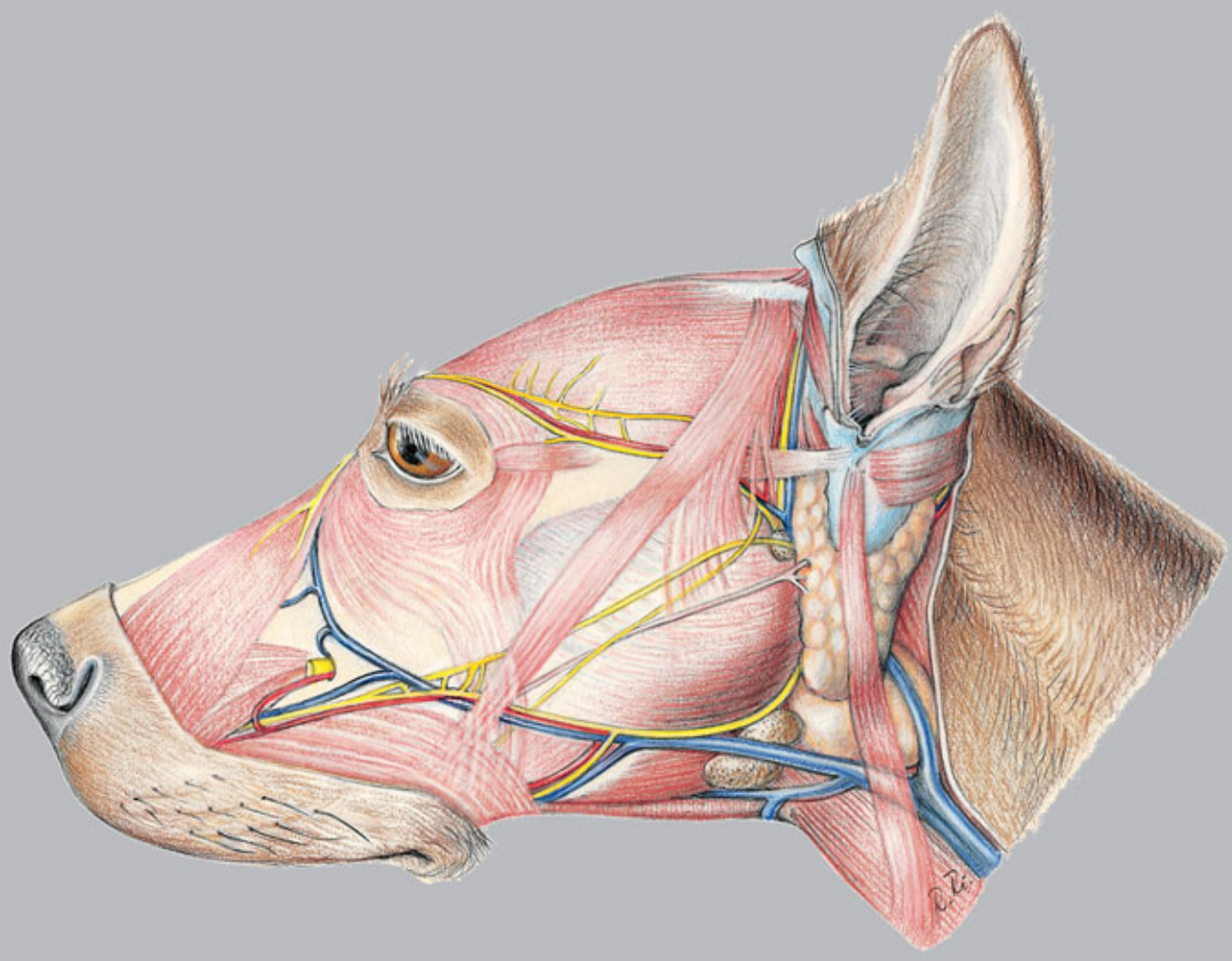
Klaus-Dieter Budras · Patrick H. McCarthy ·
Wolfgang Fricke · Renate Richter

Anatomy of the Dog



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Fifth, revised edition

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Anatomy of the Dog

Fifth, revised Edition

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How to use this book:

The framed introductions at the beginning of the text-pages dealing with topographical anatomy give information with respect to the dissection of the areas shown in the figures. At the same time, they can be used as abbreviated dissection instructions. Boldface terms of anatomical structures serve for emphasis and, insofar as they are identified by numbers, they are represented on the neighboring illustration-page where they are identified by the same number. Numbers on the margin of the text-pages refer to the 'Clinical and Functional Anatomy.' The numbers in the clinical anatomy part refer to the corresponding page in the topographical anatomy; *e.g.*, '8.2' refers to the part numbered '2' on page 8. The anatomical/medical terms and expressions occurring in the text are explained and interpreted in 'Anatomical Terms.' Abbreviations of anatomical terms follow the abbreviations as employed in the Nomina Anatomica Veterinaria (2005). Other abbreviations are explained in the appertaining text, and in the titles and legends for the illustrations. A few abbreviations that are not generally employed are listed here:

The **cranial nerves** *(Nervi craniales)* are designated with roman numerals I – XII.

Spinal nerves *(Nervi spinales)*:
n — Nervus spinalis
nd — Ramus dorsalis n. spinalis
ndl — Ramus dorsolateralis
ndm — Ramus dorsomedialis
nv — Ramus ventralis
nvl — Ramus ventrolateralis
nvm — Ramus ventromedialis
nC — Nervus cervicalis (*e.g.*, nC1 – first cervical nerve)
nCy — Nervus coccygeus s. caudalis
nL — Nervus lumbalis
nS — Nervus sacralis
nT — Nervus thoracicus

Vertebrae
vC — Vertebra cervicalis (*e.g.*, vC3 – third cervical vertebra)
vL — Vertebra lumbalis
vS — Vertebra sacralis
vT — Vertebra thoracica

Preface to the Fifth Edition

The present revised and enlarged edition is published at a time of change, which is characterized by the new appointment of all anatomically oriented chairs in the German-speaking area. The tendency to shorten the time for anatomical education has existed for a longer time, which to a moderate degree seems to be acceptable and unavoidable for the creation of free space for new educational subjects. Because this trend now seems to assume excessive proportions, the danger exists of a partial or even total renunciation of the dissection of the animal body, which since the time of Leonardo da Vinci has been considered a very efficient and essential method of deepening our knowledge. The deficiency in practical exercises cannot be compensated by our offer of anatomical drawings but will mitigate its negative impact. Especially in the initial phase of the curriculum, our realistic figures in the atlas part of our textbook have the indisputable value that they provide the essential basis for understanding much used sketches and schematic representations. Beyond that, as an illustrated guide to dissection, they promote the proper initiative for an independent dissection and contribute by that to the acquisition of a solid knowledge. For dissection and pictorial rendition, the topographical-anatomical procedure offers the enormous advantage that comprehensive subjects can be imparted with brevity in a natural reality. For the practicing veterinarian the topographical plates are suitable for orientation at surgical operations.

The consideration of computed tomography, which thanks to Dr Nöller was integrated into the current eighth edition, has the objective to safeguard an attractive field of activity for anatomy. The imparting of normal structure discoverable by computed tomography and supplemented by the presentation of clinical-functional cases creates a solid basis for the further development and application of imaging procedures in the clinical curriculum and later in the practice of veterinary medicine.

Berlin, in the summer of 2007 The Authors

Preface to the First German Edition (abridged)

The *Atlas of the Anatomy* of the Dog was conceived as a compendium and at the same time as an introduction to the topographical anatomical dissection as well as for teaching. The subject matter of anatomy was prepared from a topographical point of view with separation into systems. To do that, the osteology, myology, angiology, neurology and splanchnology of the different parts of the body were dealt with in sequence in their reciprocal re-lationship to one another and demonstrated by topographical colored plates with complementary schematic diagrams. The methods of presentation emphasize the mutual topographical relationships of the vessels and nerves considered, laying stress on their nomenclatural agreement. In that way, the concern for the multiplicity, the breadth, and the complexity of the material should be minimized. The concept chosen here, with its close relationship of content and apposition of illustration and pertinent description, has the advantage of being able to deal with the essential in the smallest space.

The present book offers to the students a clearly arranged illustrative material and an abbreviated reading supplementing textbook study and classroom material as well as an aid for review, especially for preparation for examinations. For the practising veterinarian, it is drawn up as a source of quick information and to refresh and deepen what was previously learned. The breadth, division and sequence of the subject matter according to the pre-ceding are coordinated with the topographical dissection that is offered to the students at the Free University of Berlin as the teaching program in their first semester of study. Upon the foundation achieved, the subsequent study of comparative and clinically applied anatomy is con-tinued. Topographical anatomy is the foundation and the key to understanding the associated medicine. It is of special value to the surgeon and pathologist.

Professor Fritz Preuss introduced the whole-animal topographical anatomy in Berlin, and his dissection instructions directed the way for teaching up to the dras-tinc shortening and repositioning of the dissection exercises. The successful and exacting method of dissection with the short time available places high demands on the students and requires a multisided support by the instructors. With its true to nature rendition of areas of dissection with accompanying text, the present atlas should serve for this purpose also. Instructions for dissection of the illustrated preparation and guidance to the person carrying out the exercise were placed at the beginning of the described part. Structures to be dissected are specially emphasized in the text by boldface print. To keep the space limitations, anatomical variations are given less attention. The current Nomina Anatomica Veterinaria (HOLZHAUSEN, Vienna 1973) was utilized, which also holds in the main for the applied abbreviations. Moreover, in the written material only vertebrae and nerve branches were abbreviated *(e.g.:* VL 1 for the first lumbar vertebra; nL 1vl for the ventrolateral branch of the first lumbar nerve). In the legends of the figures and the tabular compositions, owing to the limitations of space even more extensive, otherwise uncommon, abbreviations had to be used. Suggestions and wishes of the students, for example with respect to preparing the tables for special myology and for anatomical terms were largely considered.

Dissections from the anatomical collection of the Department of Anatomy, Histology and Embryology (Institute for Veterinary Anatomy, Histology and Embryology) of the Free University of Berlin served as models for the figures. These specimens were prepared by the technical staff of the department, Mr. Seifert, Mr. Dressel, and Mr. Schneider.

Berlin, summer 1983 The Authors

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Introduction to Anatomy

The term anatomy stems from the Greek word, 'anatemnein' which means to dissect, to cut apart. The important anatomist Hyrtl spoke consistently also of the art of dissection. The original meaning is true even today; although the term has gained a wider meaning. Modern anatomy is not limited to mere description but emphasizes the interrelations between form and function as well as the application of anatomical knowledge in the clinic. Then as today the student gains most of his knowledge by dissection of the animal body in the laboratory, where he lays bare the 'naked truth' (Nudas veritas). This practice also serves to obtain a necessary finger-dexterity, which in later professional life, in the first place in surgery, is of immeasurable value. Beyond that there are hardly any limits to investigation by enthusiastic dissection. Even the very best anatomical collection of outstanding demonstration-dissections cannot replace practical work in the laboratory, but can however indeed make it easier and more efficient. The thorough study of anatomical preparations is indispensable like the industrious use of textbooks and atlases. All of these aids are more important today than ever since there is much less time available for practical work in the laboratory than formerly. Shortening the teaching time allotted to anatomy in favor of newer disciplines was unavoidable.

Anatomical study is, unlike any other basic discipline, important in learning the language of medicine, the **terminology**. Many terms for diseases and methods of treatment have their origin in anatomical terms. Centuries-long research and description brought an unforeseen abundance of synonyms. The function of the international nomenclature commission has been to thin out the jungle of terms and to publish a recognized list of official terms with useful synonyms.

In its entirety, anatomy is subdivided into macroscopic (gross) anatomy, microscopic anatomy and developmental anatomy. However, the areas of anatomy flow together without boundary, forming a unit, an understanding constantly and forcefully advocated by the important Berlin veterinary anatomist and, at an earlier time, the professorial chair of our department, Professor Preuss. The oldest and most encompassing area is macroscopic anatomy, often placed equal to the term anatomy. Where the accessories to observation in macroscopic anatomy, the bare eye and the dissection hand lens no longer reach, it passes over into the area of microscopic anatomy (histology and cytology), to which the microscope serves as accessory. The boundary between macroscopic and microscopic anatomy is also called mesoscopy, which is gaining more and more in significance. The latter area deals with the same material and pursues the same goals; it is only the technique that is different. The third area, embryology, is concerned with ontogenesis (development of the individual) before and after birth and, in addition to embryological methods, applies also macroscopic, microscopic and mesoscopic methods.

Like the remaining disciplines, macroscopic anatomy can be presented from different points of view with emphasis on special areas of greater difficulty. In so doing, the basic facts remain of course unchanged.

Systematic, descriptive anatomy describes the animal body with all its parts as systems of structure and organ-systems, strictly divided from one another and therefore without attention to their natural interdependence. Expansive descriptions treat many particulars and allow some-times the view to the important to be missed; nevertheless they are a necessary prerequisite to the remaining, subsequent kinds of observations to which the descriptive anatomy has led.

Systematic anatomy can be subdivided further into general and special anatomy.

General anatomy treats of facts that are generally valid for the entire system of structure or the organ-system.

Special anatomy provides special data for these structure- and organ-systems that hold for individual structures, as for one bone.

Comparative anatomy emphasizes anatomical correlations, similarities and variations between the individual animal species and human beings. Comparisons of anatomy between the individual species are very often informative and helpful for homology and determining the function of anatomical structure. Already Goethe utilized principles of comparative anatomy to good advantage with the discovery of the incisive bone of human beings. This bone occurs regularly in our domestic animals and only occasionally in human beings. With his study of the human skull he encountered a specimen with a developed incisive bone. It was by comparison with the animal skull that he was able to identify the bone and establish its homology.

Topographical anatomy emphasizes the varying position-relationship of anatomical structures and underlines the areas of application for clinical medicine. The relationship of anatomical structures is analyzed step by step and in doing so the whole structural plan of the body is regarded.

Applied anatomy is directed clinically and emphasizes the relationship of anatomical structures from which treatments or diseases of animals can be determined or explained. In that way not only interdisciplinary cooperation and interest for the veterinary profession are promoted but also the learning of anatomy is made easier.

The anatomy of the living dog is undoubtedly a significant part of the whole of anatomy. It presents the body in its natural condition. In that way a significant completion and an adjustment for unavoidable disadvantage becomes imperative in the remaining subjects of the whole of anatomy, which must tolerate postmortem changes such as variations in color, consistency and character as well as artificial changes resulting from fixation. Anatomy of the living dog cannot be given attention here for several reasons. It is adaped even less for rendering in a book, but can be offered to the students better and more successfully in an exercise under the instruction of a clinically experienced anatomist.

Radiographic anatomy and sonography are directly connected to the clinic. In the teaching of anatomy, the first experiences are obtained in analysis of radiographs of the normal animal body. This experience will be utilized and considerably supplemented in the total associated area of study. Presentations of abnormal or even pathological changes should awaken the interest and accordingly add 'spice' to the teaching of anatomy.

The atlas of anatomy presented here is adapted in special measure to significantly combine and coordinate the different methods of presenting anatomy and the manner of viewing it. The textual part can be presented in a very compressed form since the different anatomical circumstances can be 'read off' from time to time from the adjacent color-plate. Beyond that, a good topographical color-plate presents an ideal introduction for topographical dissection, which is then completed only by brief remarks. Also the requisites of comparative veterinary anatomy are taken into account in this atlas insofar as the simply structured (from many points of view) canine body is set out as the 'cornerstone.' Building upon this knowledge, the more complicated (from many points of view) anatomy of the remaining domestic animals can be comprehended from the aspect of comparative anatomy.

Art and anatomy with their mutual interrelations are forcefully impressed on us with each visit to a museum. The artist is inspired by the corporeal beauty, and teachers and students of anatomy enjoy and profit from the talent and painstaking detail in the artistic presentation. Gifted with genius were realized the claims of Leonardo da Vinci, whose abundant anatomical drawings came about after basic studies of anatomy. Aristotle published among other things an anatomical description of senile sexual reversal in the bird as well of the horse hoof in regard to founder. What fascination of anatomy passes over to art, Rembrandt immortalized in his work 'The anatomy lesson of Dr. Nicolaes Tulp.' The greats of world history gifted with genius like Aristotle, Leonardo da Vinci and Goethe show proof of their enthusiasm for anatomy with anatomical illustrations, descriptions and research results. To Goethe's credit was the promotion of educational art and the introduction of plastic wax models in Germany, to which he, himself, was inspired during his journey to Italy, especially in Florence. The good qualities of wax models, which is true to an equal measure for well done true-to-nature illustrations, Goethe expressed in his novel 'Wilhelm Meisters Wanderjahre' with the following excellent formulation: 'If you concede that most physicians and surgeons retain in their minds only a general impression of the dissected human body and believe that to satisfy the purpose; so such models will certainly suffice, which refresh in his mind again little by little pictures that are fading and actively retain for him just the necessary.' His investigative mind held Goethe, who with his discovery of the human incisive bone felt 'unspeakable joy.'

Topographical Anatomy
Chapter 1: Surface of the Body and Axial Skeleton

1. Division of the animal body

a) **Subdivision of the Body**

The longitudinal lines and planes of the body are useful for the orientation of the body and of the body surface. The **dorsal** (**a**) **and ventral midline** (**b**) are the dorsal and ventral median lines of the body, respectively.

The **median plane** (**A**) is the plane between the two lines mentioned above. It divides the body into right and left halves. **Sagittal (paramedian) planes** (**B**) are adjacent planes parallel and lateral to the median plane. They divide the body longitudinally, but into unequal parts. **Transverse planes** (**C**) are planes that divide the body transversely and are perpendicular to the median and sagittal planes. **Dorsal planes** (**D**) lie parallel to the dorsal body surface. They divide the body perpendicular to the longitudinal (median and paramedian planes) and transverse planes. In that view, two symmetrical body sides appear and it is for that reason that dorsal planes are also called bilateral planes.

b) **Terms that Describe the Direction and Topographical Relations of Organs** derive partially from body parts, *e.g.*, in direction toward the tail (**caudal —c**), partially from landmarks of the body surface, *e.g.*, parallel to the median plane (**sagittal —d**) or designate with respect to hollow organs *external* or *internal*. Furthermore terms are used as left *(sinister)* and right *(dexter)*, short *(brevis)* and long *(longus)* or deep *(profundus)* and superficial *(superficialis)*, longitudinal *(longitudinalis)* or transverse *(transversus)* as well as lateral *(lateralis)* and toward the median plane *(medialis)*. The term **cranial** (**e**), in a direction toward the head, cannot be applied in the head region. Here the term **rostral** is used (**f**, in a direction toward the tip of the nose). The term **dorsal** (**g**) relates to the 'back' or *dorsum* of the body. It may also be used with respect to the proximal parts of the limbs; but has a different meaning on the limb extremities. The term **ventral**, in a direction toward the belly *(venter)*, may be used on the proximal parts of the limb, but is not used on the free part of the limbs. The terms **proximal** (**i**, toward the attached end) and **distal** (**m**, toward the free end) are related to the axis of the body (vertebral column and spinal cord with the origin of spinal nerves). On the limbs, from the carpus distally, the term **palmar** (**l**, the surface of the manus that faces caudally in the normal standing attitude) is employed; from the tarsus distally (**m**, the surface of the pes that faces caudally in the normal standing attitude of the animal), the term **plantar**. The term **dorsal** is utilized alike on the thoracic limb from the carpus distally and on the pelvic limb from the tarsus distally. It refers to surface of the manus and pes that is cranial in the normal standing attitude of the animal. Terms like **abaxial** (**n**, away from the axis) and **axial** (**o**, toward the axis) are related to the central axis of the hand (manus) or foot (pes), in which the axis lies between the third and fourth digits. In front (anterior), behind (posterior), above (superior) and below (inferior) are terms often used in human anatomy and refer to the human body in the normal upright attitude. To avoid misunderstanding, these terms are not applied to the quadruped animal body. Their use in veterinary anatomy is restricted to certain areas of the head; *e.g.*, upper and lower eyelids, anterior and posterior surfaces of the eye.

c) **Parts of the Body and Body Regions** subdivide the body, including the surface of the body. Parts of the body are head and trunk with neck, rump, and tail, as well as the limbs. The body regions divide the surface of the body and can be subdivided into subregions. In the latter case, they appear indented in the following table.

Regions of the Body

Regions of the cranium
1 Frontal region
2 Parietal region
3 Occipital region
4 Temporal region
5 Auricular region

Regions of the face
6 Nasal region
6' Dorsal nasal region
6'' Lateral nasal region
6''' Region of the naris
7 Oral region
7' Superior labial region
7'' Inferior labial region
8 Mental region
9 Orbital region
9' upper palpebral
9'' lower palpebral
10 Zygomatic region
11 Infraorbital region
12 Region of the temporomandibular articulation
13 Masseteric region
14 Buccal region
15 Maxillary region
16 Mandibular region
17 Intermandibular region

Regions of the neck
18 Dorsal neck region
19 Lateral neck region
20 Parotid region
21 Pharyngeal region
22 Ventral neck region
22' Laryngeal region
22'' Tracheal region

Regions of the dorsum
23 Thoracic vertebral region
23' Interscapular region
24 Lumbar region

Pectoral regions
25 Presternal region
26 Sternal region
27 Scapular region
28 Costal region
29 Cardiac region

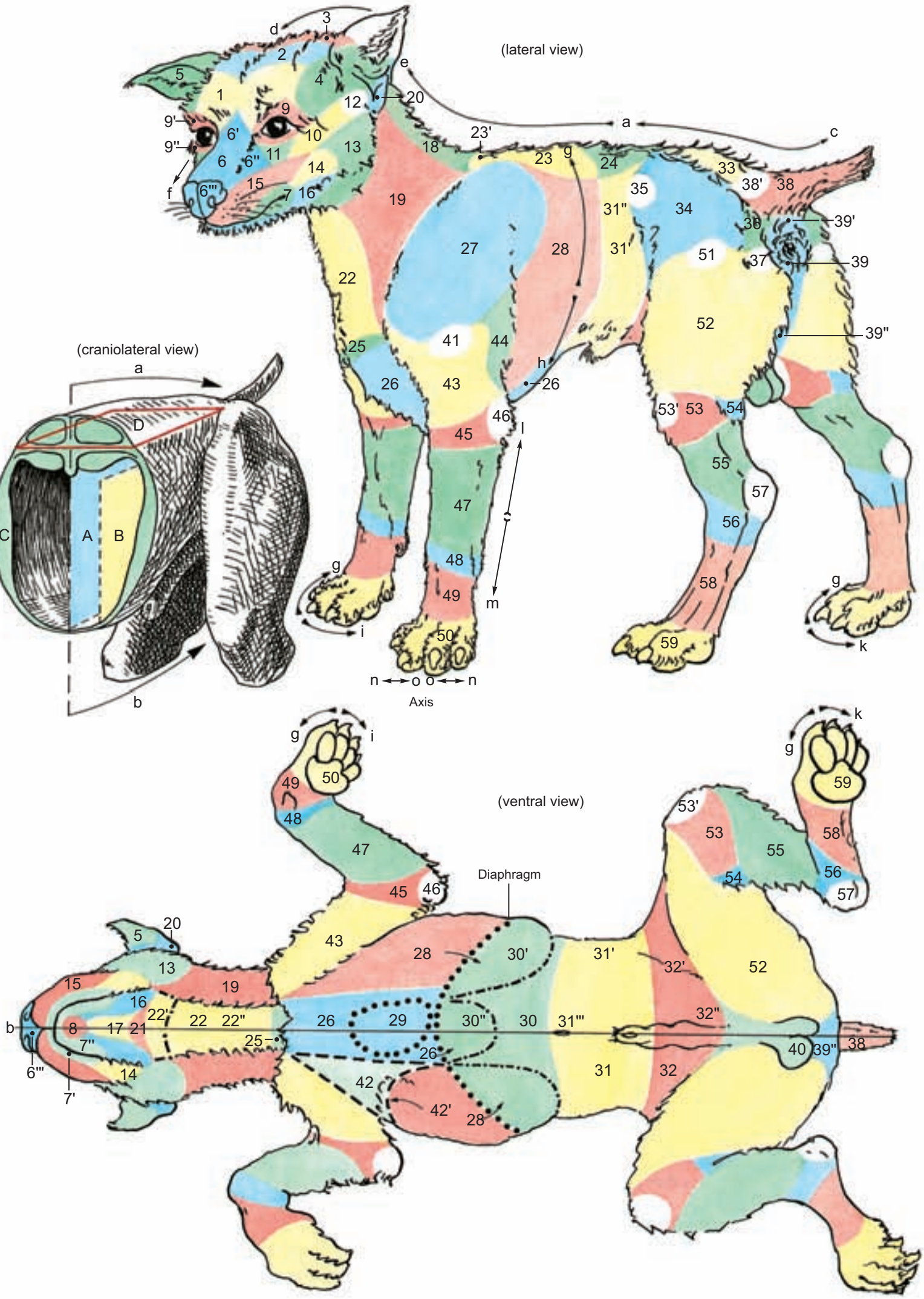
Regions of the abdomen
30 Cranial abdominal region
30' Hypochondriac region
30'' Xiphoid region
31 Middle abdominal region
31' Lateral abdominal region
31'' Paralumbar fossa
31''' Umbilical region
32 Caudal abdominal region
32' Inguinal region
32'' Pubic region and preputial region

Pelvic regions
33 Sacral region
34 Gluteal region
35 Region of the tuber coxae
36 Ischiorectal fossa
37 Region of the tuber ischiadicum
38 Caudal region (tail region)
38' Region of the root of the tail
39 Perineal region
39' Anal region
39'' Urogenital region
40 Scrotal region

Regions of the thoracic limb
41 Region of the humeral joint
42 Axillary region
42' Axillary fossa
43 Brachial region
44 Tricipital region
45 Cubital region
46 Region of the olecranon
47 Antebrachial region
48 Carpal region
49 Metacarpal region
50 Phalangeal region (region of the digits, digital region)

Regions of the pelvic limb
51 Region of the hip joint
52 Region of the thigh
53 Genual region (region of the knee, region of the stifle joint)
53' Patellar region
54 Popliteal region
55 Region of the crus (region of the leg)
56 Tarsal region
57 Calcaneal region
58 Metatarsal region
59 Phalangeal region (region of the digits, digital region)

Body regions and terms of site and direction in relation to parts of the body indicated



2. The Skin (Common Integument)

1 a) The **Skin** forms the external surface of the body and consists of two layers: I. an epithelial layer designated *epidermis* and II. a connective tissue layer designated *dermis* or *corium*. The dermis rests upon an underlying layer of connective tissue, the subcutaneous layer or *subcutis (Tela subcutanea)*. The latter consists of a fatty part, the *panniculus adiposus*, and a supporting fibrous part that, together, constitute the superficial fascia.

I. The **epidermis** (**1**) is made up of a stratified squamous epithelium that is cornified (keratinized) at its surface. Thickness and degree of keratinization depend on the mechanical stress to which this layer is subject. The epidermis is composed of a deep, still living, layer, (**stratum germinativum = basal layer, —27**) which, by mitotic division, furnishes cell replacement, a **spinous layer** (**26**), a cornifying, dying layer (**stratum granulosum, —25**) as well
2 as cornified cell layers, **stratum lucidum** (**24**) and **stratum corneum** (**23**). In addition to the epidermal cells, there are melanocytes, LANGERHANS' cells, and MERKEL'S tactile discs, especially in the stratum germinativum.

'Horn' is cornified epidermis and is of varying quality in the different regions of the body. On the pads and in other regions of the skin there is soft horn. Hard horn is found at the claw. In the skin and at the pads, the cornified cells are shed as scales owing to reduced adhesion of membrane coating materials. At the same time, because of good adhesion as a solid mass, the **horn of the claws** remains restored by distal growth **conical**. The individual horn cell of the claw is distinctly harder than that of the skin. In areas where soft horn is formed, the epidermis exhibits a stratum granulosum between the stratum spinosum and the cornified layers. The stratum granulosum is so-named because of the keratohyalin granules that it contains. The proteins within this layer of cells coat and 'glue' the keratin filaments together. At individual sites additionally a stratum lucidum occurs. It consists of young, not yet differentiated, cornifying cells, the cytoplasm of which appears somewhat transparent when examined under the microscope, hence the name stratum lucidum. In the areas of formation of hard horn, these layers are absent, so that the cells of the stratum spinosum cornify directly without intervening strata granulosum and lucidum.

The **function of the epidermis** consists of the replacement of cornified cells as a protection from radiation (radiation absorbing pigments; see histology), from the loss and entrance of water into the body, from the entrance of parasites and for protection against trauma. With traumatic injury to the skin, healing is furthered by covering the exposed dermis by epidermal cells as soon as possible.

3 II. The **dermis or corium** (**6**) consists of a thin, loosely arranged **papillary layer** (**2**), the papillae of which are seated in corresponding depressions of the epidermis, and a dense **reticular layer** (**7**). The papillary layer contains mainly loosely arranged collagenous fibrils. The reticular layer consists of a plexus of coarse nondistensible collagenic fibers with a predominant course direction. Elastic fibers are present in both layers and function to restore the typical texture of the tissue following lacerations or other distortion of the skin (with respect to the cells that are found here, especially fibrocytes, fibroblasts, mast cells, plasma cells, macrophages and pigment cells, see histology).

4 The **subcutis** (**10**) *(Tela subcutanea)* consists mainly of loose connective and adipose tissue. It is penetrated by connective tissue cords that fix the skin to the underlying fascia or periosteum. The panniculus adiposus is the layer of fat tissue within the subcutis.

Functionally, the subcutis with its subcutaneous fat tissue serves as a cushioning tissue, serves for the storage of calories and water as well as thermoregulation. Its loose connective tissue functions as a gliding layer. Where the subcutis is lacking (lips, cheeks, and eyelids) this gliding function is lacking and the striated musculature ends here directly in the dermis.

The **blood supply** of the skin is provided by larger arteries and veins of the subcutis that, owing to the mobility of the skin, have a tortuous course. They send branches to the dermis that form here two networks. The **arterial network of the dermis** (**9**) is located at the boundary with the subcutis and the **subpapillary network** (**3**) lies between the papillary and reticular layers and gives off subepidermal capillary loops into the papillary body. The corresponding venous plexuses have a comparable location. A further subfascial vascular plexus joins the blood supply of the subcutis. The blood flow can be cut short by **arteriovenous anastomoses** (**4**), thus avoiding the capillary bed, and in this way the vascularization of the skin is regulated. The papillary layer is especially well supplied with blood. These vessels dilate in order to give off heat and constrict to conserve body temperature. In this way they function like the sweat glands in thermoregulation. The venous plexuses also function as a place to store blood.

The **lymphatic supply** is by lymph capillary networks that begin subepidermally and invest the hair follicles and skin glands.

The **nerve supply** is by sensory and sympathetic neurons (sympathetic nerve plexuses invest the blood vessels and function to regulate the blood pressure and in thermoregulation). The skin can be considered as the largest sensory organ of the body. Numerous **nerve terminals** (**16**) and terminal end corpuscles (*e.g.*, **MEISSNER'S tactile discs, —17,** and **VATER-PACINIAN lamellar corpuscles, —22**) serve as receptors for sensory stimuli. With loss of their myelin sheaths, free nerve endings penetrate the epidermis at particular sites of the body and serve to mediate the sensation of pain.

b) The **Hairs** cover nearly the entire body surface, except the *planum nasale*, anus, vulvar lips and limb pads. Hairs are cornified filiform structures that are formed by the skin. The hair is subdivided into the **shaft** (**15**), which projects beyond the surface of the skin, the **root** (**21**), which is obliquely oriented within the dermis and has at its proximal end an expanded part, the **hair bulb** (**8**). Hair root and hair bulb are in a divided epithelial root sheath *(Vagina epithelialis radicularis)*. The outer part of the sheath is continuous with the superficial epidermis. Its inner part cornifies above the mouth of the **sebaceous gland** (**18**) and will be shed. The connective tissue root sheath *(Vagina dermalis radicularis)* is continuous with the surrounding connective tissue. The epidermal and dermal root sheaths together with the bulb of the hair constitute the hair follicle. The parts of the hair are **medulla** (**12**), the **cortex** (**13**) and the **superficial hair cuticle** (**14**), which consists of thin scale-like cornified cells and, the same as the medulla, is used for forensic species identification and individual diagnostic procedures. The **arrector pili muscle** (**5**) terminates below the mouth of the sebaceous gland, attaching obliquely to the dermal sheath of the root of the hair. Its contraction results in erection of the hair (in human beings, this brings about the phenomenon of 'goose pimples'). Contraction of the arrector pili muscle compresses the sebaceous glands and, in erecting the hair, increases the air space between the hairs and the skin surface for thermo-isolation.

The **hair coat** depends on the breed and is characterized by the individual and group-like arrangement of the hairs, the different portions of the individual hair types (lead hairs, guard hairs, wool hairs) as well as by the density, length and color of the hairs. There are basically three types of hairs:

The '**lead' hair** or 'main' hair is long, stiff, and slightly curved. It is independent of other hairs and in the dog occurs only rarely. **Guard hairs** are 5
shorter than the lead hair, arched near the tip and thickened. Both lead and guard hair types form the **hair coat** (**Capilli**). The third and shortest type of hair is the wool hair. It is very thin, pliable and in its course slightly or strongly undulated. Guard and wool hairs pass in a bundle or tuft together from a compound hair follicle, in which case one guard hair is surrounded by the six to twelve wool hairs that accompany it.

The **wool hairs** (**11**) predominate in the coat of the puppy. In most canine 5
breeds they lie under the hair coat and only in a few breeds such as the Puli and Commodore, do they project above the hair coat and form a superficial 'wool coat.'

Sinus or tactile hairs (**19**) are remarkably long, special forms of hair in the vicinity of the opening of the mouth *(Rima oris)*. To receive tactile stimuli, the root of the hair is ensheathed by a **blood sinus** (**20**) that is contacted by numerous sensory nerve endings. Owing to the great lever action of this long hair even the finest tactile stimuli result in stimulation of this receptor.

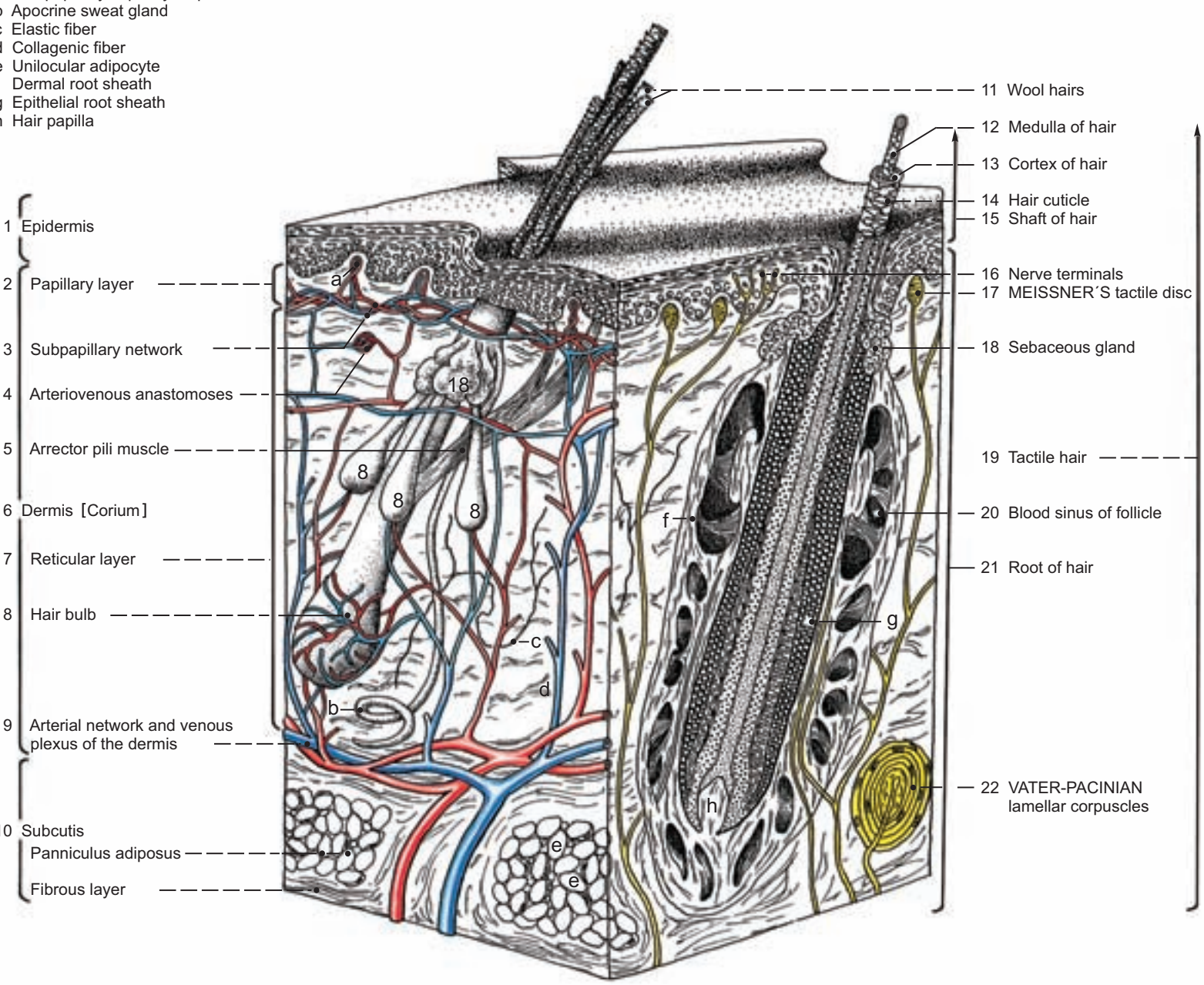
The length of the hairs varies considerably and is dependent on breed. In the ancestors of the dog, who lived in the wild, the longest hairs are found on the dorsum and the shorter ones on the belly and head. But this pattern is mostly lost with domestication. In wild Canidae, the thickness of the hairs increases toward the belly (thickness is about 0.1 mm). The color of the hair is effected by the melanin content of the cornified cells as well as the inter- and intracellular air bubbles, especially of the medullary cells.

The **direction of the hairs** characterizes the coat. That part of the coat in which the hairs have a uniform direction is called the *Flumina pilorum*. In a *vortex*, the hairs are arranged divergently or convergently with respect to a central point. By the crossing of converging lines of hairs, hair 'crosses' are formed.

Common integument

Legend:

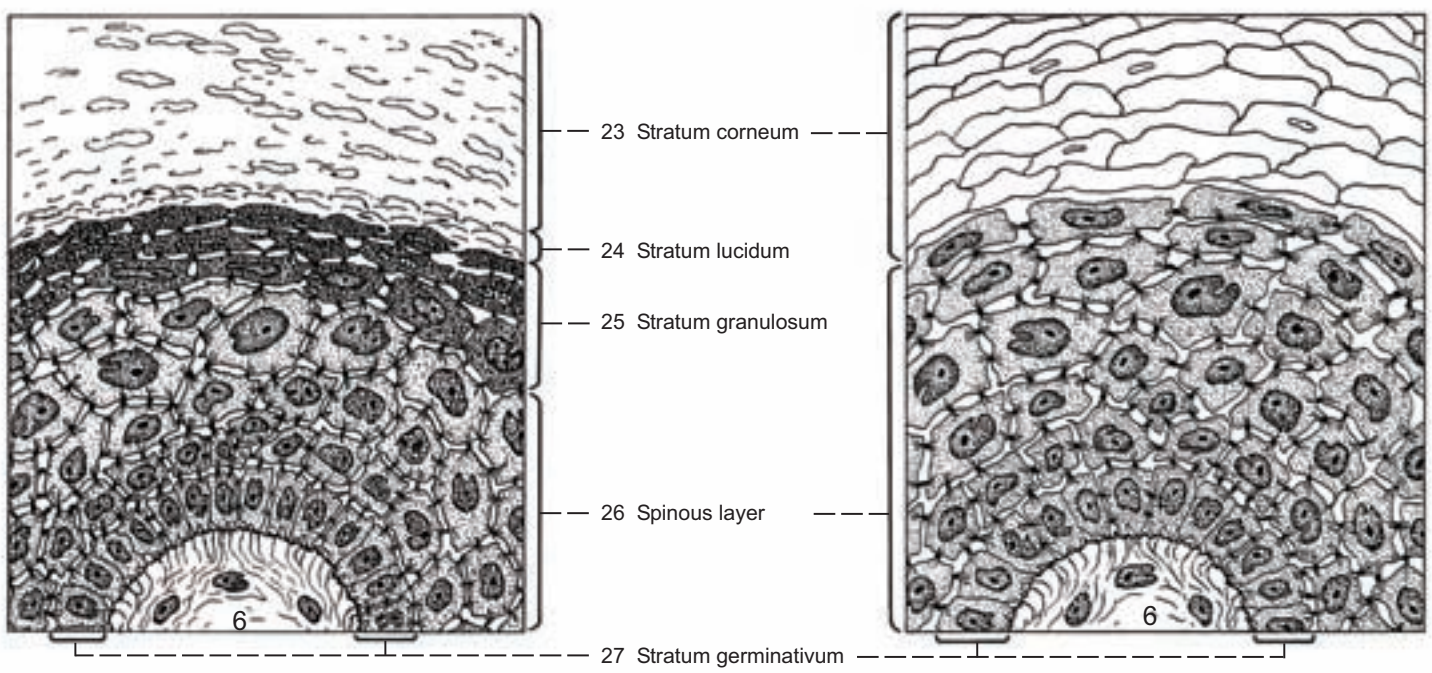
a Intrapapillary capillary loop
b Apocrine sweat gland
c Elastic fiber
d Collagenic fiber
e Unilocular adipocyte
f Dermal root sheath
g Epithelial root sheath
h Hair papilla



Epidermis

Epidermis of digital pad

Epidermis of wall of claw



3. Cutaneous Glands, Modifications of the Skin, Digital End-organs

a) The **CUTANEOUS GLANDS** comprise sebaceous and sweat glands as well as the mammary gland, which is a modified sweat gland.

1 I. The **sebaceous glands** (see p. 4) open into the hair follicles and are present at a few sites of the body independent of the presence of hairs as at the transition of the skin to the cutaneous mucous membrane (lips, anus). Sebaceous glands are lobular. The peripheral cells have a high rate of mitosis and the daughter cells are pushed centrally to the lumen of the gland. Here the enlarged and aging cells break down (holocrine secretion) and the sebum thus liberated reaches the lumen of the gland. It passes by way of a short excretory duct to the lumen of the hair follicle and thus to the skin. Sebum makes the skin soft and pliable and gives the hairs a natural sheen.

II. The **sweat or sudoriferous glands** are classified as merocrine (eccrine) and apocrine glands (odor glands). This classification was based on a supposed apocrine secretion of the (apocrine) odor glands; however, this was subsequently disproven. Both types of sweat glands secrete according to the merocrine (eccrine) manner of secretion (see histology).

The **merocrine sweat glands** are usually coiled, unbranched, tubular glands. They occur in the dog only on the pads of the limbs (see below; some authors consider these glands to be apocrine sweat glands). In human beings, real merocrine (eccrine) sweat glands are present in large areas of the skin surface.

Apocrine sweat glands or odor glands (see p. 4) are present over wide areas of the skin surface, but they are comparatively underdeveloped. These tubular glands open usually into the hair follicle. Their thick secretion has an alkaline reaction and is responsible for the individual species odor. In man, the glands are well developed but limited to a few regions of the body: anus, vulva, axilla.

III. **Special modifications of the skin** occur as the glands of the external acoustic meatus, the circumanal glands, glands of the paranal sinus ('anal sac') and glands of the dorsal tail organ, glands of the eyelids and the mammary glands.

2 The **ceruminal glands** of the external acoustic meatus are mainly sebaceous glands with fewer apocrine sweat glands. Their brown, oily secretion is called cerumen.

3 The **circumanal glands** surround the anus in the hairless or nearly hairless region of the anal cutaneous area. In the dog, we are dealing with modified sebaceous glands; in other domesticated animals, with modified apocrine sweat glands. Superficially located individual glands open into the hair follicles. Deep glands are also called hepatoid glands as their secretory cells appear similar to hepatocytes. The glands lack an excretory duct and their function is unclear.

4 The **glands of the wall of the paranal sinus** (see clinical-functional anatomy, 56.5) are apocrine sweat glands and sebaceous glands. The paranal sinus is commonly termed the 'anal sac.'

5 The **dorsal caudal (tail) organ** is composed of sebaceous and apocrine glands and is described more fully in the clinical-functional anatomy (6.5).

Glands of the eyelids are described in the clinical-functional anatomy (see also 118.1)

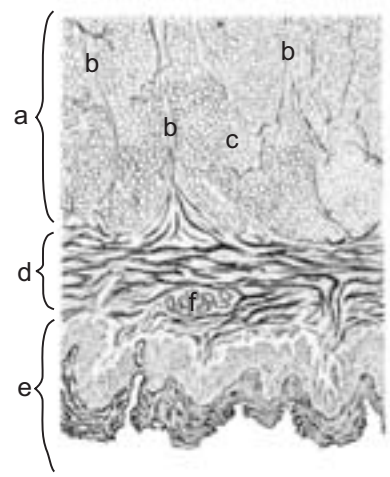
Mammary gland; see p. 32.

b) **SKIN MODIFICATIONS** are the nasal plane and the limb pads: carpal pad, metacarpal/metatarsal pad, digital pads.

I. The **nasal plane** (see p. 98), depending on breed, varies from unpigmented to its being strongly pigmented. The dermis forms distinct papillae. The epidermis is strikingly thin, and its superficial, cornified layer (stratum corneum) consists of hard 'horn' (hard cornified epidermis) that exhibits a polygonal pattern. The surface pattern is individually specific and for this reason serves to identify the individual animal. Glands are absent. The nose of the dog is kept moist by lacrimal fluid (see p. 98) and the secretion of the lateral nasal gland, which is located deeply in the maxillary recess of the nasal cavity. The evaporation of the fluid lowers the temperature of the nasal plane, which ordinarily feels cold to the touch (hence the saying, 'cold as a dog's nose').

6 II. The **pads** of the dog are the **digital pads** (**14**) at the level of the distal interphalangeal joints, the **metacarpal** (**13**) **or metatarsal pad** at the level of the metacarpophalangeal and metatarsophalangeal joints and the **carpal pad** (**12**) that is laterodistal at the carpus. The thick subcutis of the pads has much fat tissue and contains sweat glands. It is subdivided into compartments by radiating strands of collagenous and elastic fibers and is very sensitive (painful) if swollen due to increased tissue pressure when inflamed. The connective tissue strands radiate from the dermis of the pad into the subcutis and fix the pad to the underlying fascia and to the skeleton. Well-developed **connective tissue bands** (**Tractus tori —15**) are present in the metacarpal and metatarsal pads. They fix the pads proximally to the metacarpal or metatarsal bones, respectively. The dermis has very firm connective tissue bundles and forms a very high papillary body with conical papillae. The epidermis of the pad is up to 2 mm in thickness and forms corresponding depressions in the soft horn (soft cornified epidermis). The pads are richly supplied with blood and lymph vessels as well as nerves.

Cutis of pad



Legend :

a Subcutaneous tissue of pad [digital cushion] :
b Retinacula
c Panniculus adiposus
d Dermis [Corium] of pad
e Epidermis of pad
f Merocrine sweat gland

c) The **DIGITAL END-ORGAN** is the bony end of the digit invested by a highly modified cutis (skin). Except for the digital pad, a subcutis is lacking. The dermis is developed in the form of papillae, villi or laminae or it has a smooth surface. The inner surface of the epidermis has a corresponding configuration: depressions that seat the papillae and villi, narrow furrows adaped to the laminae, or a smooth surface where it contacts the smooth surface of the dermis.

The cornified epidermis of the **claw** (**Unguicula**) is conical in form and invests the **unguicular process** (**11**). Dermis and epidermis are segmentally similarly differentiated as on the fingernail of the human being and on the equine hoof. Both, dermis and epidermis, are adapted to one another like the patrix (stamp = dermis) to the matrix (impression = epidermis). 7

The bony unguicular crest is overlain basally by a prominence of the skin, the **vallum** (**7**). The external lamina of the vallum is haired; the unhaired inner lamella is comparable to the limbus (periople) of the horse. It forms a soft horn (**Eponychium, —1**) over the hard cornified epidermis of the claw. The eponychium corresponds to the periople of the horse and, like the periople, is worn off far proximal to the distal end of the claw. (On the human fingernail, the soft eponychium is removed at the manicure.)

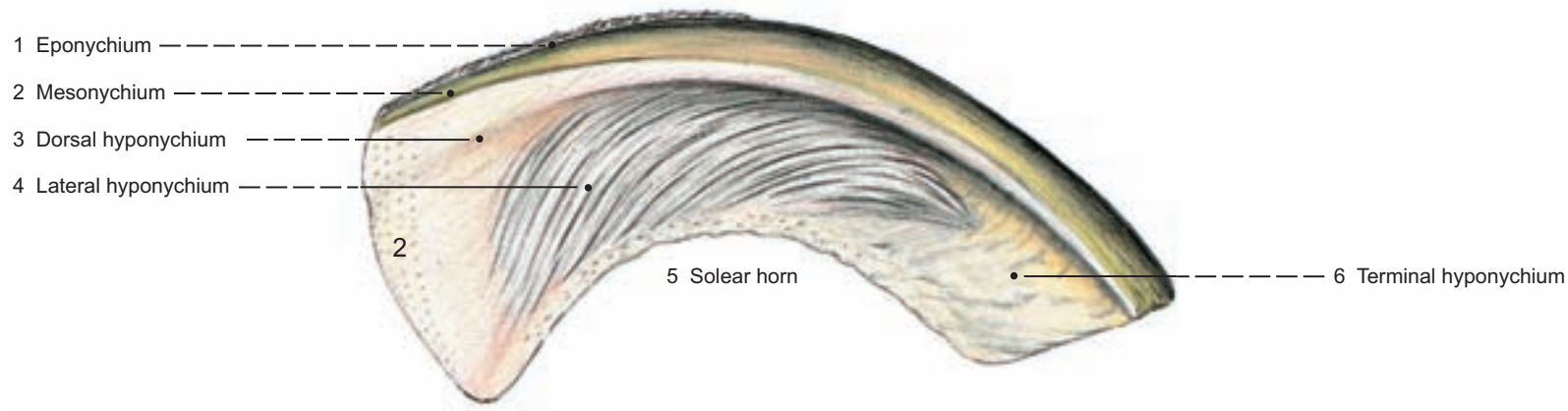
In the depth of the unguicular groove is the fold that corresponds to the coronary part of the equine hoof. Its dermis bears **papillae** (**10**). Its covering epidermis produces a tubular horn that, as a **mesonychium** (**2**), provides a considerable part of the claw. Dorsal on the unguicular process there is a smooth **dorsal swelling of the dermis** (**Dorsum dermale —8**), that is particular to the digital end-organ of the dog and that, according to our investigations, is not comparable to the coronary part of the equine hoof. On the epidermis covering it, the **dorsal horn of the wall** (**dorsal hyponychium —3**) is formed. In the lateral region of the unguicular process lamellae are present, **dermal lamellae** (**9**) and correspondingly formed non-cornified epidermal lamellae that form the lateral wall horn (**Hyponychium laterale, —4**), which is simply layered and forms the internal lining of the conical claw horn.

Palmar (plantar) on the unguicular process is the solear part on which the dermis bears distinct villi. Here, tubular **solear horn** (**5**) is formed, the cells of which undergo substantial desquamation.

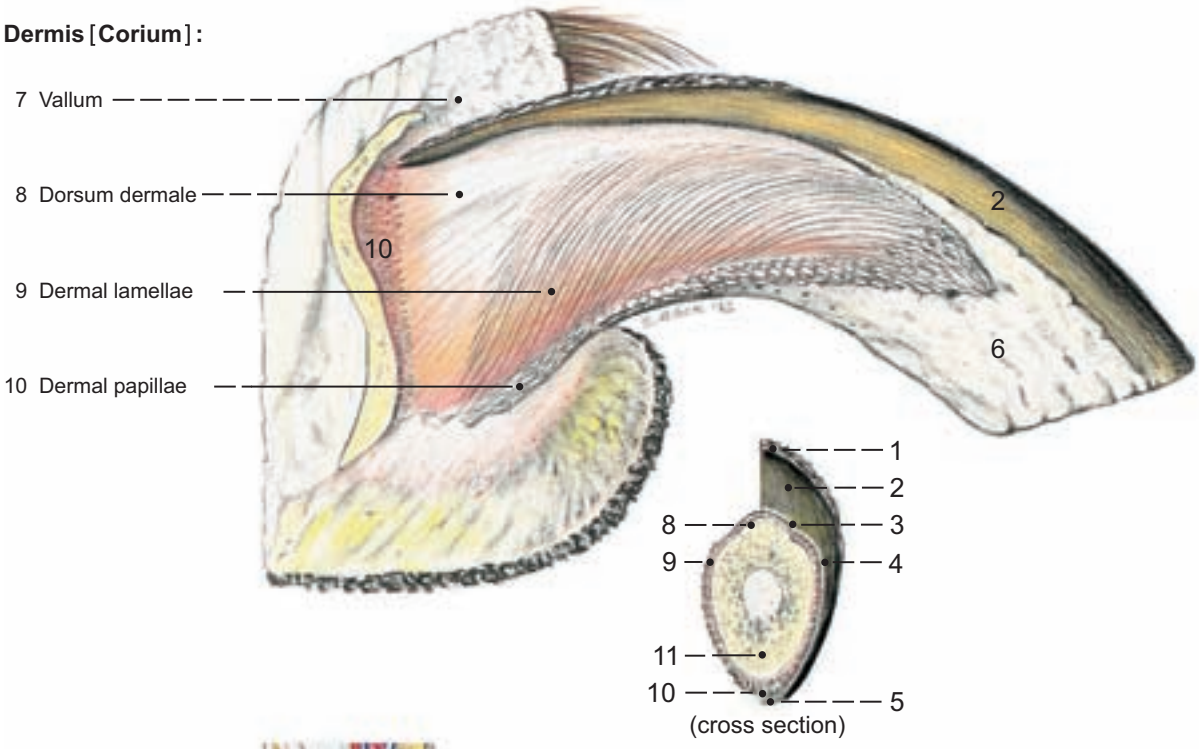
Around the tip of the unguicular process there is present a soft **terminal horn** (**Hyponychium terminale, —6**) that fills out the distal part of the conical claw horn and serves thus as a 'filling' horn.

Claw and digital pad

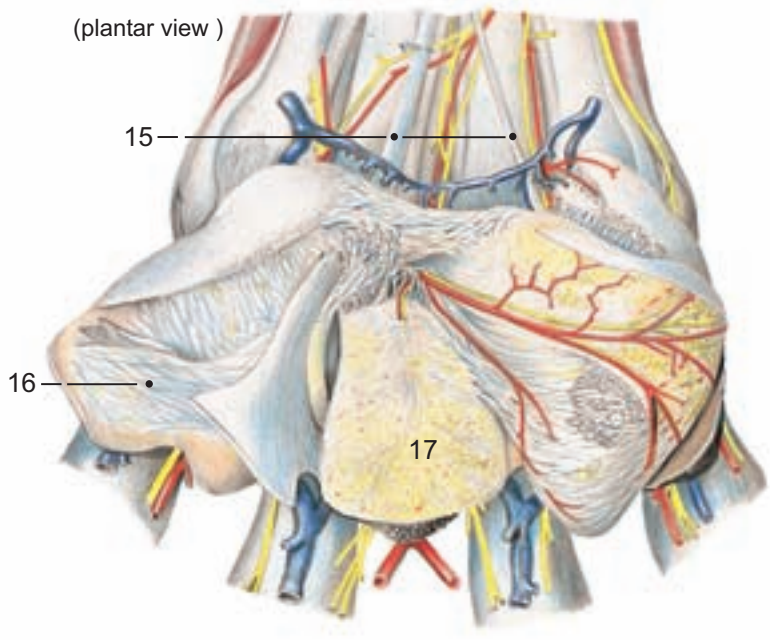
Epidermis:



Dermis [Corium]:



Digital pad



Metatarsal pad

Legend :

11 Unguicular process
12 Carpal pad
13 Metacarpal pad
14 Digital pads
15 Tractus of metatarsal pad

Subcutaneous tissue of pad:
16 Retinacula
17 Panniculus adiposus (Fat pad)

(see pp. 19, 81, 83)

4. Vertebral Column and Thorax

The vertebrae are studied individually and on the mounted skeleton to obtain a total overview of the normal S-shaped curvature with its lordoses (ventral convexities) and kyphoses (ventral concavities). From a forensic view, particular attention is placed on the identification of individual vertebrae, for which reason comparison of the different segments of the vertebral column is done.

1 a) The **VERTEBRAL COLUMN** encloses and protects the spinal cord. It has a supporting function with respect to the statics and dynamics of the animal's body. For that, stability is assured by the individual vertebrae, and elasticity as well as pliability by the intervertebral symphyses and the vertebral joints.

The vertebral column consists of seven cervical vertebrae (vC 1 – 7), thirteen thoracic (vT 1 – 13), seven lumbar (vL 1 – 7), three sacral (vS 1 – 3), which are fused to form the sacrum, and about twenty caudal (coccygeal) vertebrae (vCy 1 – 20).

2 I. The **vertebrae** (see text-illustration) consist of three basic constituents: body and its parts, arch and processes, that are modified in different ways according to the functional requirements of the particular region.

3 The **body of the vertebra** (**1**) has a **ventral crest** (**2**), (distinct in the region of the cervical vertebral column) and **cranial** (**3**) and **caudal** (**4**) extremities. On the thoracic vertebrae, both the **caudal** (**5**) **and cranial costal foveae** (**6**) form a common articular facet for the head *(Capitulum)* of the rib (see
4 below). The **vertebral foramen** (**7**) is the space enclosed by the body and arch. The vertebral canal is formed by the serial vertebral foramina and the soft tissues extending between adjacent vertebral arches and bodies. It contains the spinal cord with its cauda equina.

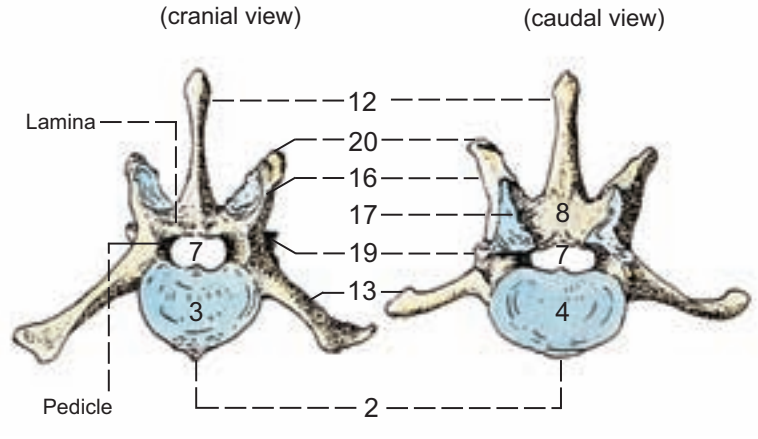
5 The **arch of the vertebra** (**8**) is made up of a pedicle basally and a flattened lamina dorsally. The **intervertebral foramina** (**9**) are bounded by the **cranial** (**10**) **and caudal** (**11**) **vertebral notches** of the vertebra of the same and preceding segments. Excepting the first cervical nerve (see below), these foramina are passages for the spinal nerves.

Of the processes of the vertebrae, the **spinous process** (**12**) is most distinct (exceptions are the first cervical vertebra and the caudal vertebrae). The **transverse processes** (**13**) are well developed on the cervical and lumbar vertebrae. On the thoracic vertebrae, they have a **costal fovea** (**14**) that bears an articular facet for the costal tubercle (see below). From the first to the sixth cervical vertebrae there are **transverse foramina** (**15**) at the base of the transverse processes, which altogether form the transverse canal that
6 transmits the vertebral artery, vein and nerve. The **cranial articular processes** (**16**) and the **caudal articular processes** (**17**) form synovial joints between the vertebrae. A **costal process** (**18**) is present on the 3rd – 6th cervical vertebrae as the ventrocranial extremity of the transverse process, which is bifurcate in this region. In the lumbar vertebral column the ends of the transverse processes represent costal processes that are remnants of the ribs, and can develop to form lumbar 'ribs.' An **accessory process** (**19**) is lacking or poorly developed in the caudal part of the lumbar vertebral column. In the cranial lumbar region it is developed as an independent process. At the transition to the thoracic vertebral column, it passes onto the caudal contour of the transverse process and no longer stands independently. The **mamillary process** (**20**) of the lumbar vertebrae is expressed on the cranial articular process (mamiloarticular process) and changes its position at the transition to the thoracic vertebral column, passing onto the transverse process, actually to the cranial contour of the transverse process.
7 **Hemal processes** (**21**) are developed from the 4th caudal vertebra and become gradually indistinct caudally. On the 4th to the 7th or 8th caudal vertebra, they may unite to form a **hemal arch** (**22**).

The interarcuate spaces are dorsal and, in life, closed off by the interarcuate ligaments. The **lumbosacral space** (**23**) and the **sacrococcygeal** (**sacrocaudal**) **space** (**24**) are especially wide and of significance in performing epidural anesthesia. The atlanto-occipital space is suitable for tapping the subarachnoid space, which is filled with cerebrospinal fluid.

Special features are present on the following cervical vertebrae: The **first cervical vertebra** (**atlas, —25**) has a broad-surfaced **lateral process** (**26**), also designated the wing of the atlas *(Ala atlantis)*. The **alar notch** (**27**) calar foramen of other domestic mammals) is cranial at the attachment of the wing of the atlas to the lateral mass (see below) and is occupied by the ventral branch of the first cervical nerve. Contrary to the other spinal nerves, the first cervical nerve does not exit the vertebral canal by an intervertebral foramen but by the **lateral vertebral foramen** (**28**). The vertebral foramen of the atlas is also different in that it is bounded dorsally by a **dorsal arch** (**29**), ventrally by a **ventral arch** (**30**). The two arches are joined laterally by bone designated the lateral mass *(Massa lateralis)*. The atlas is the only vertebra to have a ventral arch (30) in the place of the body. This is due to the caudal shift of a great part of the embryonal primordium of its vertebral body to form the dens of the axis. The **second cervical vertebra, the axis** (**31**), for this reason contains in its **dens** (**32**) the displaced part of the body of the atlas. The last cervical vertebra differs from the other cervical vertebra by its large spinous process, its caudal costal foveae for the first ribs and by the absence of the transverse foramen.

Lumbar vertebra

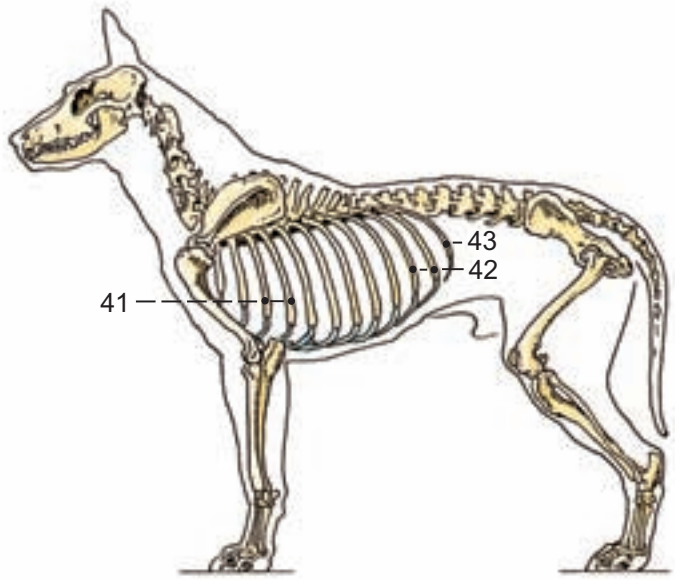


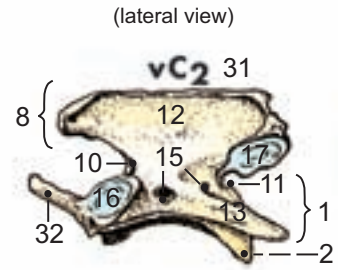
II. The **sacrum** is formed by the fusion of the three sacral vertebrae. Laterally, it bears the **sacral wing** (**33**), whose **auricular surface** (**34**) forms a synovial joint with the auricular surface of the ilium. The **median sacral crest** (**35**) is formed by an incomplete fusion of the spinous processes. The lateral ends of the fused lateral (transverse) processes form the **lateral sacral crest** (**36**). The **intermediate sacral crest** (**37**) results from the sequential arrangement of the fused mamilloarticular processes. The **promontory** (**38**) forms the cranioventral contour of the sacral bone and takes part in the limiting terminal line of the pelvic inlet. From the vertebral canal, the sacral nerves enter intervertebral foramina and leave the vertebral column after dividing into dorsal and ventral branches that emerge from the **dorsal** (**39**) **and ventral sacral foramina** (**40**), respectively, that proceed from each intervertebral foramen.

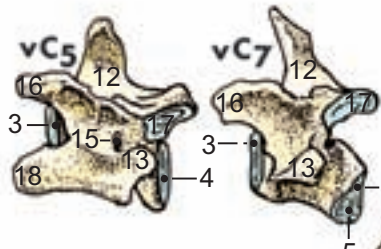
b) Of the 13 **RIBS (COSTAE),** the first through the ninth are **sternal ribs** (**41**), connected to the sternum by synovial articulation. Ribs 10 – 12 are the freely moveable, 'breathing' **asternal ribs** (**42**). By the overlapping of the cartilaginous parts of the asternal ribs, a costal arch is formed on both sides of the body. The last rib does not regularly participate in the formation of the arch. It usually terminates freely in the musculature of the abdominal wall as a **'floating' rib** (**43**). Ribs, sternum and thoracic vertebral column form the thorax, the inlet of which is bounded by the first pair of ribs and the outlet by the costal arches. The dorsal part of the rib is osseous (**Os costae, —44**). Its **head** (**45**) bears cranial and caudal **articular facets** (**46**). The two articular facets are separated by a rough crest that, in most ribs, is indirectly in contact with the intervertebral disc by means of the intercapital ligament (see illustration, p. 11). An indistinct **neck of the rib** (**47**) connects the head to the **body of the rib** (**48**). The proximodorsally located **costal tubercle** (**49**) bears an **articular surface** (**50**) for articulation with the costal fovea of the transverse process. The **angle of the rib** (**51**) is only indistinctly recognizable. The **costal cartilage** (**52**) begins at the costochondral junction and, slightly distal to this, there is a distinct bend, the **knee of the rib** (**53**) that in other domestic mammals is in the area of the costochondral junction.

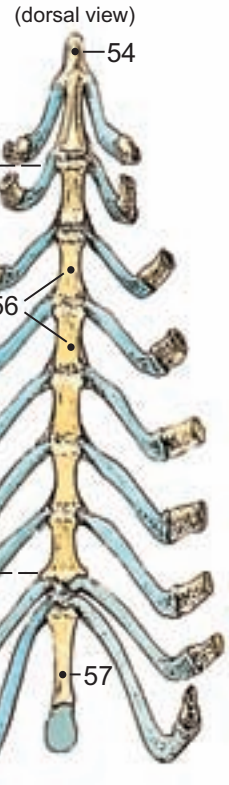
c) The **STERNUM** consists of the **manubrium** (**54**), the **body of the sternum** (**55**) with its six **sternebrae** (**56**), and the **xiphoid process** (**57**), which is bony cranially, cartilaginous caudally. The first pair of ribs articulates with the manubrium, the second at the synchondrosis that joins the manubrium to the body of the sternum, the third through the seventh at the following sternal synchondroses, and the eighth and ninth jointly at the synchondrosis joining the body to the xiphoid process.

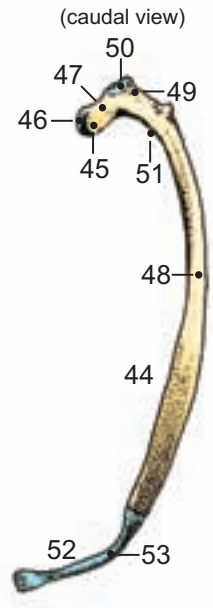
Vertebral column and bones of thorax



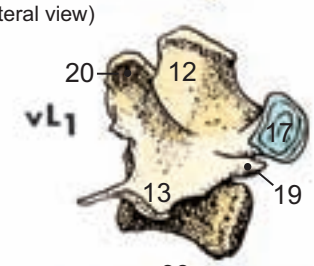


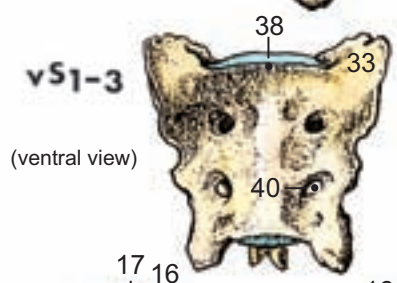






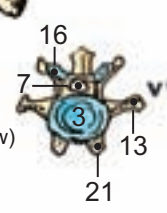
(lateral view)





(ventral view)

(cranial view)



Cervical vertebrae vC_{1-7}
Thoracic vertebrae vT_{1-13}
Lumbar vertebrae vL_{1-7}
Sacral vertebrae vS_{1-3}
Coccygeal vertebrae vCy_{1-x}
Body of vertebra (1)
  Ventral crest (2)
  Cranial extremity (3)
  Caudal extremity (4)
  Caudal costal fovea (5)
  Cranial costal fovea (6)
Vertebral canal (7)
Vertebral arch (8)
Intervertebral foramen (9)
  Cranial vertebral notch (10)
  Caudal vertebral notch (11)
Spinous process (12)
Transverse process (13)
  Costal fovea (14)
  Transverse foramen (15)
Cranial articular process (16)
Caudal articular process (17)
Costal process (18)
Accessory process (19)
Mamillary process (20)
Hemal process (21)
Hemal arch (22)
Interarcuate space
  Lumbosacral space (23)
  Sacrococcygeal space (24)

Atlas vC_1 (25)
Transverse process [wing] (26)
  Alar notch (27)
Lateral vertebral foramen (28)
Dorsal arch (29)
Ventral arch (30)

Axis (31)
Dens (32)

Os sacrum vS_{1-3}
Sacral wing (33)
  Auricular surface (34)
Median sacral crest (35)
Lateral sacral crest (36)
Intermediate sacral crest (37)
Promontory (38)
Dorsal sacral foramen (39)
Ventral sacral foramen (40)

Ribs
Sternal ribs (41)
Asternal ribs (42)
Floating rib (43)
Bony rib (44)
  Head of rib (45)
    Articular facets of head of rib (46)
  Neck of rib (47)
  Body of rib (48)
  Tubercle of rib (49)
    Articular surface of tubercle of rib (50)
  Angle of rib (51)
Costal cartilage (52)
  Knee of rib (53)

Sternum
Manubrium of sternum (54)
Body of sternum (55)
  Sternebrae (56)
Xiphoid process (57)

5. Articulations of the Vertebral Column and of the Thorax; Atlanto-Occipital and Atlanto-Axial Joints

a) **Joints (Articulations)**

	Name	Participating bones	Form/ Composition	Function	Remarks
	I. Atlanto-occipital joint	Occipital condyles and cranial articular foveae of the atlas	Elliptical joint, simple joint	Hinge joint, dorsal and ventral flexion	Right and left joint cavities communicate ventrally.
1	**II. Atlanto-axial joint**	Fovea of the dens and caudal articular fossa of the atlas, dens and ventral articular surface of the dens	Trochoid joint, simple joint	Axial rotation of the head on the neck, head 'shaking'	The atlanto-axial joint communicates with the atlanto-occipital joint.
	III. Joints of the articular processes	Articular processes of adjacent vertebrae	Plane joints	Sliding joints	Considerable mobility in the cervical region, decreasing in the thoracic and lumbar regions.
	IV. Joint of the head of the rib (costovertebral joint)	Articular surface of the head of the rib and caudal costal fovea of the more cranial vertebra and cranial costal fovea of the more caudal vertebra with which the rib head articulates	Spheroid joint, composite joint	Hinge joint that, together with the vertebrae, makes possible the variation in thoracic volume in respiration	The convex rib-head joint surface is formed by two articular facets. The articular depression is formed by the costal foveae of the two vertebral bodies and the intervening fibrocartilage of the intervertebral symphysis. The last two to three ribs articulate only with the cranial costal fovea of the same-numbered (the more caudal) vertebra.
	V. Joint of the rib tubercle (costotransverse joint)	Articular surface of the costal tubercle and the costal fovea of the transverse process of the same numbered (the more caudal) vertebra	Plane joint, simple joint	Hinge joint	On the last ribs, the costotransverse joint approaches and then fuses with the costovertebral joint.
	VI. Sternocostal joint	Cartilaginous ends of the first to the eighth ribs and the sternum	Condylar joint, simple joint	Hinge joint	The first rib articulates with the manubrium of the sternum. The ninth (last sternal) rib is not connected to the sternum by a synovial joint but by fibrous tissue.
	VII. Costochondral synchondrosis	Costal bone and costal cartilage	Synchondrosis	Nearly rigid and immoveable	Postnatally a true joint may develop from a synchondrosis.
	VIII. Sternal synchondroses	Manubrium of the sternum, sternebrae of the body of the sternum, xiphoid process	Synchondrosis	Increasingly rigid and immoveable	Of the sternal synchondroses, the manubriosternal and xiphosternal synchondroses are specially named.
2	**IX. Intervertebral symphysis** (joints between the bodies of adjacent vertebrae)	Bodies of adjacent vertebrae, starting with the axis and including the caudal vertebrae	Intervertebral disc without a space	Slight mobility	The discs in the intervertebral region of the sacrum ossify in the second year of life.
	X. Sacroiliac joint	See joints of the pelvic limb.			

b) **Ligaments of the Vertebral Column**

Three ligaments extend over longer areas of the vertebral column. Short ligaments bridge over the space between individual vertebrae.

The **ventral longitudinal ligament** is attached ventrally to the bodies of the
3 vertebrae and to the intervertebral discs. It extends from the second cervical vertebra to the sacrum.

The **dorsal longitudinal ligament** lies on the floor of the vertebral canal and attaches at the dorsal border of the intervertebral disc. It extends from the axis to the first caudal vertebrae.

The **nuchal ligament** (see p. 29) in the dog consists only of the paired elastic **funiculus nuchae**. It bridges over the cervical vertebral column from the caudal end of the spinous process of the axis and extends to the spinous process of the first thoracic vertebra. Here it is continued by the **supraspinous ligament** with loss of elasticity and attaches to the spinous process of all the vertebrae up to the third sacral vertebra.

The **ligamenta flava** extend as short elastic ligaments from vertebral arch to vertebral arch and thus close the interarcuate spaces dorsally.

Interspinous ligaments are lacking. The **M. interspinalis** lies between the spinous processes of adjacent vertebrae.

c) **Ligaments of the Atlanto-Occipital and Atlanto-Axial Joints, and of the Thorax**

At the **atlanto-occipital joint,** the **dorsal atlanto-occipital membrane** reinforces the joint capsule and bridges over the atlanto-occipital space (access to the cerebellomedullar cistern for withdrawal of cerebrospinal fluid for diagnostic purposes). The **ventral atlanto-occipital membrane** is a ventral rein-forcement of the joint capsule. The **lateral ligament** is a lateral reinforcement of the joint capsule.

On the **atlanto-axial** joint the dens is held to the floor of the vertebral canal and to the occipital bone by the **apical ligament of the dens**, the **transverse atlantal ligament** and the **alar ligaments**. The transverse atlantal ligament is underlain by a synovial bursa and is attached to either side of the atlas. In the case of rupture of these ligaments or fracture of the dens following car accidents or strangulation, damage to the spinal cord may occur with paralysis and death as consequences. The elastic **dorsal atlanto-axial membrane** extends from the cranial projection of the spine of the axis to the dorsal arch of the atlas.

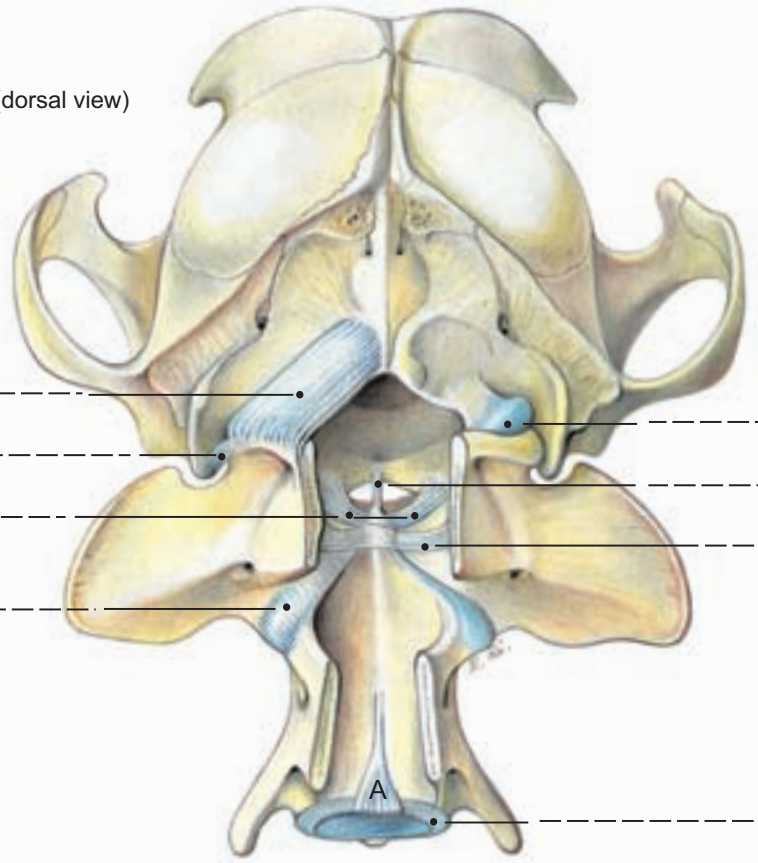
The **joints between the articular processes** of the vertebrae lack ligaments. The joint capsule is either tightly attached or more loose according to the degree of movement and influences the direction of the movement, which depends on the position of the articular surfaces.

At the **joint of the rib-head**, the **intra-articular ligament of the head of the rib** connects the costal heads of both sides and lies over the intervertebral disc. It is also called the **intercapital ligament**. It is lacking at the first and the last two pairs of ribs. The **radiate ligament of the head of the rib** is present as a strengthening of the joint capsule.

At the **costotransverse joints**, the joint capsule is reinforced by a **costotransverse ligament**.

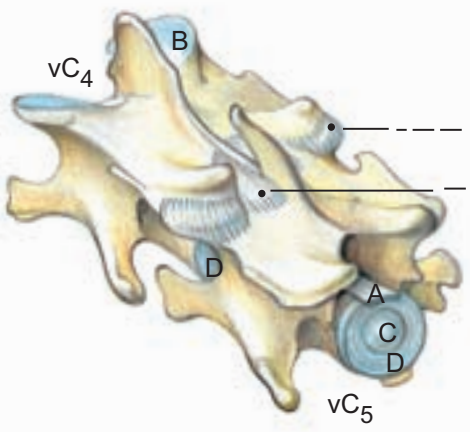
Joints of the vertebral column and the thorax

(dorsal view)



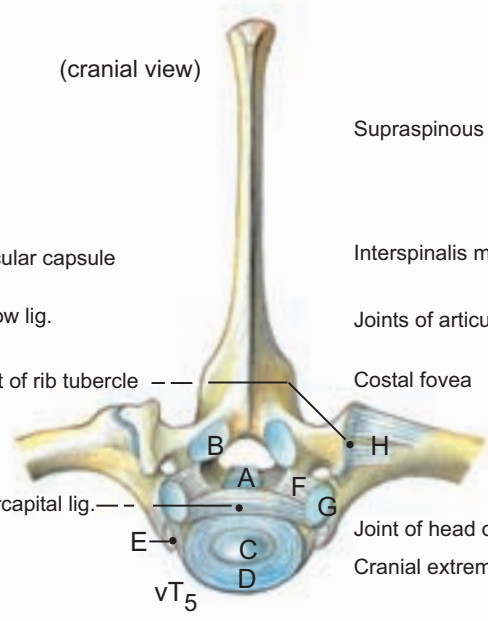
Atlanto-occipital and atlanto-axial joints

(caudolat. view)

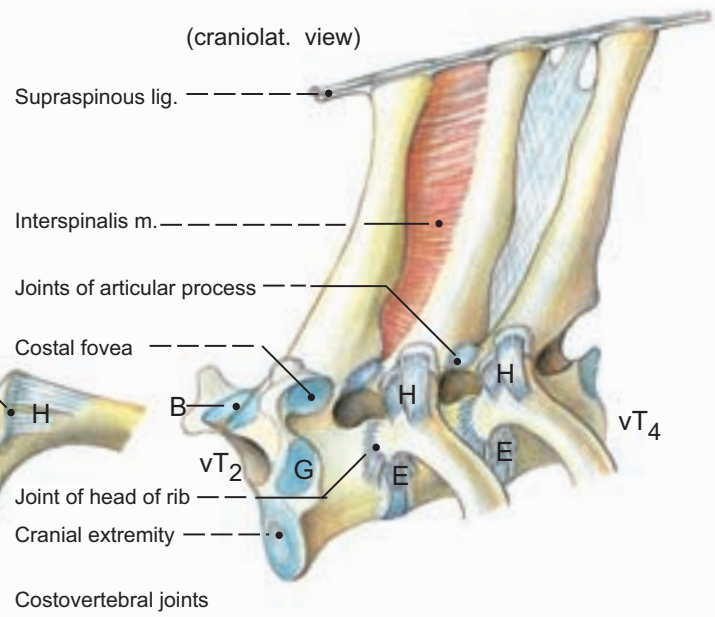


Joint of articular process

(cranial view)

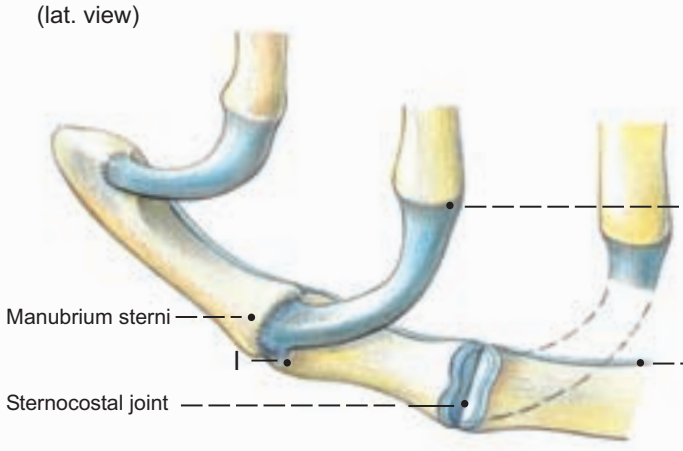


(craniolat. view)



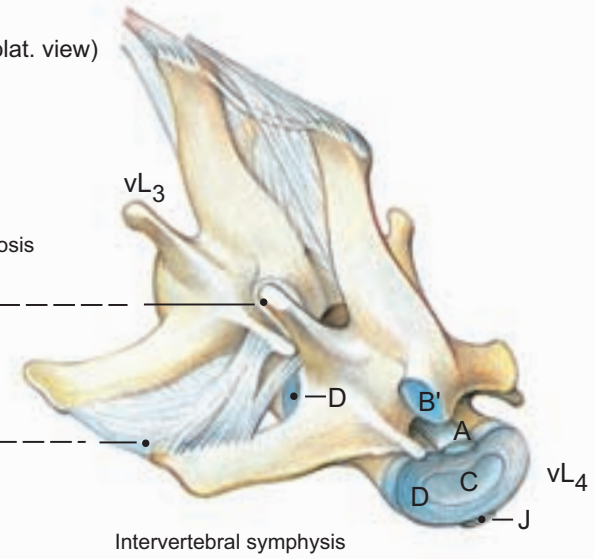
Costovertebral joints

(lat. view)



Sternocostal joints and sternal synchondroses

(caudolat. view)



Intervertebral symphysis

Legend :

A Dorsal longitudinal lig.
B Cran. articular process
B' Caud. articular process

Intervertebral disc:
C Nucleus pulposus
D Anulus fibrosus

E Radiate lig. of head of rib
F Intra-articular lig. of head of rib
G Cran. costal fovea

H Costotransverse lig.
I Radiate sternocostal lig.
J Ventral longitudinal lig.

(see pp. 9, 89, 91)

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