Thieme Dissector

Education

Volume I
Upper Limb and Thorax

Second Edition

Vishram Singh
G. P. Pal
S. D. Gangane
Sanjoy Sanyal

Based on the work of
Michael Schuenke
Erik Schulte
Udo Schumacher

Illustrations by
Markus Voll
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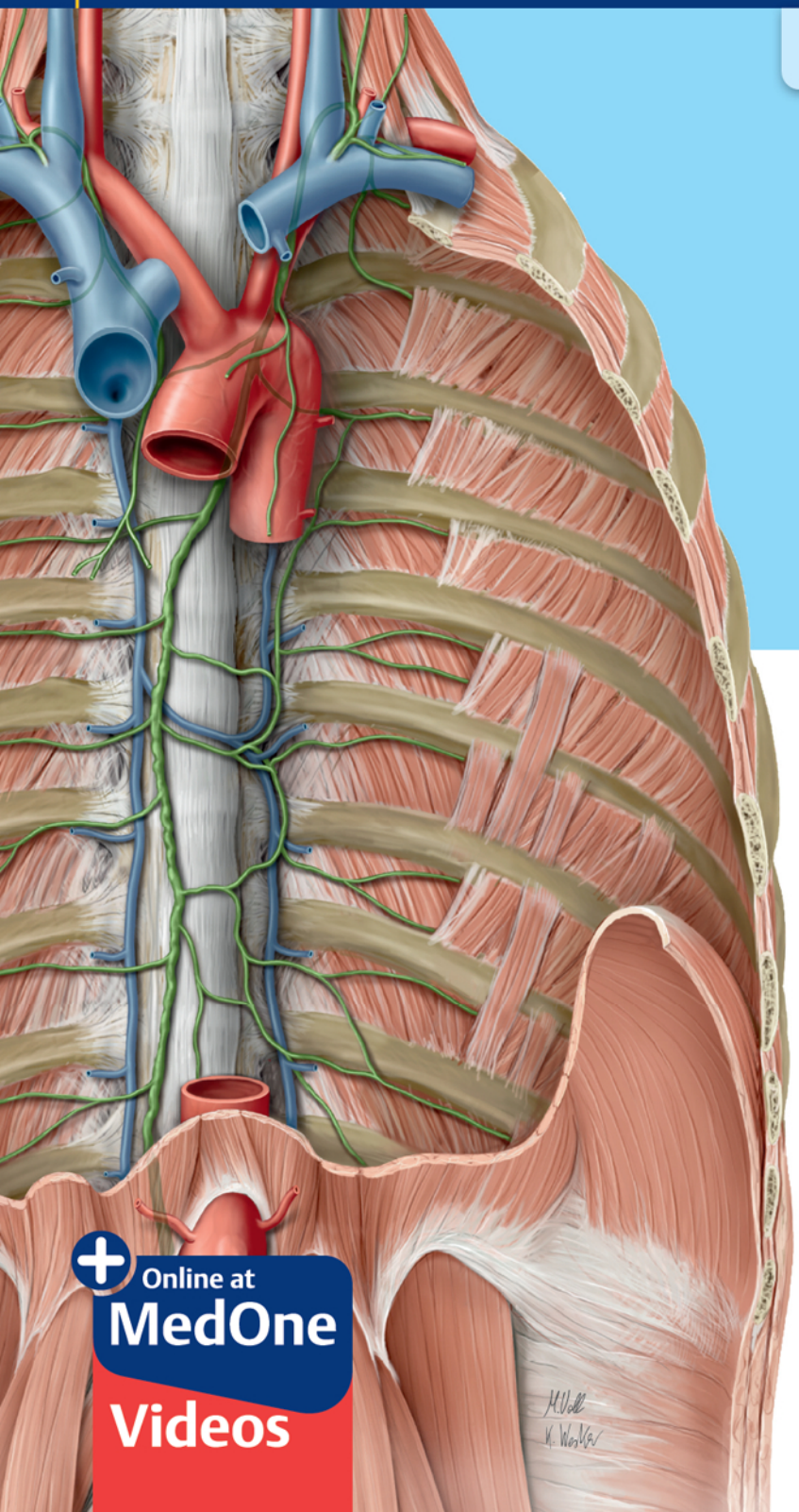

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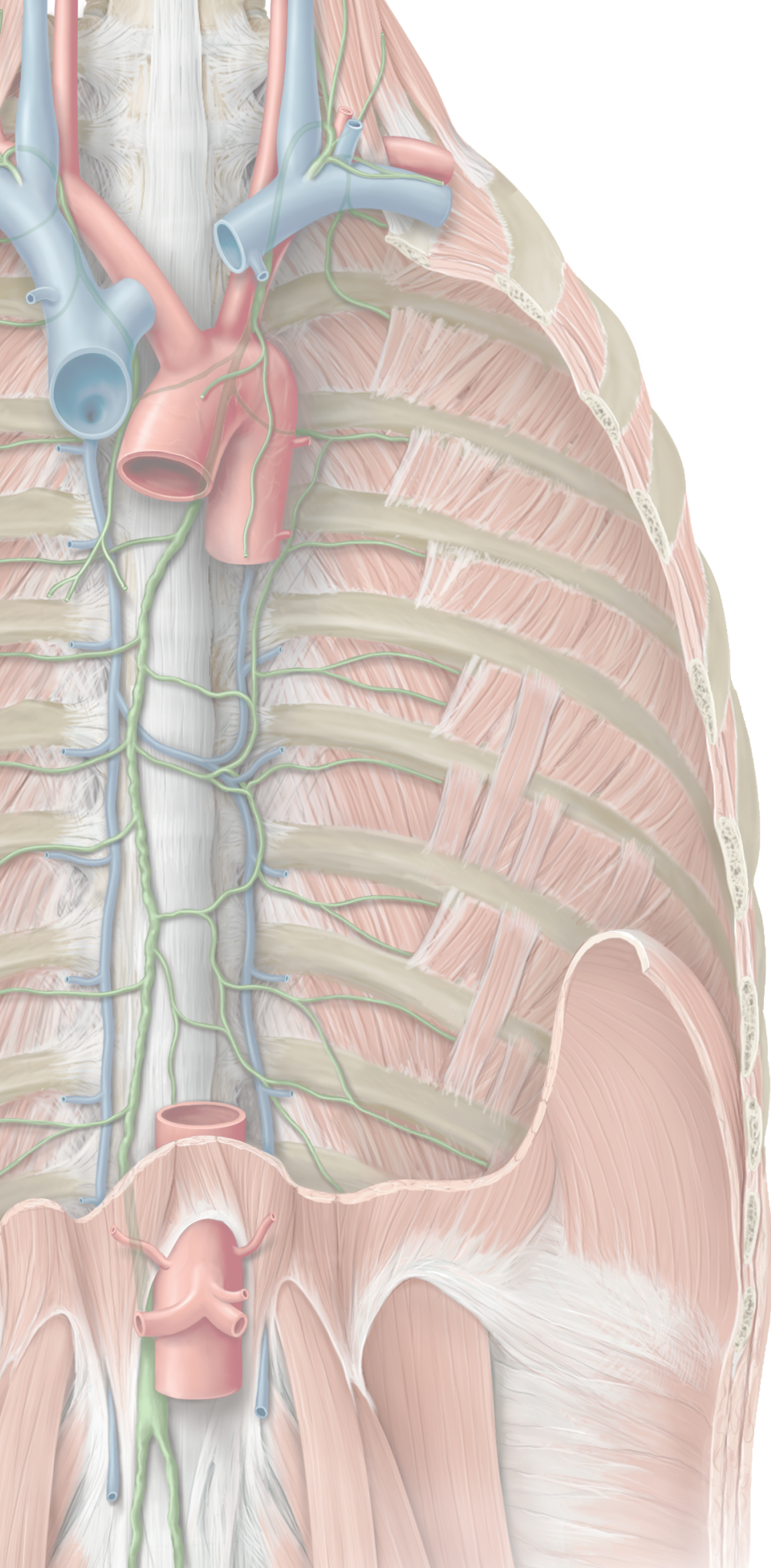

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Volume I

Upper Limb and Thorax

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Thieme addresses people of all gender identities equally. We encourage our authors to use gender-neutral or gender-equal expressions wherever the context allows.

To my students, past and present.

Vishram Singh

To my grandson, Yatharth.

G. P. Pal

To my family and colleagues, for their support;
my patients and students, for teaching me to learn from them;
the willed body-donors, for their silent altruism to medical science.

Sanjoy Sanyal

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Note from the Authors

There was a long-felt need of a good dissection manual for first-year undergraduate medical students undertaking the anatomy course. Anatomy is the foundation of all medical subjects, and hence, its thorough knowledge is essential for all students aspiring to become good doctors, especially in surgical fields.

The best *modus operandi* to learn anatomy is through dissection. Recently, due to information explosion in the medical field, the health sciences curricula have markedly reduced the time allocation for studying and teaching anatomy; yet it is realized by all that the gross structure of the human body, including its three-dimensional conceptualization, must be understood thoroughly before proceeding further to learn medicine.

Therefore, we have made a sincere effort to meet all the needs of the students in creating this three-volume set of dissection manuals. They not only delineate instructions for students to perform perfect dissection but also provide gross anatomy descriptions, supplemented by clinical correlations of gross structures studied during dissection. The textual descriptions are complemented by numerous colored illustrations that will help students recognize significant structures with more precision. To further enhance understanding, the content of the volumes is organized in sections like (a) Learning Objectives, (b) Surface Landmarks, (c) Dissection and Identification, (d) Description of Gross Anatomy, and (e) Clinical Notes. Laced with all these features, we hope that these volumes will be useful not only for medical and dental students but also for teachers of anatomy. The value of these volumes is further enhanced by providing videos at relevant places.

As educators of anatomy, we have tried our best to make these manuals easy for learning. We highly appreciate the contribution of Prof. Poonam Kharb and Mr. D. Krishna Chaitanya in Volume II and Prof. Shabana M. Borate in Volume I. For further improvements, we would sincerely welcome comments and suggestions from all students and teachers.

The second edition of this dissection manual is thoroughly updated with new line diagrams, X-ray pictures, and CT and MRI scans.

All dissection steps are supplemented by dissection videos in all the three volumes for easy understanding of gross and clinical anatomy by the students.

Vishram Singh, MBBS, MS, PhD (hc), MICPS, FASI, FIMSA

The medical curriculum in India requires basic anatomy, along with some other basic subjects, to be taught to students in the first year of the course. This often leads to an information overload for them. For some students, the situation is made even more difficult due to linguistic limitations and late admissions. As a result, there has long been a pressing need for comprehensive teaching resources that create thorough understanding of these courses in a short time span. Specifically for anatomy, one cannot stress enough on the value of a complete and detailed dissection manual that explains basic concepts in a simple and lucid manner, without duplication of facts or unnecessary complexities.

In Volume III, every care has been taken to describe all steps involved in the dissection of the head, neck, and brain in a stepwise manner that is easy to understand for the beginners. Several high-quality illustrations have been used to explain each step. They help show the dissections with a great amount of detailing and clarity. To make the discourse interesting, relevant clinical conditions have also been presented under separate sections called “Clinical Notes.”

Producing a book with hundreds of illustrations is a joint effort by the author and the publisher in a true sense.

I strongly believe that this book will be an invaluable learning resource for students and teachers of anatomy in medical and dental courses.

G. P. Pal, MBBS, MS, DSc, FASI, FAMS, FNASc, FASc, Bhatnagar Laureate

Cadaveric dissection is an integral part of teaching anatomy in medical schools. It offers an unmatched firsthand experience of exploring the structure of organs and their relationship with each other. *Thieme Dissector* provides a complete account of dissection of human body through a set of three volumes.

The first volume deals with the upper limb and thorax. The introduction of this volume gives general information about preservation of cadaver, instruments required for dissection, and anatomical terms, followed by a discussion on basic tissues of the body. This is followed by 10 chapters on upper limb and 5 chapters on thorax. Each chapter begins with "Learning Objectives," followed by an introduction to the topic, dissection steps with description of the relevant structures, and clinical notes.

To facilitate understanding of the subject, photographs of actual dissected parts and real dissection videos have been provided. Access to these videos will help and enrich students' learning process.

My heartfelt gratitude to Dr. Shabana M. Borate, Associate Professor, Department of Anatomy, at Grant Government Medical College and Sir J. J. Group of Hospitals, Mumbai, Maharashtra, India, Dr. Sachin Yadav, Assistant Professor at Grant Government Medical College and Sir J. J. Group of Hospitals, Mumbai, Maharashtra, India, and Dr. Shilpa Domkundwar, Professor and Head, Department of Radiodiagnosis, Grant Government Medical College and Sir J. J. Group of Hospitals, Mumbai, Maharashtra, India, for their untiring efforts in preparation of this volume. I am grateful to the entire team of Thieme Publishers for their constant support, and special thanks to Dr. Vishram Singh sir, who has been the guiding force for all of us in preparation of the *Thieme Dissector*.

S. D. Gangane, MBBS, MS, FAIMS

Thieme has taken a positive step by introducing this book for imparting anatomy education to medical students worldwide. The process of depicting videos and pictures of actual cadaver dissections in a textbook is indeed a monumental task. It starts with planning of the region to be dissected. This is followed by meticulous dissection of the region itself, which can take hours if not days. Then comes the process of accurate live narration of the dissection of the region on camera, while the video recording is in progress. The back-breaking task of editing and captioning the video frames and clips follows next, because many anatomical and medical terms used in the narration may otherwise be incomprehensible to the student. Since clinical students like content related to radiology, some videos have radiological images embedded within the frames. The relevant still shots from the dissections are then edited and labeled. Finally, of course, comes the task of publishing the finished product.

There are many digital anatomy tools available to the medical academia, ranging in size and versatility from usage in classrooms and digital labs to those used in individual laptops and tablets. Some have virtual reality–like, immersive three-dimensional, or augmented reality applications. They vary in accuracy, comprehensiveness, and versatility. They are good study tools, which are interactive and interesting to use in teaching and learning anatomy. They show body parts and spatial relationships. They are available offline, accessible anytime, anywhere, and can even show rare pathology. They present consolidated anatomy information to suit users' learning styles. They do not have the legal, ethical, religious, social, regional, and logistical constraints of human cadaver procurement. These factors are weaning away institutions from the hoary art of cadaver dissection.

However, cadaver dissection is still the gold standard for learning human anatomy and surgery. It is the benchmark for measuring the success of newer learning technologies. Cadavers are medical students' first "patients." Digital resources are to be considered as supplements to the armamentarium

of learning methods in human anatomy. Digital technologies lack haptic qualities of human tissue, which are essential for a surgeon. Therefore, they can never completely replace cadaver dissection for anatomy students and surgical residents under training. Nobody would want to be treated by surgeons who acquired their entire quantum of expertise in operating on the human body through virtual reality alone, just like nobody would want to be flown by an airline pilot whose only flying experience was in the digital flight simulator.

The author is truly gratified knowing that students have learned the subject of anatomy and mastered the intricacies of the human body by watching *Thieme Dissector* videos and illustrations.

Sanjoy Sanyal, MBBS, MS, MSc, ADPHA

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A renowned anatomist, Prof. Singh has taught undergraduate and postgraduate students at several colleges and institutes, such as GSVM Medical College, Kanpur; King George Medical College, Lucknow; All India Institute of Medical Sciences, New Delhi; and Al Arab Medical University, Benghazi, Libya. He has more than 50 years of experience in teaching, research, and clinical practice. He has various bestselling titles to his credit, such as *Textbook of Clinical Neuroanatomy, Textbook of Anatomy*—three volumes, and *Textbook of Clinical Embryology*. He has published more than 20 books and more than 100 research articles in reputed national and international journals.

Prof. Singh has received various recognitions and awards for his contributions in the field of gross anatomy, neuroanatomy, and embryology.

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Prof. Gangane has also worked as an Officer of Special Duty (OSD) for the Government of Maharashtra under the Directorate of Medical Education and Research. He is a member of the advisory panel for the South Asian region of the international publishing house, Lippincott Williams and Wilkins. He is the founder Trustee of "Sandnya Sanwardhan Sanstha", an organization that takes care of mentally challenged children by imparting vocational training and enabling them to lead better lives.

Sanjoy Sanyal

(Contributor of Videos, Volumes I, II, and III)

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A prolific medical and educational researcher, he has published 25 original research papers in peer-reviewed journals and presented 15 papers in many international conferences in 11 countries. He is the recipient of five Outstanding Professor Awards from several different universities and medical schools.

He is a surgical skills instructor to American Medical Students' Association (AMSA). He is a life-member of Indian Medical Association (IMA), and annual member of American Association for Anatomy (AAA) and American Association of Clinical Anatomists (AACA). He is a provisional patent holder (January 2014) of a computerized medical program from the United States Patent and Trademark Office (USPTO). He is peer reviewer of several medical journals.

Dr. Sanjoy Sanyal is honorary faculty of the Multimedia Educational Resource for Learning and Online Teaching (MERLOT), a program of the California State University (CSU), Long Beach, partnering with educational institutions, professional societies, and industry. He is Gold-level MERLOT contributor, having authored more than 350 learning materials. He is a member of Virtual Speaker's Bureau (VSB) of MERLOT. He is also the recipient of Innovative Use of MERLOT award.

With an underpinning philosophy of lifelong learning, his motto is to make each succeeding generation better than the previous.

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Introduction to Dissection

Anatomy is one of the basic subjects in medical education. It deals with the structure of human body. A sound knowledge of this subject provides better understanding of the clinical subjects. The subject of anatomy is best studied by dissection. It will be appropriate to say that dissection forms an integral part of teaching or learning anatomy. It gives you an opportunity to explore, observe, and learn about structures/organs. The experience that you gain in the dissection room is unmatched. It cannot be compared to learning through books, illustrations, CDs, and DVDs that are available to learn the subject. Dissecting a cadaver improves your skill of handling the tissues and instruments that you will be trying later when you start practicing on living subjects. It gives you an understanding about the relationship of various structures to each other and helps you know what is normal and what is anomalous. It offers an anatomical basis of tests that you may do, various signs and symptoms that you encounter in a patient, variations that you may see in some subjects, and overall better understanding of many disease processes. It is well said that *the cadaver is the best teacher of anatomy*. Once it is accepted, it is our duty to treat the cadaver with the same respect and dignity which is offered to a living patient.

Preservation of the Cadavers

It is done by embalming the cadaver with the embalming fluid which contains a strong fixative. Subsequently, the cadaver is submersed in the preservative fluid. When the cadaver is partly dissected, proper care should be taken by wrapping it so that it is kept moist, or else the cadaver will desiccate and once the part is dry it cannot be restored. Therefore, expose only the part which is to be dissected. Ideally, all the parts of the body should be periodically inspected and moistened during the dissecting session.

Anatomical Terms

It is essential to get familiar with many anatomical terms which are repeatedly used to describe structures, organs, parts, etc. Some of them are given in the following paragraphs.

Anatomical Position

It is the position of the body with the person standing erect, feet approximated (together), toes pointing forward, arms hanging by the side of the body, palms facing forward, and the eyes looking at horizon (**Fig. 1**).

All the descriptions in anatomy are provided assuming the body is in anatomical position, though the cadaver is lying horizontally on the dissection table. Its relationship with the neighboring structures is essential when you study the structure; remember that the description applies assuming the structure is in anatomical position. The frequently used terms can be put into two groups: the terms of positions and the terms of movements.

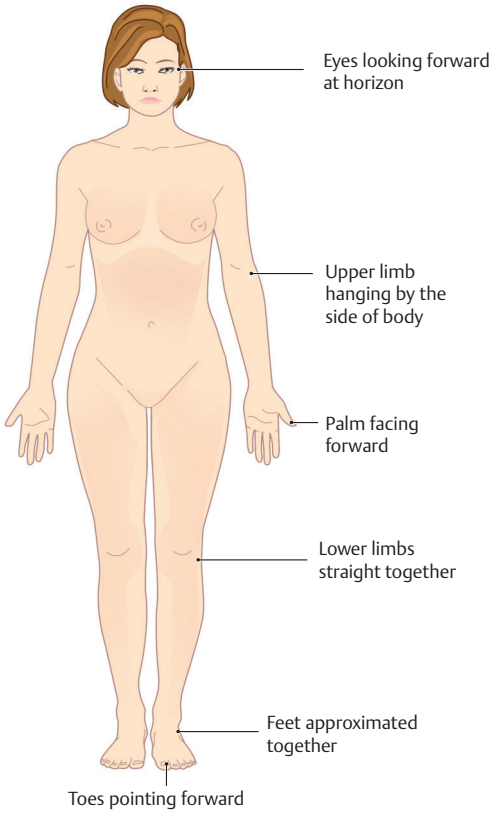

Fig. 1 Anatomical position.

Terms of Positions (Fig. 2)

1. *Anterior*: It means nearer to the front of the body.
2. *Posterior*: It means nearer to the back.
3. *Ventral* and *dorsal* are used in the case of trunk instead of anterior and posterior, respectively.
4. In the hand, *palmar* means anterior and *dorsum* means posterior. In the foot, the terms used are *dorsum* for the upper side and *plantar* for the sole of the foot.
5. *Median*: It means in the middle.
6. *Medial*: It means nearer the median plane.
7. *Median plane*: It is an imaginary plane bisecting the body into nearly two equal halves.
8. *Lateral*: It means away from the median plane; for example, there are two forearm bones, the radius is on the lateral side and the ulna is on the medial side. In the bones of the leg, the tibia is on the medial side and the fibula is on the lateral side.
9. *Superficial*: It means nearer to the skin of surface.
10. *Deep/Profundus*: It means deeper (as compared to superficial) from the surface.
11. *Proximal* (nearer to): It indicates relative position of the structure.
12. *Distal* (further from): For example, elbow is distal to the shoulder but proximal to the wrist.
13. *Superior/Cephalic*: The term refers to the position of the part which is nearer to the head.
14. *Inferior/Caudal*: It means nearer to the feet.

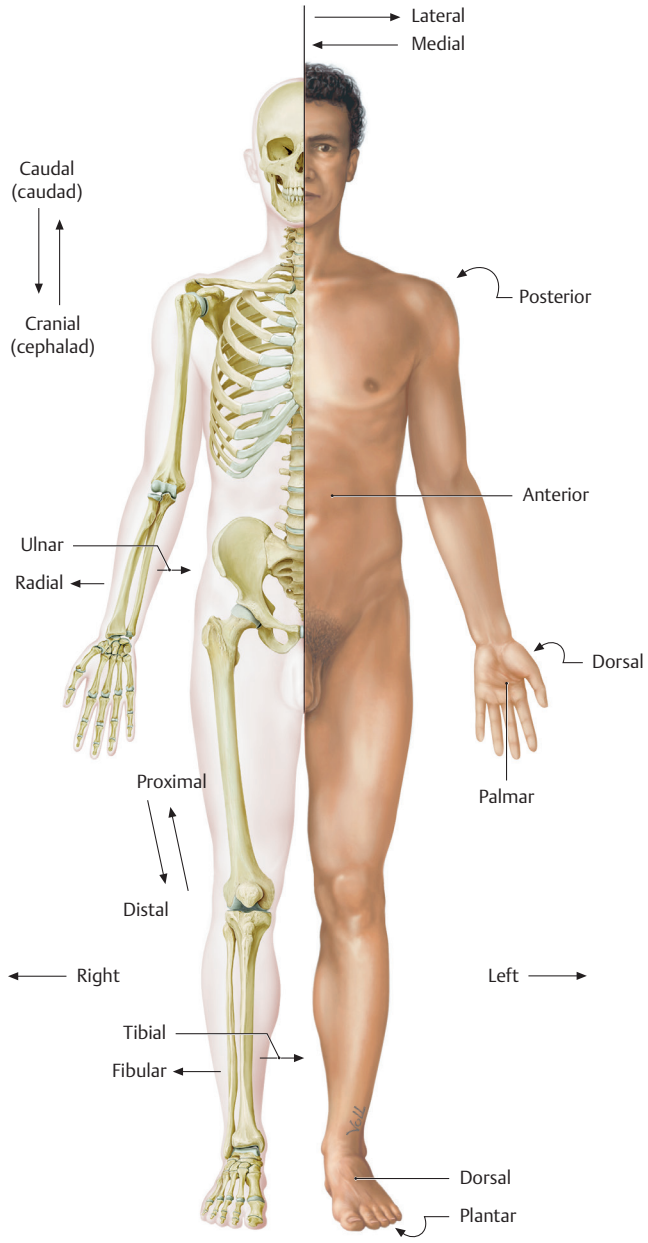

Fig. 2 A diagram illustrating the use of anatomical terms. (From: Schuenke M, Schulte E, Schumacher U. THIEME Atlas of Anatomy. General Anatomy and Musculoskeletal System. Illustrations by Voll M and Wesker K. © Thieme 2020.)

Anatomical Planes

There are four imaginary planes (**Fig. 3**) that pass through the body in anatomical position:

1. *Median/Sagittal plane*: A vertical plane which passes through the center of the body and divides it into two equal halves.
2. *Paramedian/Parasagittal plane*: Any vertical plane which is parallel to the median plane.
3. *Coronal plane*: Any vertical plane perpendicular to the median plane.
4. *Transverse/Horizontal plane*: Any plane at right angle to coronal and sagittal planes.

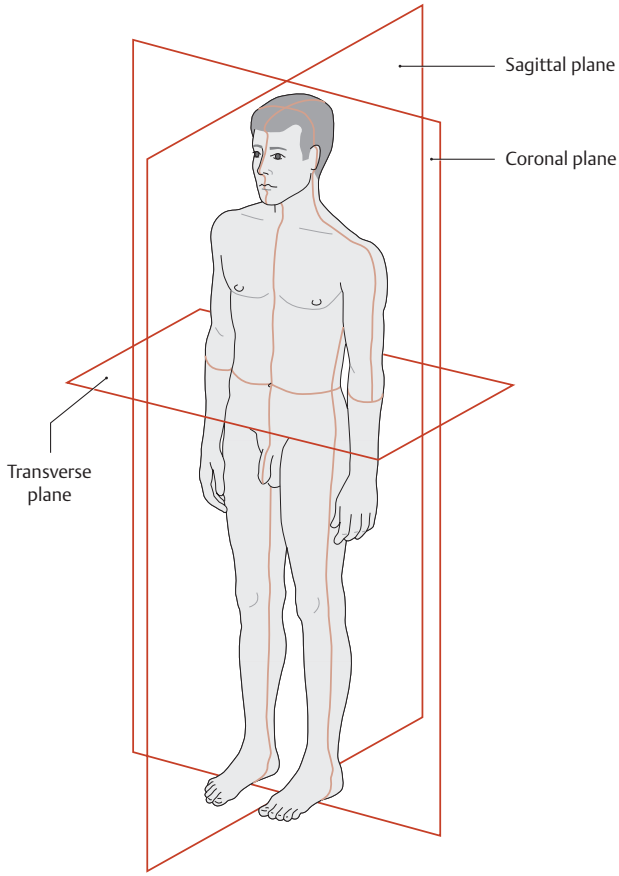

Fig. 3 Anatomical planes. (From: Schuenke M, Schulte E, Schumacher U. THIEME Atlas of Anatomy. General Anatomy and Musculoskeletal System. Illustrations by Voll M and Wesker K. © Thieme 2020.)

Terms of Movements

1. *Flexion*: It means forward bending of the trunk and folding of limbs.
2. *Extension*: In case of the trunk, it is backward or posterior bending and in limbs it is straightening.
3. *Dorsiflexion*: It is the movement of the foot toward the dorsum. It occurs at the ankle joint.
4. *Plantar flexion*: It is the movement of the foot toward the sole. It also occurs at the ankle joint.
5. *Adduction*: The movement toward the median plane.
6. *Abduction*: The movement away from the median plane.
7. *Lateral flexion*: It is movement of the trunk in the coronal plane.
8. *Pronation and supination*: These are movements involving the forearm and occur at the radioulnar joints (joints between the forearm bones, the radius and ulna). In anatomical position, the forearm is supinated and the palm faces forward. In pronation, the palm faces backwards/posteriorly.
9. *Inversion and eversion*: These movements involve the foot and occur at the subtalar and calcaneocuboid joints (joints of the tarsal bones, the bones of the foot). In inversion, the medial border of the foot is raised so that the sole faces medially. In eversion, the lateral border of the foot is raised and the sole of the foot faces laterally.
10. *Rotation*: The term signifies the movement where the part of the body is turned around its own longitudinal axis. In the limbs, it can be *medial* or *lateral rotation* at a particular joint, for example, the shoulder joint.

Structures That Are Encountered in Dissection

The body surface is covered by the skin, beneath which lies the superficial fascia and still deeper lies the deep fascia.

Skin

The *skin* consists of the outer, avascular, stratified, keratinized epithelium, the *epidermis,* and inner vascular, dense, fibrous tissue, the *dermis*. Dermis has protrusions into the epidermis. This increases the area of contact between them; thus, the two are firmly bound together.

Superficial Fascia

It consists of fat-filled fibrous mesh, connecting the dermis (of the skin) with the deep fascia. In the region of the scalp, palms of the hands, soles of the feet, and the back of the neck, the superficial fascia is dense. Hence, in these places the skin is firmly bounded to the underlying deep fascia. In other parts of the body, the superficial fascia is loose and elastic so that the skin can move freely.

The amount of fat in the superficial fascia varies. It is scanty in the nipple and areola of the breast and absent in some parts of the external genital organs. The subcutaneous fat is responsible for the rounded contours of the body and differs in its distribution in males and females. The superficial fascia contains the cutaneous blood vessels, lymphatics, and nerves.

At this stage, it is pertinent to understand how to differentiate between arteries, veins, and nerves. To accomplish this task, students should know the relationship of these structures to each other. It is well said, "*Your eyes see the things that your mind knows*." Therefore, students are advised to go through the text to learn about the relationship between arteries, veins, and nerves.

Blood Vessels

The blood vessels comprise arteries and veins (**Fig. 4**). The arteries convey blood (oxygenated) from the heart to the tissues under high pressure. The arteries can be categorized as follows: (a) *Large* or *elastic arteries*, for example, the aorta, resist high internal pressure and their elastic recoil smoothens the intermittent systolic pumping action of the heart producing a continuous flow of blood. (b) The medium-sized arteries are also called *muscular or distributing arteries*. Their lumen is controlled by the sympathetic nerves, which determines the volume of blood to be distributed through them. (c) As the arteries branch and rebranch into finer vessels, the muscular tissue increases and the elastic elements reduce. The smallest among them, having diameter of less than 0.1 mm, are called *arterioles*. They then end up into capillaries.

The arteries during dissection look wiggly and maintain more or less circular shape.

Anastomosis found in many tissues form tubular loops through which some smaller arteries unite with each other. The anastomoses are found around joints, for example, the cubital anastomosis around the elbow joint. Anastomosis also occurs at the base of the brain, in the gastrointestinal tract, and at other sites. The importance of anastomosis is that it maintains the circulation when *one of the arteries is blocked*. Under these circumstances, the anastomosing channels enlarge to a considerable extent to establish *collateral circulation*. In some tissues, the extent of anastomosis between the adjacent arteries is scanty and hence blockage of such an artery results in death of the tissue supplied by it. Such arteries are called *end arteries*. This situation occurs in the brain, eyes, kidneys, lungs, etc.

Capillaries: The arterioles discharge blood through the microscopic tubes called *capillaries* into the tributaries of the veins. The capillary has a single layer of flat endothelial cells forming its wall. Through this thin wall, substances can be exchanged between the blood and tissues.

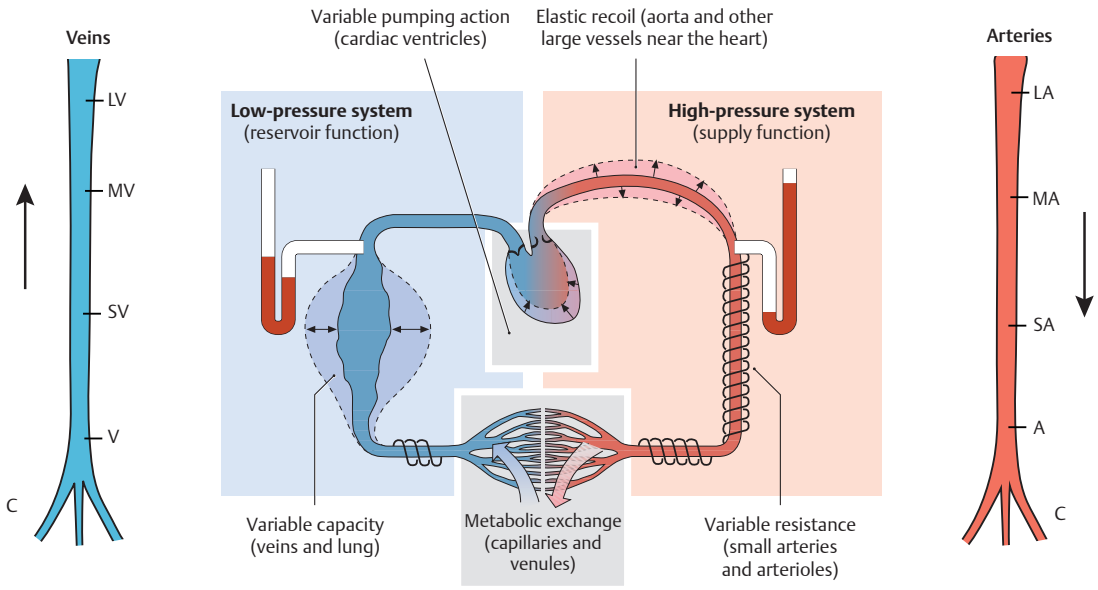

Fig. 4 Basic functional diagram of the circulatory system (no distinction is made between the systemic and pulmonary systems in the diagram). A, arteriole; C, arterial end of capillaries; LA, large artery; LV, large vein; MA, medium-sized artery; MV, medium-sized vein; SA, small artery; SV, small vein; V, venule. (From: Schuenke M, Schulte E, Schumacher U. THIEME Atlas of Anatomy. General Anatomy and Musculoskeletal System. Illustrations by Voll M and Wesker K. © Thieme 2020.)

Arteriovenous anastomosis: In this, the capillaries do not exist and there is direct communication between the smaller arteries and veins. Such anastomoses exist in many exposed parts of the body, for example, the skin. A considerable amount of blood flows when this anastomosis opens. The increased blood flow permits greater transfer of heat without raising the metabolic rate of the tissue. This promotes heat loss from the skin.

Veins: The blood delivered to the tissue/organ through the arteries and capillaries is collected by the veins. The flow of blood in the veins is sluggish. This is because in each inspiration, there is a fall in intrathoracic pressure helping to draw air as well as venous blood into thorax and compression of veins by the surrounding muscles. Even a light compression can retard the blood flow in the veins because of low pressure within them. However, to prevent the backward flow of blood, veins are provided with *valves*. The position of these valves can be observed in the superficial veins of the forearm as localized swellings when the veins are distended with blood by compression at the elbow.

Venae comitantes: This refers to the veins that accompany deep arteries. This helps in maintaining the temperature of the venous blood as it returns to the heart. The surrounding muscles serve as pumps to direct the flow of blood through the veins. Once these deep veins are emptied by muscular contraction, they get filled again by the communications (perforators) between deep and superficial veins. The veins in cadavers tend to be collapsed/flattened.

Lymphatics and Lymph Nodes

Lymph nodes are small bean-shaped structures which are usually less than 12 mm across, that is, equal to size of a pea or baked bean. They are firm gland-like structures serving as filters for the *lymph*. Lymph is a clear fluid that flows through the lymph vessels. Lymphatics/Lymph vessels are fine tubes (**Fig. 5**). They are more in number in tissues closer to the epithelial surfaces, for example, the skin, the lining of the gastrointestinal tract, and respiratory epithelium. They are absent in the central nervous system. Lymph passes into the tissue through the capillary walls. It provides a medium of exchange of

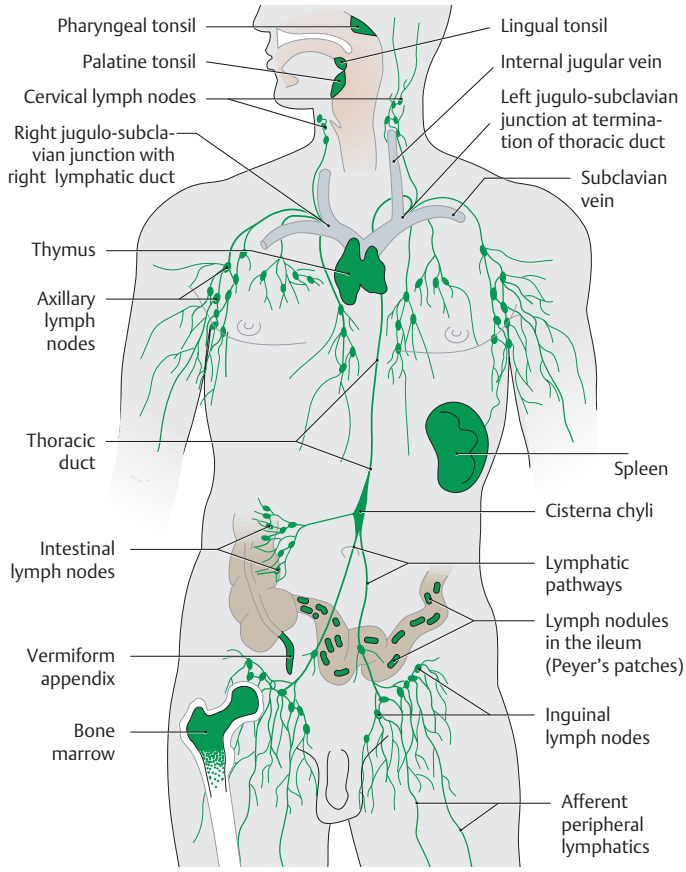

Fig. 5 Lymphatic system (lymphatics and lymph nodes). (From: Schuenke M, Schulte E, Schumacher U. THIEME Atlas of Anatomy. General Anatomy and Musculoskeletal System. Illustrations by Voll M and Wesker K. © Thieme 2020.)

substances between the blood and tissues. It is drained by the lymph vessels. More lymph is produced in the active tissues and the inflamed tissues. In fact, the lymph capillaries collect lymph from the tissues and form plexus. They unite to form larger lymph vessels. The larger lymph vessels carry lymph to the lymph node. They are called *afferent vessels*. From the hilum of the lymph node, an efferent vessel carries it further. Lymph nodes vary in size. They produce lymphocytes. They are enlarged and become palpable when inflammation occurs in the areas/tissues they drain or when a tumor growth occurs in the tissue. They are particularly large in the groin and axilla. They are often associated with veins. They decrease in size in old age. Though the lymph vessels cannot be traced in cadaveric dissection except the largest one, that is, the *thoracic duct*, they are clinically important as they permit spread of infection or cancerous growth (tumors). In *infection*, the regional nodes are enlarged and become tender. In *tumor*/*cancerous* growth, the regional nodes become stony hard. Thus, they provide important information to the clinician about the disease process.

Nerves

The nerve cell along with its processes is called *neuron*. The cell body is called *soma*, the short processes are *dendrites*, and a single long process is called *axon*.

Nerves are pale-looking cords comprising a large number of thin filaments called *nerve fibers*. The nerve fiber is a process (axon) of the nerve cell (neuron) that carries nerve impulses away from nerve cell body to another neuron or with muscle or gland (**Fig. 6**). Each nerve fiber is surrounded by the *endoneurium*, a fibrous sheath. A collection of these fibers forms a fascicle/bundle which is