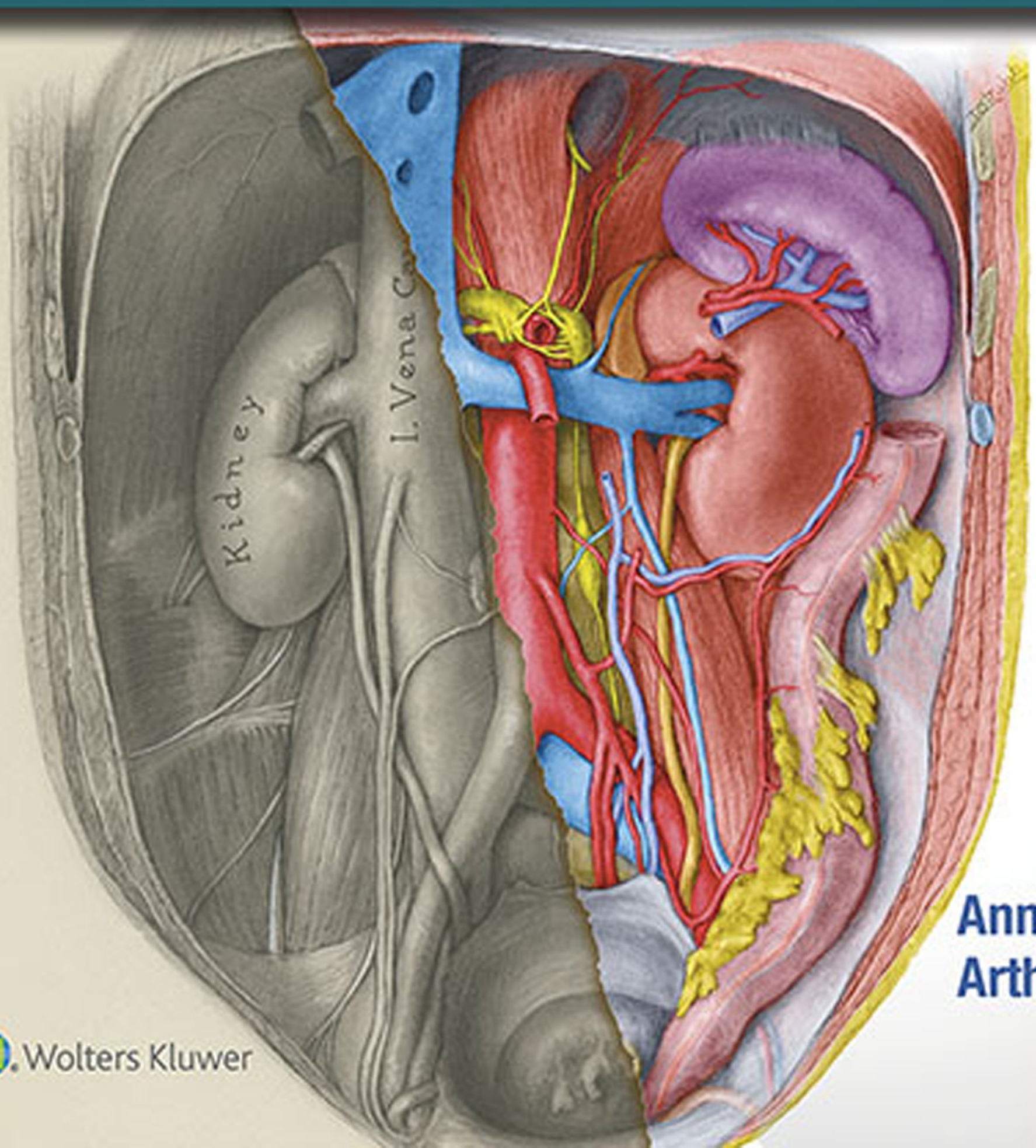
Grant's Atlas of Anatomy



Edition 14

Anne M. R. Agur
Arthur F. Dalley

Wolters Kluwer

Grant's Atlas of Anatomy Edition 14

Grant's Atlas of Anatomy

Edition 14

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To my husband Enno and to my family Kristina, Erik, and Amy
for their support and encouragement
(A.M.R.A.)

To Muriel
My bride, best friend, counselor, and mother of our sons;
To my family
Tristan, Lana, Elijah, Finley, Sawyer and Dashiell,
Denver, and Skyler and Sara
With great appreciation for their support, humor, and patience
(A.F.D.)

And with sincere appreciation for the anatomical donors
Without whom our studies would not be possible

Dr. John Charles Boileau Grant

1886–1973

by Dr. Carlton G. Smith, MD, PhD (1905–2003)
Professor Emeritus, Division of Anatomy,
Department of Surgery
Faculty of Medicine, University of Toronto,
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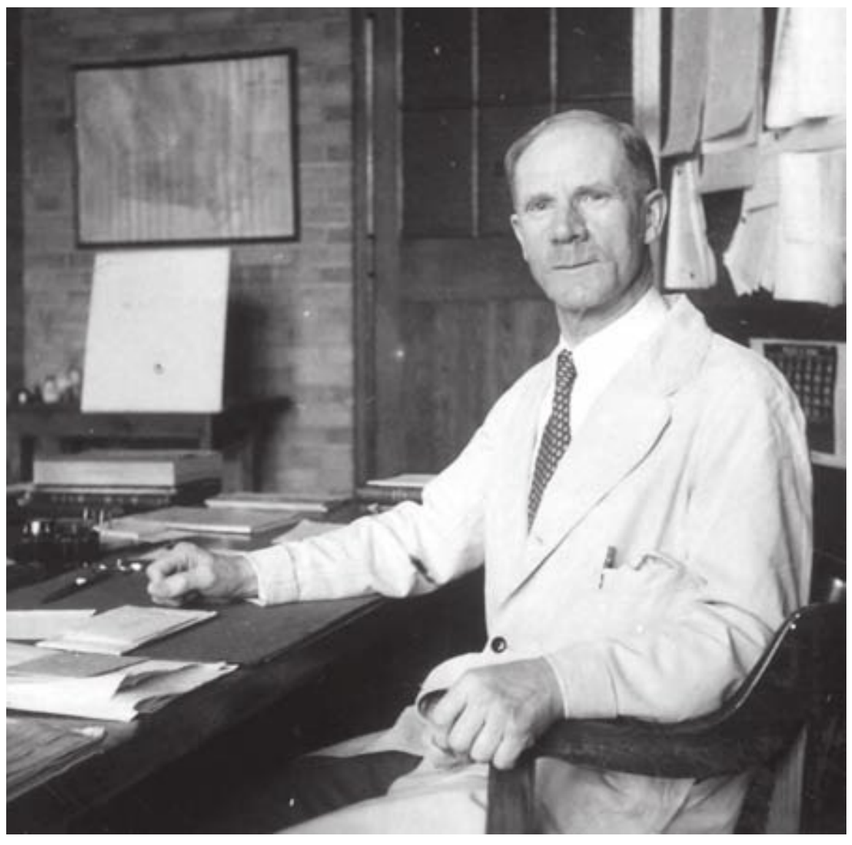

Dr. J.C. Boileau Grant in his office, McMurrich Building, University of Toronto, 1946. Through his textbooks, Dr. Grant made an indelible impression on the teaching of anatomy throughout the world. (Courtesy of Dr. C. G. Smith.)

The life of Dr. J.C. Boileau Grant has been likened to the course of the seventh cranial nerve as it passes out of the skull: complicated but purposeful.[1] He was born in the parish of Lasswade in Edinburgh, Scotland, on February 6, 1886. Dr. Grant studied medicine at the University of Edinburgh from 1903 to 1908. Here, his skill as a dissector in the laboratory of the renowned anatomist, Dr. Daniel John Cunningham (1850–1909), earned him a number of awards.

Following graduation, Dr. Grant was appointed the resident house officer at the Infirmary in Whitehaven, Cumberland. From 1909 to 1911, Dr. Grant demonstrated anatomy in the University of Edinburgh, followed by 2 years at the University of Durham, at Newcastle-on-Tyne in England, in the laboratory of Professor Robert Howden, editor of *Gray's Anatomy*.

With the outbreak of World War I in 1914, Dr. Grant joined the Royal Army Medical Corps and served with distinction. He was mentioned in dispatches in September 1916, received the Military Cross in September 1917 for "conspicuous gallantry and devotion to duty during attack," and received a bar to the Military Cross in August 1918.[1]

In October 1919, released from the Royal Army, he accepted the position of Professor of Anatomy at the University of Manitoba in Winnipeg, Canada. With the frontline medical practitioner in mind, he endeavored to "bring up a generation of surgeons who knew exactly what they were doing once an operation had begun."[1] Devoted to research and learning, Dr. Grant took interest in other projects, such as performing anthropometric studies of Indian tribes in northern Manitoba during the 1920s. In Winnipeg, Dr. Grant met Catriona Christie, whom he married in 1922.

Dr. Grant was known for his reliance on logic, analysis, and deduction as opposed to rote memory. While at the University of Manitoba, Dr. Grant began writing *A Method of Anatomy, Descriptive and Deductive*, which was published in 1937.[2]

In 1930, Dr. Grant accepted the position of Chair of Anatomy at the University of Toronto. He stressed the value of a "clean" dissection, with the structures well defined. This required the delicate touch of a sharp scalpel, and students soon learned that a dull tool was anathema. Instructive dissections were made available in the Anatomy Museum, a means of student review on which Dr. Grant placed a high priority. Illustrations of these actual dissections are included in *Grant's Atlas of Anatomy*.

The first edition of the *Atlas*, published in 1943, was the first anatomical atlas to be published in North America.[3] *Grant's Dissector* preceded the *Atlas* in 1940.[4]

Dr. Grant remained at the University of Toronto until his retirement in 1956. At that time, he became Curator of the Anatomy Museum in the University. He also served as Visiting Professor of Anatomy at the University of California at Los Angeles, where he taught for 10 years.

Dr. Grant died in 1973 of cancer. Through his teaching method, still presented in the Grant's textbooks, Dr. Grant's life interest—human anatomy—lives on. In their eulogy, colleagues and friends Ross MacKenzie and J. S. Thompson said, "Dr. Grant's knowledge of anatomical fact was encyclopedic, and he enjoyed nothing better than sharing his knowledge with others, whether they were junior students or senior staff. While somewhat strict as a teacher, his quiet wit and boundless humanity never failed to impress. He was, in the very finest sense, a scholar and a gentleman."[1]

---

[1]Robinson C. *Canadian Medical Lives: J.C. Boileau Grant: Anatomist Extraordinary.* Ontario, Canada: Associated Medical Services Inc/Fithzenry & Whiteside, 1993.

[2]Grant JCB. *A Method of Anatomy: Descriptive and Deductive.* Baltimore, MD: Williams & Wilkins Co, 1937.

[3]Grant JCB. *Grant's Atlas of Anatomy.* Baltimore, MD: Williams & Wilkins Co, 1943.

[4]Grant JCB, Cates HA. *Grant's Dissector (A Handbook for Dissectors).* Baltimore, MD: Williams & Wilkins Co, 1940.

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Preface

This edition of *Grant's Atlas* has, like its predecessors, required intense research, market input, and creativity. It is not enough to rely on a solid reputation; with each new edition, we have adapted and changed many aspects of the *Atlas* while maintaining the commitment to pedagogical excellence and anatomical realism that has enriched its long history. Medical and health sciences education, and the role of anatomy instruction and application within it, continually evolve to reflect new teaching approaches and educational models. The health care system itself is changing, and the skills and knowledge that future health care practitioners must master are changing along with it. Finally, technologic advances in publishing, particularly in online resources and electronic media, have transformed the way students access content and the methods by which educators teach content. All of these developments have shaped the vision and directed the execution of this fourteenth edition of *Grant's Atlas*, as evidenced by the following key features.

Recolorization of the original carbon-dust images from high-resolution scans. Grant's Atlas The entire collection of carbon-dust illustrations were remastered and recolored for the fourteenth edition using a vibrant new palette. The stunning detail and contrast of the original Grant's art was maintained while adding a new level of luminosity of organs and especially transparency of tissues, enabling demonstrations of deeper relationships not possible with merely recolored grayscale illustrations, thereby enhancing the student learning experience. The student is able to visualize and appreciate clearly the newly revealed relationships between structures, enabling the formation of three-dimensional (3D) constructs for each region of the body. The recolorization, enabled by modern image processing, allows reproduction and viewing of the images—both in print and electronically—with unprecedented high resolution and fidelity, continuing their vital role informing future generations of medical and health care providers about the structure and function of the human body.

A unique feature of *Grant's Atlas* is that rather than providing an idealized view of human anatomy, the classic illustrations represent actual dissections that the student can directly compare with specimens in the lab. Because the original models used for these illustrations were real cadavers, the accuracy of these illustrations is unparalleled, offering students the best introduction to anatomy possible.

Schematic illustrations. Updated for the fourteenth edition with a modern uniform style and consistent color palette, the full-color schematic illustrations and orientation figures supplement the dissection figures to clarify anatomical concepts, show the relationships of structures, and give an overview of the body region being studied.

The illustrations conform to Dr. Grant's admonition to "keep it simple": Extraneous labels were deleted, and some labels were added to identify key structures and make the illustrations as useful as possible to students.

Legends with easy-to-find clinical applications. Admittedly, artwork is the focus of any atlas; however, the *Grant's* legends have long been considered a unique and valuable feature of the *Atlas*. The observations and comments that accompany the illustrations assist orientation and draw attention to salient points and significant structures that might otherwise escape notice. Their purpose is to interpret the illustrations without providing exhaustive description. Readability, clarity, and practicality were emphasized in the editing of this edition. Clinical comments, which deliver practical "pearls" that link anatomical features with their significance in health care practice, appear in blue text within the figure legends. New clinical comments based on current practices have been added in this edition, providing even more relevance for students searching for medical application of anatomical concepts.

Enhanced diagnostic imaging and surface anatomy. Because medical imaging has taken on increased importance in the diagnosis and treatment of injuries and illnesses, diagnostic images are used liberally throughout and at the end of each chapter. Over 100 clinically significant magnetic resonance images (MRIs), computed tomography (CT) scans, ultrasound scans, and corresponding orientation drawings are included, many of which are new to or updated for this edition. Labeled surface anatomy photographs which, like the illustrations, feature ethnic diversity continue to be an important feature in this new edition.

Updated and improved tables. Tables help students organize complex information in an easy-to-use format ideal for review and study. In addition to muscles, tables summarizing nerves, arteries, and other relevant structures are included. Tables are made more meaningful with illustrations strategically placed on the same page, demonstrating the structures and relationships described in the tables.

Logical organization and layout. The organization and layout of the *Atlas* have always been determined with ease of use as the goal. In this edition, to facilitate dissection, the body regions have been reordered in the same sequence as the more recent and current editions of *Grant's Dissector*. The order of plates within every chapter was scrutinized to ensure that it is logical and pedagogically effective.

We hope that you enjoy using this fourteenth edition of *Grant's Atlas* and that it becomes a trusted partner in your educational experience. We believe that this new edition safeguards the *Atlas's* historical strengths while enhancing its usefulness to today's students.

Anne M.R. Agur
Arthur F. Dalley II

Recoloring *Grant's Atlas*

The principal illustrations for *Grant's Atlas*, created in the 1940s and 1950s, use classic techniques of carbon dust or wash in pure grayscale. Although the detail of the grayscale carbon-dust illustrations was outstanding (see below figure on the left), the need for color was soon obvious. Early editions of the *Atlas* layered solid colors over parts of the grayscale artwork to highlight the presence and relationships of important structures such as veins, arteries, and nerves. This didactic approach and technology persisted throughout the first eight editions.

In the early 1990s, the *Atlas* was revised using a complex pre-digital technique where the original illustrations were photographed and printed on photographic paper. The prints were then colorized by hand with photo dyes, and the resulting colored prints were rephotographed for reproduction in print. Although this process resulted in a significant enrichment of the illustrations, the technique sometimes led to loss of detail and reduction of contrast. Over the next several editions, the color of the digital images were adjusted and enhanced (see below figure in the middle).

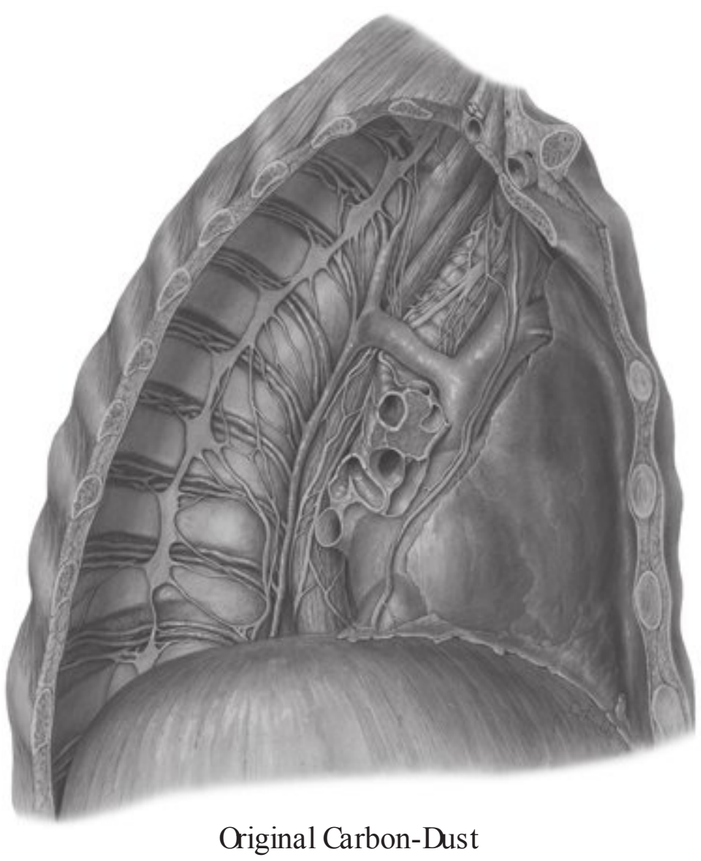
In the late 1990s, the University of Toronto assumed care of the original illustrations. The illustrations had been handled roughly over their long lives and were in many cases deteriorating due to their non-archival substrates. In 2008, an interdisciplinary team[1] of communications scholars, illustrators, and archivists applied for and received funding from the Social Sciences and Humanities Research Council of Canada to study the illustrations and to create a digital archive of the corpus. The team catalogued, documented, and scanned the artifacts at high resolution. The effort revealed a number of "lost" illustrations among the more than 1,000 images. Some of these images have been restored to the current edition.

Once the database of high-resolution images was compiled, the possibility arose to "remaster" and recolor the images for the next edition of *Grant's Atlas*. A system was set up to clean the images and create new layers of color.

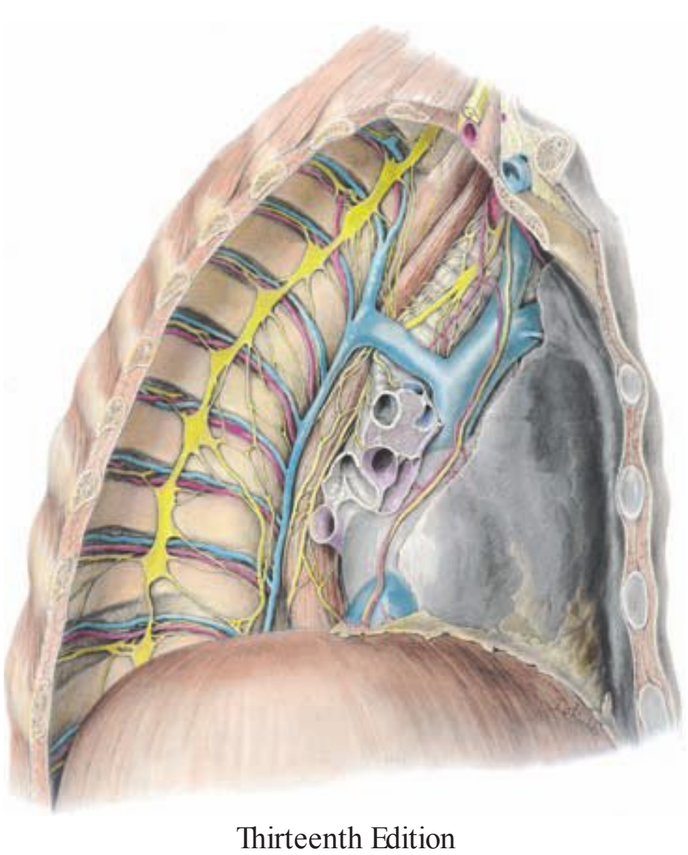
- Almost all of the original illustrations contained hand-lettered labels and leader lines that had to be removed. This was accomplished by the careful use of digital cloning and retouching tools.
- The tonal range and contrast was adjusted to maximize clarity and dynamic range.
- A series of color layers were added over the cleaned scans, based on a carefully chosen palette. Most layers were set to the color transfer mode, which was chosen to assure that the grayscale balance of the underlying scans would not be altered.
- All of the recolored illustrations went through numerous rounds of revision with the authors to assure accuracy and reflect the pedagogic needs of the new edition.

This work was overseen by Nicholas Woolridge and carried out by two graduates of the Master of Science in Biomedical Communications (MScBMC) program: Nicole Clough and Marissa Webber. The retouching process was designed to preserve the detail, texture, and contrast of the original artwork (see below image on the right), allowing the illustrations to continue informing students about the structure and function of the human body for decades to come.

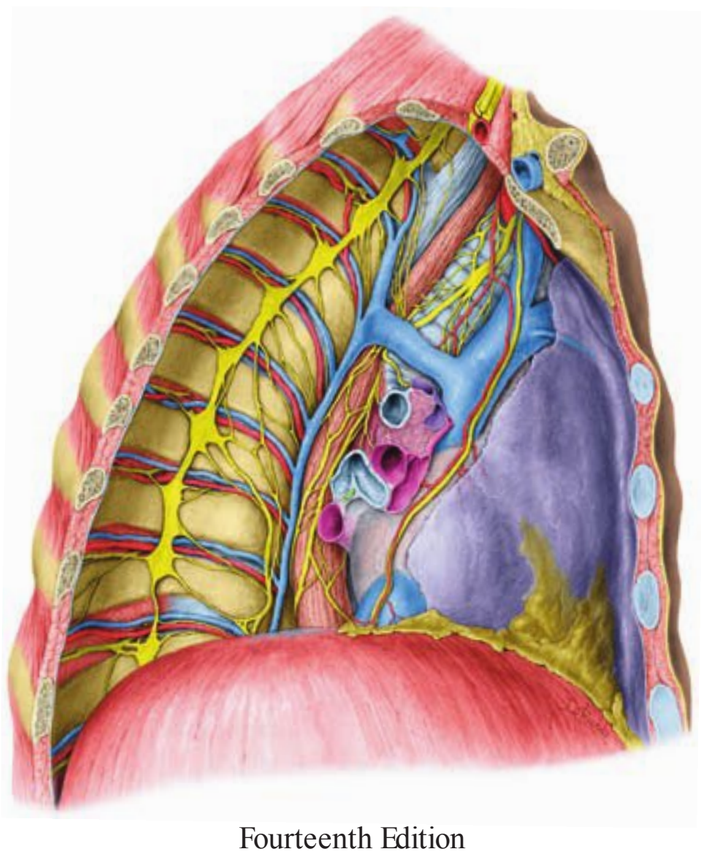
Nicholas Woolridge
Director, Master of Science
in Biomedical Communications Program
University of Toronto
September 2015



Original Carbon-Dust



Thirteenth Edition
with Added Color



Fourteenth Edition
with Enhanced Color and Detail

[1]Led by Kim Sawchuk, from Concordia University, and included Nancy Marrelli, Nicholas Woolridge, Brian Sutherland, Nina Czegledy, Mél Hogan, Dave Mazierski, and Margot Mackay.

Acknowledgments

Starting with the first edition of *Grant's Atlas* published in 1943, many people have given generously of their talents and expertise and we acknowledge their participation with heartfelt gratitude. Most of the original carbon-dust halftones on which this book is based were created by Dorothy Foster Chubb, a pupil of Max Brödel and one of Canada's first professionally trained medical illustrators. She was later joined by Nancy Joy. Mrs. Chubb was mainly responsible for the artwork of the first two editions and the sixth edition; Professor Joy, for those in between. In subsequent editions, additional line and halftone illustrations by Elizabeth Blackstock, Elia Hopper Ross, and Marguerite Drummond were added. In recent editions, the artwork of Valerie Oxorn and the surface anatomy photography of Anne Rayner of Vanderbilt University Medical Center's Medical Art Group have augmented the modern look and feel of the atlas.

Much credit is also due to Charles E. Storton for his role in the preparation of the majority of the original dissections and preliminary photographic work. We also wish to acknowledge the work of Dr. James Anderson, a pupil of Dr. Grant, under whose stewardship the seventh and eighth editions were published.

The following individuals also provided invaluable contributions to previous editions of the atlas and are gratefully acknowledged: C.A. Armstrong, P.G. Ashmore, D. Baker, D.A. Barr, J.V. Basmajian, S. Bensley, D. Bilbey, J. Bottos, W. Boyd, J. Callagan, H.A. Cates, S.A. Crooks, M. Dickie, C. Duckwall, R. Duckwall, J.W.A. Duckworth, F.B. Fallis, J.B. Francis, J.S. Fraser, P. George, R.K. George, M.G. Gray, B.L. Guyatt, C.W. Hill, W.J. Horsey, B.S. Jaden, M.J. Lee, G.F. Lewis, I.B. MacDonald, D.L. MacIntosh, R.G. MacKenzie, S. Mader, K.O. McCuaig, D. Mazierski, W.R. Mitchell, K. Nancekivell, A.J.A. Noronha, S. O'Sullivan, V. Oxorn, W. Pallie, W.M. Paul, D. Rini, C. Sandone, C.H. Sawyer, A.I. Scott, J.S. Simpkins, J.S. Simpson, C.G. Smith, I.M. Thompson, J.S. Thompson, N.A. Watters, R.W. Wilson, B. Vallecoccia, and K. Yu.

FOURTEENTH EDITION

We are indebted to our students, colleagues, and former professors for their encouragement—especially Joel Vilensky, Sherry Downie, Ryan Splittgerber, Mitchell T. Hayes, Edward Weber, and Douglas J. Gould for their invaluable input.

We wish to thank Dr. Joel A. Vilensky and Dr. Edward C. Weber for their contribution of new images to update and enhance the imaging sections of this edition.

We extend our gratitude to Professors Nick Woolridge and David Mazerski who developed the carbon-dust recolorization process and along with Nicole Clough and Marissa Webber who recolorized all of the carbon-dust images. Their artistic skills and anatomical insights made substantial contributions to this edition. We would also like to acknowledge Jennifer Clements, Art Director at Wolters Kluwer, who managed the art program for this edition.

Special thanks go to everyone at Wolters Kluwer—especially Crystal Taylor, Senior Acquisitions Editor, and Greg Nicholl, Senior Product Development Editor. We also thank Bridgett Dougherty, Production Project Manager. All of your efforts and expertise are much appreciated.

We would like to thank the hundreds of instructors and students who have over the years communicated via the publisher and directly with the editor their suggestions for how this *Atlas* might be improved. Finally, we would like to acknowledge the reviewers who reviewed previous editions of the *Atlas* as well as the reviewers who reviewed the fourteenth edition and provided expert advice on the development of this edition.

Contents

List of Tables

Figure and Table Credits

CHAPTER 1

Back

Figures 1.3D&E, 1.4, and 1.17B. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 1.7A–D, 1.9A,B,D&E, 1.14B, 1.15C, 1.18A–C, 1.19A&B, 1.21A&B, 1.31A–E, 1.32A–D, 1.38C, 1.41A&C, 1.42A&B, 1.45B, 1.46A–E, 1.47, 1.48, and 1.49A&B. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figure 1.8A&B. Courtesy of J. Heslin, University of Toronto, Ontario, Canada.

Figures 1.8C&D and 1.50C. Courtesy of D. Armstrong, University of Toronto, Ontario, Canada.

Figures 1.9C and 1.53A–D. Courtesy of D. Salonen, University of Toronto, Ontario, Canada.

Figure 1.43A–E. Modified from Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. Baltimore, MD: Lippincott Williams & Wilkins, 2009.

Figures 1.50A&B, 1.51A&B, and 1.52A&B. Courtesy of the Visible Human Project; National Library of Medicine; Visible Man 1805.

CHAPTER 2

Upper Limb

Figures 2.3A,B,D,&E, 2.5A&B, 2.7A–D, 2.19, 2.22B, 2.25B, 2.34F, 2.45C, 2.48B, 2.53D, 2.61A&B, 2.62, 2.70B, 2.72D, 2.73, 2.80, 2.81A&B, 2.86C&D, 2.87D, and Table 2.8. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figures 2.4A–C, 2.6, 2.8A–D, 2.9A&B, 2.12A&B, 2.13A–C, 2.23B&C, 2.24A&B, 2.29B, 2.44B, 2.47B&D, and 2.67B. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figure 2.10. Modified from Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. Baltimore, MD: Lippincott Williams & Wilkins, 2009.

Figures 2.18A–D, 2.31A–D, 2.33D, 2.35A–D, 2.63A, 2.64A, 2.65A, 2.72A–C, and 2.83A&B. Modified from Clay JH, Pounds DM. *Basic Clinical Massage Therapy*. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figures 2.24C and 2.90F. Courtesy of D. Armstrong, University of Toronto, Ontario, Canada.

Figures 2.48C, 2.55B, 2.96A–C, 2.97B–D, and 2.98A–C. Courtesy of D. Salonen, University of Toronto, Ontario, Canada.

Figures 2.48D and 2.99B. Courtesy of R. Leekam, University of Toronto and West End Diagnostic Imaging, Ontario, Canada.

Figure 2.54A&B (MRIs). Courtesy of J. Heslin, University of Toronto, Ontario, Canada.

Figure 2.90C&D. Courtesy of E. Becker, University of Toronto, Ontario, Canada.

CHAPTER 3

Thorax

Figures 3.7B, 3.14A&B, 3.15B, 3.19, 3.20, 3.27A–C, 3.28A,C,&D, 3.34A–F, 3.43C, 3.48A–C, 3.49A&D, 3.50A&C, 3.53A–C, 3.60C, 3.65A–C, 3.71A&B, 3.77E, and 3.78F&H. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figures 3.14C, 3.15A, 3.28B, 3.51A&C–E, 3.52A&B, 3.54B, 3.55B, 3.56B&C, 3.57C, 3.58B, 3.70, and 3.72B. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 3.43B&E, 3.49C, and 3.57B. Courtesy of I. Verschuur, Joint Department of Medical Imaging, UHN/Mount Sinai Hospital, Toronto, Ontario, Canada.

Figure 3.50B&D. Courtesy of I. Morrow, University of Manitoba, Canada.

Figure 3.51B. Courtesy of Dr. J. Heslin, Toronto, Ontario, Canada.

Figure 3.52C. Feigenbaum H, Armstrong WF, Ryan T. *Feigenbaum's Echocardiography*, 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2005:116.

Figure 3.64B. Courtesy of Dr. E.L. Lansdown, University of Toronto, Ontario, Canada.

Figures 3.79A–E, 3.80A&B, and 3.81A&B. Courtesy of Dr. M.A. Haider, University of Toronto, Ontario, Canada.

CHAPTER 4

Abdomen

Figures 4.3, 4.5, 4.7A, 4.10D&E, 4.17A–E, 4.18, 4.20C, 4.22B, 4.24A&B, 4.27B, 4.31A–C, 4.32A, 4.33A&B, 4.35A, 4.44 (insets), 4.51B&C, 4.54A, 4.55, 4.66A, 4.72A, 4.76B, 4.79C, 4.80A–D, 4.81, 4.83, 4.85A&B, 4.89A,B,&D–F, and 4.93A–C (schematics on left). Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figure 4.7B. Lockhart RD, Hamilton GF, Fyfe FW. *Anatomy of the Human Body*. Philadelphia, PA: JB Lippincott, 1959.

Figure 4.9A–E. Modified from Clay JH, Pounds DM. *Basic Clinical Massage Therapy*, 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2008.

Figures 4.10A&B, 4.42C–E, 4.43B, 4.58B&C, 4.62A–H, 4.73A–E, and 4.85C. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 4.32C (photo) and 4.34A. Dudek RW, Louis TM. *High-Yield Gross Anatomy*, 4th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2010.

Figures 4.34B, 4.36, 4.45B, and 4.61A&B. Courtesy of Dr. J. Heslin, Toronto, Ontario, Canada.

Figures 4.34C&D, 4.42B, 4.45A, and 4.72B. Courtesy of Dr. E.L. Lansdown, University of Toronto, Ontario, Canada.

Figure 4.42A. Courtesy of Dr. C.S. Ho, University of Toronto, Ontario, Canada.

Figure 4.47. Courtesy of Dr. K. Sniderman, University of Toronto, Ontario, Canada.

Figure 4.53B. Courtesy of A.M. Arenson, University of Toronto, Ontario, Canada.

Figure 4.66B (MRI). Courtesy of G.B. Haber, University of Toronto, Ontario, Canada.

Figure 4.66B (photo). Courtesy of Mission Hospital Regional Center, Mission Viejo, California.

Figure 4.73B (MRI). Courtesy of M. Asch, University of Toronto, Ontario, Canada.

Figures 4.91B&D, 4.92B&C, and 4.93A–C (MRIs). Courtesy of Dr. M.A. Haider, University of Toronto, Ontario, Canada.

CHAPTER 5

Pelvis and Perineum

Figures 5.3C, 5.4B&C, 5.11B, 5.12B, 5.16B–D, 5.18A–D, 5.19, 5.26B, 5.27A&B, 5.28B–D, 5.29A&B, 5.38A&B, 5.39B–D, 5.47B–E, 5.48A–F, 5.51B, 5.52B, and 5.54C. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figure 5.7A&B. Snell R. *Clinical Anatomy by Regions*, 9th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2012.

Figures 5.24A&B (MRIs), 5.30B, 5.43A, 5.57B&E–H, and 5.64A–D,F,&H. Courtesy of Dr. M.A. Haider, University of Toronto, Ontario, Canada.

Figure 5.24C. Modified from Bickley LS. *Bates' Guide to Physical Examination and History Taking*, 10th ed. Philadelphia, PA: Wolters Kluwer Health, 2009.

Figures 5.28A, 5.30E&F, 5.33A–C, 5.39A, 5.40, 5.41, and 5.59B. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 5.30C and 5.34A&B. Courtesy of A.M. Arenson, University of Toronto, Ontario, Canada.

Figure 5.35D. Reprinted with permission from Stuart GCE, Reid DF. Diagnostic studies. In: Copeland LJ. *Textbook of Gynecology*. Philadelphia, PA: WB Saunders, 1993.

Figures 5.43B and 5.57C. From the Visible Human Project; National Library of Medicine; Visible Woman Image Numbers 1870 and 1895.

CHAPTER 6

Lower Limb

Figures 6.2A&B, 6.9A&B, 6.12A, 6.13A, 6.15A&B, 6.17B, 6.19C, 6.29A&B, 6.30A, 6.32B&C, 6.38A, 6.45 (schematics), 6.48B&C, 6.53A, 6.58A&B, 6.61A&B, 6.63D, 6.65A&B, 6.66D, 6.67B, and 6.72A–C. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figure 6.3A&C. Courtesy of P. Babyn, University of Toronto, Ontario, Canada.

Figures 6.7A–D, 6.12B, 6.13B, 6.24B&C, 6.33B, 6.59A&E, 6.67E, 6.68B, 6.71A&B, 6.74A, 6.75A, 6.76A, 6.77A, 6.80B&C, 6.81D, and 6.87A. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figure 6.8A&B. Based on Foerster O. The dermatomes in man. *Brain*. 1933;56(1):1–39.

Figure 6.8C&D. Based on Keegan JJ, Garrett FD. The segmental distribution of the cutaneous nerves in the limbs of man. *Anat Rec*. 1948;102:409–437.

Figure 6.14B. Courtesy of Dr. E.L. Lansdown, University of Toronto, Ontario, Canada.

Figures 6.22A–E&H, 6.29C–F, 6.30B–D, and 6.62C&D. Modified from Clay JH, Pounds DM. *Basic Clinical Massage Therapy*. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figure 6.34A&B. Modified from Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. Baltimore, MD: Lippincott Williams & Wilkins, 2009.

Figure 6.39A. Courtesy of E. Becker, University of Toronto, Ontario, Canada.

Figures 6.39C, 6.56C&D, 6.92C–E (MRIs), and 6.94A–D (MRIs). Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

Figure 6.49C. Courtesy of Dr. Robert Peroutka, Cockeysville, MD.

Figure 6.70A. Courtesy of Dr. D. K. Sniderman, University of Toronto, Ontario, Canada.

Figure 6.82B. Courtesy of E. Becker, University of Toronto, Ontario, Canada.

Figures 6.85B and 6.86B. Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

Figure 6.90E. Courtesy of Dr. P. Bobechko, University of Toronto, Ontario, Canada.

CHAPTER 7

Head

Figures 7.1B,E,&F, 7.76B, 7.103A–F, 7.107A–E (MRIs), 7.108A–F, and 7.109A–C. Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.

Figures 7.3C, 7.6B, 7.17A&B, 7.19, 7.21B&C, 7.29, 7.31B, 7.44A, 7.45B, 7.60B, 7.63C, 7.64A&C, 7.68B, 7.70A&B, 7.71A&B, 7.72A (top), 7.82A&B, 7.84D, 7.98A&C, and Table 7.15. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 7.14A, 7.15A&B, 7.18A&B, 7.20B, 7.21A, 7.22A–D, 7.24B, 7.25A&B, 7.30B&C, 7.33B&C, 7.39B,C,&E, 7.42B–E, 7.43A&B, 7.44B, 7.45D, 7.46B, 7.48A&D, 7.51, 7.52A&B, 7.55B&C, 7.56A–C, 7.57A–D, 7.58A&B, 7.59A–C, 7.67A–C, 7.78A–C, 7.79D&E, 7.85A, 7.86A, 7.89B, 7.90C–E, 7.91A&B, and 7.92A–D. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figure 7.34A–C. Courtesy of I. Verschuur, Joint Department of Medical Imaging, UHN/Mount Sinai Hospital, Toronto, Ontario, Canada.

Figures 7.35A&B, 7.38D, 7.94B&C, and 7.95B. Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

Figure 7.46A. Courtesy of J.R. Buncic, University of Toronto, Ontario, Canada.

Figure 7.53A–C. Modified from Clay JH, Pounds DM. *Basic Clinical Massage Therapy*. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figure 7.56 (MRIs). Langland OE, Langlais RP, Preece JW. *Principles of Dental Imaging*, 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figure 7.65D. Courtesy of M.J. Phatoah, University of Toronto, Ontario, Canada.

Figure 7.66E. Courtesy of Dr. B. Libgott, Division of Anatomy/Department of Surgery, University of Toronto, Ontario, Canada.

Figures 7.76C and 7.77B. Courtesy of E. Becker, University of Toronto, Ontario, Canada.

Figure 7.96A&B. Courtesy of the Visible Human Project; National Library of Medicine; Visible Man 1107 and 1168.

Figures 7.99–7.102, 7.104, 7.105B&C, and 7.106. Colorized from photographs provided courtesy of Dr. C.G. Smith, which appears in Smith CG. *Serial Dissections of the Human Brain*. Baltimore, MD: Urban & Schwarzenber, Inc and Toronto: Gage Publishing Ltd, 1981. (© Carlton G. Smith)

CHAPTER 8

Neck

Figures 8.2A–C, 8.3A, 8.5A&C–G, 8.6B&C, 8.8B, 8.12B, 8.15A–C, 8.17B, 8.19A, 8.36B–F&H–J, 8.37D, and 8.39. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

Figures 8.4A&B, 8.8D&E, 8.23A, 8.28C, and 8.31C. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figure 8.5B. Courtesy of J. Heslin, University of Toronto, Ontario, Canada.

Figures 8.7B&C, 8.12A, and 8.24A&B. Modified from Clay JH, Pounds DM. *Basic Clinical Massage Therapy*. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figure 8.15D. Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.

Figures 8.28A and 8.43B. Modified from Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. Baltimore, MD: Lippincott Williams & Wilkins, 2009.

Figure 8.30B. From Liebgott B. *The Anatomical Basis of Dentistry*. Philadelphia, PA: Mosby, 1982.

Figure 8.37A. Rohen JW, Yokochi C, Lutjen-Drecoll E, et al. *Color Atlas of Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2002.

Figures 8.37C and 8.40A–C. Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

Figure 8.42A. Courtesy of Dr. E. Becker, University of Toronto, Ontario, Canada.

Figure 8.43A. Siemens Medical Solutions USA, Inc.

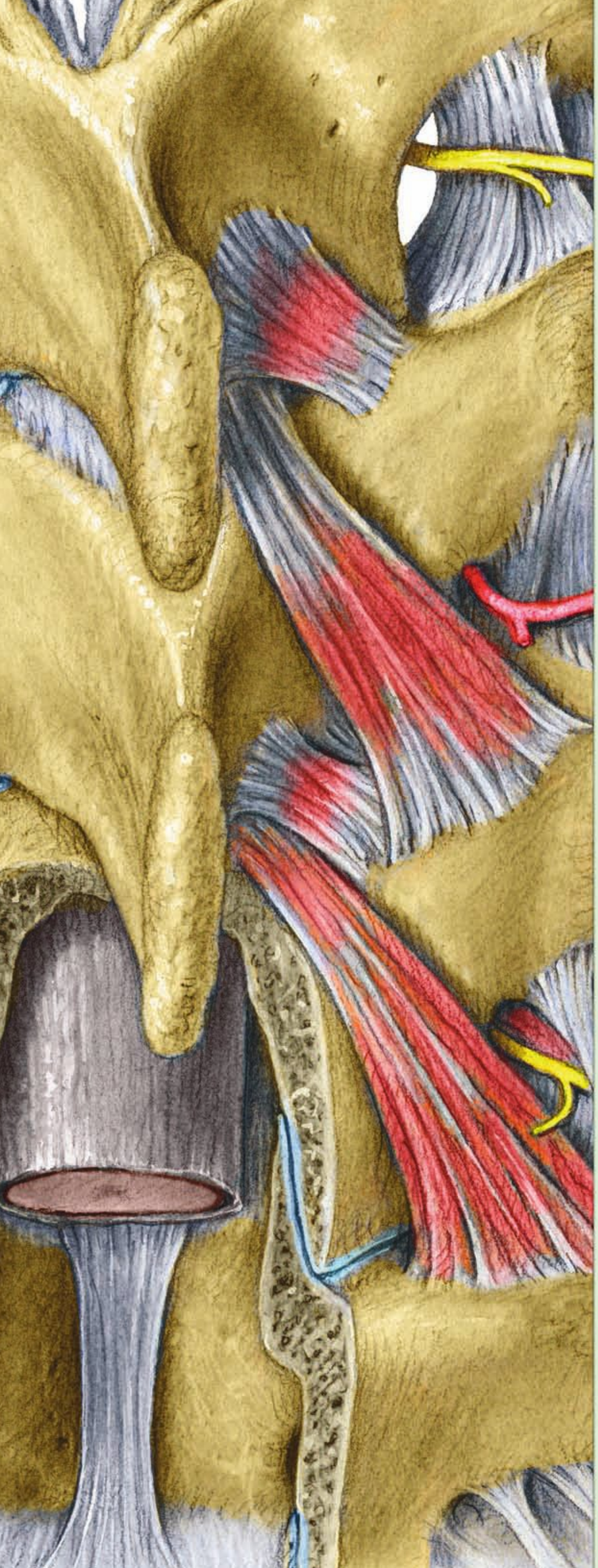
CHAPTER 9

Cranial Nerves

Figures 9.3, 9.5A&B, 9.6A–C, 9.7, 9.8C&D, 9.10A, 9.11B, 9.13B–E, 9.14A, 9.15B&C, 9.16D, 9.17A, 9.18A,B,&D, 9.19A, 9.20B, and 9.21. Modified from Moore KL, Agur MR, Dalley AF. *Essential Clinical Anatomy*, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2015.

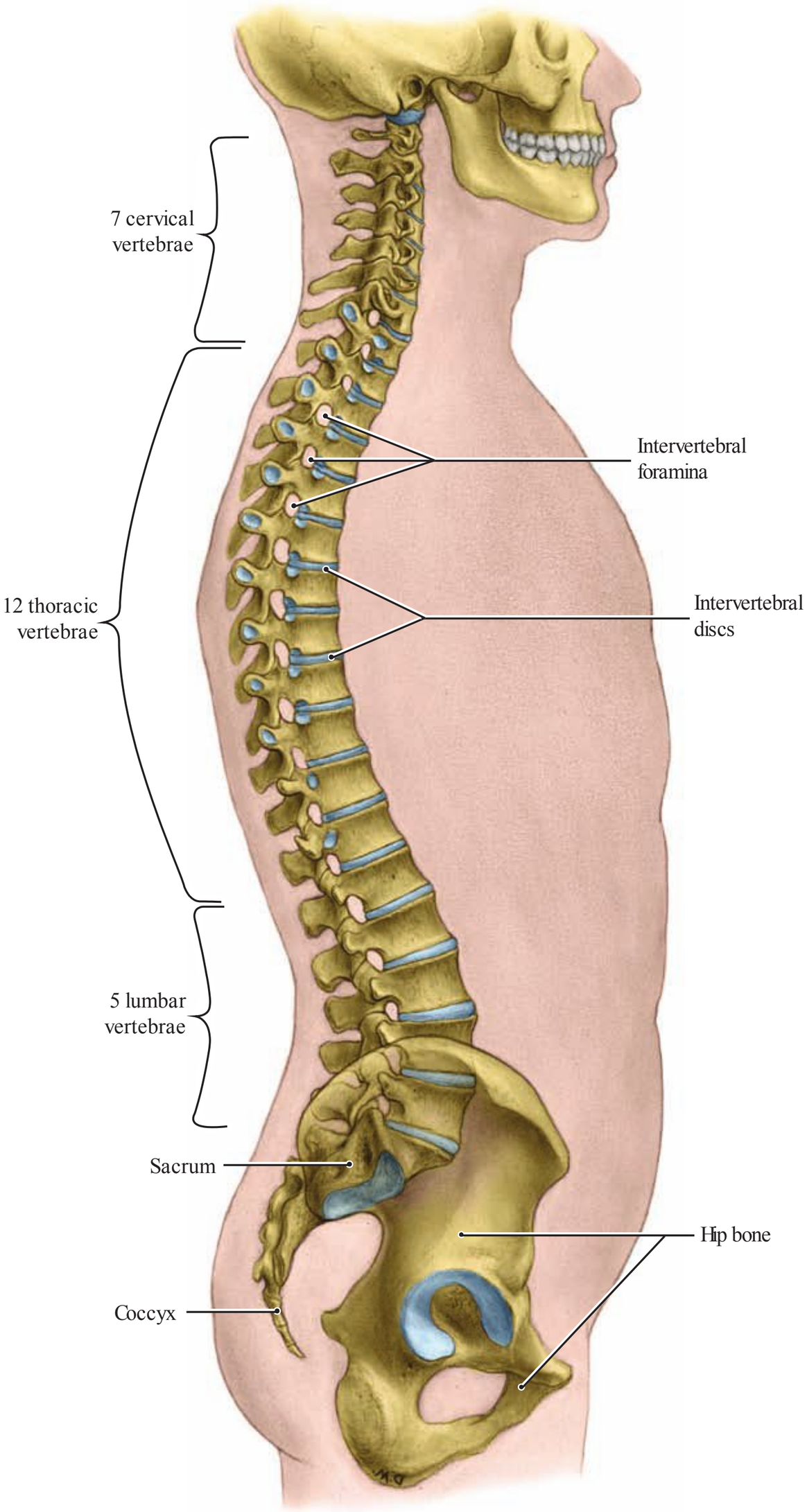
Figure 9.16C. Modified from Moore KL, Dalley AF, Agur MR. *Clinically Oriented Anatomy*, 7th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2014.

Figures 9.23A–F and 9.24A–C. Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

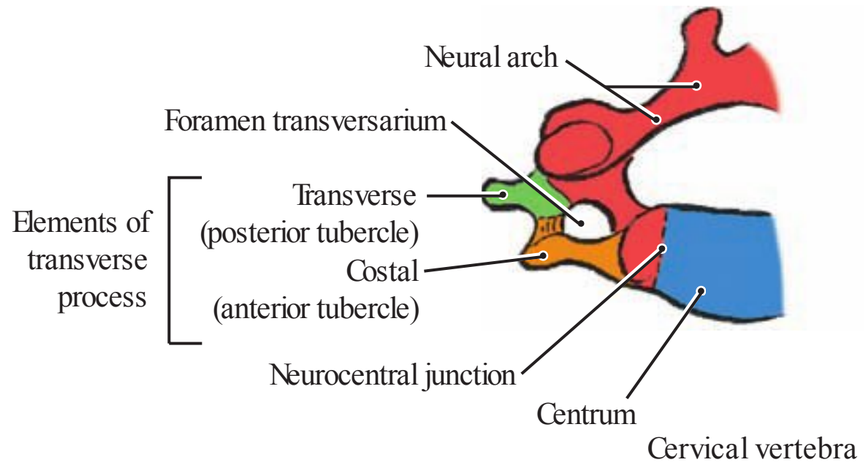


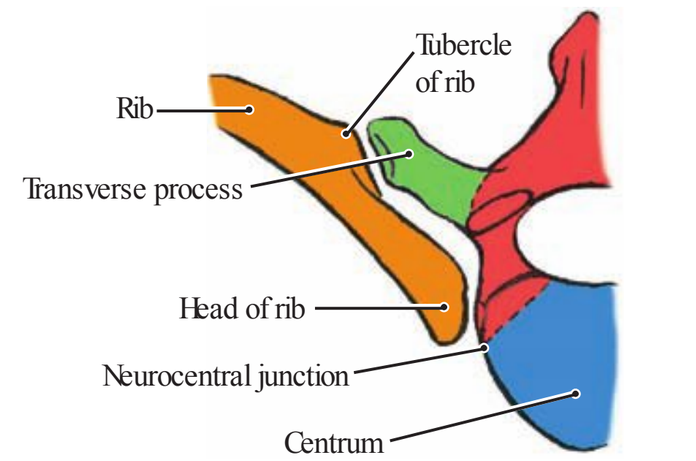
CHAPTER 1

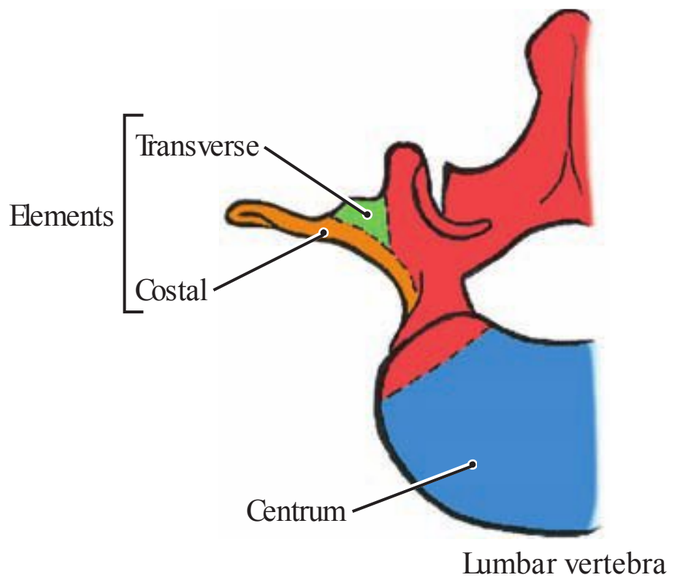
Back

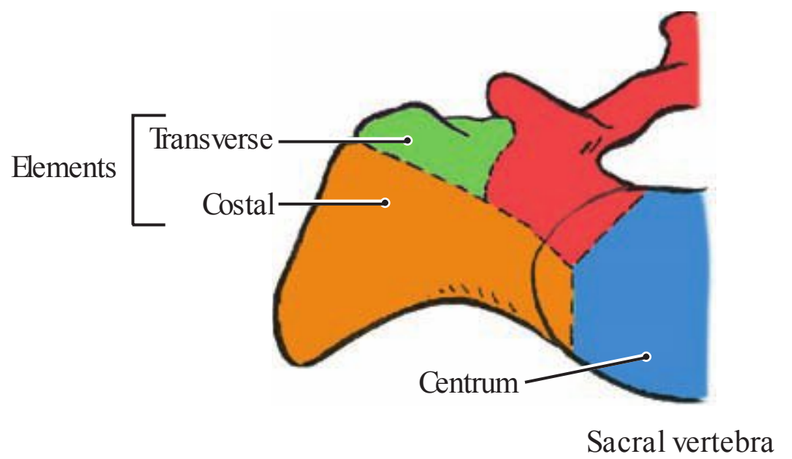


A. Lateral View









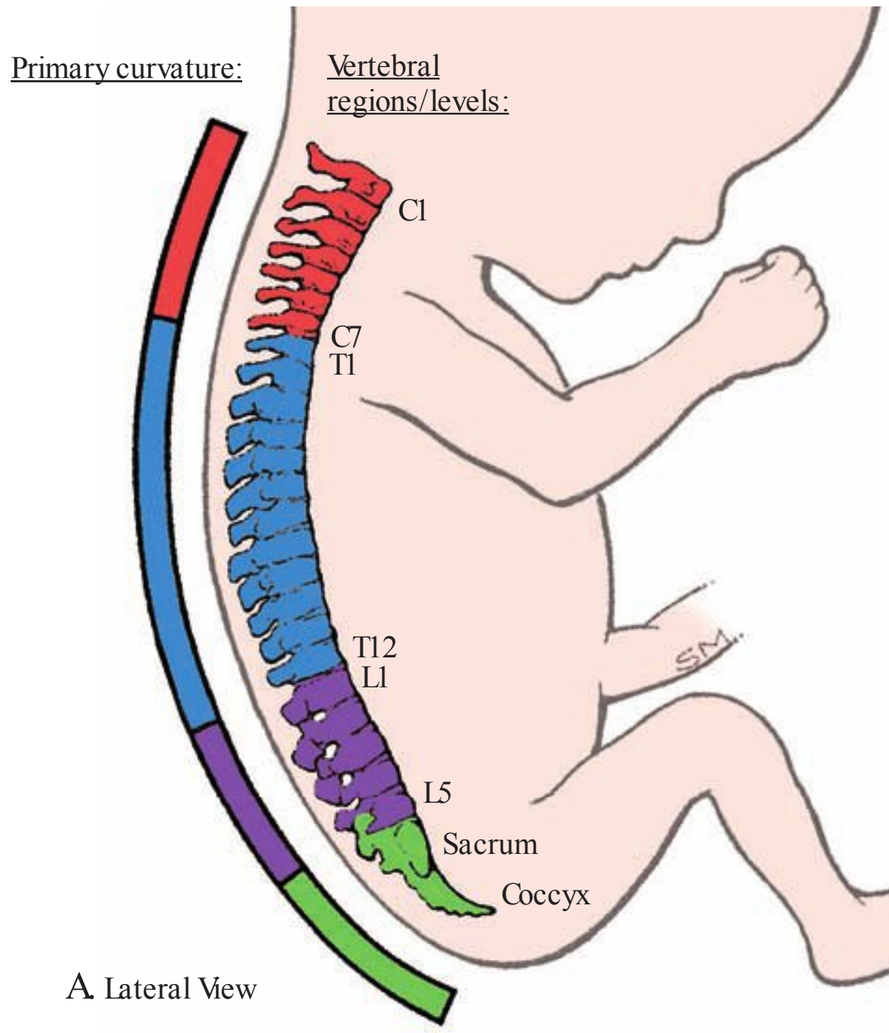
B. Superior Views

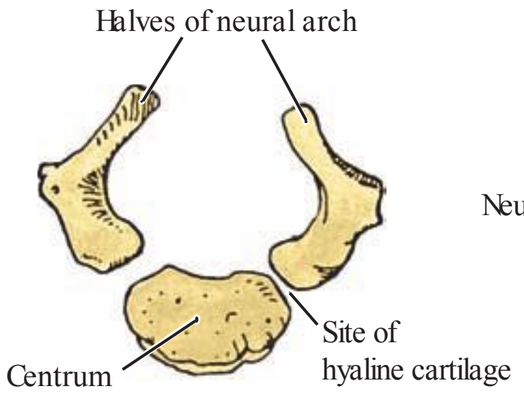
1.1 OVERVIEW OF VERTEBRAL COLUMN

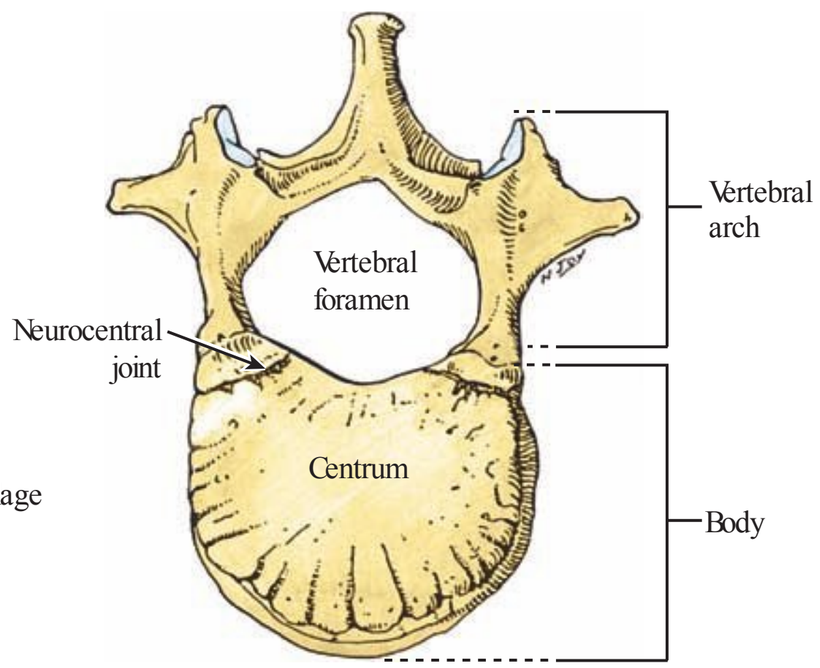
A. Vertebral column showing articulation with skull and hip bone.

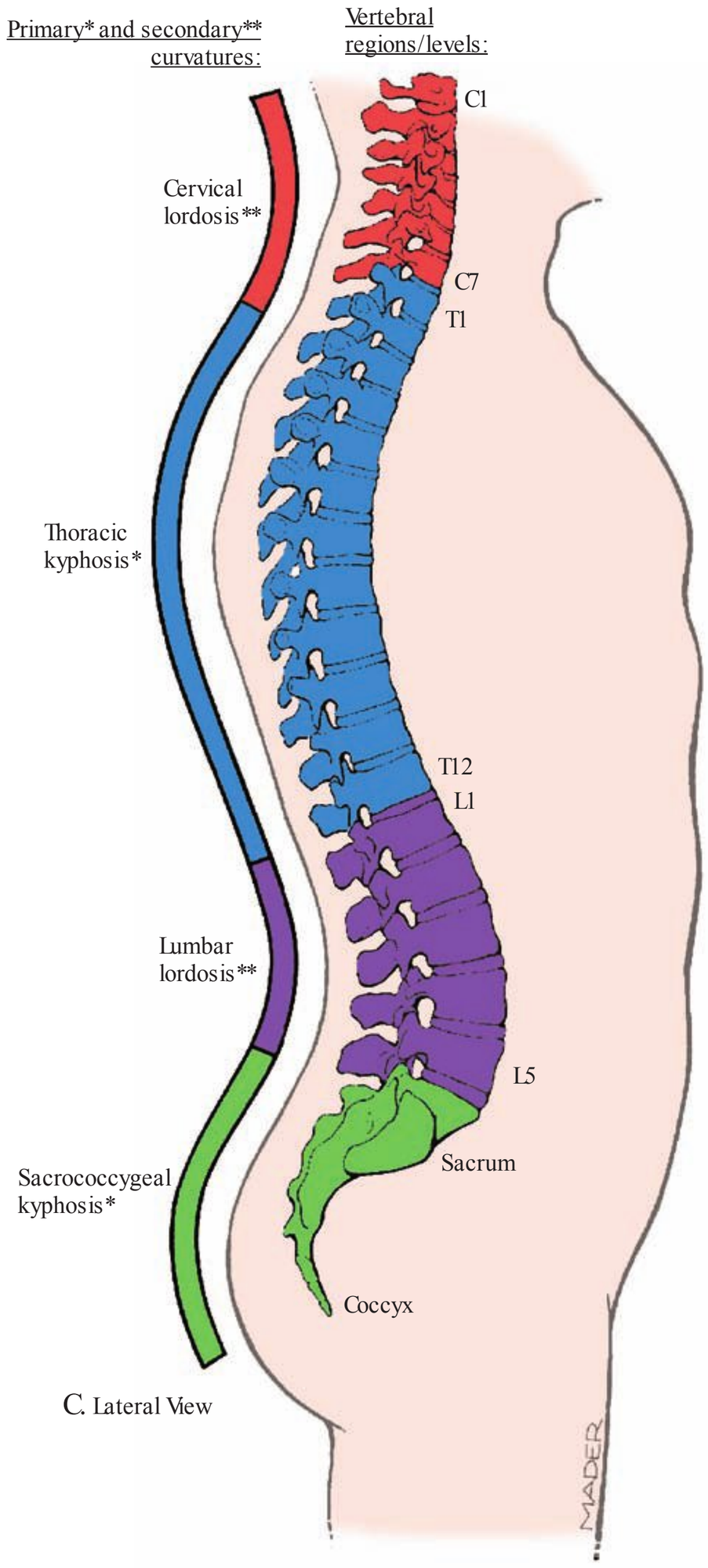
- The vertebral column usually consists of 24 separate (presacral) vertebrae, 5 fused vertebrae in the sacrum, and variably 4 fused or separated coccygeal vertebrae. Of the 24 separate vertebrae, 12 support the ribs (thoracic vertebrae), 7 are in the neck (cervical vertebrae, and 5 are in the lumbar region (lumbar vertebrae).
- The spinal nerves exit the vertebral (spinal) canal via the intervertebral (IV) foramina. There are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 to 2 coccygeal spinal nerves.

B. Homologous parts of vertebrae. A rib is a free costal element in the thoracic region; in the cervical and lumbar regions, it is represented by the anterior part of a transverse process, and in the sacrum, by the anterior part of the lateral mass.



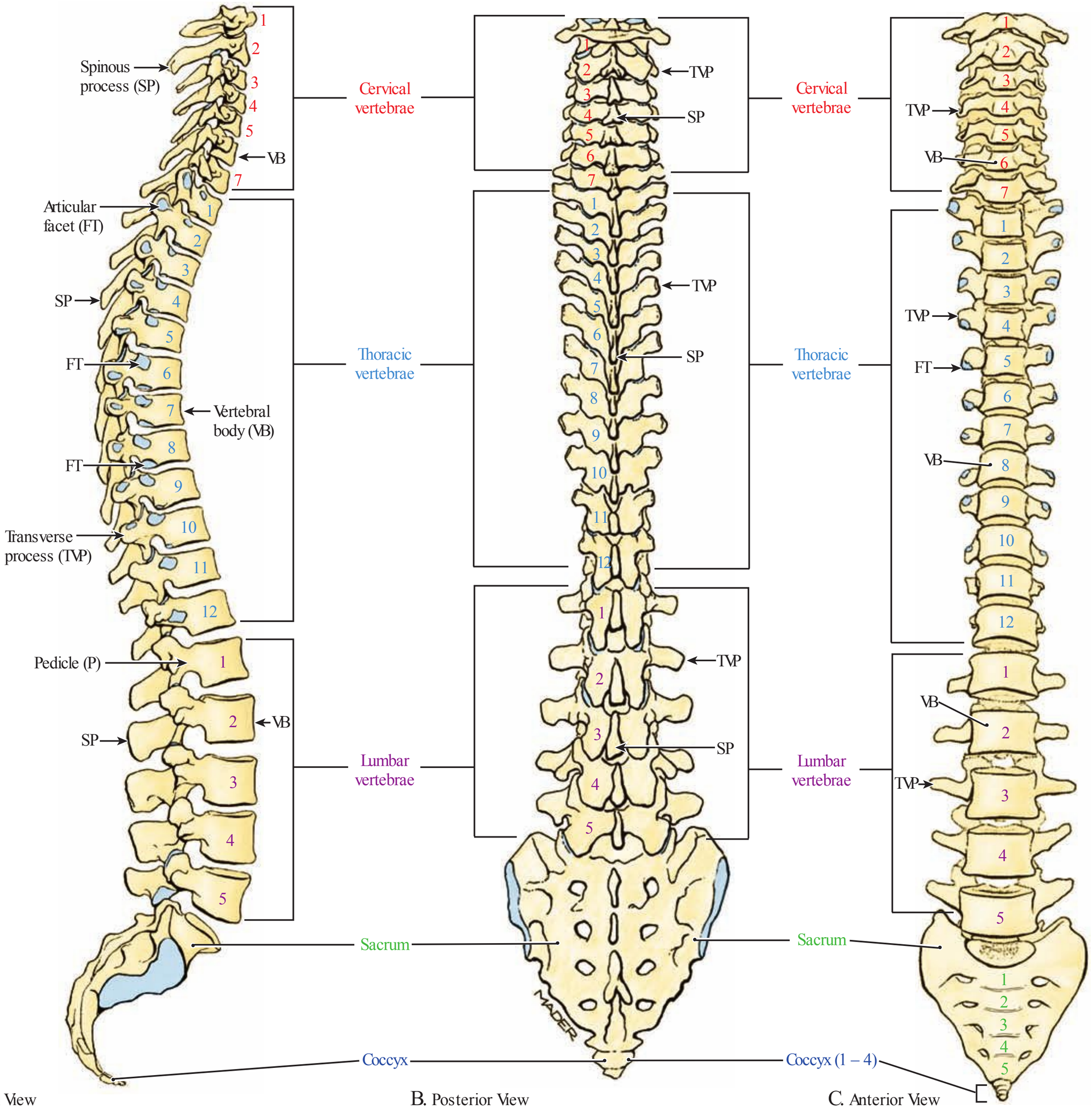






CURVATURES OF VERTEBRAL COLUMN 1.2

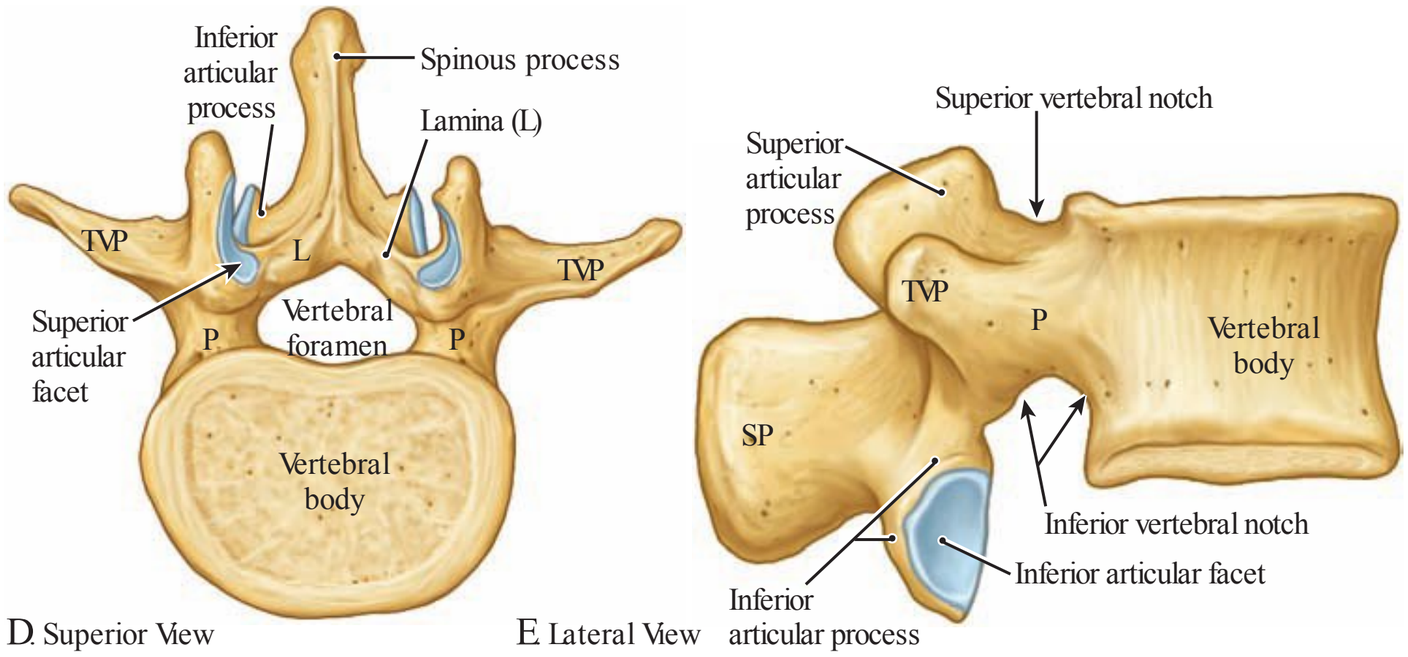
A. Fetus. Note the C-shaped curvature of the fetal spine, which is concave anteriorly over its entire length. **B.** Development of the vertebrae. At birth, a vertebra consists of three bony parts (two halves of the neural arch and the centrum) united by hyaline cartilage. At age 2, the halves of each neural arch begin to fuse, proceeding from the lumbar to the cervical region; at approximately age 7, the arches begin to fuse to the centrum, proceeding from the cervical to lumbar regions. **C.** Adult. The four curvatures of the adult vertebral column include the cervical lordosis, which is convex anteriorly and lies between vertebrae C1 and T2; the thoracic kyphosis, which is concave anteriorly, between vertebrae T2 and T12; the lumbar lordosis, convex anteriorly and lying between T12 and the lumbosacral joint; and the sacrococcygeal kyphosis, concave anteriorly and spanning from the lumbosacral joint to the tip of the coccyx. The anteriorly concave thoracic kyphosis and sacrococcygeal kyphosis are primary curves, and the anteriorly convex cervical lordosis and lumbar lordosis are secondary curves that develop after birth. The cervical lordosis develops when the child begins to hold the head up, and the lumbar kyphosis develops when the child begins to walk.



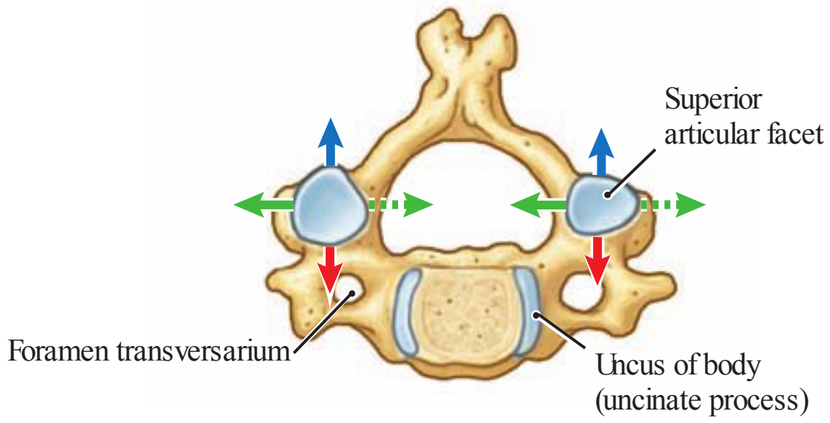
A. Lateral View B. Posterior View C. Anterior View

1.3 PARTS OF VERTEBRAL COLUMN

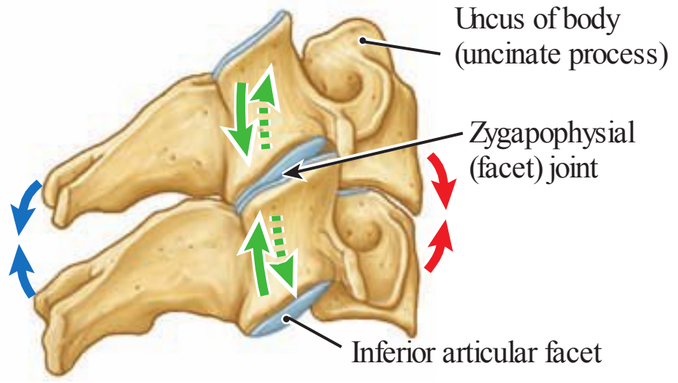
A. Lateral view. **B.** Posterior view. **C.** Anterior view. **D.** and **E.** Parts of a typical vertebra (e.g., the 2nd lumbar vertebra). *FT*, facet for articulation with the ribs; *L*, lamina; *P*, pedicle; *SP*, spinous process; *TVP*, transverse process; *VB*, vertebral body.

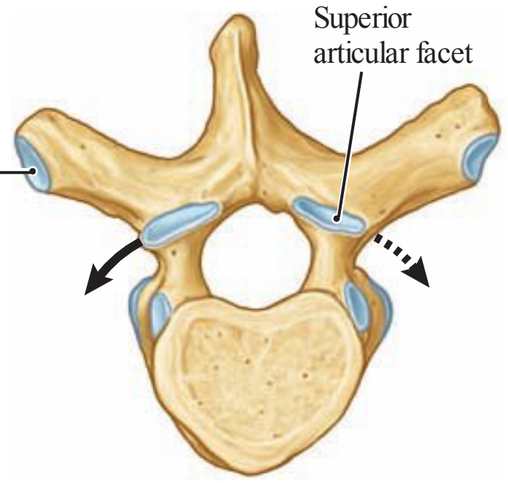


D. Superior View E. Lateral View

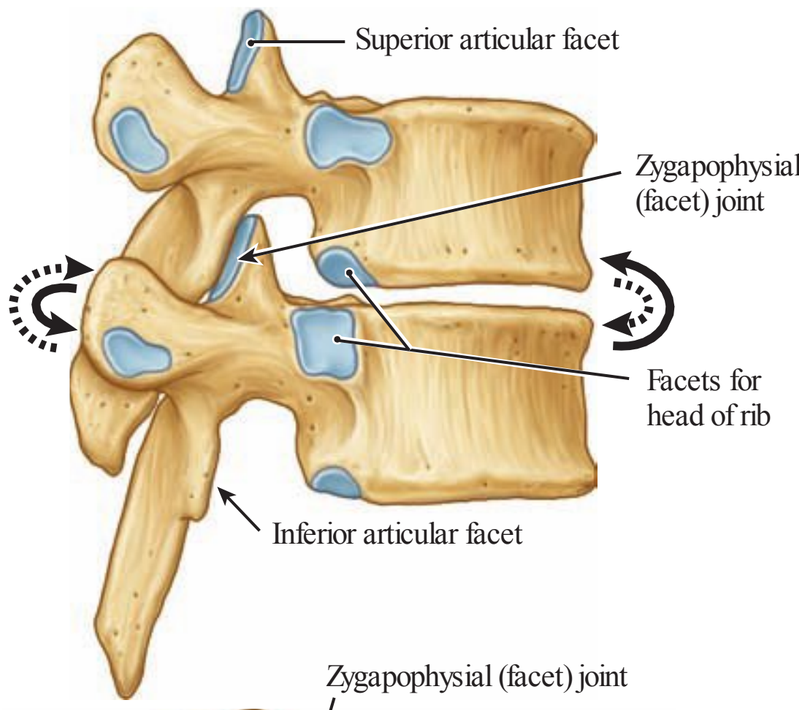


Cervical vertebrae



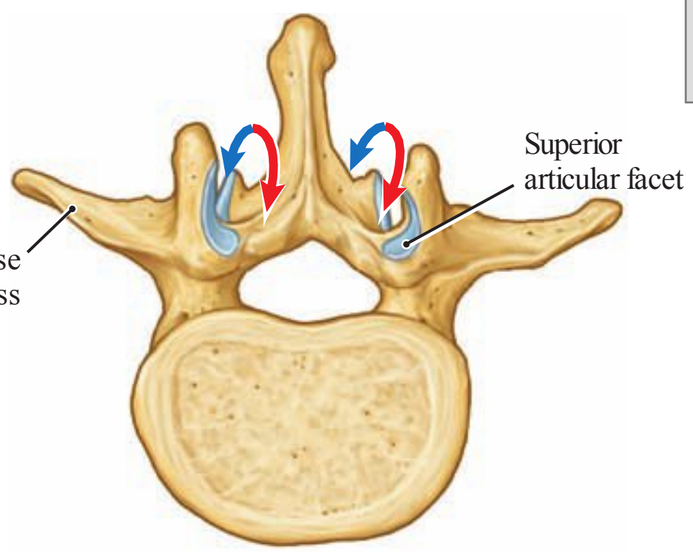


Thoracic vertebrae

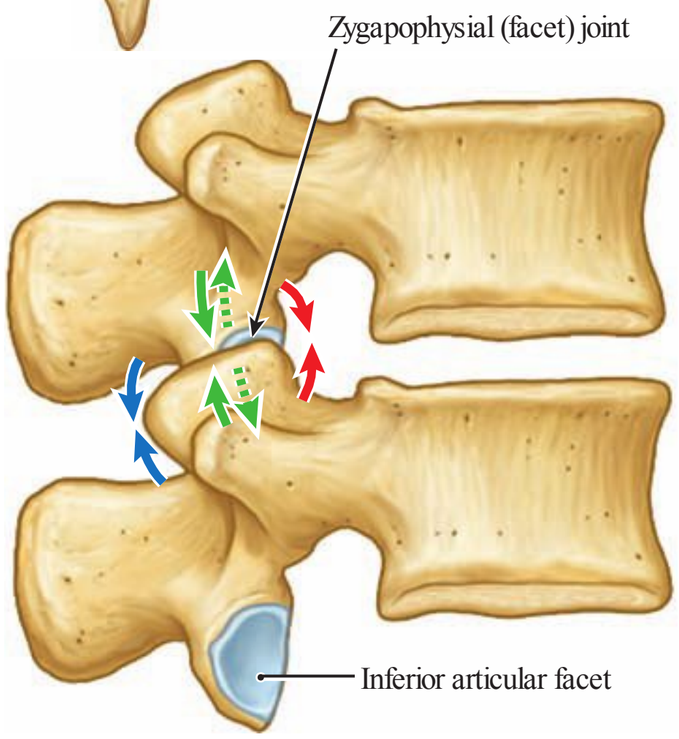


Key

- Flexion
- Extension
- Lateral flexion to right
- Lateral flexion to left
- Rotation to left
- Rotation to right



Lumbar vertebrae

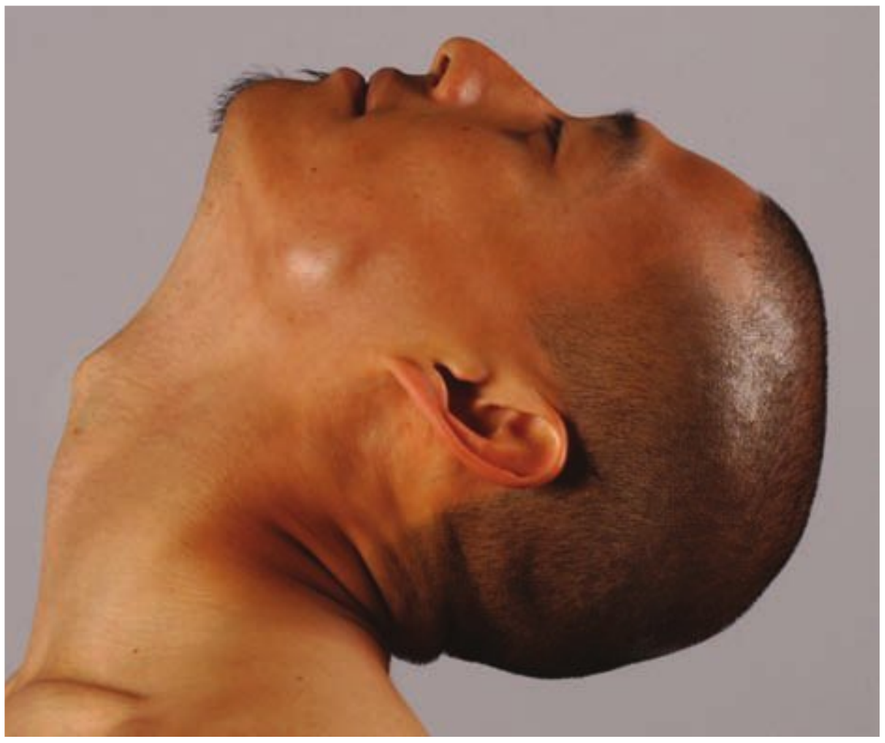


Superior Views - arrows indicate direction of movement of superior adjacent vertebra (not shown) relative to the inferior vertebra (shown here)

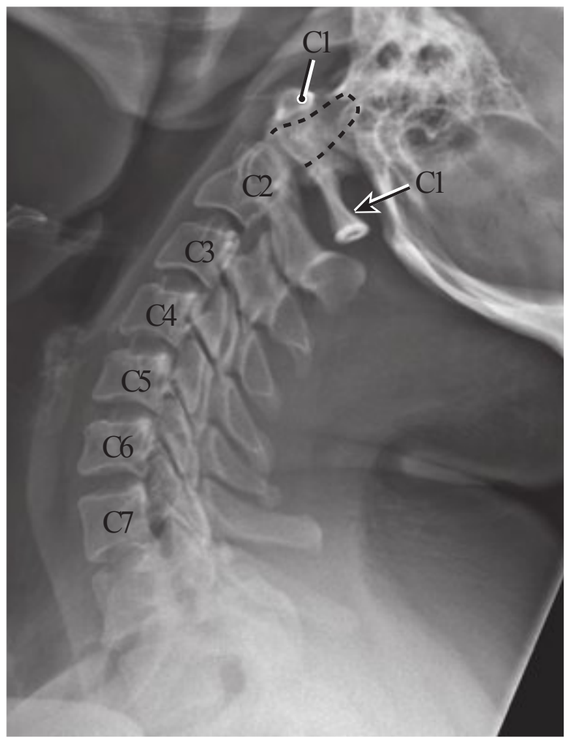
Lateral Views - arrows indicate direction of movement of the superior and inferior vertebra relative to each other

VERTEBRAL FEATURES AND MOVEMENTS 1.4

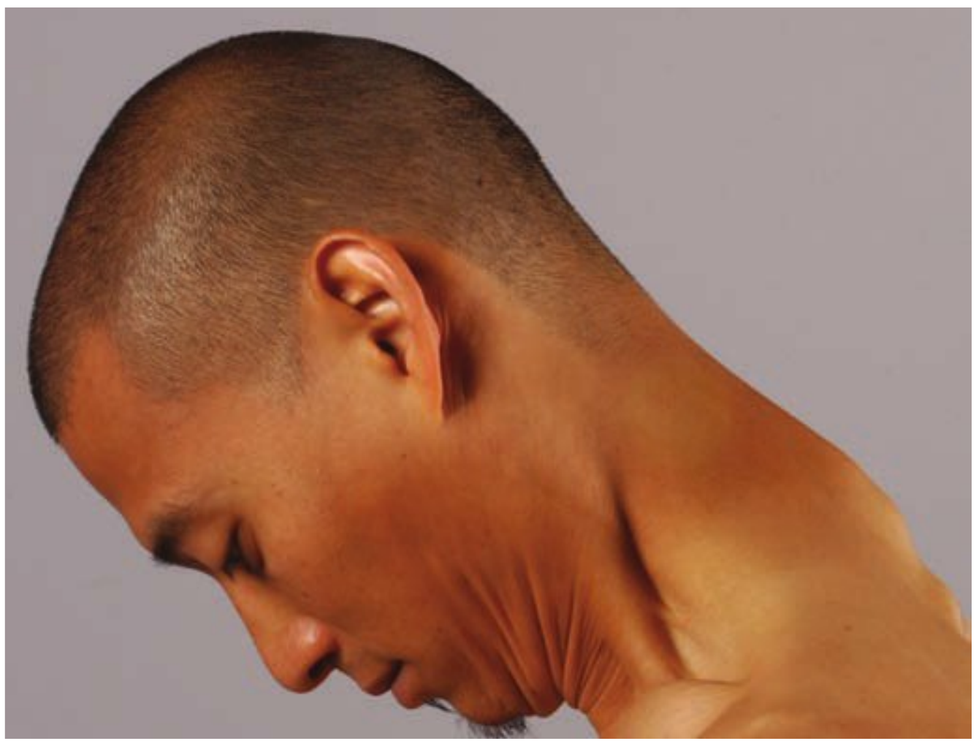
- In the thoracic and lumbar regions, the articular processes/facets lie posterior to the vertebral bodies and in the cervical region posterolateral to the bodies. Superior articular facets in the cervical region face mainly superiorly, in the thoracic region, mainly posteriorly, and in the lumbar region, mainly medially. The change in direction is gradual from cervical to thoracic but abrupt from thoracic to lumbar.
- Although movements between adjacent vertebrae are relatively small, the summation of all the small movements produces a considerable range of movement of the vertebral column as a whole.
- Movements of the vertebral column are freer (have greater range of motion) in the cervical and lumbar regions than in the thoracic region. Lateral bending is freest in the cervical and lumbar regions; flexion is greatest in the cervical region; extension is most marked in the lumbar region, but the interlocking articular processes prevent rotation.
- The thoracic region is most stable because of the external support gained from the articulations of the ribs and costal cartilages with the sternum. The direction of the articular facets permits rotation, but flexion, extension, and lateral bending are severely restricted.



A. Lateral View

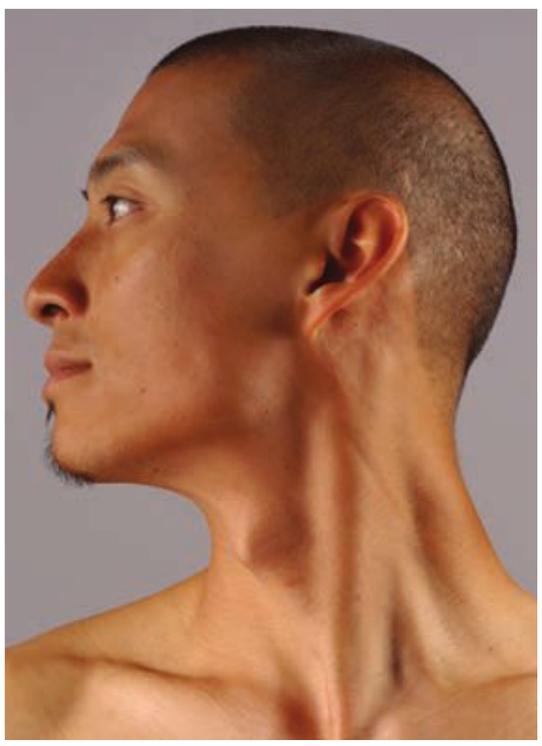


B. Lateral Radiograph

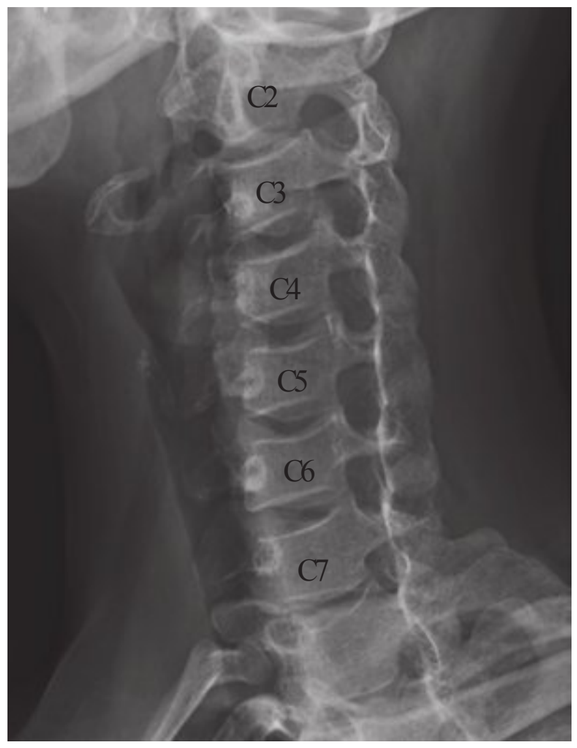


C. Lateral View

D. Lateral Radiograph



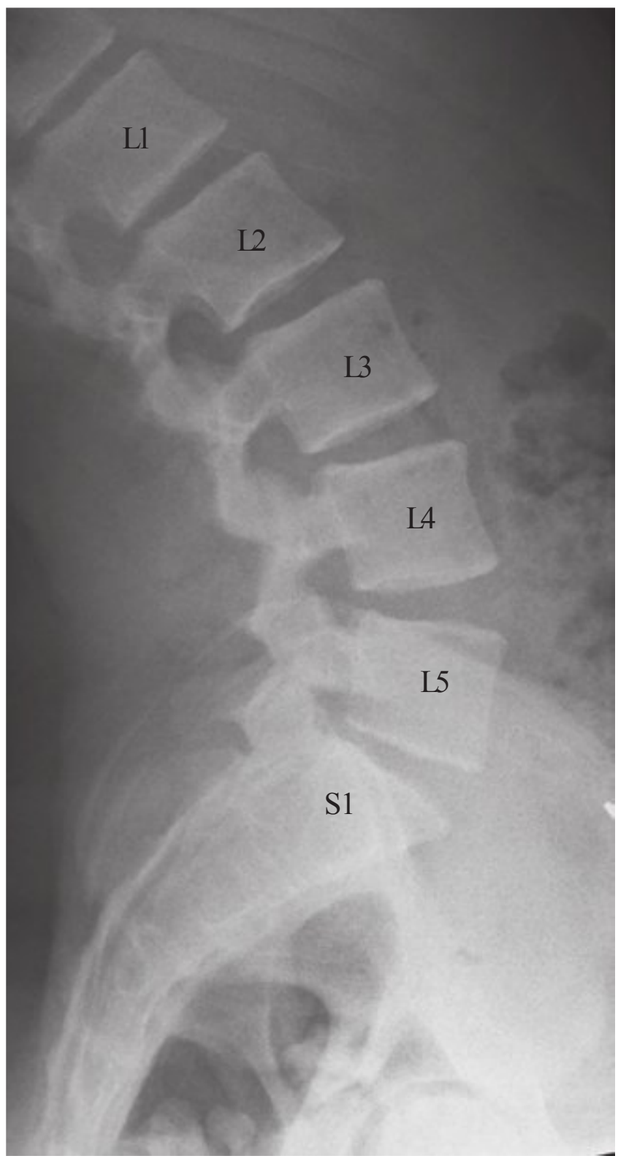
E. Anterior View



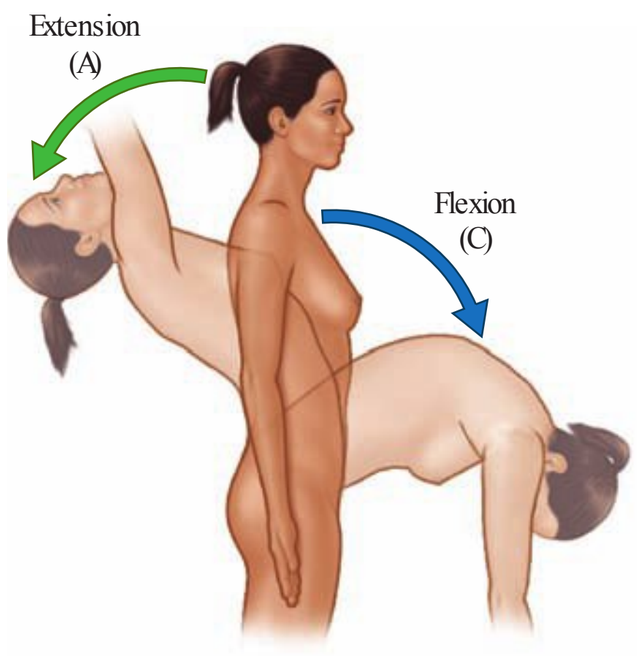
F. Oblique Radiograph

1.5 SURFACE ANATOMY WITH RADIOGRAPHIC CORRELATION OF SELECTED MOVEMENTS OF THE CERVICAL SPINE

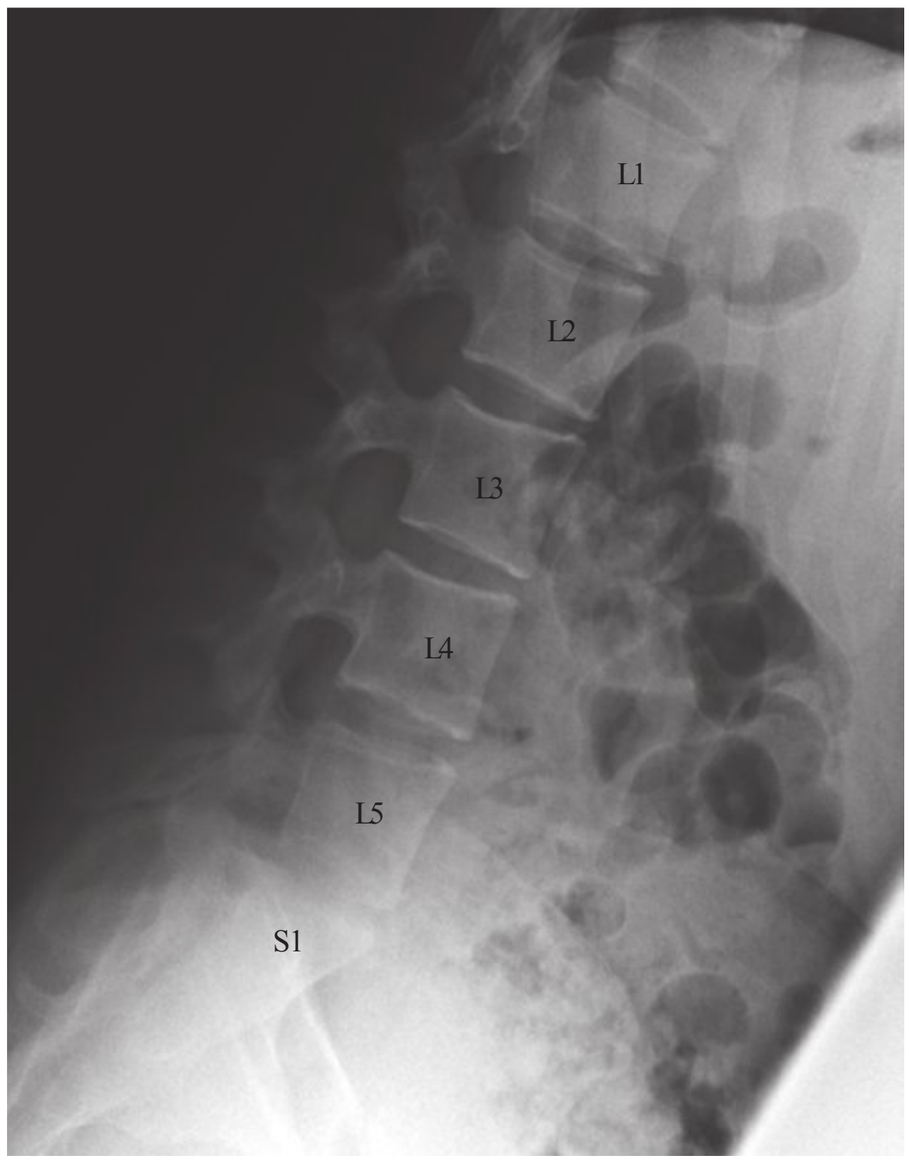
A. Extension of the neck. **B.** Radiograph of the extended cervical spine. **C.** Flexion of the neck. **D.** Radiograph of the flexed cervical spine. **E.** Head rotated (turned) to left. **F.** Radiograph of cervical spine rotated to left.



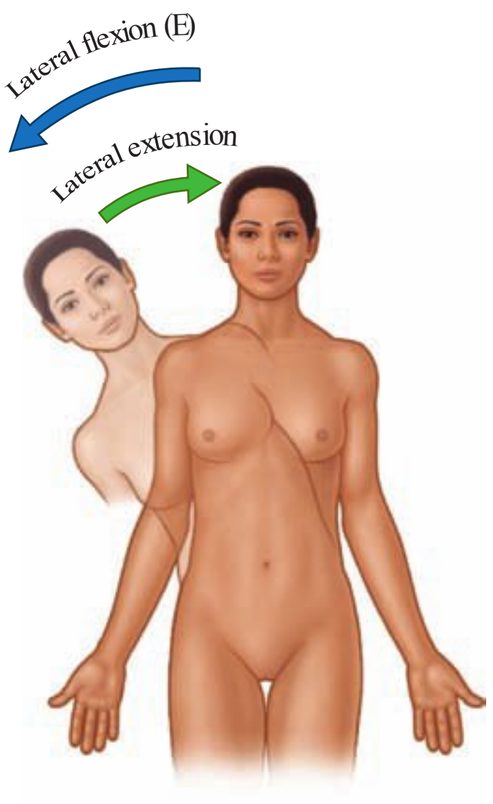
A. Lateral Radiograph, Lumbar Vertebrae Extended



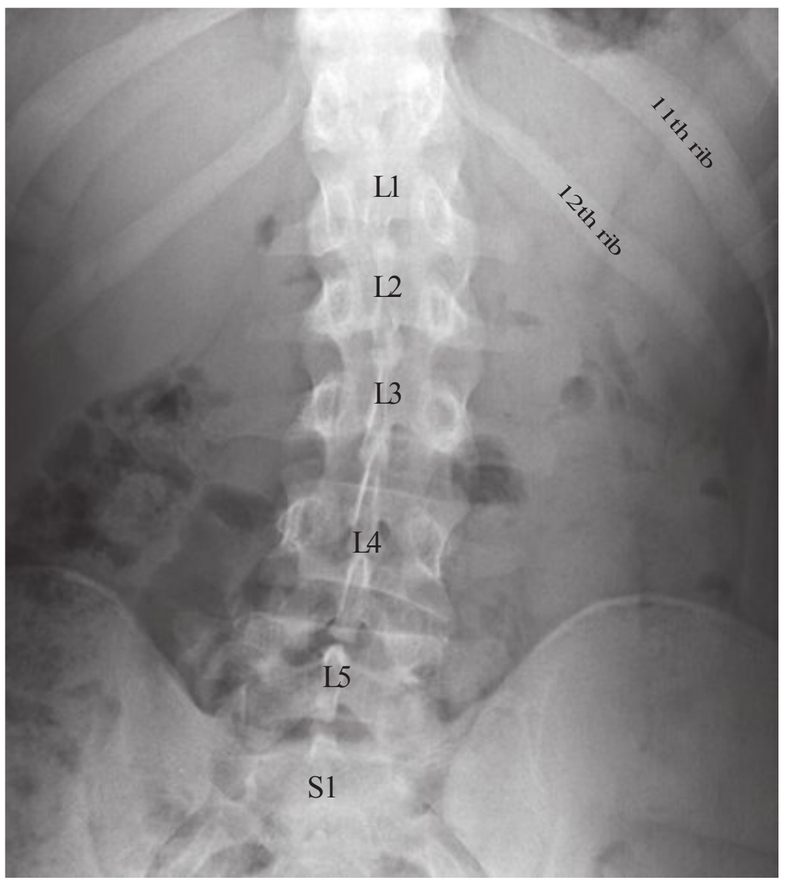
B. Lateral View



C. Lateral Radiograph, Lumbar Vertebrae Flexed



D. Anterior View



E. Anteroposterior Radiograph, Lumbar Vertebrae Laterally Flexed to Right

SURFACE ANATOMY WITH RADIOGRAPHIC CORRELATION OF SELECTED MOVEMENTS OF THE LUMBAR SPINE 1.6

A. Radiograph of the extended lumbar spine. **B.** Schematic illustration of flexion and extension of the trunk. **C.** Radiograph of the flexed lumbar spine. **D.** Schematic illustration of lateral (side) flexion of the trunk. **E.** Radiograph of the lumbar spine during lateral bending.

The range of movement of the vertebral column is limited by the thickness, elasticity, and compressibility of the IV discs; shape and orientation of the zygapophysial joints; tension of the joint capsules of the zygapophysial joints; resistance of the ligaments and back muscles; connection to thoracic (rib) cage and bulk of surrounding tissue.

1.7 CERVICAL SPINE

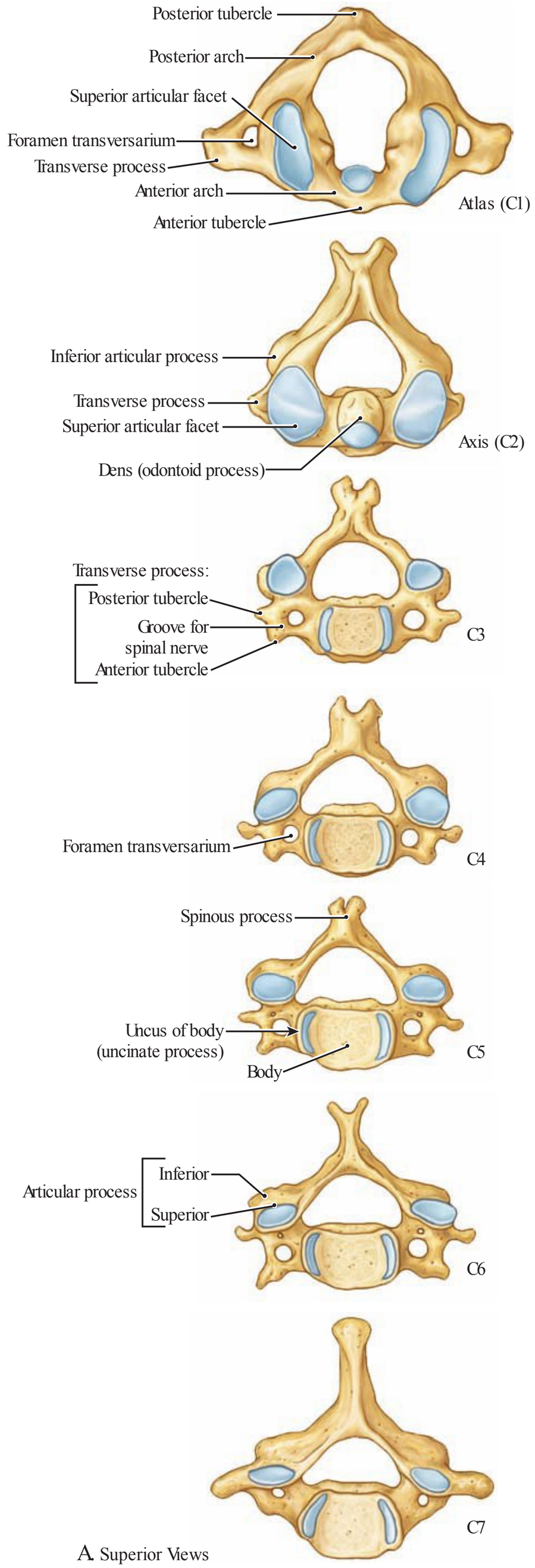
A. Disarticulated cervical vertebrae. The bodies of the cervical vertebrae can be dislocated in neck injuries with less force than is required to fracture them. Because of the large vertebral canal in the cervical region, some dislocation can occur without damaging the spinal cord. When a cervical vertebra is severely dislocated, it injures the spinal cord. If the dislocation does not result in "facet jumping" with locking of the displaced articular processes, the cervical vertebrae may self-reduce ("slip back into place") so that a radiograph may not indicate that the cord has been injured. Magnetic resonance imaging (MRI) may reveal the resulting soft tissue damage.

Aging of the IV disc combined with the changing shape of the vertebrae results in an increase in compressive forces at the periphery of the vertebral bodies, where the disc attaches. In response, osteophytes (bony spurs) commonly develop around the margins of the vertebral body, especially along the outer attachment of the IV disc. Similarly, as altered mechanics place greater stresses on the zygapophysial joints, osteophytes develop along the attachments of the joint capsules, especially those of the superior articular process.

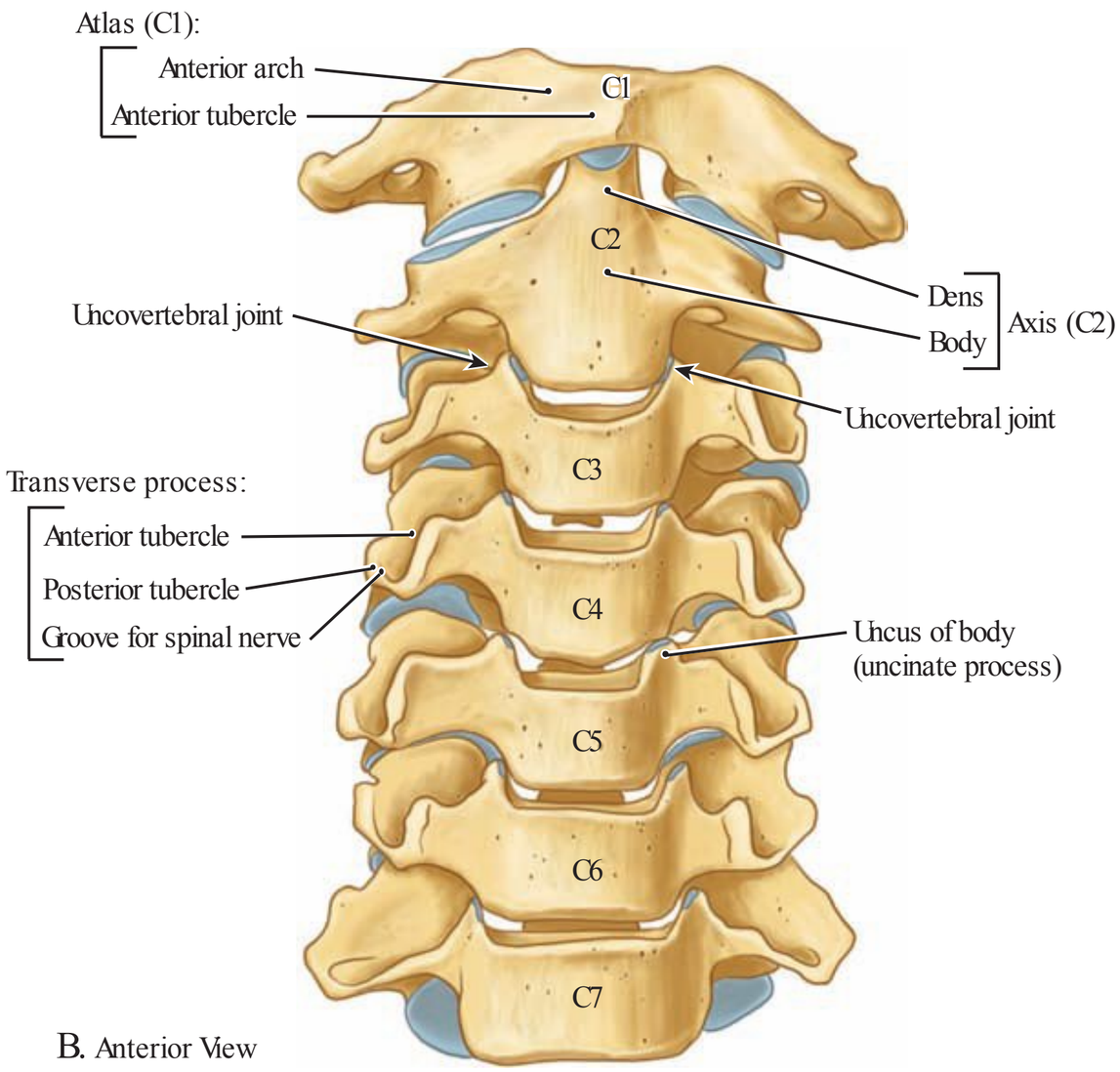
TABLE 1.1 TYPICAL CERVICAL VERTEBRAE (C3–C7)[a]

Part	Distinctive Characteristics
Body	Small and wider from side to side than anteroposteriorly; superior surface is concave with an uncus of body (uncinate process bilaterally); inferior surface is convex
Vertebral foramen	Large and triangular
Transverse processes	Foramina transversaria small or absent in vertebra C7; vertebral arteries and accompanying venous and sympathetic plexuses pass through foramina, except C7 foramina, which transmits only small accessory vertebral veins; anterior and posterior tubercles separated by groove for spinal nerve
Articular processes	Superior articular facets directed superoposteriorly; inferior articular facets directed infero-anteriorly; obliquely placed facets are most nearly horizontal in this region
Spinous process	Short (C3–C5) and bifid, only in Caucasians (C3–C5); process of C6 is long but that of C7 is longer; C7 is called "vertebra prominens"

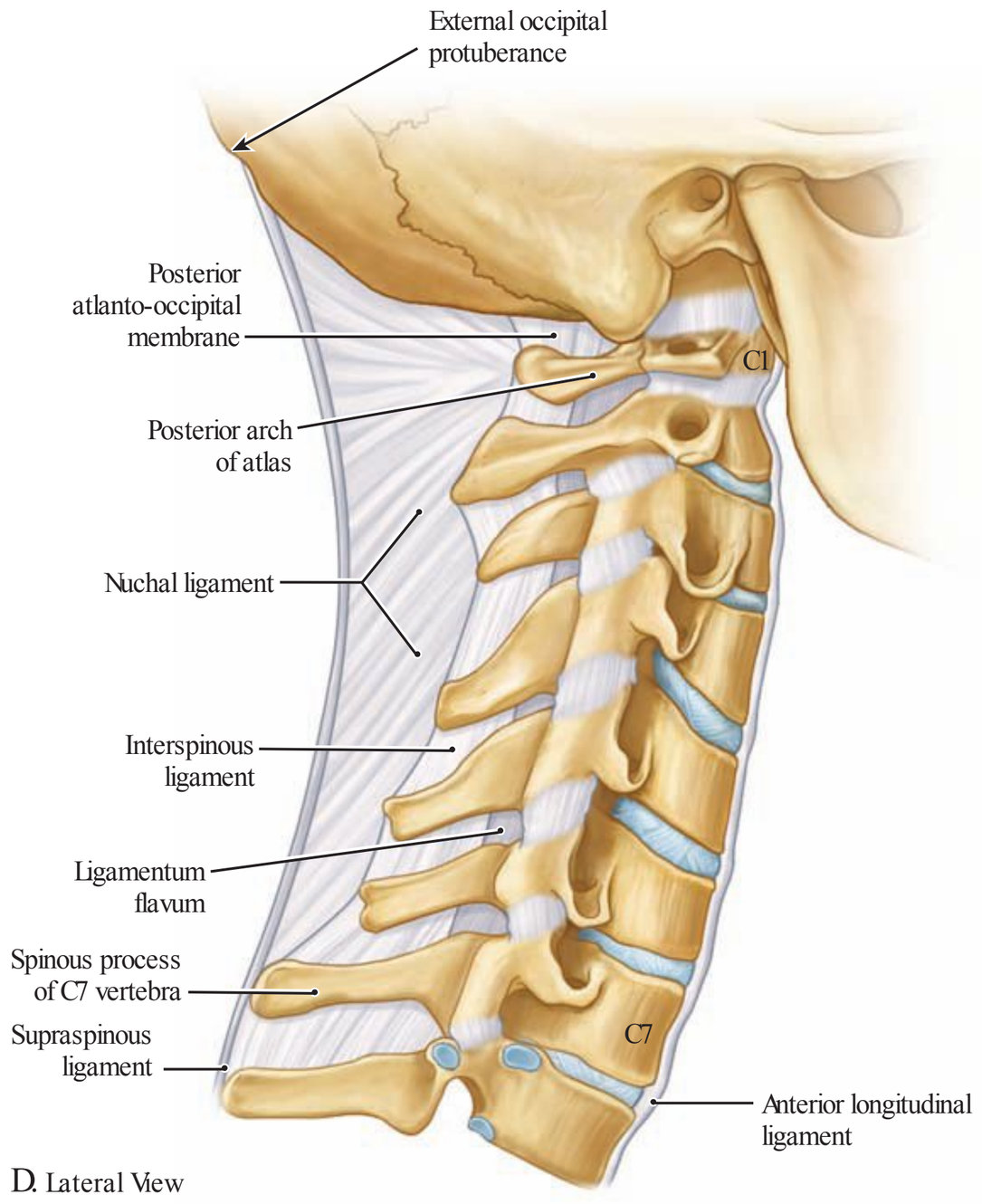
[a]C1 and C2 vertebrae are atypical.



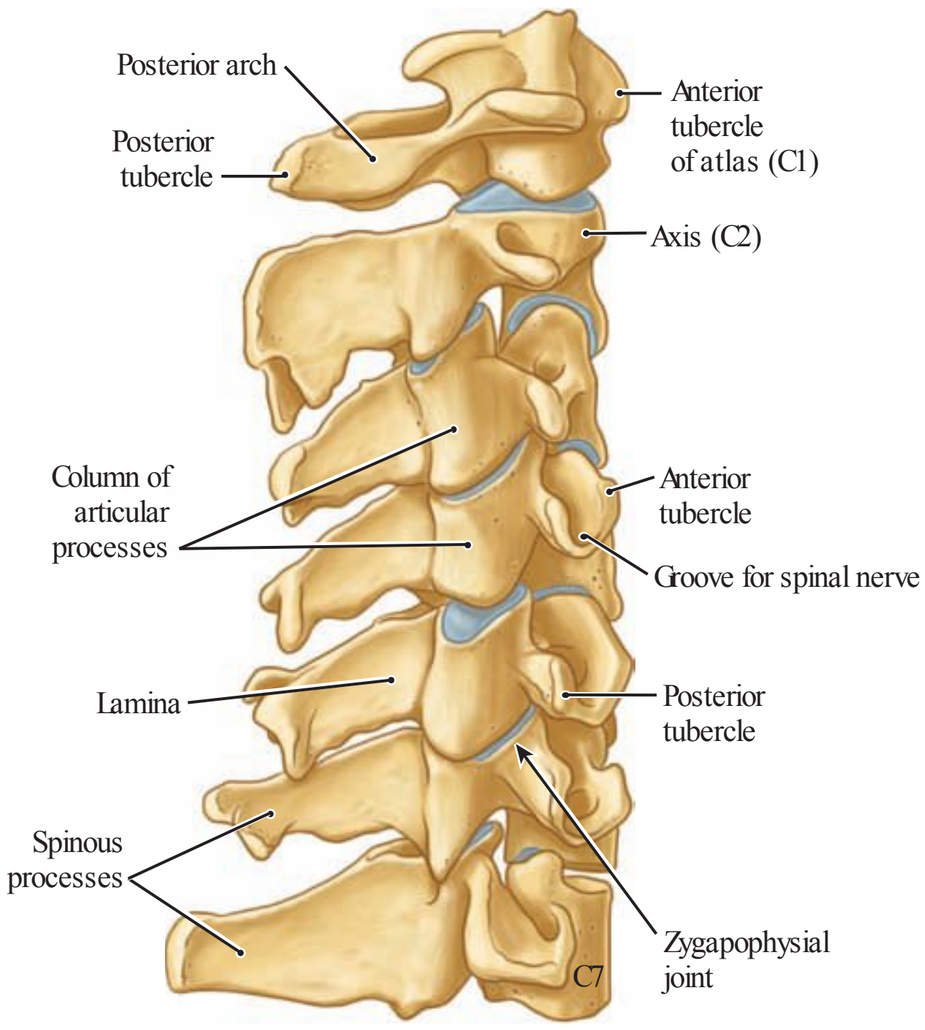
A. Superior Views



B. Anterior View



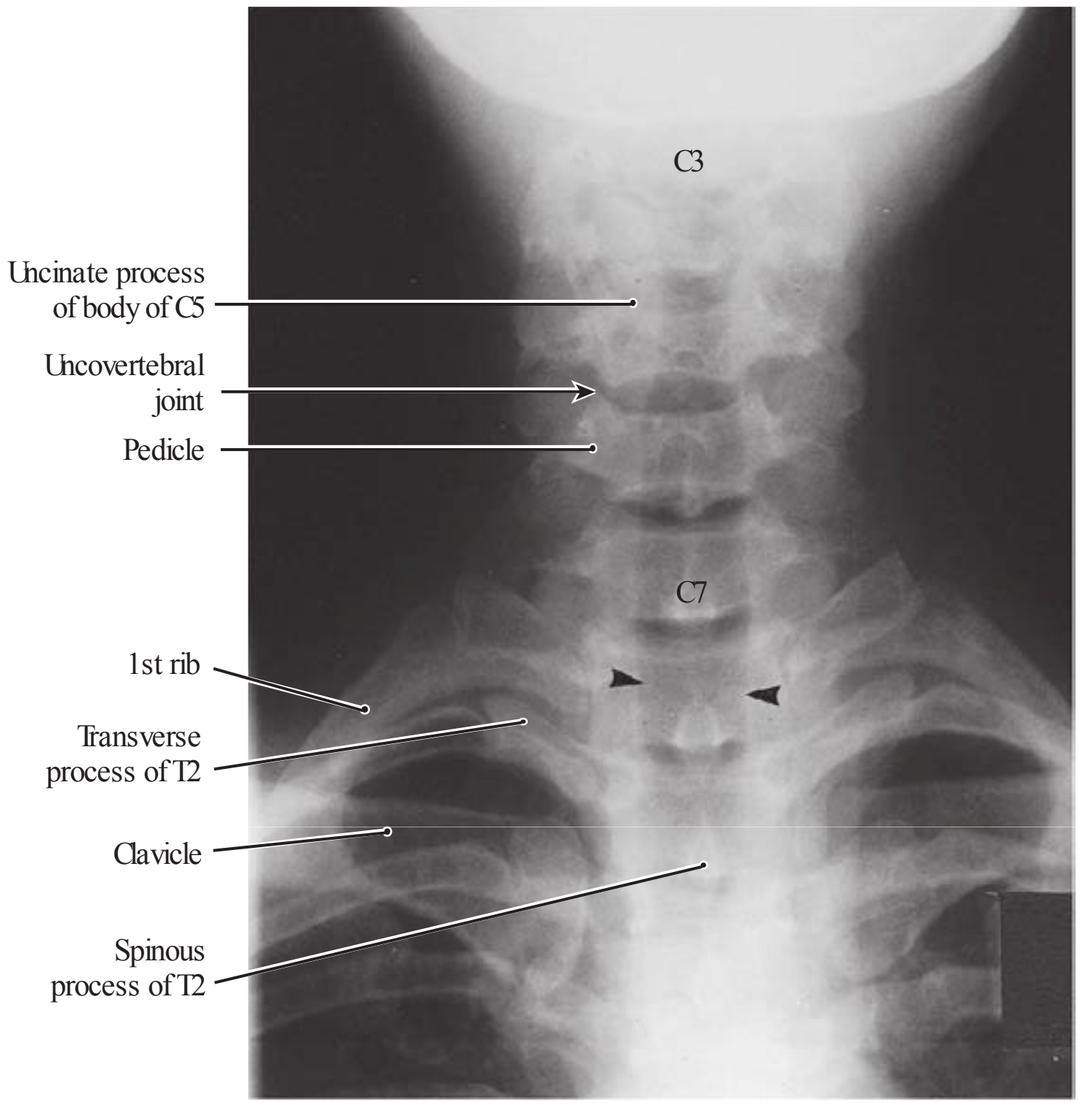
D. Lateral View



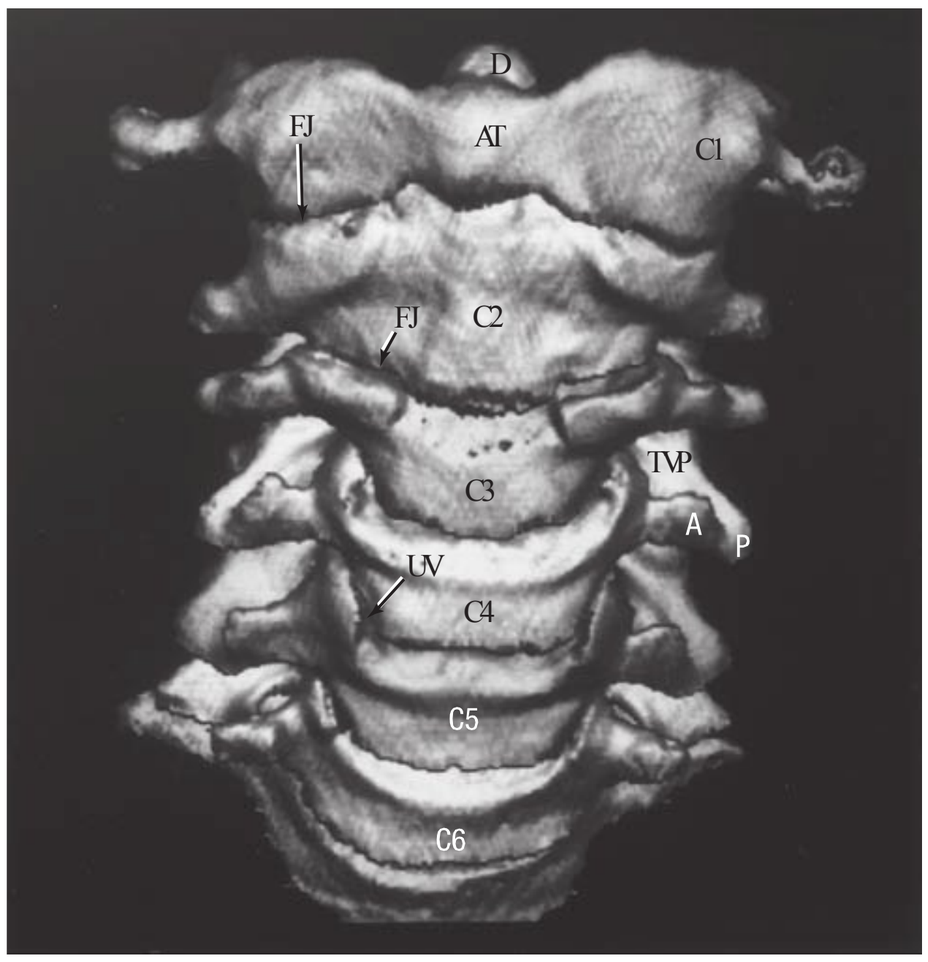
C. Lateral View

CERVICAL SPINE (*continued*) 1.7

B. and **C.** Articulated cervical vertebrae. **D.** Ligaments.

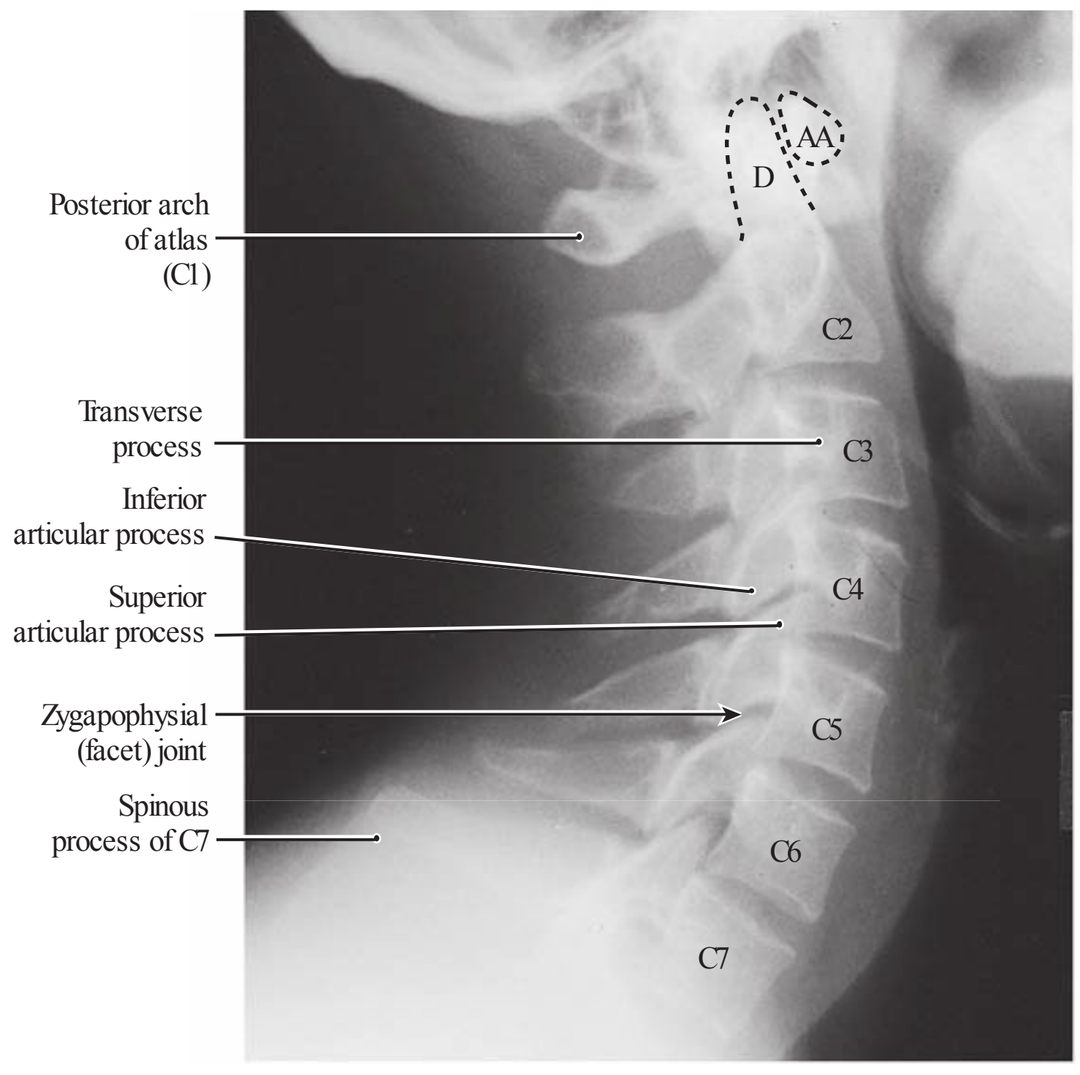


A. Anteroposterior View

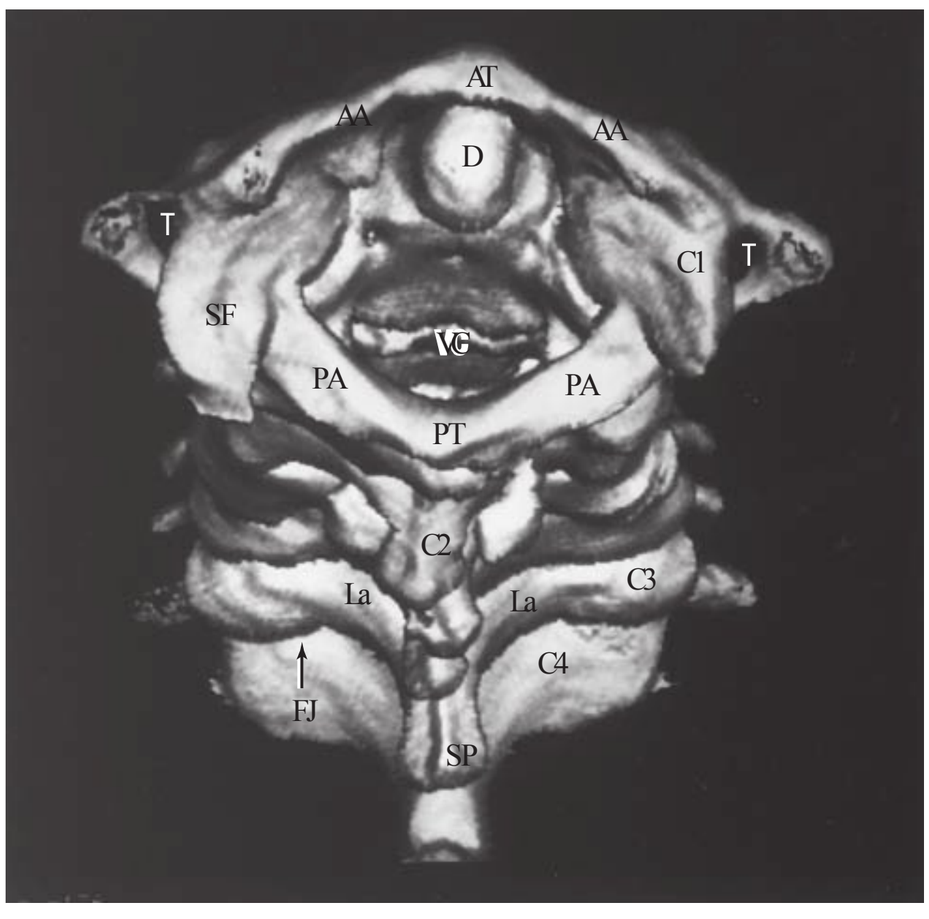


C. Anterior View

Key			
A	Anterior tubercle of transverse process	PA	Posterior arch of C1
AA	Anterior arch of C1	PT	Posterior tubercle of C1
AT	Anterior tubercle of C1	SF	Superior articular facet of C1
C1–C7	Vertebrae	SP	Spinous process
D	Dens (odontoid) process of C2	T	Foramen transversarium
FJ	Zygapophysial (facet) joint	TVP	Transverse process
La	Lamina	UV	Uncovertebral joint
P	Posterior tubercle of transverse process	VC	Vertebral canal



B. Lateral View



D. Posterior View

1.8 IMAGING OF THE CERVICAL SPINE

A. and **B.** Radiographs. The *arrowheads* demarcate the margins of the *(black)* column of air in the trachea. **C.** and **D.** Three-dimensional reconstructed computed tomographic (CT) images.