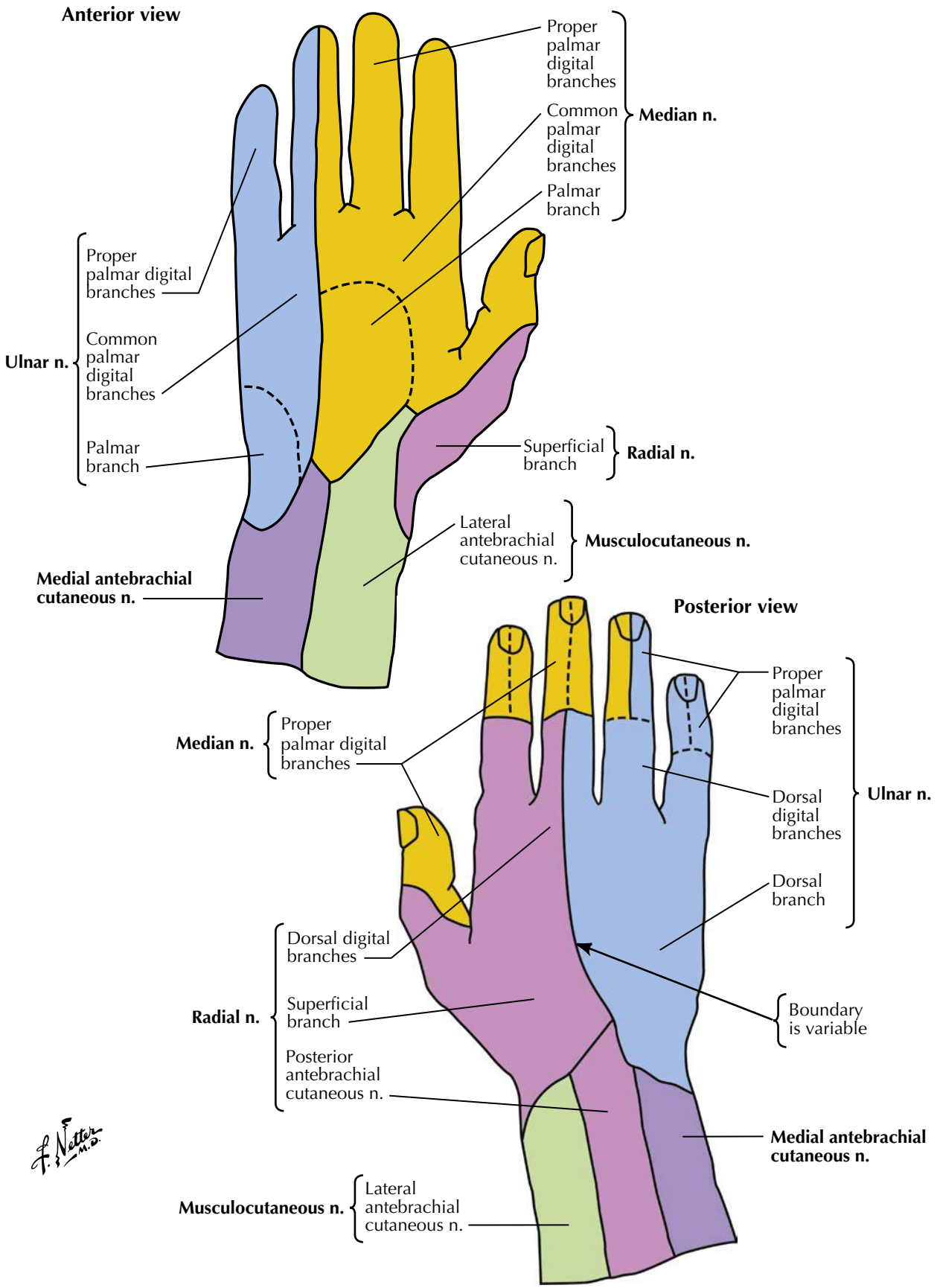
Schematic based on Lee MW, McPhee RW, Stringer MD. An evidence-based approach to human dermatomes. Clin Anat. 2008;21(5):363–373. doi: 10.1002/ca.20636. PMID: 18470936. Please note that these areas are not absolute and vary from person to person. S3, S4, S5, and Co supply the perineum but are not shown for reasons of clarity. Of note, the dermatomes are larger than illustrated as the figure is based on best evidence; gaps represent areas in which the data are inconclusive.

See also **Plates S–14, S–20, S–107**

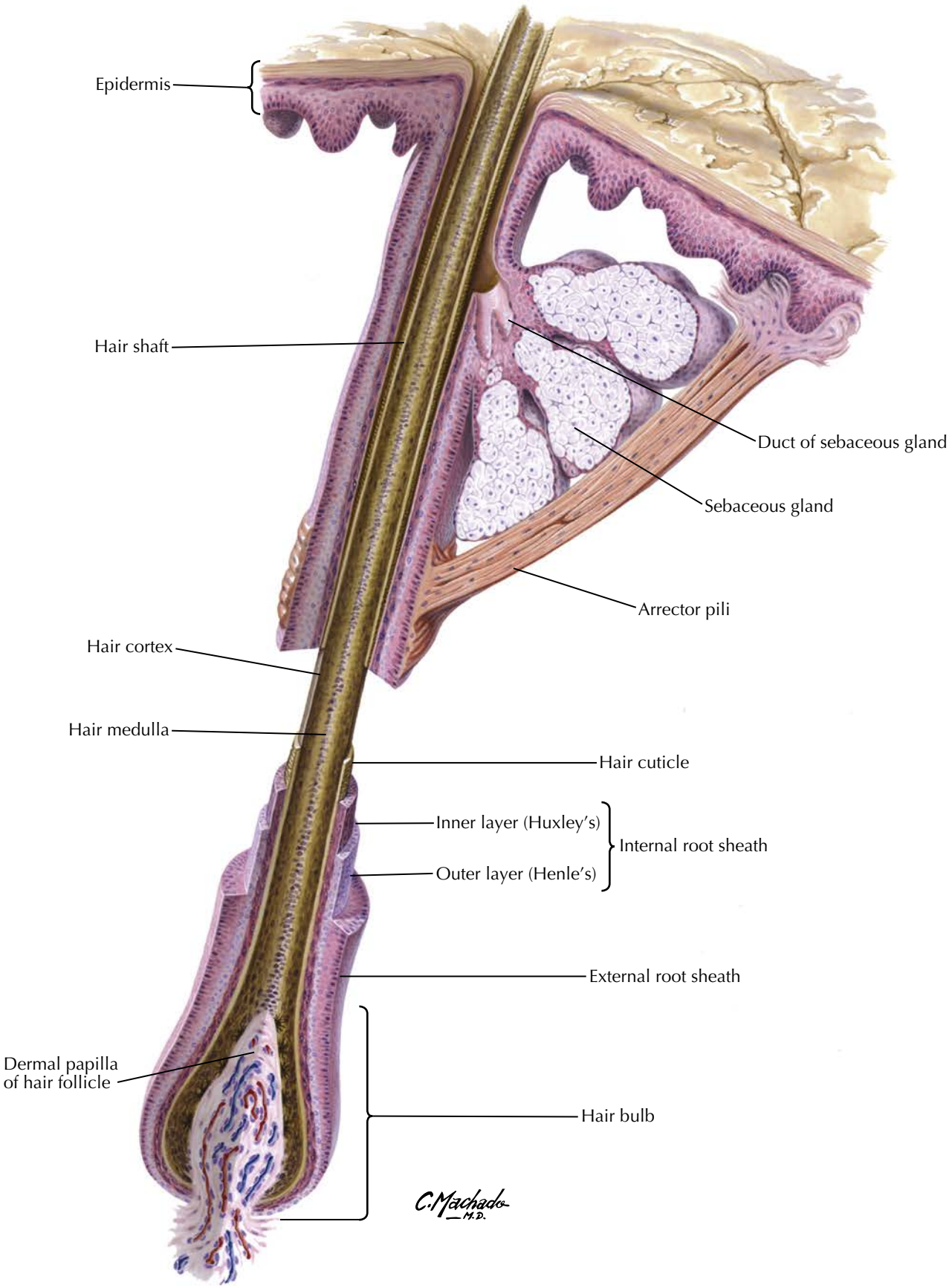


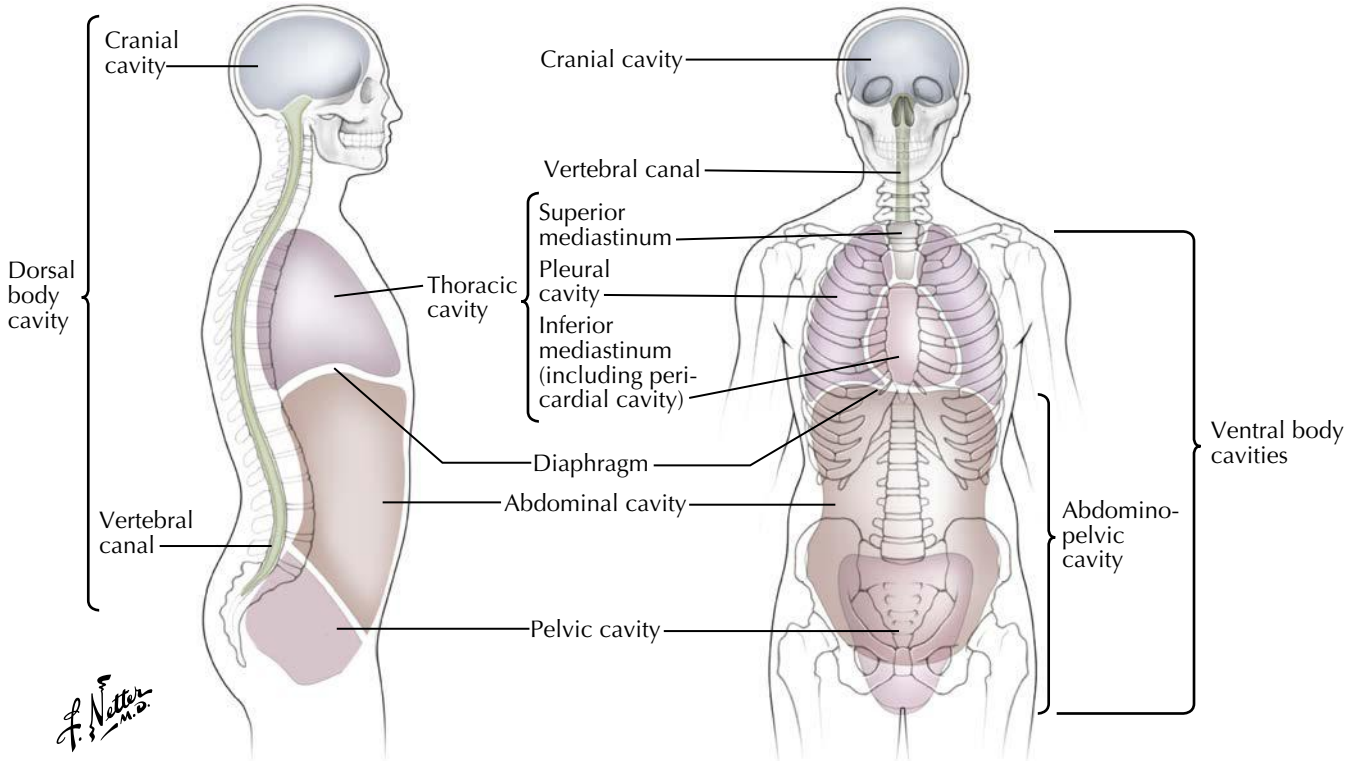
Note: Division variable between ulnar and radial innervation on dorsum of hand and often aligns with middle of 4th digit instead of 3rd digit as shown.

See also **Plates S–13, S–107, S–109, S–253**



See also **Plate S–4**




Cranial cavity
Dorsal body cavity
Thoracic cavity
Vertebral canal
Diaphragm
Abdominal cavity
Pelvic cavity
Cranial cavity
Vertebral canal
Superior mediastinum
Pleural cavity
Inferior mediastinum (including peri-cardial cavity)
Abdomino-pelvic cavity
Ventral body cavities