

ATLAS OF ANATOMY

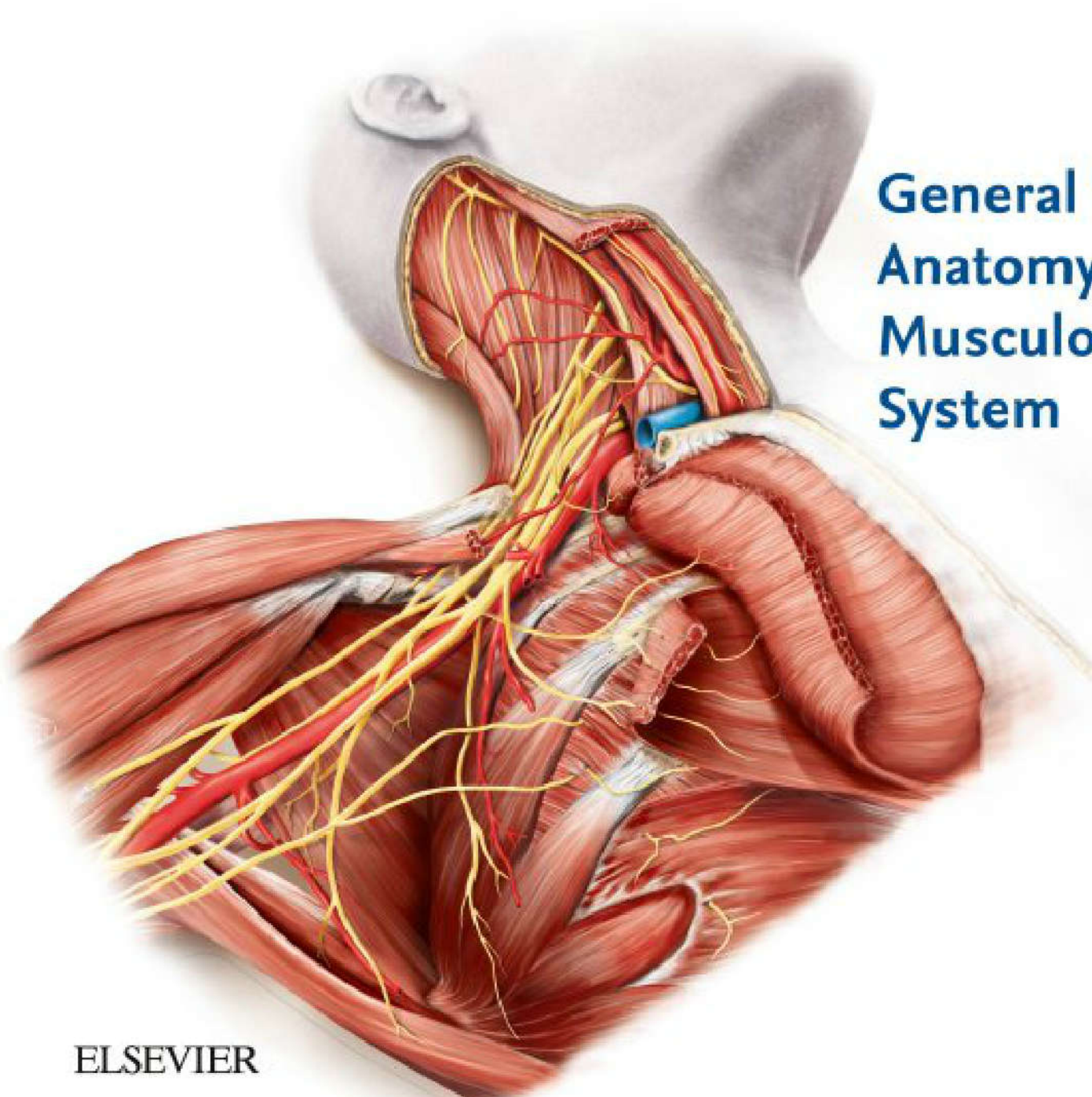
# Sobotta

16<sup>th</sup> Edition

Edited by  
Friedrich Paulsen and  
Jens Waschke

English Version with  
Latin Nomenclature

**General  
Anatomy and  
Musculoskeletal  
System**



ELSEVIER



F. Paulsen, J. Waschke

# Sobotta

Atlas of Anatomy



Friedrich Paulsen, Jens Waschke (Eds.)

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**General Anatomy  
and Musculoskeletal System**

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## ELSEVIER

Hackerbrücke 6, 80335 Munich, Germany  
All business correspondence should be made with:  
books.cs.muc@elsevier.com

Original Publication  
Sobotta Atlas der Anatomie  
© Elsevier GmbH, 2017.  
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ISBN 978-3-437-44021-2

This translation of Sobotta Atlas der Anatomie, 24<sup>th</sup> edition by Friedrich Paulsen and Jens Waschke was undertaken by Elsevier GmbH.

ISBN 978-0-7020-5269-9

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Bibliographic information published by the Deutsche Nationalbibliothek  
The Deutsche Nationalbibliothek lists this publication in the Deutschen Nationalbibliografie; detailed bibliographic data is available on the Internet at <http://www.d-nb.de/>.

18 19 20 21 22

5 4 3 2 1

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Content Strategist: Dr Konstanze Knies, Susanne Szczepanek  
Content Project Management: Dr Andrea Beilmann, Sibylle Hartl  
Translation: Lingo24 Ltd., Edinburgh, United Kingdom  
Production Management: Dr Andrea Beilmann, Sibylle Hartl  
Layout: Nicola Kerber, Olching, Germany  
Composed by: abavo GmbH, Buchloe, Germany  
Printed and bound by: Drukarnia Dimograf Sp. z o. o., Bielsko-Biała, Poland  
Cover Design: Stefan Hilden, hilden\_design, München, Germany;  
SpieszDesign, Neu-Ulm, Germany

More information at [www.elsevier.de](http://www.elsevier.de)

This atlas was founded by Johannes Sobotta †, former Professor of Anatomy and Director of the Anatomical Institute of the University in Bonn, Germany.

### German Editions:

1<sup>st</sup> Edition: 1904–1907 J. F. Lehmanns Verlag, Munich, Germany  
2<sup>nd</sup>–11<sup>th</sup> Edition: 1913–1944 J. F. Lehmanns Verlag, Munich, Germany  
12<sup>th</sup> Edition: 1948 and following editions  
Urban & Schwarzenberg, Munich, Germany  
13<sup>th</sup> Edition: 1953, ed. H. Becher  
14<sup>th</sup> Edition: 1956, ed. H. Becher  
15<sup>th</sup> Edition: 1957, ed. H. Becher  
16<sup>th</sup> Edition: 1967, ed. H. Becher  
17<sup>th</sup> Edition: 1972, eds. H. Ferner and J. Staubesand  
18<sup>th</sup> Edition: 1982, eds. H. Ferner and J. Staubesand  
19<sup>th</sup> Edition: 1988, ed. J. Staubesand  
20<sup>th</sup> Edition: 1993, eds. R. Putz and R. Pabst, Urban & Schwarzenberg, Munich, Germany  
21<sup>st</sup> Edition: 2000, eds. R. Putz and R. Pabst, Urban & Fischer, Munich, Germany  
22<sup>nd</sup> Edition: 2006, eds. R. Putz and R. Pabst, Urban & Fischer, Munich, Germany  
23<sup>rd</sup> Edition: 2010, eds. F. Paulsen and J. Waschke, Urban & Fischer, Elsevier, Munich, Germany  
24<sup>th</sup> Edition: 2017, eds. F. Paulsen and J. Waschke, Elsevier, Munich, Germany

### Foreign Editions:

Arabic  
Chinese  
Croatian  
Czech  
English (nomenclature in English or Latin)  
French  
Greek  
Hungarian  
Indonesian  
Italian  
Japanese  
Korean  
Polish  
Portuguese  
Russian  
Spanish  
Turkish  
Ukrainian



## Prof. Friedrich Paulsen

### Dissection course for students

In his teaching, Friedrich Paulsen puts great emphasis on ensuring that the students in his dissection classes can actually work on body donation cadavers. *'Carrying out dissection yourself is not only extremely important for gaining a three-dimensional understanding of anatomy, forming the fundamental basis of virtually any field of medical science. In dissection classes you will also experience for the first time the touch and feeling of the human body, the organs and individual tissues, but in most cases it will also be your first intensive encounter with issues around death and dying, and the clinical causes of death. You will not only study anatomy, but also learn how to deal with a quite unique and challenging situation as part of a team. Never again will you be in such close contact with your fellow students and teaching staff.'*

Friedrich Paulsen was born in Kiel in 1965 and, after completing his 'Abitur' in Brunswick, he initially trained as a nurse. He then studied medicine at the Christian Albrecht University (CAU) in Kiel. After his house officer training at the Oromaxillofacial Surgery Clinic and a period as resident physician at the ENT Clinic of CAU, in 1998 he moved to the Anatomical Institute of CAU where he graduated as medical doctor in 1997 and further qualified by performing his State doctorate in anatomy in 2001. In 2003 he was offered full professorship at the Anatomy Departments of the Ludwig Maximilians University (LMU) in Munich and the Martin Luther University (MLU) in Halle/Wittenberg. In Halle, he founded a clinical anatomy training centre. After declining yet another professorship, this time at the University of Saarland, he accepted a post at the Friedrich Alexander University (FAU) in Nürnberg as Professor of Anatomy and Head of its Anatomical Institute, a post he has held since 2010. He has continued to decline professorships offered by a number of other renowned universities.

Friedrich Paulsen is an honorary member of the Anatomical Society of Great Britain and Ireland as well as Romania and has been granted numerous scientific awards including the Dr Gerhard Mann Sicca research prize, the Sicca research prize of the German Federation of Ophthalmologists, and the Commemorative Medal of the Comenius University in Bratislava. Additionally, he received several teaching awards.

The key focus of his research is on the innate immune response of the eye surface, and on investigating the causes of dry eyes. Visiting research fellowships have taken him to Spain and the United Kingdom. He is the editor of the journal *Annals of Anatomy* and, as vice-president of Learning and Teaching (until 3/2018), and now People (since 4/2018) also a member of the FAU university administration since 2016.

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## Prof. Jens Waschke

### Making courses more clinically relevant

For Jens Waschke, one of the most important challenges in the teaching of modern anatomy is how to optimally adapt the courses to meet the requirements of clinical training and subsequent professional practice.

*'The clinical aspects of the Atlas give students in the first semesters of medical school a grounding in anatomy and at the same time show them the importance of having a thorough understanding of human anatomy for their subsequent clinical practice, instead of just learning anatomical structures by rote. On the other hand, we prefer to avoid covering highly specialised details that are only needed by a few specialists for occasional diagnostic procedures or surgery, as is the case in other contemporary anatomy books. Since students at the beginning of their training are unable to distinguish between the necessary basics and specialised details, this can cause a mental overload and prevent them from focusing on the essentials.'*

Jens Waschke (born in 1974 in Bayreuth) studied medicine at the University of Würzburg, achieving a doctorate in anatomy under Prof. Detlev Drenckhahn in the year 2000. After his internship training in the Anatomy and Internal Medicine Departments, he qualified as a professor of anatomy and cell biology in 2007. Jens Waschke spent nine months as a visiting scholar at the Davis campus of the University of California under Prof. Fitz-Roy Curry in 2003–2004. From 2008 onward he chaired the newly established Department III of the University of Würzburg before being appointed professor at the Ludwig Maximilians University in Munich, where he has been the head of Department I (Vegetative Anatomy) of the Anatomical Institute since 2011. Jens Waschke is heavily involved in the German Anatomical Society as an examiner in specialist anatomy and a member of its Study Commission, and he heads their working group on reducing formaldehyde exposure. He is a representative of the IFAA (International Federation of Associations of Anatomists) and an honorary member of the Anatomical Society of Ethiopia (ASE). In his research he primarily investigates the biological mechanisms regulating cell adhesion and the external and internal barrier functions of the human body. His research predominantly focuses on the regulation of the endothelial barrier during inflammation, and also the mechanisms behind the impaired cell adhesion seen in diseases such as the blistering skin disorder pemphigus, Crohn's disease and arrhythmogenic cardiomyopathy. The aim is to better understand cell adhesion and to discover new treatment approaches.

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## Preface of the 24<sup>th</sup> German Edition

In the preface of the first edition of his atlas in May 1904, Johannes Sobotta writes: 'Long-standing experience in cadaver dissection classes has prompted the author to ensure that the illustrations of the peripheral nervous system and the blood vessels depict the relevant structures in the same way that the student is accustomed to seeing them on the cadaver, i.e. that they depict the vessels and nerves from the same region together. Furthermore, the atlas alternates between pages of text and full-page diagrams. The latter contain the key illustrations in the atlas, while the former – in addition to sketches and schematic drawings and legends – contain a brief, concise text to help the student find information quickly when using the book in the dissection hall.'

Just as fashions change on a regular basis, so do students' reading and studying habits. The ubiquitousness of multi-media and the ready availability of information and stimuli are surely the main reasons why these habits are changing at a much faster rate than ever before. Publishers and publishing houses must stay abreast of these developments and of students' changing expectations regarding atlases and textbooks they wish to use, as well as ensuring the digital availability of the contents. In addition to interviews with students and systematic surveys, a publisher can sometimes gauge students' expectations from the textbook market itself. Detailed textbooks claiming to be completely comprehensive are increasingly being abandoned in favour of textbooks that didactically meet students' educational needs and cover the contents of their courses and exams – whether they are studying medicine, dentistry or biomedical science. Likewise, although the images in atlases such as Sobotta have fascinated many generations of doctors and medical professionals around the world with their precise naturalistic representations of real dissections, they are sometimes perceived by students as being too complicated and too detailed. This realisation requires us to consider how we can build upon the obvious strengths of an atlas – which in the course of over 100 years of tradition and 23 German editions, has become a benchmark of accuracy and quality – to meet modern didactic concepts without the overall work losing its unique, exclusive characteristic and its originality.

For educational reasons, we have maintained the Sobotta's original concept and chosen to publish the atlas, as it has been since the first edition, in three volumes: General Anatomy and Musculoskeletal System (1); Internal Organs (2); and Head, Neck and Neuroanatomy (3). And while the concept mentioned in the preface of the first edition, i.e. linking the pictures in the Atlas with an explanatory text, may be old-fashioned, it

has now come back into fashion – we have simply modernised the concept. Each picture is thus completed with a short explanatory text to introduce the students to the structure depicted and to explain why those particular dissection and depiction methods have been chosen for that particular region. The individual chapters have been systematically structured to follow today's methods of studying, while various illustrations have been updated or replaced. The majority of these new illustrations have been designed from the point of view of the learner, to make it easier to study the key pathways of blood supply and innervation. We have furthermore revised numerous existing illustrations and reduced the number of labels, using bold type to facilitate access to the anatomical content. The numerous clinical practice examples ('Clinical Remarks') show the somewhat 'dry' subject of anatomy at its most vibrant best, demonstrating to beginners how relevant anatomy is for their subsequent professional life and giving them a tantalising taste of their clinical training to come. Another revised feature is the introductory preface to the individual chapters, which sum up the content and the key issues, and include a real-life clinical case. In addition, each chapter ends with a summary of questions which would typically be asked in oral anatomy exams and exam tests. As in the 23<sup>rd</sup> edition, each chapter contains a brief introduction to the embryology of each body region.

Readers should please note two things:

1. The 24<sup>th</sup> edition of the Sobotta Atlas cannot replace an explanatory textbook.
2. No matter how good an educational concept is, students still have to put in many hours of intensive studying themselves – a good concept can but make that knowledge more accessible. Learning anatomy is not difficult, but it does take a lot of time; time that is well spent, since everybody – doctor and patient – will benefit from it in the long run. The aim of the 24<sup>th</sup> edition of the Sobotta Atlas is not only to facilitate your study, but also to make the time you spend studying engaging and interesting, so that the atlas is something you will repeatedly want to pick up and consult, both during your medical training and your subsequent professional career.

Erlangen and Munich, summer of 2017,  
exactly 113 years after the first edition was published

*Friedrich Paulsen and Jens Waschke*



## Acknowledgements of the 24<sup>th</sup> German Edition

The work on the 24<sup>th</sup> edition of the Sobotta Atlas has once again been a lot of fun, and this intensive involvement has continued to strengthen our sense of pride in the Sobotta.

Today, more than ever, an extensive anatomy atlas of the calibre of the Sobotta requires a lot of teamwork with the coordination of the publishing house. The cornerstone of the 24<sup>th</sup> edition has been laid by Dr Katja Weimann, who extensively coordinated the project. We are very grateful for her hard work. Also, without the long-standing experience of Dr Andrea Beilmann, who has worked on several previous editions of the Sobotta and has been a true pillar of strength for the Sobotta team, many things would not have been possible. We would like to thank her again most profusely for all her help and support. Benjamin Rempe, another member of the four-person team behind the 24<sup>th</sup> edition of the Sobotta, has contributed to Sobotta for the first time, approaching the task with real passion and enthusiasm. His unique way of motivating the team served as a continual source of encouragement and motivation for the editors. Benjamin: thank you very much. We fondly recall the monthly conference calls in which Benjamin Rempe and Dr Andrea Beilmann helped us carefully craft the Sobotta Atlas and, despite their different approaches, showing a remarkable gift for intuitively adopting a uniform working style. Sibylle Hartl coordinated the project in collaboration with Dr Andrea Beilmann and was responsible for the entire print production. We are truly grateful to her. Without the tenacity and the protective hand of Dr Dorothea Hennessen and Rainer Simader, who were both in charge of the overall management of the 'Sobotta 24<sup>th</sup> edition' project and who never lost faith in their Sobotta team or the tight schedule, this edition in its present form would not have been possible. Others whom we are similarly grateful to for their involvement in the project and their share of its success are: Dr Antje Kronenberg (editing), the abavo GmbH team (technical image processing and typesetting) and Nicola Kerber (layout design). We would very much like to thank Dr Ursula Osterkamp-Baust for exhaustively compiling the index.

Special thanks to our team of illustrators Dr Katja Dalkowski, Marie Davidis, Johannes Habla, Anne-Kathrin Hermanns, Martin Hoffmann, Sonja Klebe, Jörg Mair and Stephan Winkler, who in addition to updating the existing images also helped us develop a large number of new illustrations.

For their help in producing the clinical images, we would also like to thank Dr Frank Berger, Institute of Clinical Radiology of Ludwig Maximilians University, Munich; Prof. Christopher Bohr, Phoniatrics and Paediatric Audiology, ENT Clinic at Friedrich Alexander University, Erlangen/Nürnberg; Dr Eva Louise Bramann, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Prof. Andreas Dietz, Director of the ENT Clinic and Outpatients' Clinic at the University of Leipzig; Prof. Gerd Geerling, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Dr Berit Jordan, University Clinic and Outpatients' Clinic for Neurology, Martin Luther University, Halle/Wittenberg; Dr Axel Kleespies, Surgical Clinic, Ludwig Maximilians University, Munich; Prof. Norbert Kleinsasser, University Clinic for Illnesses of the Ear, Nose and Throat, Julius Maximilians University, Würzburg; Dr Hannes Kutta, ENT practice, Hamburg-Altona/Ottensen; Dr Christian Markus, Anaesthesiology Clinic, Julius Maximilians University, Würzburg; Jörg Pekarsky, Institute for Anatomy II, Friedrich Alexander University, Erlangen/Nürnberg; Dr Dietrich Stövesandt, Clinic for Diagnostic Radiology, Martin Luther University, Halle/Wittenberg; Prof. Jens Werner, Surgical Clinic, Ludwig Maximilians University, Munich; Dr Tobias Wicklein, Erlangen, and Prof. Stephan Zierz, Director of the University Clinic and Outpatients' Clinic for Neurology, Martin Luther University Halle/Wittenberg.

Last but not least, we would like to thank our families, who not only were very gracious and understanding of all the time we devoted to the 24<sup>th</sup> edition of the Sobotta, but who also gave us very helpful suggestions whenever we needed feedback. You have been a true support.

Erlangen and Munich, summer of 2017  
*Friedrich Paulsen and Jens Waschke*

# 1. List of Abbreviations

## Singular:

A. = Arteria  
 Lig. = Ligamentum  
 M. = Musculus  
 N. = Nervus  
 Proc. = Processus  
 R. = Ramus  
 V. = Vena  
 Var. = Variation

## Plural:

Aa. = Arteriae  
 Ligg. = Ligamenta  
 Mm. = Musculi  
 Nn. = Nervi  
 Procc. = Processus  
 Rr. = Rami  
 Vv. = Venae

♀ = female  
 ♂ = male

### Percentages:

In the light of the large variation in individual body measurements, the percentages indicating size should only be taken as approximate values.

# 2. General Terms of Direction and Position

The following terms indicate the position of organs and parts of the body in relation to each other, irrespective of the position of the body (e.g. supine or upright) or direction and position of the limbs. These terms are relevant not only for human anatomy but also for clinical medicine and comparative anatomy.

## General terms

*anterior – posterior* = in front – behind (e.g. Arteriae tibiales anterior et posterior)

*ventralis – dorsalis* = towards the belly – towards the back

*superior – inferior* = above – below (e.g. Conchae nasales superior et inferior)

*cranialis – caudalis* = towards the head – towards the tail

*dexter – sinister* = right – left (e.g. Arteriae iliacaes communes dextra et sinistra)

*internus – externus* = internal – external

*superficialis – profundus* = superficial – deep (e.g. Musculi flexores digitorum superficialis et profundus)

*medius, intermedius* = located between two other structures (e.g. the Concha nasalis media is located between the Conchae nasales superior and inferior)

*medianus* = located in the midline (Fissura mediana anterior of the spinal cord). The median plane is a sagittal plane which divides the body into right and left halves.

*medialis – lateralis* = located near to the midline – located away from the midline of the body (e.g. Fossae inguinales medialis et lateralis)

*frontalis* = located in a frontal plane, but also towards the front (e.g. Processus frontalis of the maxilla)

*longitudinalis* = parallel to the longitudinal axis (e.g. Musculus longitudinalis superior of the tongue)

*sagittalis* = located in a sagittal plane

*transversalis* = located in a transverse plane

*transversus* = transverse direction (e.g. Processus transversus of a thoracic vertebra)

## Terms of direction and position for the limbs

*proximalis – distalis* = located towards or away from the attached end of a limb or the origin of a structure (e.g. Articulationes radioulnares proximalis et distalis)

for the upper limb:

*radialis – ulnaris* = on the radial side – on the ulnar side (e.g. Arteriae radialis et ulnaris)

for the hand:

*palmaris – dorsalis* = towards the palm of the hand – towards the back of the hand (e.g. Aponeurosis palmaris, Musculus interosseus dorsalis)

for the lower limb:

*tibialis – fibularis* = on the tibial side – on the fibular side (e.g. Arteria tibialis anterior)

for the foot:

*plantaris – dorsalis* = towards the sole of the foot – towards the back of the foot (e.g. Arteriae plantares lateralis et medialis, Arteria dorsalis pedis)















# 3. Use of Brackets

[ ]: Latin terms in square brackets refer to alternative terms as given in the Terminologia Anatomica (1998), e.g. Ren [Nephros]. To keep the legends short, only those alternative terms have been added that differ in the root of the word and are necessary to understand clinical terms, e.g. nephrology. They are primarily used in figures in which the particular organ or structure plays a central role.




( ): Round brackets are used in different ways:

- for terms also listed in round brackets in the Terminologia Anatomica, e.g. (M. psoas minor)
- for terms not included in the official nomenclature but which the editors consider important and clinically relevant, e.g. (Crista zygomaticoalveolaris)
- to indicate the origin of a given structure, e.g. R. spinalis (A. vertebralis).

# Colour Chart

	Concha nasalis inferior		Os occipitale
	Mandibula		Os palatinum
	Maxilla		Os parietale
	Os ethmoidale		Os sphenoidale
	Os frontale		Os temporale
	Os lacrimale		Os zygomaticum
	Os nasale		Vomer

In the newborn the following cranial bones are indicated by only one colour:

	Os nasale, Os temporale, Mandibula
	Maxilla, Os incisivum
	Os occipitale, Os palatinum

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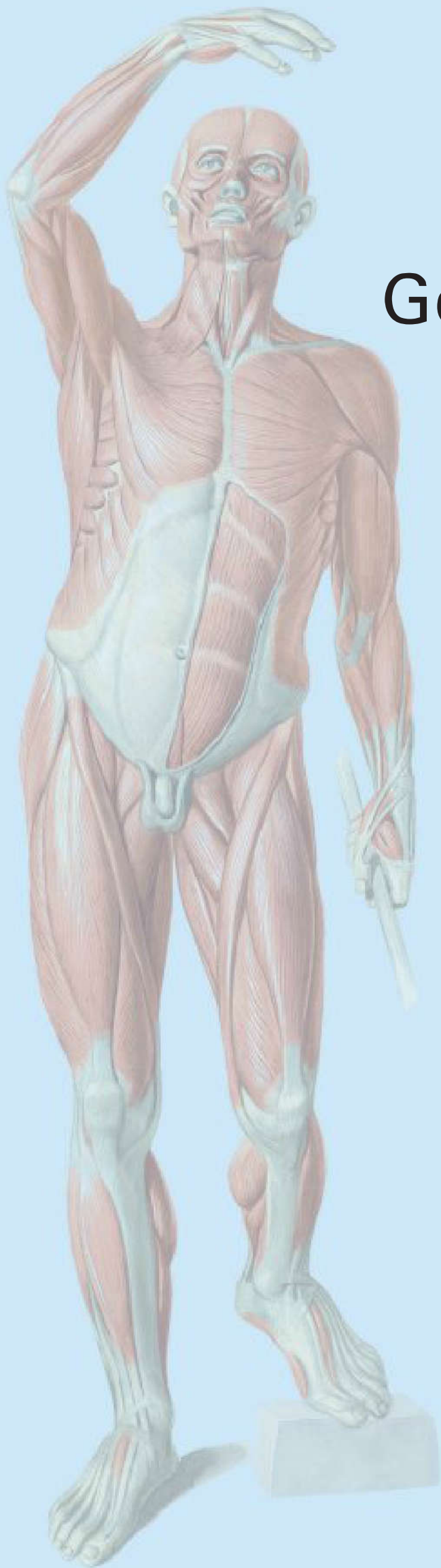
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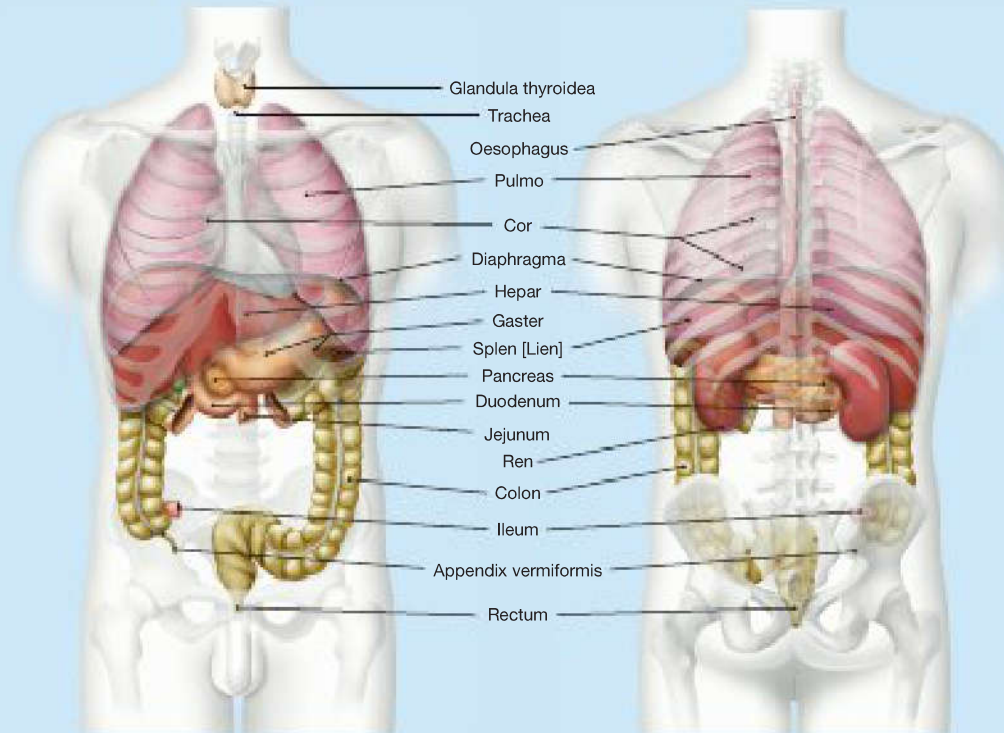




# General Anatomy

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1



## Overview

The Greek word 'ἀνατεμνείν' (**anatemnein**) means 'cut open'. It describes the oldest method in anatomy, which was already practised in ancient times. Anatomy is the study of the structure of the healthy body. Without the knowledge of anatomy, no functions can be derived and without the knowledge of structure and function, no pathological changes can be understood. In order to learn a new language, there needs to be a foundation of vocabulary and grammatical knowledge. The same is true of anatomy. In order to be able to learn the subject, you need principles and functional knowledge which will be of **central importance** throughout your

medical studies. Not only do levels, axes and orientation lines on the body, descriptions and possibilities of movement play a role in clinical practice, but also knowledge of the musculoskeletal system, including biomechanical processes, the location of internal organs and their projection onto the body surface, the circulatory systems of the body and the structure of the nervous system. They form the **basis** for any diagnostic (especially imaging techniques such as X-ray, ultrasound, scintigraphy, computed tomography, magnetic resonance imaging) and therapeutic measures.

## Main Topics

*After studying this chapter, you should be able to:*

- orientate yourself on the human body, divide the body into different sections and describe its blueprint, know the main axes and levels, describe movement directions and know directional terms, the position of the parts of the body and general terms of anatomy;
- divide the body surface into regions and describe the projection of inner organs onto the body surface;
- explain principles of embryonic development, starting with fertilisation;
- know principles of the musculoskeletal system, such as the classification of bones, construction of a tubular bone, names of bones of the skeleton, structure of a joint, joint types, terminology of joint motion and auxiliary structures of joints (intervertebral joints, labra, bursae, ligaments);
- explain basic concepts of general muscle theory, such as the structure of a skeletal muscle, muscle types, tendon attachment sites, auxiliary muscles and tendons, and describe principles of muscle mechanics;
- describe the various circulatory systems, such as systemic circulation, including the heart and major arteries and veins, pulmonary circulation, organisation of the prenatal cardiovascular system, portal vein circulation and lymphatic vessel system (lymph circulation) with lymph nodes;
- understand the nervous system (structure, somatic and autonomous nervous system) and know the dermatomes on the body surface;
- describe principles of diagnostic imaging techniques such as conventional X-ray, sonography (ultrasound), computed tomography, magnetic resonance imaging, scintigraphy;
- describe the structure of the skin and its appendages.

# Clinical Relevance

In order not to lose reference to future everyday clinical life with so many anatomical details, the following describes a typical case that shows why the content of this chapter is so important.

## An Open Ductus Arteriosus (BOTALLI) (PDA)

### Case Study

A premature infant, born in the 34<sup>th</sup> week of pregnancy plus two days (34+2 NNW) develops shortly after birth (4<sup>th</sup> day of life) increased shortness of breath and poor feeding. The girl is very pale and her hands and feet are relatively cold.

### Result of Examination

The on-duty pediatrician at the neonatal station notices on palpation of the abdomen an enlargement of the liver and spleen (hepatosplenomegaly) and auscultation of the heart reveals a loud machine-like murmur (systolic crescendo and diastolic decrescendo murmur) in the 2<sup>nd</sup> intercostal space on the left, which is accompanied by a tactile whirring across the chest. Palpation of the pulse shows a fast pulse with high blood pressure (Pulsus celer et altus). He immediately takes further diagnostic steps.

### Diagnostic Procedure

The electrocardiogram (ECG) shows left-ventricular stress. The chest X-ray indicates an enlarged pulmonary vessel and a left-sided widening of the heart. The completed echocardiography (colour Doppler examination, → Fig. a) shows blood flow between the aorta and pulmonary vessels, enabling the direct imaging of a shunt.

*A shunt is a short circulation connection between normally separate vessels or cavities.*

The diagnosis of a patent Ductus arteriosus (BOTALLI) (PDA) (→ Fig. b) is thus confirmed.

### Diagnosis

An open Ductus arteriosus (BOTALLI).

### Treatment

A drug treatment with the prostaglandin synthesis inhibitor ibuprofen is initiated to close the haemodynamically effective open PDA.

### Further Developments

Although the symptoms improve slightly under treatment, a pronounced systolic heart murmur can still be heard and the PDA is detectable in the colour Doppler examination. For this reason, an interventional closure by means of cardiac catheterisation is introduced the following day by inserting an umbrella system. Shortly after the procedure, the pulse of the girl is already within the normal range, breathing is calm and no heart murmur is detectable. The girl remains for some time on the neonatal ward and progresses well, and can therefore be discharged.

### Dissection Lab

Consider the pressure and flow conditions in the large and small circulation with the heart as the central organ and reflect on how the blood flows in the baby girl with PDA (→ Fig. 1.39).

*Consider which other shunts are obliterated after birth.*

### Back in the Clinic

After birth, the increasing oxygen concentration arising from the lungs unfolding and the first breaths normally cause the ductus arteriosus to contract and close. In premature babies many organs are not yet fully developed. The cause of the persistence of a PDA is therefore attributed to the fact that the vessel muscles here contract less well, as they are less developed, and a relatively high prostaglandin concentration leaves Ductus arteriosus open.

*From pregnancy week 28 women should not take prostaglandin synthesis inhibitors (e.g. ibuprofen) for pain medication, so that the Ductus arteriosus does not close too early.*

After birth, the prostaglandin levels normally drop quickly and the ductus arteriosus closes up spontaneously. Therefore, therapeutic measures with prostaglandin synthesis inhibitors are often successful.

*Right after birth, initial examination of the newborn is carried out in order to determine whether all vital functions, such as the respiratory and cardiovascular systems, are in order.*

In the case of a haemodynamically effective PDA, a left-to-right shunt occurs due to high pressure in the systemic circulation and low pressure in the pulmonary circulation with volume overload on the left side of the heart, so that blood from the aorta flows into the lungs, which causes increased pulmonary blood flow and increased pressure in the pulmonary circulation. Thus a certain part of the blood from the lungs reaching the left ventricle and from there the aorta, circulates through the Patent ductus arteriosus again with the lungs (machine-like murmur). There is a lack of circulating blood in the systemic circulation (cold hands and feet); as a reaction, the heart rate increases (Pulsus celer et altus) in order to transport enough oxygen to the periphery of the body. If the PDA is not treated, the continual increased pressure leads to damage of the vessels in the lungs. These thus react to a remodelling (modification of the vessel structure), whereby the increased pressure is further 'fixed' and may increase so much that it exceeds the pressure of the systemic circulation with the result of a shunt reverse (right-to-left shunt), whereby blood reaches the systemic circulation directly from the pulmonary circulation, without being pre-saturated with oxygen. The result is cyanosis (bluish discolouration of the skin, lips and mucous membranes) and a rapid decrease in capacity. At some point the heart undergoes decompensation.

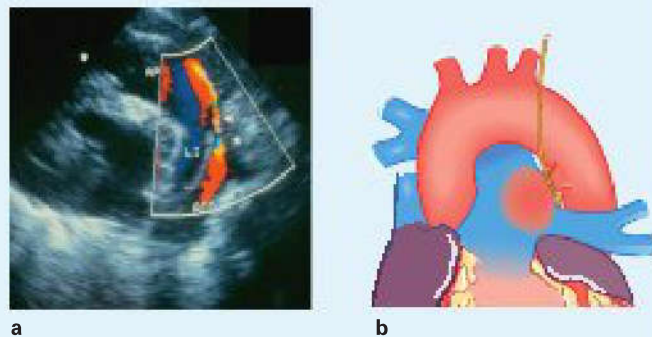


Fig. a A colour Doppler examination. [O548]

Fig. b Patent Ductus arteriosus (BOTALLI). [L126]