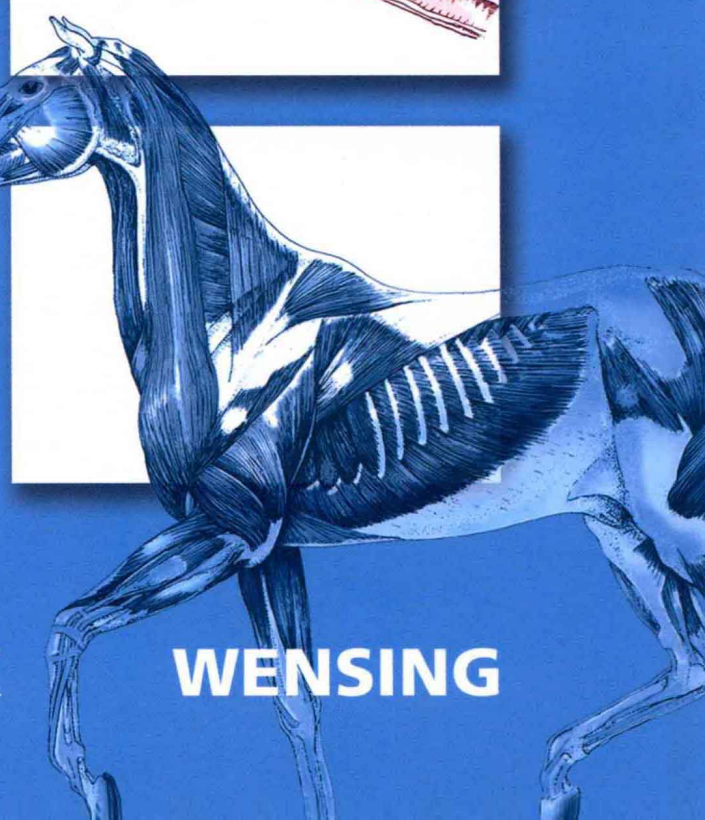
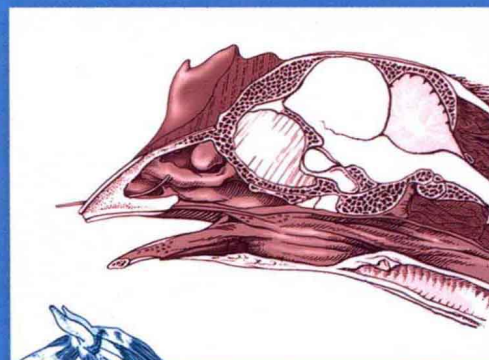
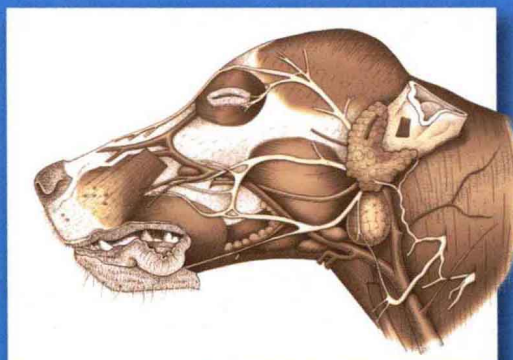
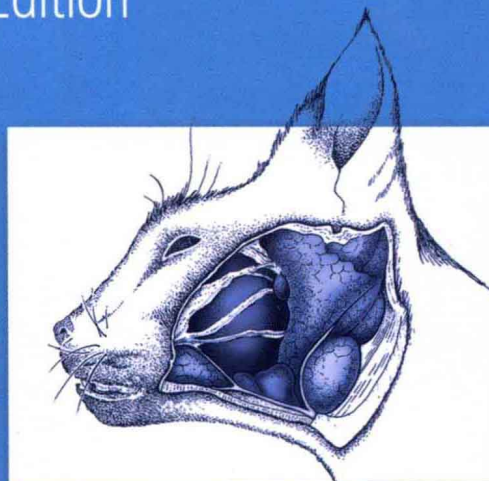
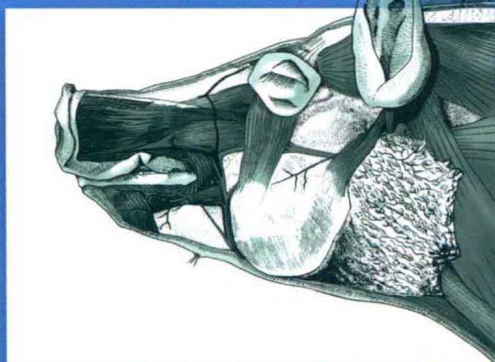


TEXTBOOK OF VETERINARY ANATOMY

Fourth Edition



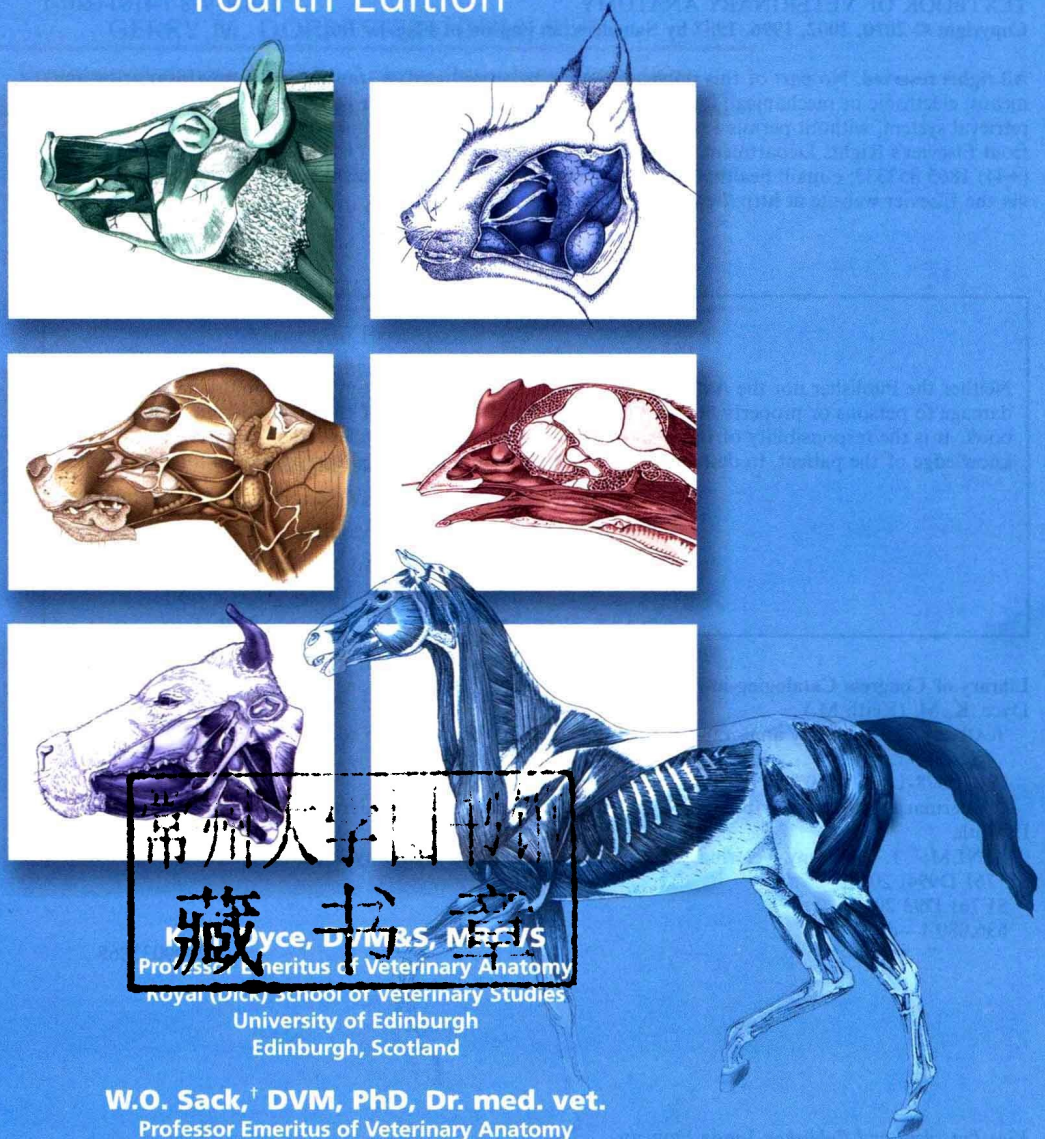
DYCE

SACK

WENSING

TEXTBOOK OF VETERINARY ANATOMY

Fourth Edition

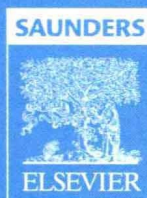


常州大学图书馆
藏书章

K. Dyce, DVM&S, MScS
Professor Emeritus of Veterinary Anatomy
Royal (Dick) School of Veterinary Studies
University of Edinburgh
Edinburgh, Scotland

W.O. Sack,[†] DVM, PhD, Dr. med. vet.
Professor Emeritus of Veterinary Anatomy
College of Veterinary Medicine
Cornell University
Ithaca, New York

C.J.G. Wensing,[†] DVM, PhD
Professor Emeritus of Veterinary Anatomy and Embryology
School of Veterinary Medicine
State University Utrecht
The Netherlands



[†]Deceased.

SAUNDERS
ELSEVIER

3251 Riverport Lane
St. Louis, Missouri 63043

TEXTBOOK OF VETERINARY ANATOMY

ISBN: 978-1-4160-6607-1

Copyright © 2010, 2002, 1996, 1987 by Saunders, an imprint of Elsevier Inc.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Permissions may be sought directly from Elsevier's Rights Department: phone: (+1) 215 239 3804 (US) or (+44) 1865 843830 (UK); fax: (+44) 1865 853333; e-mail: healthpermissions@elsevier.com. You may also complete your request on-line via the Elsevier website at <http://www.elsevier.com/permissions>.

Notice

Neither the Publisher nor the Authors assume any responsibility for any loss or injury and/or damage to persons or property arising out of or related to any use of the material contained in this book. It is the responsibility of the treating practitioner, relying on independent expertise and knowledge of the patient, to determine the best treatment and method of application for the patient.

The Publisher

Library of Congress Cataloging-in-Publication Data

Dyce, K. M. (Keith M.)

Textbook of veterinary anatomy / K.M. Dyce, C.J.G. Wensing.—4th ed.

p. ; cm.

ISBN 978-1-4160-6607-1

I. Veterinary anatomy—Textbooks. I. Wensing, Cornelis Johannes Gerardus.

II. Title.

[DNLM: 1. Anatomy, Veterinary. 2. Animals, Domestic—anatomy & histology.

SF 761 D994t 2010]

SF761.D93 2010

636.089'1—dc22

2009033865

Vice President and Publisher: Linda Duncan

Publisher: Penny Rudolph

Senior Developmental Editor: Shelly Stringer

Publishing Services Manager: Julie Eddy

Senior Project Manager: Laura Loveall

Design Direction: Jessica Williams

Artwork Colorization: Rogier Trompert

Maartje Kunen

Printed in China

Last digit is the print number: 9 8 7 6 5 4 3 2

Working together to grow
libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

BOOK AID
International

Sabre Foundation

To access your Student Resources, visit:

<http://evolve.elsevier.com/Dyce/vet anatomy/>



Evolve Student Resources for *Textbook of Veterinary Anatomy* offer the following features:

- **Sample Flash Cards**

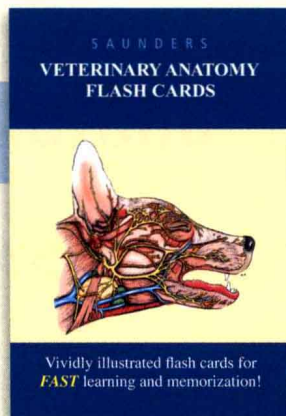
20 sample flash cards to be used as a sneak preview to Saunders Veterinary Anatomy Flash Cards

- **Board Practice Questions**

230 questions similar to those on the NAVLE, which have a self-assessment feature



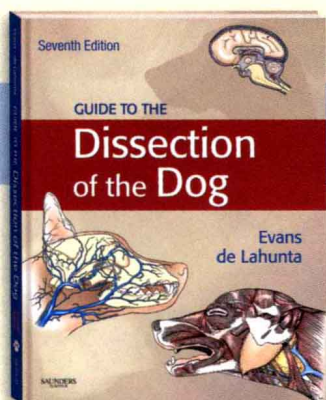
Master the essentials of veterinary anatomy!



Study anywhere, anytime!

Saunders Veterinary Anatomy Flash Cards

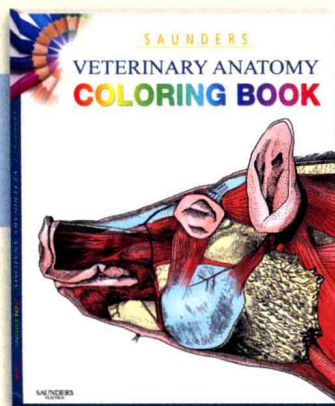
2010 • 360 cards, 400 illus. • ISBN: 978-1-4377-1440-1



Apply concepts to practice

Guide to the Dissection of the Dog, 7th Edition

2010 • 320 pp., 300 illus. • ISBN: 978-1-4377-0246-0



**Reinforce your understanding with
hands-on review**

Saunders Veterinary Anatomy Coloring Book

2010 • Approx. 256 pp., 320 illus. • ISBN: 978-1-4377-1439-5

Order your copies today!

- Order securely at elsevierhealth.com.
- Call toll-free: 1-800-545-2522.
- Visit your local bookstore.

Contributors

GERRY M. DORRESTEIN, DVM, PhD

Professor Avian and Exotic Animal Pathology, Brno (Cz)
Dutch Research Institute for Avian and Exotic Animals (NOIVBD)
Veldhoven
The Netherlands
Anatomy of Birds

C.F. WOLSCHRIJN, DVM, PhD

Associate Professor
Department of Veterinary Pathobiology
Division of Anatomy and Physiology
University Utrecht
The Netherlands
The Head and Ventral Neck of the Dog and Cat
The Neck, Back, and Vertebral Column of the Dog and Cat
The Thorax of the Dog and Cat
The Abdomen of the Dog and Cat
The Pelvis and Reproductive Organs of the Dog and Cat
The Forelimb of the Dog and Cat
The Hindlimb of the Dog and Cat

Advisors

B. COLENBRANDER, DVM, PhD

Professor Emeritus of Male Fertility
Veterinary Faculty
Utrecht University
The Netherlands

E.G. DINGBOOM, DVM, PhD

Assistant Professor
Department Veterinary Pathobiology
Division Anatomy and Physiology
Utrecht University
The Netherlands

W. KERSTEN, BSc

Curator of the Anatomical Collection
Department Veterinary Pathobiology
Division Anatomy and Physiology
Utrecht University
The Netherlands

M.M. SLOET VAN OLDRIJTENBORGH-OOSTERBAAN, DVM, PhD

Associate Professor
Department of Equine Sciences
Utrecht University
The Netherlands

D.F. SWAAB, MD, PhD

Professor of Neuroscience
Institute of Neuroscience
University of Amsterdam
The Netherlands

K. TEERDS, PhD

Associate Professor
Department of Physiology
Wageningen University and Research Center
The Netherlands

TECHNICAL COORDINATOR

J.M.A. ZUKETTO, PharmD

Bilthoven
The Netherlands

Preface to the Fourth Edition

This edition is the first to have been prepared without the participation of Wolf Sack who sadly died in 2005. While we have greatly missed the energy, enthusiasm, and commitment that he would have brought to the task of revision, the more painful loss is the friendship that we enjoyed for so many years. We would like to dedicate this edition to his memory.

Turning now to happier matters, the newly acquired license to introduce color to the text pages has provided both the opportunity and the stimulus to review the body of illustrations. Many of the old black-and-white drawings are now presented in fresh form; others have been replaced by photographs of the specimens from which they were prepared. Many photographs formerly banished to distant plates have been brought home to their proper contexts, while various other photographs and images have been supplemented or replaced by more satisfactory examples. We are immensely grateful and indebted to those who made these improvements possible. It has been a particular pleasure to work with Maartje Kunen and Rogier Trompert, the artists who produced the colored versions of the drawings.

We are also grateful to the technical staff of the Veterinary Anatomy Department at Utrecht who prepared the dissections and to Dr. Ben Colenbrander, who generously provided many new illustrations. Dr. G. Voorhout and Dr. A. van der Belt of the Veterinary Radiology Department in Utrecht provided a large number of replacement radiographs for use in the carnivore and horse chapters.

The text has been revised with the twin aims, not always easily reconciled, of reducing the demands made of the student reader while adapting the content to the changing needs of general practice. We have shorn some sections of material probably superfluous to basic requirements. This mainly affected certain chapters of the first part and, in the second part, those devoted to the production animals for which herd medicine now tends to dominate over treatment of the individual. New material has been introduced into the chapters dealing with the horse, avian anatomy and, most especially, with the companion species. To ensure the relevance of the revision, we invited certain colleagues to review and provide advice on the chapters relating to their special fields of interest. Those who accepted these invitations and provided this much valued assistance are specifically acknowledged on the contributor page.

In an age in which up-to-date information is so readily available, it seems unnecessary to continue to

burden the text with references to a literature that is evolving so rapidly.

We have now accumulated so many benefactors that it seems almost inevitable that we have failed to give specific acknowledgment everywhere it was due. We hope any we have failed to recognize will forgive our lapse and be assured of our gratitude.

Finally, and certainly not least, we have to thank Dr. Jo Zuketto for assistance, generously offered and eagerly accepted, with computer matters. His arcane skills transformed many illustrations and wondrously combined text and figures, old and new, in a fashion that we could never have achieved without his help. In periods of the ill health of one of the authors, he really helped to keep the process moving and he also kept our spirits up.

K.M. Dyce

C.J.G. Wensing[†]

.....

The Preface printed above accompanied the completed typescript. Now, only a short time later, it is sadly necessary to record the death of Cees Wensing who died in May 2009 after a long battle with illness fought with inspiring courage. Amongst other innovations Cees had made himself responsible for the comprehensive revision and renewal of the illustrations, and he was eager to see this edition, which so clearly bears his imprint, through to publication.

Even when it had become evident that this was unlikely, he worked on with undiminished determination, and he was busy correcting proofs only a few days before he died. He greatly appreciated the help and support he received from family and friends, and it is testimony to the high regard in which he was held that two of these friends, Jo Zuketto and Ben Colenbrander, whose help had been unstinted while he lived, should have undertaken to continue to assist with correction of the proofs.

His role with this book was only a small part of his achievements, especially as Director of the Research Institute at Lelystad—Central Veterinary Institute, later called ID-Lelystad, now called Animal Science Group. He will be missed greatly.

I now regard this edition as dedicated to the memory of both departed friends and colleagues.

K.M. Dyce

[†]Deceased.

Preface to the First Edition

What one does not understand one does not possess.—*Goethe*

A few words in explanation of the purpose and arrangement of this book may not be out of place. It is intended to meet the needs of the veterinary student, providing first that general knowledge of mammalian structure that is indispensable to the understanding of the other basic sciences, and secondly the more detailed information that is directly applicable to the practice of veterinary medicine. Though we shall naturally be pleased if others find our book useful, we have regarded the interest of the student reader as paramount.

The dual role of anatomy determined the division of the book into two parts. The first part comprises ten chapters, one a general introduction, the others devoted to the various body systems. For these we have taken as our model the dog, the animal best suited to this purpose by its relatively unspecialized anatomy and its widespread use as the initial dissection subject. We allude to the salient differences found in other domesticated species but do not dwell upon them at this time when our concern is to emphasize general concepts and function rather than specific details. The remarks on development are intended to elucidate the broad features of adult anatomy and do not profess to provide a complete amount of this branch of our subject. Since these chapters deal largely with elementary, well-established, and noncontroversial matters, we decided that it would be an affectation to embellish them with references to the literature.

The second part of the book presupposes a working knowledge of the first. It consists of several series of chapters, each series dealing with the regional anatomy of a particular species—or group of species since we have accommodated the cat with the dog, the small ruminants with cattle. This part seeks to emphasize those features and topics that have direct relevance to clinical work. Though the several chapters that deal with the same region of the body of different animals follow a common plan, they do so only loosely; we have expanded, curtailed, and diversified the accounts according to our perceptions of contemporary clinical concern with different species, and occasionally according to the availability of relevant information. This

method of proceeding results in some repetition, but we hope compensation will be found in the independence of these chapters, which can be read or consulted in any order and without reference to each other. Finally, there is a single chapter on systematic avian anatomy in which the main subject is the chicken, although some attention is given to cagebirds and other species of veterinary importance. Since the chapters of this second part deal with matters of immediate practical concern, we have furnished them with a selection of references for the benefit of those who may wish to inform themselves more fully.

Inevitably, the principal difficulty we encountered when writing this book lay in the selection of appropriate material from the vast array. Since in most schools, courses of anatomy have been progressively, and sometimes savagely, shortened in recent years, there is an obligation to identify and retain “core” material while rigorously pruning matters of more peripheral concern. Alas, there neither is nor can be a unanimous view of what constitutes the “core” while the continuing development and increasing specialization of veterinary medicine attach significance to many details that formerly lacked importance. The reconciliation of these opposing pressures places both teachers and authors in a dilemma from which there is not clear route of escape, and, though we hope we have chosen wisely, we anticipate that some colleagues will reproach us for being overtimid in our culling while others will be as ready to judge us overbold. Readers who take the former view may find that the subdivision of the text enables them to skim or skip judiciously; those more demanding may find some consolation in the references. We hope both groups of readers will welcome the digressions from the conventional stuff of anatomy with which we have sought to make the account more interesting—for it would be folly to deny that anatomical description does not always make the most lively reading.

While each of us has been responsible for the initial draft of portions of the text, the final version represents the consensus of our views. We like to think that there has been advantage in our having gained experience in

a variety of schools, and we have sought to avoid tailoring the text to fit any particular course too closely. Problems of nomenclature receive some attention in Chapter 1, but it may be well to state here that we have consistently employed anglicized versions of the terms contained in the most recent (1983) version of the *Nomina Anatomica Veterinaria*.

Such have been our intentions. Whether they were well conceived or have been properly put into effect we must leave to the judgment of each reader.

K.M. Dyce

W.O. Sack

C.J.G. Wensing

Sources of Nonoriginal Illustrations

Figure 1–3: After Feeney DA, Fletcher TF, Hardy RM: *Atlas of correlative imaging anatomy of the normal dog*, Philadelphia, 1991, Saunders.

Figures 1–14, A; 1–20, A; 1–22, A; 2–1; 2–23; 2–24; 2–27; 2–53; 11–44; 12–9; 12–11; 15–12; 16–2; 16–5; 16–13; 17–6; 30–5: Drawn by DS Geary. Courtesy Dr. A Horowitz, Oregon State University; and from Horowitz A: *Guide for the laboratory examination of the anatomy of the horse*, Columbus, 1965, The University of Ohio, Dept. of Veterinary Anatomy [Published by the author]; and Horowitz A: *The fundamental principles of anatomy: dissection of the dog*, Saskatoon, 1970, University of Saskatchewan [Published by the author].

Figure 1–5, A: Courtesy Dr. JS Boyd, Glasgow University.

Figures 1–5, B; 22–16: Courtesy Dr. BA Ball, Cornell University.

Figure 1–12: After Dawkins MJR, Hull D: The production of heat by fat, *Scient Am* 213:62–67, 1965.

Figure 1–15: After Brookes M, Elkin AC, Harrison RG, Heald CB: A new concept of capillary circulation in bone cortex, *Lancet* 1:1078–1081, 1961.

Figure 1–20, B: Courtesy Dr. KD Budras, Berlin.

Figures 2–15; 2–63, A–B; 17–5: After Taylor IA: *Regional and Applied Anatomy of the Domestic Animals*, Edinburgh, 1970, Oliver & Boyd.

Figures 2–25, B; 15–11, C: Courtesy Dr. A Rijnberk, Utrecht University.

Figure 2–26: After Bradley OC: *Topographic anatomy of the dog*, ed 6, Edinburgh, 1959, Oliver & Boyd.

Figures 2–37; 3–25; 5–38; 18–3, B: Based on (Figures 2–37; 5–33; 18–3, B; 18–36) and with permission (Figure 3–25) from Nickel R, Schummer A, Seiferle E: *Lehrbuch der anatomie der haustiere*, Berlin, 1987, Paul Parey.

Figures 3–37; 10–18; 10–19: Redrawn from Ellenberger W, Baum H: *Handbuch der vergleichenden anatomie der haustiere*, ed 18, Berlin, 1974, Springer.

Figure 3–45: Courtesy Dr. F Preuss, Berlin.

Figures 4–3, B; 11–10, B; 11–42; 11–45, B; 13–13, B; 14–11, B; 14–16, B; 14–25, B; 23–22; 23–24, A: Courtesy Dr. PV Scrivani, Cornell University.

Figures 4–10; 4–18: After Nickel R, Schummer A, Seiferle E, Sack WO: *The viscera of the domestic animals*, ed 2, New York, 1978, Springer.

Figures 5–40; 5–62, B; 5–73, B; 15–8; 15–9; 29–16; 34–3: Courtesy Dr. B Colenbrander, Utrecht University.

Figure 5–68: Courtesy Dr. DF Antczak, Cornell University.

Figures 5–73; 15–26; 11–2; 11–3; 11–4: Courtesy M Gaus, Lelystad.

Figures 5–72, A; 5–73, B; 37–20: Courtesy Dr. JM Fentener van Vlissingen, Rotterdam.

Figure 7–2: Redrawn after Noden, DM, and de Lahunta A: *The embryology of domestic animals*, Baltimore, 1985, Williams & Wilkins.

Figure 7–25: Redrawn after Moore KL: *The developing human: clinically oriented embryology*, ed 5, Philadelphia, 1993, Saunders.

Figures 7–38: After Simoens P, de Vos NE: Angiology. In Schaller O, editor: *Illustrated veterinary anatomical nomenclature*, Kinderhook, NY, 1992, IBD Ltd.

Figure 7–40: Based on Evans HE, de Lahunta A: *Guide to the dissection of the dog*, ed 7, Philadelphia, 2010, Saunders.

Figures 7–41, 7–43: After Budras KD, Fricke W: *Atlas der anatomie des hundes, kompendium für tierärzte und studierende*, Hannover, 1993, Schlütersche Verlagsanstalt.

Figures 7–52; 7–53: Based on Frewein J, Vollmerhaus B, editors: *Anatomie von hund und katze*, Berlin, 1994, Blackwell.

Figures 7–54; 7–58: After Baum H: *Das lymphgefässsystem des hundes*, Berlin, 1918, Hirschwald.

Figure 7–59: Based on Vollmerhaus B: In Nickel R, Schummer A, Seiferle E, editors: *The anatomy of the domestic animals*, Vol. 3, Berlin, 1981, Paul Parey.

Figure 7–61: After Steger G: Zur biologie der milz der haussäugetiere, *Deutsch Tierärztl Wochenschr* 39:609–614, 1939.

Figures 8–12; 8–25: Based on Romer AS: *The vertebrate body*, ed 3, Philadelphia, Saunders, 1962.

Figures 8–21; 8–20, C; 8–58; 11–19; 11–20: Courtesy Dr. J Ruberte, Barcelona.

Figure 8–61: From de Lahunta A: *Veterinary neuroanatomy and clinical neurology*, ed 3, Philadelphia, 2009, Saunders.

Figure 8–76: Redrawn from Mizeres, NJ: The anatomy of the autonomic nervous system in the dog, *Am J Anat* 96:285–318, 1955.

Figures 9–4; 9–6; 9–14, A–B; 11–37, A–B: Courtesy Dr. F Stades and Dr. M Boeve, Utrecht University.

Figure 9–22: Courtesy Dr. P Simoens, Gent University.

Figures 11–7, B; 11–10, C; 16–11, E–F; 17–8, B: Courtesy Dr. C Poulsen Nautrup, Hannover.

- Figures 11–18; 11–31, A–B; 11–43, A–B:** Courtesy Dr. AJ Venker van Haagen, Utrecht University.
- Figures 11–17, B; 15–2; 16–3, C–D; 16–8, C–D; 16–10, C–D; 17–1, C–D; 18–6; 18–26; 23–7; 23–9; 23–13:** Courtesy Dr. N Dykes, Cornell University.
- Figure 11–22:** Redrawn from de Lahunta A, Habel RE: *Applied veterinary anatomy*, Philadelphia, 1998, Saunders.
- Figures 11–23; 13–18; 15–23, B; 17–3, D; 17–7, C–D; 37–16, B:** Courtesy Dr. BJ Smith, Virginia Technical and State University.
- Figures 13–4; 14–2; 14–3:** After Marthen G: Über die arterien der körperwand des hundes, *Morph Jahrb* 84:187–219, 1939.
- Figure 15–17:** After Vaerst L: Über die blutversorgung des hundepenis, *Morph Jahrb* 81:307–352, 1938.
- Figure 15–20:** Redrawn from Christensen GC: Angioarchitecture of the canine penis and the process of erection, *Am J Anat* 95:227–262, 1954.
- Figures 16–12; 17–9:** Courtesy Dr. RL Kitchell, University of California, Davis.
- Figures 18–21; 18–22:** Courtesy Dr. I Kassianoff, Hannover.
- Figures 18–24; 18–25:** Courtesy Dr. L de Schaepdrijver, Gent University.
- Figure 18–33:** Courtesy Dr. KE Baptiste, Copenhagen.
- Figures 21–14; 21–21; 23–33; 23–38, A; 24–15, A:** From (and based on) Schmaltz R: *Atlas der anatomie des pferdes*, Vol. 4, Die Eingeweide, Berlin, 1927, Paul Parey; and Schmaltz R: *Atlas der anatomie des pferdes*, ed 3, Vol. 1. Berlin und Hamburg, 1911, Paul Parey.
- Figures 22–4:** Modified from Hopkins GS: *Guide to the dissection and study of the blood vessels and nerves of the horse*, ed 3, Ithaca, NY, 1937, [Published by the author].
- Figures 29–13, A–D; 31–7:** Courtesy Dr. GC van der Weyden, Utrecht.
- Figure 22–12, A–B:** Dr. TAE Stout, Utrecht University.
- Figure 23–1:** After Blythe LL, Kitchell RL: Electrophysiologic studies of the thoracic limb of the horse, *Am J Vet Res* 43:1511–1524, 1982.
- Figure 23–4:** After Ellenberger W, Dittrich H, Baum H: *Atlas of animal anatomy for artists*, New York, 1956, Dover Publications.
- Figure 23–14, B:** Courtesy Dr. AJ Nixon, Cornell University.
- Figures 23–16; 24–4; 24–10, A:** After B Volmerhaus, München.
- Figure 23–35, B:** Courtesy Dr. N Crevier-Denoix, École National Vétérinaire Alfort.
- Figure 23–37:** Courtesy Dr. H Brugalla, Berlin.
- Figure 24–19:** After Pohlmeier K, Redecker, R: Die für die klinik bedeutsamen nerven an den gliedmassen des pferdes einschliesslich möglicher varianten, *Deutsche Tierärztl Wschr* 81:501–505, 1974.
- Figures 25–25; 30–14, A; 30–16; 31–9, A; 31–12, A:** Courtesy Dr. JE Smallwood, North Carolina State University.
- Figure 26–1, B:** Courtesy Dr. A Meekma, The Netherlands.
- Figure 27–1:** Courtesy Dr. C Pavaux, Toulouse.
- Figures 28–16, A; 28–17:** Courtesy Dr. RR Hofmann, Berlin.
- Figure 28–20:** After Lagerlöf N: Investigations of the topography of the abdominal organs in cattle, and some clinical observations and remarks in connection with the subject, *Skand Vet* 19:1–96, 1929.
- Figure 29–4:** Redrawn from Habel RE: *Guide to the dissection of domestic ruminants*, ed 3, Ithaca, NY, 1983, [Published by the author].
- Figure 29–22:** Courtesy Dr. JR Hill, Cornell University.
- Figure 29–38:** Courtesy Dr. GH Wentink, Arnhem.
- Figure 29–44:** Courtesy J Peter, Zürich.
- Figure 30–1:** Courtesy Dr. AD McCauley and Dr. FH Fox, Cornell University.
- Figure 31–3:** Courtesy Dr. C Maala, University of the Philippines.
- Figures 32–3; 32–14:** Drawn by Kramer B, Geary DS: From Sack WO, editor: *Horowitz/Kramer atlas of the musculoskeletal anatomy of the pig*, Ithaca, NY, 1982, Veterinary Textbooks.
- Figure 32–13:** After Saar LI, Getty R: The interrelationship of the lymph vessel connections of the lymph nodes of the head, neck, and shoulder regions of swine, *Am J Vet Res* 25:618–636, 1964.
- Figure 35–9:** After Mollerus FW: *Zur funktionellen anatomie des eberpenis*, Berlin (FU), 1967, Vet. Diss.
- Figure 35–10, C:** After Meyen J: Neue untersuchungen zur funktion des präputialbeutels des schweines, *Zentralbl Vet Med* 5:475–492, 1958.
- Figures 37–2; 37–4:** After Lucas AM, Stettenheim PR: *Avian anatomy: integument, parts I and II. Agriculture handbook* 362, Washington DC, 1972, US Government Printing Office.
- Figure 37–3:** Courtesy Dr. M Frankenhuys, Amsterdam Zoo.
- Figure 37–21, C:** After King AS, McLelland J: *Birds-their structure and function*, ed 2, London, 1984, Baillière Tindall.
- Figure 37–22:** After Komarek V: Die männliche kloake der entenvögel, *Anat Anz* 124:434–442, 1969.

Contents

PART I: General Anatomy

- CHAPTER 1:** Some Basic Facts and Concepts, 1
- CHAPTER 2:** The Locomotor Apparatus, 32
- CHAPTER 3:** The Digestive Apparatus, 100
- CHAPTER 4:** The Respiratory Apparatus, 148
- CHAPTER 5:** The Urogenital Apparatus, 167
- CHAPTER 6:** The Endocrine Glands, 216
- CHAPTER 7:** The Cardiovascular System, 223
- CHAPTER 8:** The Nervous System, 268
- CHAPTER 9:** The Sense Organs, 332
- CHAPTER 10:** The Common Integument, 355

PART II: Dogs and Cats

- CHAPTER 11:** The Head and Ventral Neck of the Dog and Cat, 374
- CHAPTER 12:** The Neck, Back, and Vertebral Column of the Dog and Cat, 407
- CHAPTER 13:** The Thorax of the Dog and Cat, 420
- CHAPTER 14:** The Abdomen of the Dog and Cat, 434
- CHAPTER 15:** The Pelvis and Reproductive Organs of the Dog and Cat, 454
- CHAPTER 16:** The Forelimb of the Dog and Cat, 476
- CHAPTER 17:** The Hindlimb of the Dog and Cat, 490

PART III: Horses

- CHAPTER 18:** The Head and Ventral Neck of the Horse, 501
- CHAPTER 19:** The Neck, Back, and Vertebral Column of the Horse, 532
- CHAPTER 20:** The Thorax of the Horse, 537

CHAPTER 21: The Abdomen of the Horse, 545

CHAPTER 22: The Pelvis and Reproductive Organs of the Horse, 563

CHAPTER 23: The Forelimb of the Horse, 586

CHAPTER 24: The Hindlimb of the Horse, 624

PART IV: Ruminants

CHAPTER 25: The Head and Ventral Neck of the Ruminant, 644

CHAPTER 26: The Neck, Back, and Tail of the Ruminant, 664

CHAPTER 27: The Thorax of the Ruminant, 670

CHAPTER 28: The Abdomen of the Ruminant, 677

CHAPTER 29: The Pelvis and Reproductive Organs of the Ruminant, 698

CHAPTER 30: The Forelimb of the Ruminant, 728

CHAPTER 31: The Hindlimb of the Ruminant, 742

PART V: Pigs

CHAPTER 32: The Head and Ventral Neck of the Pig, 752

CHAPTER 33: The Vertebral Column, Back, and Thorax of the Pig, 762

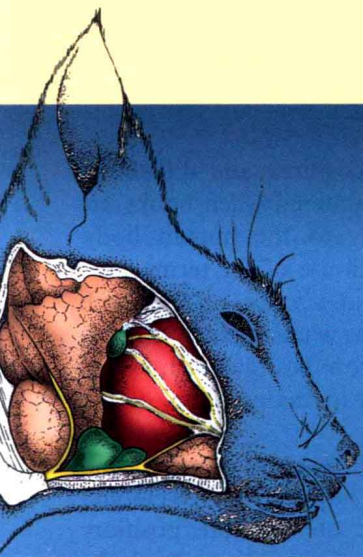
CHAPTER 34: The Abdomen of the Pig, 765

CHAPTER 35: The Pelvis and the Reproductive Organs of the Pig, 772

CHAPTER 36: The Limbs of the Pig, 780

PART VI: Birds

CHAPTER 37: Anatomy of Birds, 784



General Anatomy

Some Basic Facts and Concepts

1

THE SCOPE OF ANATOMY

Anatomy is the branch of knowledge concerned with the form, disposition, and structure of the tissues and organs that comprise the body. The word, which is of Greek origin, literally means “cutting apart,” and the dissection of the dead is the traditional method used in anatomy. However, anatomists employ a host of other techniques to supplement the knowledge of *gross anatomy* obtained by use of the scalpel. Details invisible to the naked eye are revealed by light and electron microscopy and constitute the subdivision known as *microscopic anatomy*. The discipline is also extended by the study of the stages through which the organism evolves from conception through birth, youth, and maturity to old age; this study, known as *developmental anatomy*, is rather broader in scope than is classic embryology, which confines its attention to the unborn. Few anatomists are now satisfied by the mere description of the body and its parts, and most seek to understand the relationships between structure and function. The study of these relationships clearly merges into physiology, biochemistry, and other life sciences; it can be described as functional anatomy, but we prefer to regard a functional approach as one that should pervade all branches rather than constitute a quasi-independent study.

This book is mainly concerned with gross anatomy, which is a limitation justified by the general practice of presenting microscopic and developmental anatomy in separate courses. Nonetheless, we have allowed

ourselves to draw on microscopic and developmental aspects when this has seemed helpful in promoting an understanding of gross anatomy or as a means of enlivening what would otherwise be a rather dry account.

The information obtained by dissection can be arranged and organized in two principal and complementary ways. In the first, *systematic anatomy*, attention is successively directed to groups of organs that are so closely related in their activities that they constitute body systems with an evident common function—the digestive system, the cardiovascular system, and so forth. Systematic anatomy lends itself to a comparative approach; readily combines gross, microscopic, developmental, and functional aspects; and provides the basis for the study of the other medical sciences. Moreover, for the beginner, it is easier to understand than regional anatomy. It is the approach employed in Chapters 2 through 10.

The alternative approach, *regional anatomy*, is used in the second and larger part of this book. Regional (or topographical) anatomy is directly concerned with the form and relationships of all the organs present in particular parts or regions of the body. It pays less attention to function, other than the simpler, mechanical functions, than does systematic anatomy but obtains a compensating importance from its immediate application to clinical work. Because matters of detail that may lack theoretical interest are often relevant to the clinician, it is necessary to give separate consideration to the regional anatomy of the different species. Regional anatomy is one of the foundations of clinical practice,

and different aspects pursued with particular aims are sometimes known as *surface*, *applied*, *surgical*, and *radiological anatomy*—terms whose connotations overlap but hardly require definition.

THE LANGUAGE OF ANATOMY

Anatomical language must be precise and unambiguous. In an ideal world each term would have a single meaning, each structure a single name. Unhappily, there has long been an alarming superfluity of terms and much inconsistency in their use. In the hope of reducing this confusion, an internationally agreed-on vocabulary—*Nomina Anatomica Veterinaria* (NAV)*—was introduced in 1968 and has since obtained wide acceptance. It is revised periodically, most recently in 1994, and we have tried to use it consistently throughout this work. Occasionally, we have included a second, older, and unofficial alternative when such a term appears to be so deeply rooted in clinical usage that it is unlikely to be eliminated by edict. The terms of the NAV are in Latin, but it is permissible to translate them into vernacular equivalents and is usual in English-speaking countries to do so. We have given preference to translations that so closely resemble the original Latin that the equivalence is immediately recognizable. We therefore give the Latin name only when the translation could be in doubt. No handy English equivalents exist for some official terms; in these cases it is conventional to use the Latin terms, perhaps in abbreviated form, as though they were English words or phrases. The resulting mixture of languages is jarring but not easily avoided, particularly when describing groups of muscles. The names, whether in Latin or in English, are intended to be informative and an aid to comprehension. It is more sensible to look up any word whose meaning is not self-evident in an anatomical or medical dictionary than to use it “parrot fashion.”

The names that are given to particular structures will be encountered gradually, but the terms that indicate position and direction must be mastered at once. These official terms are more precise than the common alternatives because they retain their relevance regardless of the actual posture of the subject. They are defined in the following list, and their use is illustrated in Figure 1–1. We have not thought it sensible to use them pedantically when there is no reasonable prospect of misunderstanding. When we use common terms (*above*, *behind*, and so forth), we always have in mind a standard anatomical position, which, for a quadruped, is that in which the animal stands square and alert. This differs

from the human anatomical position, and difficulties with terminology will be encountered when books are consulted that refer primarily to the human body. Medical anatomists make much use of the terms *anterior* and *posterior*, *superior* and *inferior*, all of which have very different connotations when applied to quadrupeds. These terms are therefore best avoided, except for a few specific applications to the anatomy of the head.

The principal recommended terms of position and direction are arranged in pairs, and it should be emphasized that they refer to relative, not absolute, position. Most of these adjectives form corresponding adverbs by the addition of the suffix *-ly*.

Dorsal structures (or positions) lie toward the back (dorsum) of the trunk or, by extension, toward the corresponding surface of the head or tail.

Ventral structures lie toward the belly (venter) or the corresponding surface of the head or tail.

Cranial structures lie toward the head (cranium, literally skull), *caudal* ones toward the tail (cauda). Within the head, structures toward the muzzle (rostrum) are said to be *rostral*; caudal remains appropriate.

Medial structures lie toward the median plane (medianus, in the middle) that divides the body into symmetrical right and left “halves.”

Lateral structures lie toward the side (latus, flank) of the animal.

Different conventions apply within the limbs. Structures that lie toward the junction with the body are *proximal* (proximus, near), whereas those at a greater distance are *distal* (distantia, distance). Within the proximal part of the limb (which is defined for this purpose as extending to the proximal limit of the carpus [wrist] or tarsus [hock, ankle]), structures that lie toward the “front” are said to be *cranial*, those that lie toward the “rear,” *caudal*. Within the remaining distal part of the limb, structures toward the “front” are *dorsal* (dorsum, back of the hand), and those toward the “rear” are *palmar* (palma, palm of the hand) in the forelimb or *plantar* (planta, sole of the foot) in the hindlimb. Additional terms may be applied to the anatomy of the digits. *Axial* structures lie close to the axis of a central digit, close to the axis of the limb if this passes between two digits; *abaxial* (ab, away from) positions are at a distance from the reference axis.

The terms *external* and *internal*, *superficial* and *deep* (profundus) hardly require explanation or definition.

Sometimes it is necessary to refer to a section through the body or a part of it (see Figure 1–1). The *median plane* divides the body into symmetrical right and left halves. Any plane parallel to this is a *sagittal plane*, and those close to the median are sometimes termed *paramedian planes*. A *dorsal plane* sections the trunk or other part parallel to the dorsal surface. A *transverse plane*

*There is a separate but similar vocabulary (*Nomina Anatomica Avium*) that is concerned with the anatomy of birds.

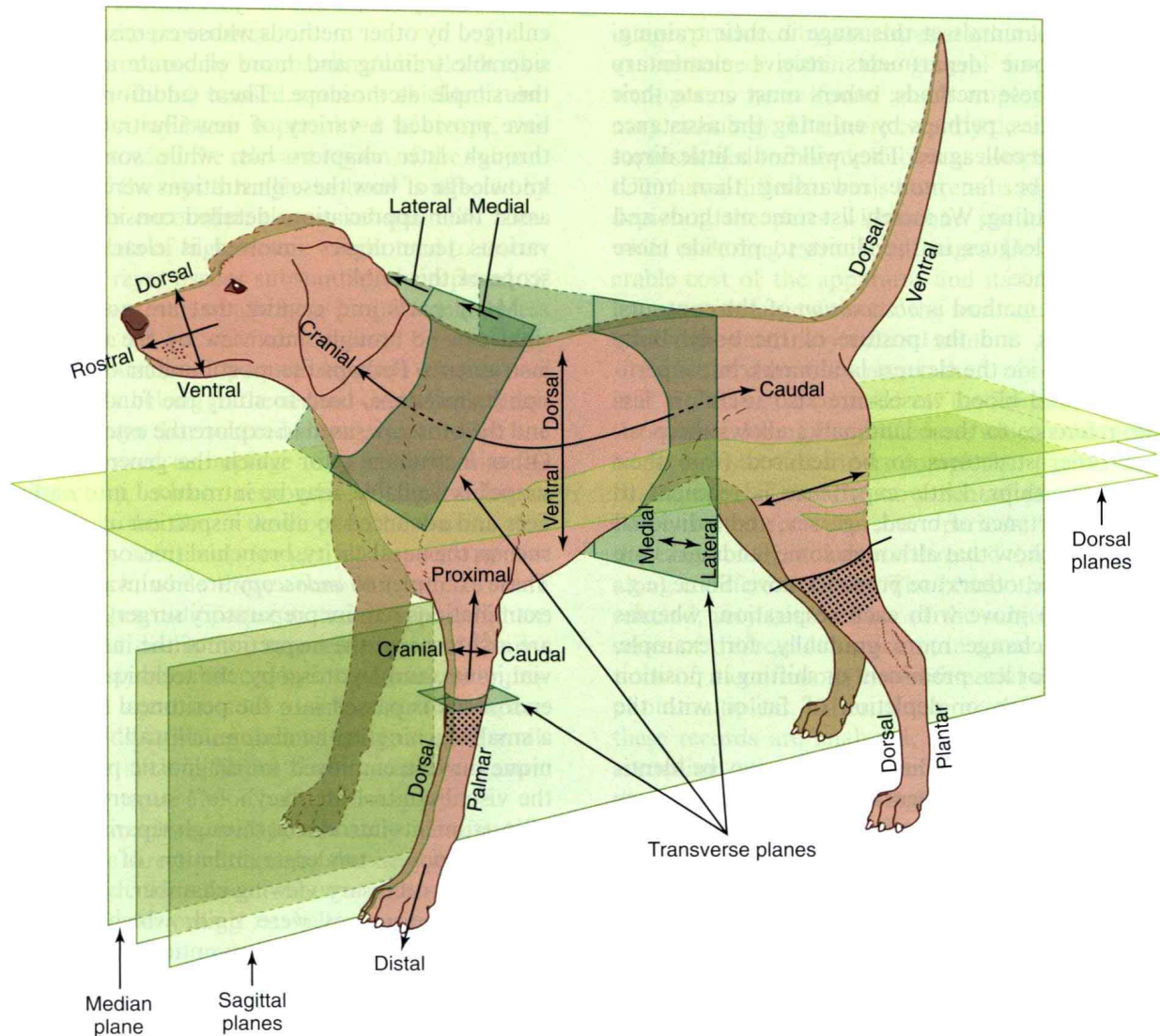


Figure 1–1 Directional terms and planes of the animal body. The stippled areas represent the carpus and tarsus on forelimbs and hindlimbs, respectively.

transects the trunk, head, limb, or other appendage perpendicular to its own long axis.

AN INTRODUCTION TO REGIONAL ANATOMY

Although the first nine chapters that follow deal with systematic anatomy, those readers who are about to begin a laboratory course will find that they require an elementary knowledge of several systems at once. It is the principal purpose of the remainder of this chapter to supply that background. However, devoting some attention to the live animal also has benefits.

STUDY OF THE LIVE ANIMAL

Regional anatomy is conveniently studied by dissection, but this has obvious limitations if the goal is knowledge of the anatomy of the living. When embalmed, organs are uncharacteristically inert and greatly changed in color and consistency from their living state. The impressions gained in the dissection room or from prosection must therefore be modified and corrected by frequent reference to fresh material and by observation of surgical operations, whenever possible. Because most of those who study the anatomy of domestic animals do so with a future professional career in mind, they will find it both stimulating and advantageous to learn

how to apply the simpler methods of clinical examination to normal animals at this stage in their training. Students in some departments receive elementary instruction in these methods; others must create their own opportunities, perhaps by enlisting the assistance of senior student colleagues. They will find a little direct experience to be far more rewarding than much unsupported reading. We merely list some methods and rely on our colleagues in the clinics to provide more adequate guidance.

The simplest method is *observation* of the contours, the proportions, and the posture of the body. Bony projections provide the clearest landmarks, but superficial muscles and blood vessels are also useful, if less striking; reference to these landmarks allows the positions of other structures to be deduced from their known relationships. Little experience is required to reveal the importance of breed, age, sex, and individual variation or to show that although some landmarks are fixed and reliable, others are prone to move. Some (e.g., the costal arch) move with each respiration, whereas other features change more gradually, for example, becoming more or less prominent or shifting in position with the deposition or depletion of fat or with the advance of pregnancy.

Structures that are not directly visible may be identified by touch, that is, by gentle or firmer *palpation* as circumstances require. Bones may be identified by their rigidity, muscles by their contraction, arteries by pulsation, veins by swelling when the blood flow is interrupted by pressure, and lymph nodes and internal organs by their size, configuration, and consistency. Nonetheless, variation is great and is affected by many factors that make it difficult to know whether one should expect to be able to identify certain organs in all normal subjects, which is, itself, another useful lesson. Palpation through the skin can be supplemented by digital or manual exploration per rectum and per vaginam.

Certain organs may be identified by *percussion* to elicit resonance when the overlying skin is struck a sharp blow (in a prescribed fashion). Different materials produce different notes; that from a gas-filled organ is more resonant than the duller one elicited from an organ that is solid or filled with fluid. The normal activities of certain organs produce sounds continuously or intermittently. Although the lungs and heart (not forgetting the fetal heart) are the prime examples of organs whose positions can be determined by *auscultation*, the movement of blood within vessels or of gas or ingesta within the stomach or intestines can also be a useful source of anatomical information. When these two techniques are applied, it must not be forgotten that the vagaries of sound conduction through materials of different densities may provide a distorted indication of the position and dimensions of the source.

The study of the anatomy of the live animal can be enlarged by other methods whose exercise requires considerable training and more elaborate apparatus than the simple stethoscope. These additional procedures have provided a variety of new illustrations scattered through later chapters but, while some elementary knowledge of how these illustrations were obtained may assist their appreciation, detailed consideration of the various technologies involved is clearly beyond the scope of this book.

Many parts and cavities that are normally out of sight can be brought into view by the use of various instruments. Perhaps the most familiar of these are the ophthalmoscope, used to study the fundus of the eye, and the otoscope, used to explore the external ear canal. Other instruments, for which the generic title “endoscope” is available, may be introduced into natural orifices and advanced to allow inspection of deeper parts, such as the nasal cavity, bronchial tree, or gastric lumen. These examples of *endoscopy* are noninvasive, but other examinations require preparatory surgery. Among these are arthroscopy, the inspection of the interior of synovial joints, and laparoscopy, the technique in which an endoscope is passed into the peritoneal cavity through a small opening in the abdominal wall. This last technique may be employed for diagnostic purposes or for the visual control of (“keyhole”) surgery with the use of instruments introduced through separate portals. For both purposes, moderate inflation of the abdomen creates the necessary viewing chamber.

Early endoscopes were rigid, which limited their utility, but the modern fiber-optic version is flexible and can negotiate bends while its tip may be turned, under remote control, to widen the field that may be scrutinized. The essential components of the fiber-optic instrument are two bundles of glass fibers. Such fibers, when suitably prepared and coated, conduct light from one end to the other without significant leakage to the side. One bundle is used to convey light distally, from an external source to the region to be viewed; the component fibers can be relatively coarse and randomly arranged. The second bundle conveys the image and is composed of finer fibers that maintain fixed positions in relation to each other. The image is composed of many tiny units, each corresponding to an individual fiber, and is presented to the eye (or to a camera or video system) at the proximal end of the instrument.

Radiographic anatomy has for some time been an indispensable component of every course of anatomy influenced by clinical considerations. Most departments routinely display previously prepared radiographs and, although students are unlikely to be involved in their production, it is prudent to remind them that considerable risks are associated with x-radiation—risks that