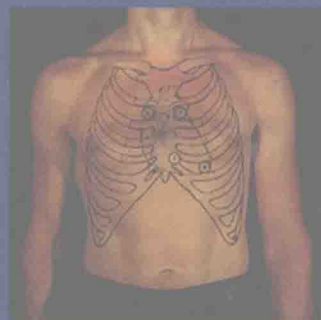
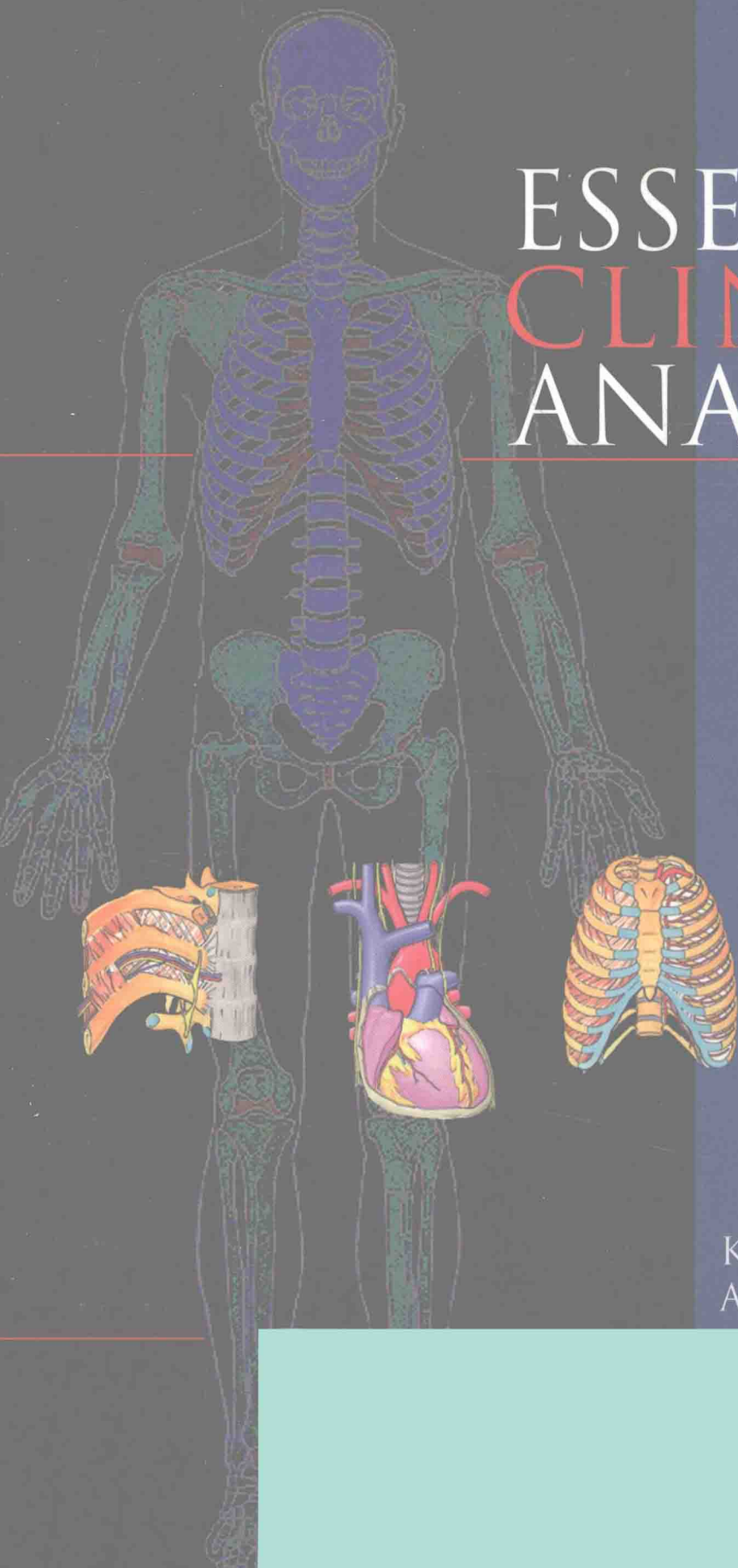


ESSENTIAL CLINICAL ANATOMY



KEITH L. MOORE
ANNE M. R. AGUR

ESSENTIAL CLINICAL ANATOMY

Keith L. Moore, PhD, FIAC, FRSM

Professor Emeritus of Anatomy and Cell Biology
Faculty of Medicine, University of Toronto
Toronto, Ontario, Canada
Visiting Professor of Clinical Anatomy
Department of Anatomy, Faculty of Medicine
University of Manitoba, Winnipeg, Manitoba, Canada
Former Head of Anatomy, University of Manitoba
Former Chair of Anatomy, University of Toronto

Anne M. R. Agur, BSc (OT), MSc

Associate Professor of Anatomy and Cell Biology, Occupational Therapy,
Physical Therapy, and Biomedical Communications
Faculty of Medicine, University of Toronto
Toronto, Ontario, Canada

With the assistance of

Marion Moore, BA
Kam Yu, BSc, AAM



Williams & Wilkins

A WAVERLY COMPANY

BALTIMORE • PHILADELPHIA • LONDON • PARIS • BANGKOK
BUENOS AIRES • HONG KONG • MUNICH • SYDNEY • TOKYO • WROCLAW



Editor: Patricia Coryell

Development Editors: Laura M. Bonazzoli, Lisa Donohoe

Project Editor: Therese Grundl

Designer: Norman W. Och

Illustration Planners: Lorraine C. Wrzosek, Image Foundry Ltd., MK Designs

Cover Designer: Tom Scheuerman

Production Coordinators: Anne Stewart Seitz, Carol Eckhart

Copyright © 1995

Williams & Wilkins

351 West Camden Street

Baltimore, Maryland 21201-2436, USA



All rights reserved. This book is protected by copyright. No part of this book may be reproduced in any form or by any means, including photocopying, or utilized by any information storage and retrieval system without written permission from the copyright owner.

Accurate indications, adverse reactions, and dosage schedules for drugs are provided in this book, but it is possible that they may change. The reader is urged to review the package information data of the manufacturers of the medicines mentioned.

Printed in the United States of America

Library of Congress Cataloging in Publication Data

Moore, Keith L.

Essential clinical anatomy \ Keith L. Moore, Anne M.R. Agur.

p. cm.

Compilation of material extracted from Clinically oriented anatomy

/ Keith L. Moore. 3rd ed. and Grant's atlas of anatomy / Anne M.R. Agur. 9th ed.

Includes bibliographical references and index. ISBN 0-683-06128-3

1. Human anatomy. 2. Human anatomy—Atlases. I. Agur, A. M. R.

II. Moore, Keith L. Clinically oriented anatomy. III. Agur, A. M.

R. Grant's atlas of anatomy. IV. Title.

[DNLM: 1. Anatomy—handbooks. QS 39 M822e 1995]

OM23.2.M673 1995

61 1—dc20

DNLM/DLC

for Library of Congress

94-36235

CIP

97 98 99

3 4 5 6 7 8 9 10

Reprints of chapters may be purchased from Williams & Wilkins in quantities of 100 or more.
Call our Special Sales Department, (800) 358-3583.

*To Marion, my wife and best friend, who was presented
with the Williams & Wilkins Golden Crab Award
for her contribution to the editing
and preparation of this book*

Keith L. Moore

To my husband, Enno, and for my children, Erik and Kristina

Anne M. R. Agur

PREFACE

It is clear that many students and practitioners in the health care professions and related disciplines require a compact yet thorough textbook of clinical anatomy. The parent of this book, *Clinically Oriented Anatomy* (COA), by the senior author, is recommended as a resource for more complete and detailed descriptions of human anatomy and its relationship and importance to medicine and surgery.

Essential Clinical Anatomy is an overview of the important aspects of anatomy described in COA. The number of structures described is limited to those deemed likely to be important to the practitioner. Furthermore, the structures receive an amount of attention that is roughly proportionate to their importance. Presentations are brief and

- Provide a basic text of human anatomy for use in current health sciences curricula
- Present an appropriate amount of anatomical material in a readable and interesting form
- Provide a concise clinically oriented anatomical reference for clinical courses in subsequent years
- Serve as a rapid review when preparing for examinations, particularly the national boards
- Offer enough information for those wishing to refresh their knowledge of anatomy

Essential Clinical Anatomy is a concise text with a strong clinical orientation and many descriptive figures and tables. Most illustrations are in full color and are designed to highlight important facts and show their relationship to clinical medicine and surgery. Some illustrations are from *Grant's Atlas*, by the junior author; others are from COA. Current diagnostic imaging techniques (radiographs, CTs, and MRIs) are also included to demonstrate anatomy as it is often viewed clinically. Interspersed in blue boxes and white boxes with blue borders are clinical comments that relate anatomy to clinical practice. They are introduced with the intention of illustrating the importance of correlating preclinical and clinical subjects.

Surface anatomy is emphasized because the examination of every patient involves applied knowledge of this approach to the study of anatomy. Bony and other anatomical landmarks are used as points of reference during physical

examinations and for surgical approaches to internal organs. The fundamental aim of surface anatomy is visualization of the structures that lie beneath the skin. Surface anatomy information is presented in white boxes headed with a pink bar.

The terminology conforms with the sixth edition of *Nomina Anatomica* (1989). To facilitate communication, unofficial widely used alternative terms appear in parentheses [e.g., uterine tube (Fallopian tube), omental bursa (lesser sac), and rectouterine pouch (pouch of Douglas)]. Many terms are anglicized for those who prefer not to use Latin terms [e.g., deep brachial artery (profunda brachii artery) and hip bone (os coxae)].

We welcome your comments and suggestions for improvements in the next edition.

Keith L. Moore
Anne M. R. Agur

ACKNOWLEDGMENTS

We thank Marion Moore for her indefatigable support and encouragement during the preparation of the manuscript and for providing constructive comments during its development. We also thank the medical artist, Kam Yu, who prepared the superb color illustrations. Other drawings from *Clinically Oriented Anatomy* and *Grant's Atlas* were prepared previously by Angela Cluer, Nina Kilpatrick, Stephen Mader, David Mazierski, Sari O'Sullivan, and Bert Vallecoccia. The photographs were taken by Paul Schwartz of IMS Creative Communications, University of Toronto.

We are grateful to the following for their constructive comments during the preparation of this book: Dr. Joseph Bast, The University of Kansas Medical Center; Dr. Richard Drake, University of Cincinnati Medical Center; Marilyn Li, student at Brown University School of Medicine; Dr. Margaret H. Hines, The Ohio State University College of Medicine; Dr. Todd R. Olson, Albert Einstein College of Medicine; Dr. Charles Pincus, University of Toronto, Faculty of Medicine; Dr. E. George Salter, The University of Alabama at Birmingham; Dr. William J. Swartz, Louisiana State University Medical Center; and Dr. Linda L. Wright, Boston University School of Medicine.

We also acknowledge the assistance of many physicians who have helped us. We are greatly indebted to Dr. W. Kucharczyk, Professor and Chair of Radiology, and Dr. E. Becker, Associate Professor of Radiology, University of Toronto, Faculty of Medicine, Toronto, Ontario, Canada. They and other colleagues, acknowledged in the figure and table credits, provided most of the radiographs, CTs, and MRIs. Dr. Tom White, Department of Radiology, College of Medicine, The Health Science Center, University of Tennessee at Memphis, also provided some excellent CTs.

We are indebted to many people at Williams & Wilkins for their patience and invaluable cooperation: Timothy S. Satterfield, Nancy Evans, Norman W. Och, Lorraine C. Wrzosek, Therese Grundl, Carol Eckhart, and Anne Stewart Seitz. We should also recognize the friendly support of the former President, Professional and Reference Group, Sara Finnegan, who invited us several years ago to join the Williams & Wilkins team of authors.

Keith L. Moore
Anne M. R. Agur
University of Toronto
Toronto, Ontario, Canada

CONTENTS

<i>Preface</i>	<i>v</i>
<i>Acknowledgments</i>	<i>x</i>

1/ Introduction to Clinical Anatomy	1
Approaches to Studying Anatomy	1
Anatomical and Medical Terminology	3
Diagnostic Imaging Techniques	5
Skin and Fascia	8
Skeletal System	9
Muscular System	16
Cardiovascular System	19
Lymphatic System	22
Nervous System	24
2/ Thorax	32
Thoracic Wall	32
Thoracic Cavity	45
3/ Abdomen	80
Anterolateral Abdominal Wall	81
Peritoneum and Peritoneal Cavity	94
Abdominal Viscera	98
Thoracic Diaphragm	129
Posterior Abdominal Wall	133
4/ Pelvis and Perineum	145
Pelvis	145
Pelvic Viscera	154
Perineum	176
5/ Back	190
Vertebral Column	190

	Muscles of the Back	204
	Spinal Cord and Meninges	209
6/	Lower Limb	217
	Bones	217
	Fasciae	225
	Nerves and Vessels	225
	Organization of Thigh Muscles	228
	Gluteal Region	239
	Posterior Thigh Muscles	242
	Popliteal Fossa	247
	Leg	250
	Foot	261
	Joints	266
7/	Upper Limb	281
	Bones	281
	Fasciae	287
	Cutaneous Nerves	289
	Superficial Veins	289
	Lymphatic Drainage	289
	Pectoral Muscles	289
	Axilla	299
	Back and Shoulder Regions	301
	Arm	306
	Forearm	313
	Wrist and Hand	318
	Joints of Upper Limb	334
8/	Head	342
	Skull	342
	Face	348
	Scalp	355
	Cranial Meninges and Cerebrospinal Fluid	358
	Brain	361
	Orbit	367
	Temporal Region	378
	Temporomandibular Joint	384

Oral Cavity	385
Pterygopalatine Fossa	395
Nose	397
Ear	402
9/ Neck	409
Fasciae of Neck	409
Triangles of Neck	415
Deep Structures in Neck	424
Root of Neck	424
Lymphatics in Neck	428
Cervical Viscera	428
10/ Summary of	
 Cranial Nerves	446
Olfactory Nerve (CN I)	449
Optic Nerve (CN II)	450
Oculomotor Nerve (CN III)	451
Trochlear Nerve (CN IV)	452
Trigeminal Nerve (CN V)	452
Abducent Nerve (CN VI)	453
Facial Nerve (CN VII)	455
Vestibulocochlear Nerve (CN VIII)	457
Glossopharyngeal Nerve (CN IX)	459
Vagus Nerve (CN X)	460
Accessory Nerve (CN XI)	462
Hypoglossal Nerve (CN XII)	462
<i>Suggested Readings</i>	<i>467</i>
<i>Figure and Table Credits</i>	<i>469</i>
<i>Index</i>	<i>471</i>

1 / INTRODUCTION TO CLINICAL ANATOMY

Approaches to Studying Anatomy

Anatomy is the science of the structure of the body. There are three main approaches to studying anatomy:

- Systemic anatomy
- Regional anatomy
- Clinical anatomy

Surface anatomy is the study of the living body at rest and in action and is used in all three approaches. The main aim of surface anatomy is the visualization of structures that lie beneath the skin. Regardless of which approach is used, one must visualize the three-dimensional structure of the body.

SYSTEMIC ANATOMY

Systemic anatomy is the study of the body as a series of organ systems.

- The integumentary system (dermatology) consists of the skin (integument) and its appendages (e.g., hair and nails); the skin forms a protective covering for the body
- The skeletal system (osteology) consists of bones and cartilage; it provides support for the body and protects vital organs (e.g., ribs and sternum protect the heart and lungs)
- The articular system (arthrology) consists of joints and their associated ligaments
- The muscular system (myology) is composed of muscles that move parts of the body (e.g., bones at joints)
- The nervous system (neurology) consists of the central nervous system (brain and spinal cord) and the peripheral nervous system (cranial and spinal nerves, together with their motor and sensory endings); the nervous system controls and coordinates functions of organs (e.g., heart) and other structures (e.g., muscles) and relates the body to the environment
- The circulatory system (angiology) consists of the cardiovascular and lymphatic systems, which function in parallel: the cardiovascular system consists of the heart and blood vessels that conduct blood through the body; the lymphatic system is a network of lymphatic vessels that withdraws excess tissue fluid (lymph) from the body's interstitial (intercellular) fluid compartment, filters it through the lymph nodes, and returns it to the bloodstream
- The digestive system (gastroenterology) is composed of the organs associated with ingestion, digestion, and absorption of food
- The respiratory system (respirology) is composed of the air passages and lungs that supply oxygen and eliminate carbon dioxide
- The urinary system (urology) consists of the kidneys, ureters, urinary bladder, and urethra, which produce, transport, store, and intermittently excrete urine, respectively
- The reproductive system consists of the genital organs that are concerned with reproduction
- The endocrine system (endocrinology) consists of the ductless glands (e.g., thyroid gland) which produce hormones that are carried by the circulatory system to all parts of the body; they influence metabolism and other body processes (e.g., menstrual cycle)

REGIONAL ANATOMY

Regional anatomy (topographic anatomy) is the study of the regions of the body (e.g., thorax and abdomen) (Fig. 1.1). This approach deals with structural relationships of the parts of the body in the region that is being studied. Most laboratory courses in human anatomy are based on regional dissection.

CLINICAL ANATOMY

Clinical anatomy emphasizes aspects of structure and function of the body that are important in the practice of medicine, dentistry, and the allied health sciences. It incorporates the regional and systemic approaches and

stresses clinical applications. In addition, surgical and imaging techniques (e.g., radiography) are used to demonstrate living anatomy. Case studies are an integral part of clinical anatomy.

The structure of people varies considerably; hence, anatomical variations are common. For example, bones of the skeleton vary among themselves, not only in their basic shape, but in lesser details of surface structure. There is also a wide variation in the size, shape, and form of the attachment of muscles. Similarly, there is variation in the method of division of nerves and arteries. A marked deviation from normal is called an *anomaly* (malformation) (e.g., a limb defect caused by the prenatal administration of thalidomide).

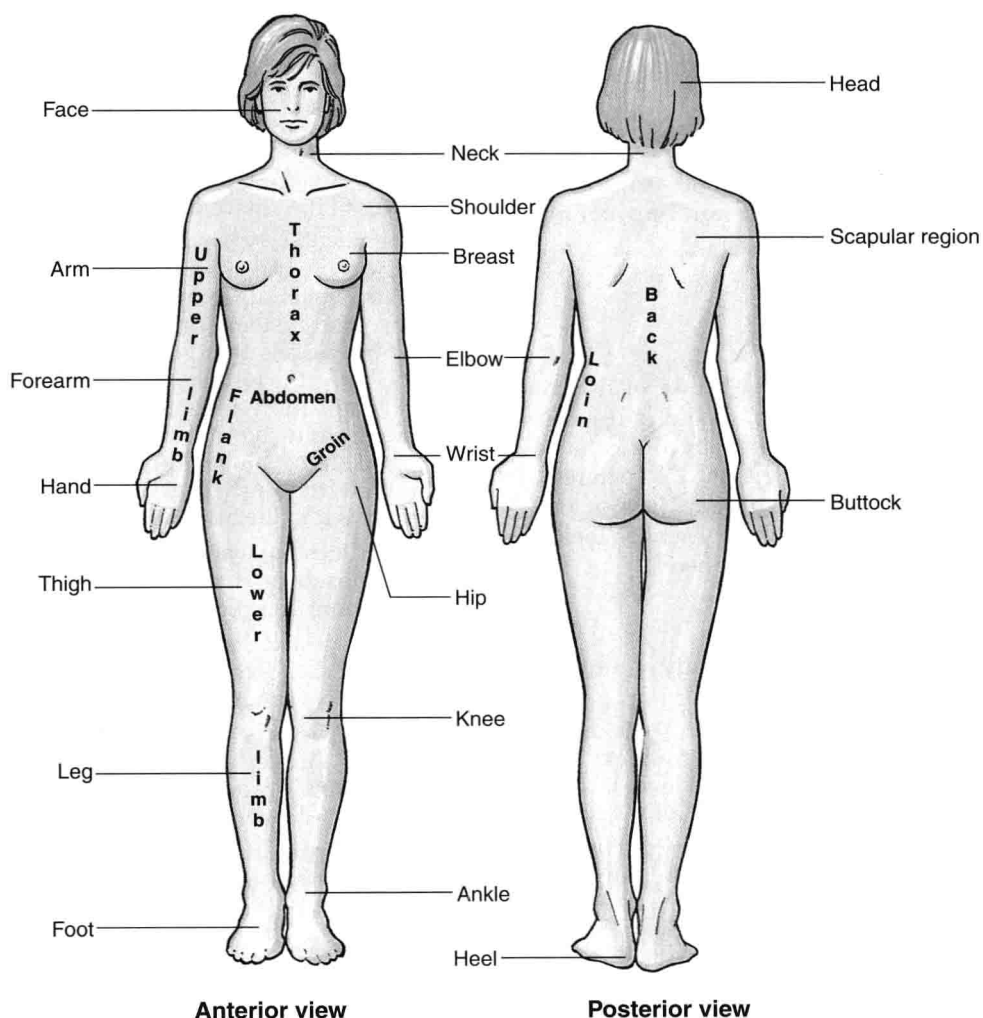


Figure 1.1. Anatomical position and regions of the body. All descriptions are based on the assumption that the person is standing in the anatomical position.

Anatomical and Medical Terminology

Anatomy has an international vocabulary, so accurate use of the words is important. Anatomical terms have precise meanings and form a major part of medical terminology. Although eponyms are not used in official anatomical terminology, those commonly used appear in parentheses throughout this book to avoid ambiguity and misunderstanding because some clinicians still use them [e.g., cerebral arterial circle (circle of Willis)]. Similarly, unofficial alternative terms appear in parentheses for clarity [e.g., internal thoracic artery (internal mammary artery)].

ANATOMICAL POSITION

All anatomical descriptions are expressed in relation to the anatomical position to ensure that the descriptions are unambiguous (Fig. 1.1). A person in the anatomical position

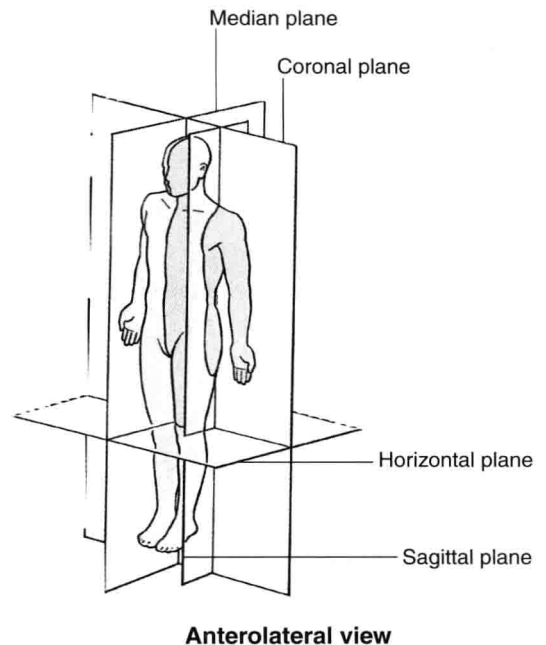
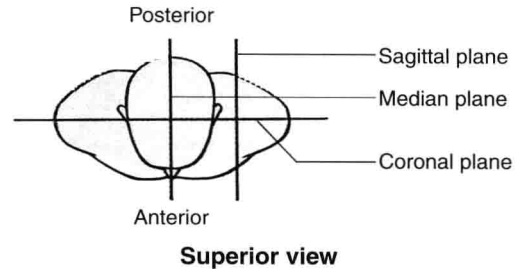
- Is standing erect or lying supine (on one's back) as if erect, with head, eyes, and toes directed anteriorly (forward)
- Has upper limbs by the sides with palms facing anteriorly
- Has lower limbs together with the feet directed anteriorly

ANATOMICAL PLANES

Anatomical descriptions are based on four anatomical planes that pass through the body in the anatomical position:

- Median plane (midsagittal plane) is the vertical plane passing longitudinally through the body, dividing it into right and left halves
- Sagittal planes are vertical planes passing through the body parallel to the median plane (it is helpful to give a point of reference such as a sagittal plane through the midpoint of the clavicle)
- Coronal planes are vertical planes passing through the body at right angles to the median plane, dividing it into anterior (front) and posterior (back) portions
- Horizontal planes are transverse planes passing through the body at right angles to

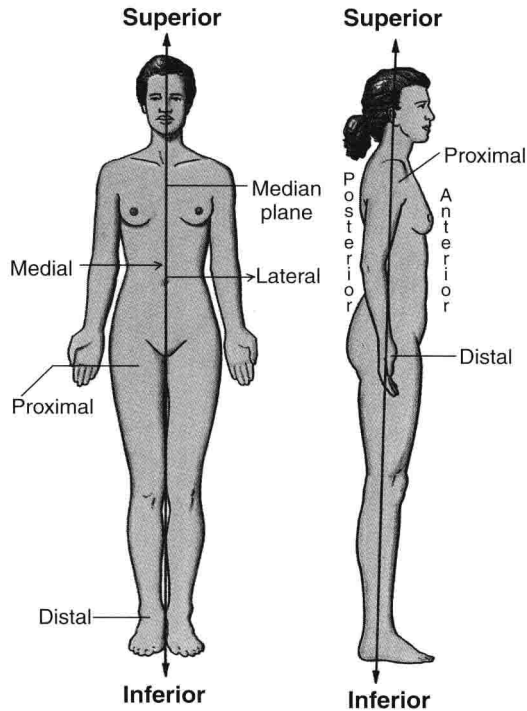
the median and coronal planes; a horizontal plane divides the body into superior (upper) and inferior (lower) parts (it is helpful to give a reference point such as a horizontal plane through the umbilicus).



TERMS OF RELATIONSHIP AND COMPARISON

Various adjectives, explained and illustrated in Table 1.1, are arranged as pairs of opposites (e.g., superior and inferior). They are used to describe the relationship of parts of the body in the anatomical position and to compare the relative position of two structures with each other. For example, the great (big) toe is on the medial side of the foot, whereas the thumb is on the lateral side of the hand.

Table 1.1
Commonly Used Terms of Relationship and Comparison



Term	Meaning	Usage
Superior (cranial)	Nearer to head	The heart is superior to the stomach
Inferior (caudal)	Nearer to feet	The stomach is inferior to heart
Anterior (ventral)	Nearer to front	The sternum is anterior to the heart
Posterior (dorsal)	Nearer to back	The kidneys are posterior to the intestine
Medial	Nearer to median plane	The fifth digit (little finger) is on the medial side of the hand
Lateral	Farther from median plane	The first digit (thumb) is on the lateral side of the hand
Proximal	Nearer to trunk or point of origin (e.g., of a limb)	The elbow is proximal to the wrist, and the proximal part of an artery is its beginning
Distal	Farther from trunk or point of origin (e.g., of a limb)	The wrist is distal to the elbow and the distal part of the lower limb is the foot
Superficial	Nearer to or on surface	The muscles of the arm are superficial to its bone (humerus)
Deep	Farther from surface	The humerus is deep to the arm muscles

TERMS OF MOVEMENT

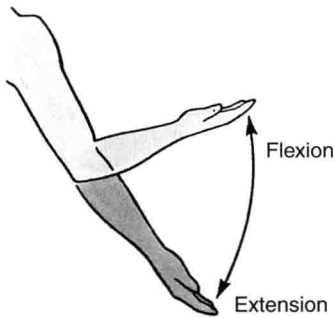
Various terms are used to describe movements of the body [e.g., flexion of the limbs (Table 1.2)]. Movements take place at joints where two or more bones or cartilages articulate with one another. They are described as pairs of opposites (e.g., flexion and extension).

Diagnostic Imaging Techniques

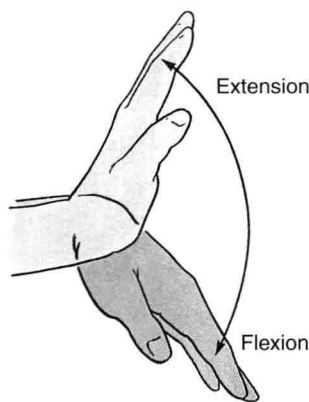
Familiarity with diagnostic imaging techniques commonly used in clinical settings

Table 1.2
Terms of Movement

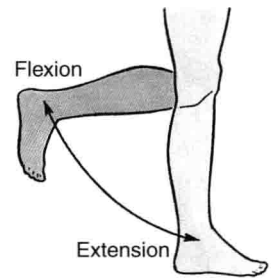
Flexion means bending of a part or decreasing the angle between body parts. *Extension* means straightening a part or increasing the angle between body parts.



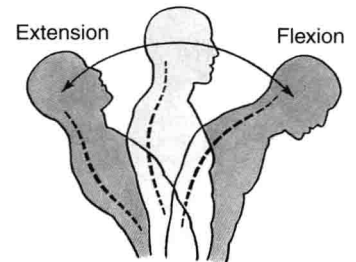
Flexion and extension of forearm at elbow joint



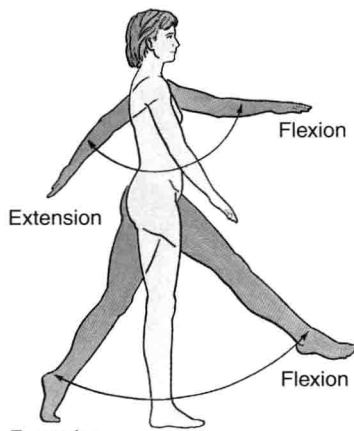
Flexion and extension of hand at wrist joint



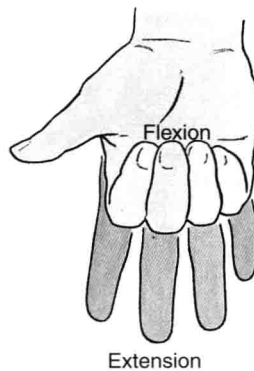
Flexion and extension of leg at knee joint



Flexion and extension of vertebral column at intervertebral joints



Flexion and extension of upper limb at shoulder joint and lower limb at hip joint



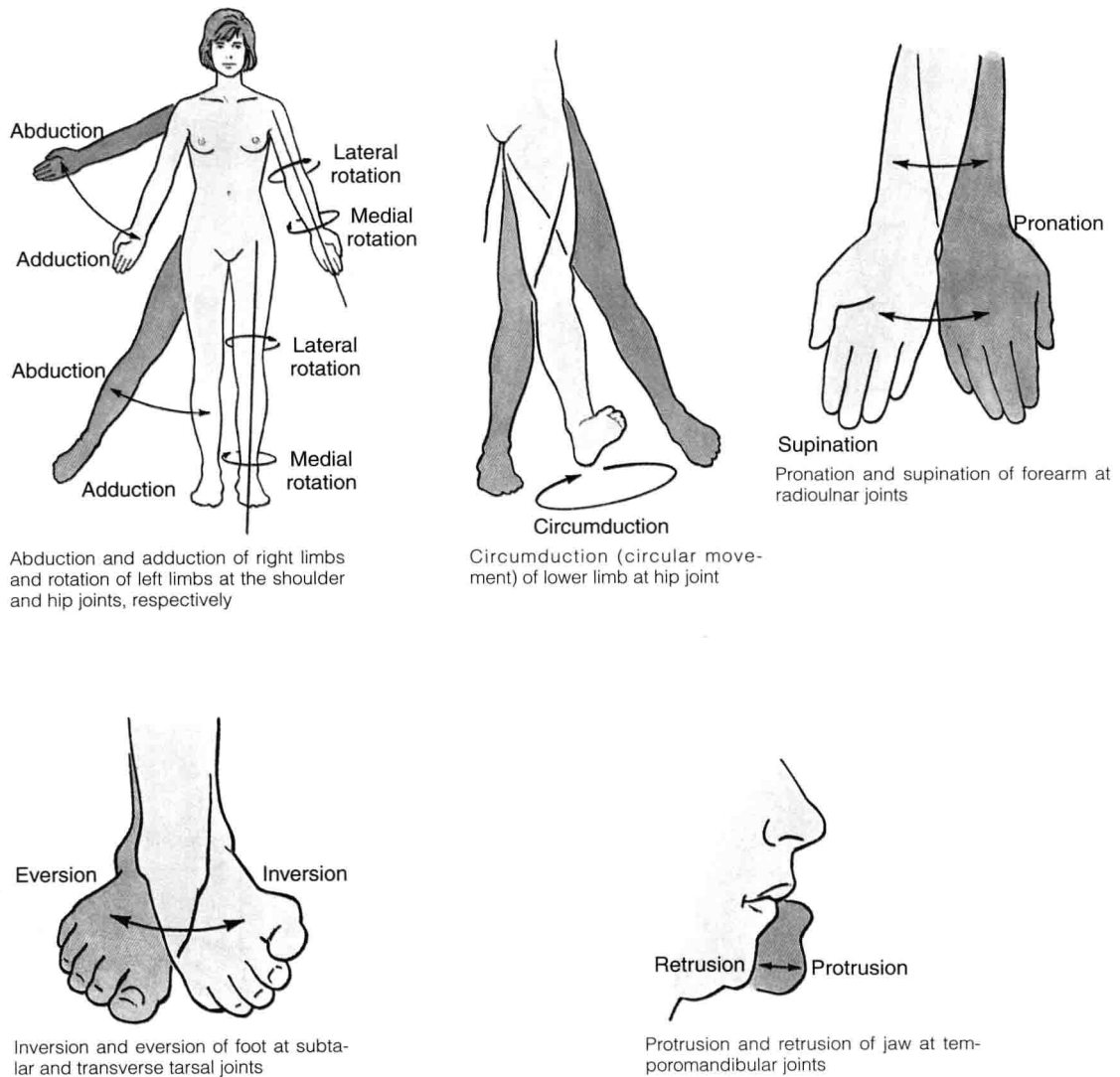
Flexion and extension of digits (fingers) at interphalangeal joints



Dorsiflexion and plantarflexion of foot at ankle joint

Table 1.2. Continued

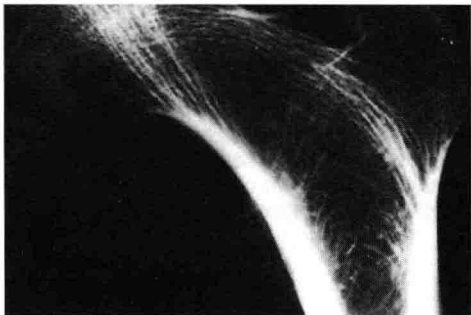
Abduction means moving away from the median plane of the body in the coronal plane. *Adduction* means moving toward the median plane of the body in the coronal plane. In the digits (fingers and toes), abduction means spreading them, and adduction refers to drawing them together. *Rotation* means moving a part of the body around its long axis. Medial rotation turns the anterior surface medially and lateral rotation turns this surface laterally. *Circumduction* is the circular movement of the limbs, or parts of them, combining in sequence the movements of flexion, extension, abduction, and adduction. *Pronation* is a medial rotation of the forearm and hand so that the palm faces posteriorly. *Supination* is a lateral rotation of the forearm and hand so that the palm faces anteriorly, as in the anatomical position. *Eversion* means turning sole of foot outward. *Inversion* means turning sole of foot inward. *Protrusion* (protraction) means to move the jaw anteriorly. *Retrusion* (retraction) means to move the jaw posteriorly.



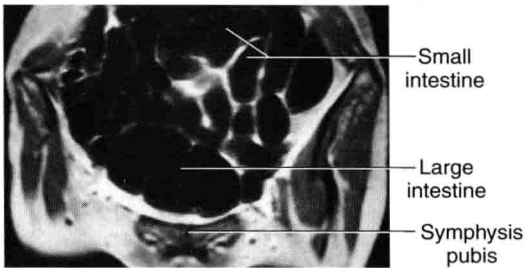
enables one to recognize abnormalities such as congenital anomalies, tumors, and fractures. The most commonly used diagnostic imaging techniques follow (Table 1.3):

- Radiography
- Computerized tomography
- Magnetic resonance imaging
- Ultrasonography

Table 1.3
Diagnostic Imaging Techniques



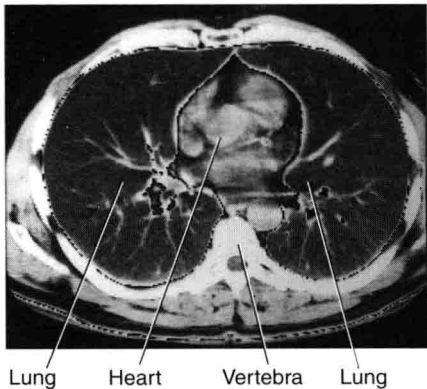
Radiograph of a coronal section of the proximal end of the femur, showing compact and spongy bone, which appears white and dark, respectively.



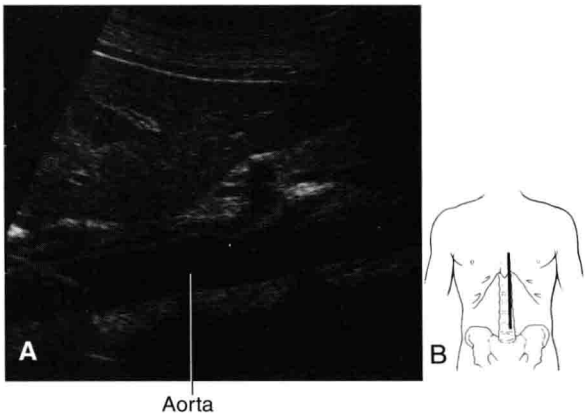
Coronal magnetic resonance image of abdomen.

Computerized tomography shows images of sections of the body. A beam of x-rays is passed through the body as the x-ray tube moves in a circle around the body. The amount of radiation absorbed by each different type of tissue of the chosen body plane varies with the amount of fat, cancellous and compact bone, and water density of the tissue in each element. A multitude of linear energy absorptions is measured and stored in a computer that compiles and generates images.

Ultrasonography (sonography) gives images of deep structures in body by recording reflections of pulses of ultrasonic waves directed into the tissues. A common use of diagnostic ultrasound imaging in pregnancy is to assess fetal age and well-being.



Computerized tomography scan of the thorax showing the heart, lungs, and vertebra. It is customary to view such sections so that the body is supine and the inferior aspect of the section is seen from below. Hence, the right side of the body is on your left.



A. Sagittal ultrasound scan of abdomen through aorta. **B.** Orientation sketch. Black line, plane of scan.