R.D. SINELNIKOV

ATLAS OF HUMAN ANATOMY

I

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Р. Д. СИНЕЛЬНИКОВ

АТЛАС АНАТОМИИ ЧЕЛОВЕКА

ТОМ I

УЧЕНИЕ О КОСТЯХ, СУСТАВАХ, СВЯЗКАХ И МЫШЦАХ

МОСКВА
«МЕДИЦИНА»

R.D. SINELNIKOV

ATLAS OF HUMAN ANATOMY

Volume I

The Science of Bones, Joints, Ligaments and Muscles

Translated from the Russian
by
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MIR PUBLISHERS
MOSCOW

First published 1988
Revised from the 1978 Russian edition

Printed in the German Democratic Republic

На английском языке

ISBN 5-03-000323-1
5-03-000322-3

PREFACE

This edition of Professor R.D. Sinelnikov's *Atlas of Human Anatomy* is a translation of the 5th Russian edition. The *Atlas* was first published in 1952-1958 and has for more than 30 years served in training several generations of medical students and physicians working in various branches of medicine. Adherence to the principles on which the book is based, as well as the continuing need for it, explain why five editions of it in Russian, four in Spanish, and two in Czech have been published. A translation of the *Atlas* into Arabic is currently being prepared for publication. In preparing every new edition extensive research was carried out to supplement and improve the material of the book and to update it on the basis of the achievements of modern anatomical science. Up till 1981 work on the *Atlas* was conducted by R.D. Sinelnikov with the collaboration of Ya.R. Sinelnikov and in recent years only by Ya.R. Sinelnikov.

Several new drawings have been added to this edition and new sections introduced pertaining to age features, particularly to those of children. To bring the fundamental theoretical discipline, which is what human anatomy is, closer to clinical practice, much space among the illustrations has been allotted to radiographs.

The illustrations and the terminology in the text conform with the Paris Nomina Anatomica (PNA)[1]. However, some Latin names on the illustrations are given according to the Basle Nomina Anatomica (BNA). Many drawings have been redrawn to show the anatomical structures included in the new nomenclature, the text has been supplemented accordingly, and the subject index has been updated.

The material is presented in line with the dialectical principles of studying the body as an organic whole with consideration of all the links binding its systems. Special attention is focused on the data of macro-microscopic anatomy.

The material in this edition is arranged in the following manner. The first volume consists of sections on osteology, arthrology, and myology. The second volume is devoted to splanchnology and angiology. The third volume provides descriptions of the nervous system, the sense organs, and the endocrine glands.

The sections on the science of the muscles and viscera point out the connection of every skeletal muscle and each internal organ with its nerves and vessels. Moreover, the description of the bony canals, grooves, and foramina is supplemented by information about the nerves and vessels which they transmit, thus making it easier to understand the interrelations of the body's different systems. The *Atlas* contains illustrations of complex preparations allowing simultaneous study of several parts of the body, which ensures a deeper knowledge of the links binding the different parts into a single whole.

Some of the illustrations in the *Atlas* demonstrate not only the features of normal anatomy, but the existing topographo-anatomical correlations so as to bring anatomical concepts close to the requirements of medical practice.

The illustrations to this edition were made by different artists over a span of more than thirty years. Foremost among these illustrators were A.A. Alekseev and F.K. Kovbasa, who made the greater number of original drawings. With the addition of new illustrations which was necessary as the systematic revision of the *Atlas* progressed, the old ones of the former editions were corrected and updated.

Prof. Ya.R. Sinelnikov

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1 English equivalents to the Latin terms are given according to the Birmingham Revision (BR) of the Paris Anatomical Nomenclature (PNA) (*Butterworths Medical Dictionary*, 1978, second edition, Editor-in-Chief MacDonald Critchley).

ABBREVIATIONS AND SYMBOLS

A., a., Aa., aa.—arteria, arteriae.
V., v., VV., vv.—vena, venae.
M., m., Mm., mm.—musculus, musculi.
Lig., lig., Ligg., ligg.—ligamentum, ligamenta.
Gl., gl., Gll., gll.—glandula, glandulae.
N., n., Nn., nn.—nervus, nervi.
R., r., Rr., rr.—ramus, rami.
S., seu, sive—or.
C_1, C_2, C_3—first, second, third cervical nerve.
Th_1, Th_2, Th_3—first, second, third thoracic nerve.
L_1, L_2, L_3—first, second, third lumbar nerve.
S_1, S_2, S_3—first, second, third sacral nerve.
Constantly present nerve segments are put in round brackets, e.g. (C_1, C_2), (Th_1, Th_2).
Inconstantly present nerve segments are put in round brackets which are enclosed within square brackets, e.g. [C_1(C_2)-C_7(C_8)].
($^1/_1$), ($^1/_2$) etc. in the captions show the proportion of the size of the drawings to the natural size.

CONTENTS

THE SCIENCE OF THE BONES

Osteologia

The skeleton formed by bones and joints is the supporting structure of the human body.

The **bones** *(ossa)* give rigid support to the soft tissues of the body and form levers which move due to muscle contraction.

In the whole body the bones form the **skeletal system** *(systema skeletale)* (Figs 1, 2, and 3b) which is made up of the **axial skeleton** *(skeleton axiale)* and the **appendicular skeleton** *(skeleton appendiculare)*. The **skull** *(cranium)*, the **spinal column** *(columna vertebralis)*, and the **chest bones** *(ossa thoracis)* form the axial skeleton. The appendicular skeleton consists of the **bones of the upper limbs** *(ossa membri superioris)* and the **bones of the lower limbs** *(ossa membri inferioris)*.

The skeletal system includes over 200 bones, 85 of which are paired.

Each bone is a complex organ composed of various types of connective tissue; it contains bone marrow which is supplied with vessels and nerves.

Most bones of a human adult consist of a bony and cartilaginous framework, as a result of which a **bony part** *(pars ossea)* and a **cartilaginous part** *(pars cartilaginosa)* are distinguished in the skeletal system. The bony part makes up most of the bone. The **articular cartilages** *(cartilagines articulares)*, the **epiphyseal cartilages** *(cartilagines epiphysiales)* (Figs 5, 6, and 7), and the **costal cartilages** *(cartilagines costales)* form the cartilaginous part of the skeletal system.

On the outside the bone is covered with a fine connective-tissue membrane, the **periosteum** (Fig. 4), in which a fibrous and an osteogenic layer are distinguished. The superficially situated fibrous layer is connected to the bone by fibres penetrating the bone and contains blood and lymph vessels and nerves. From this layer the vessels and nerves pass into the bone through **nutrient foramina** *(foramina nutricia)* and thence into the **nutrient canal** *(canalis nutricius)*. The inner osteogenic layer contains osteogenic cells (osteoblasts) which take part in the processes of development and reorganization of bony tissue under normal conditions and after injuries and fractures. At the junction with the articular cartilage covering the ends of the bone, the periosteum is continuous with the **perichondrium**. As a result the bone as an organ is covered with a continuous connective-tissue membrane. This membrane covers the surface of the bone and all the structures situated on it: processes, spines, cristae, tubers, tubercles, roughened lines *(lineae asperae)*, pits and depressions *(fovea, fossae)*, etc.

The bone is lined on the inside by a finer membrane, the **endosteum**.

According to shape, **long bones** *(ossa longa)*, **short bones** *(ossa brevia)*, and **flat bones** *(ossa plana)* are distinguished (Fig. 3a). Some bones contain cavities filled with air and are called **pneumatic** *(ossa pneumatica)*.

The long bones (humerus, clavicle, femur, phalanges, etc.) have a middle part, the **diaphysis**, and two end parts, the **epiphyses**. The epiphysis located closer to the axial skeleton is called the **proximal epiphysis** *(epiphysis proximalis)*, the epiphysis of the same bone but situated further from the axial skeleton is called the **distal epiphysis** *(epiphysis distalis)* (Fig. 5). The wider parts of long bones between the diaphysis and the epiphysis are known as **metaphyses**. Their boundaries are visible only in the bones of children and adolescents when a cartilaginous layer, the **epiphyseal cartilage** *(cartilago epiphysialis)* (Figs 5, 7), still remains between the diaphysis and epiphyses. The bone grows intensely in length at the expense of this cartilage, which is later replaced by bony tissue forming the **epiphyseal line** *(linea epiphysialis)*, which can hardly be detected with age.

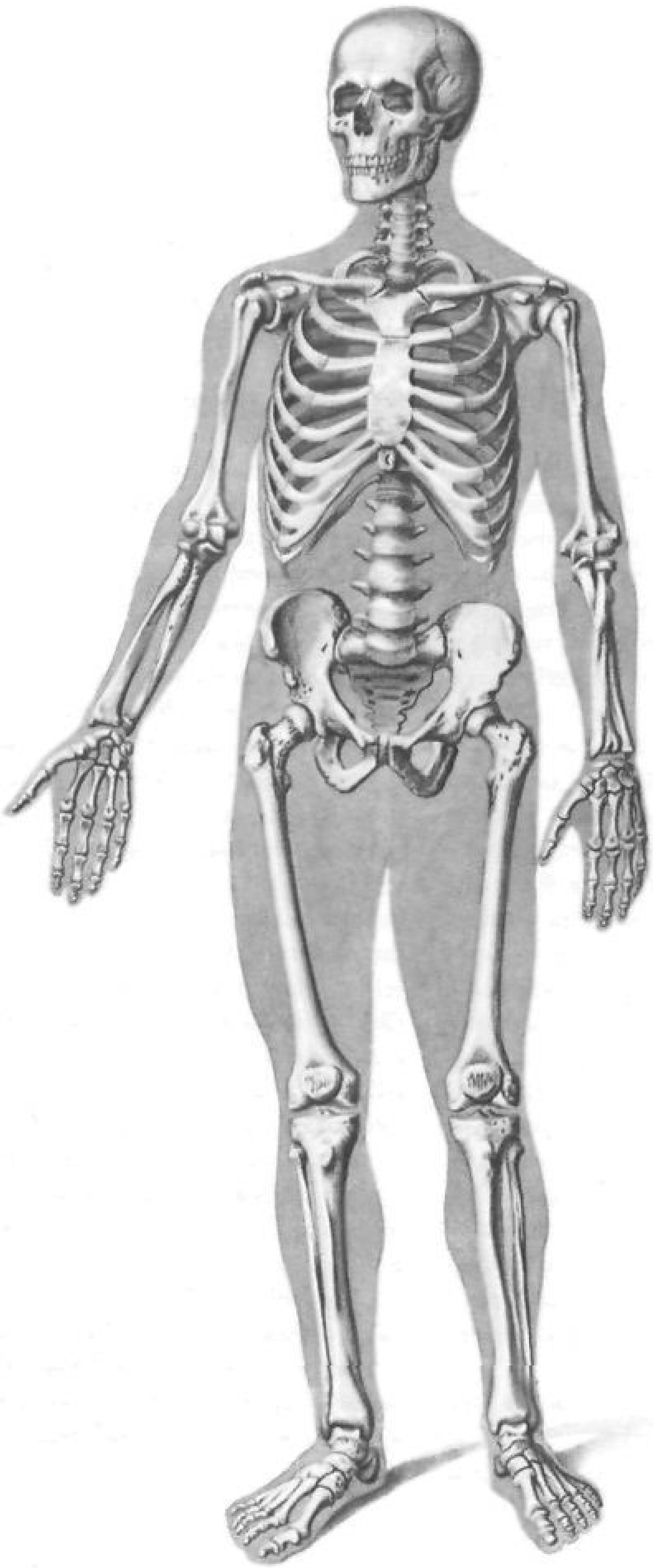
In a cross-section of a long bone (Fig. 6) one can distinguish the **compact substance** *(substantia compacta)* forming the outer layers of the bone and the **spongy** (cancellous) **substance** *(substantia spongiosa)* found deeper than the compact substance, mainly in the epiphyses and metaphyses. In the diaphyses of long tubular bones the compact substance surrounds the **medullary canal** *(cavitas medullaris)* shaped like a tube.

A cross-section of short bones (Fig. 3a) (vertebrae, carpal bones, tarsal bones, etc.) reveals on the surface a thinner layer of compact substance surrounding the trabeculae of the spongy substance which forms the greater part of the bone. The trabeculae of the spongy substance form a complex meshwork but are arranged in each bone of the skeletal system strictly in accordance with the functional loads.

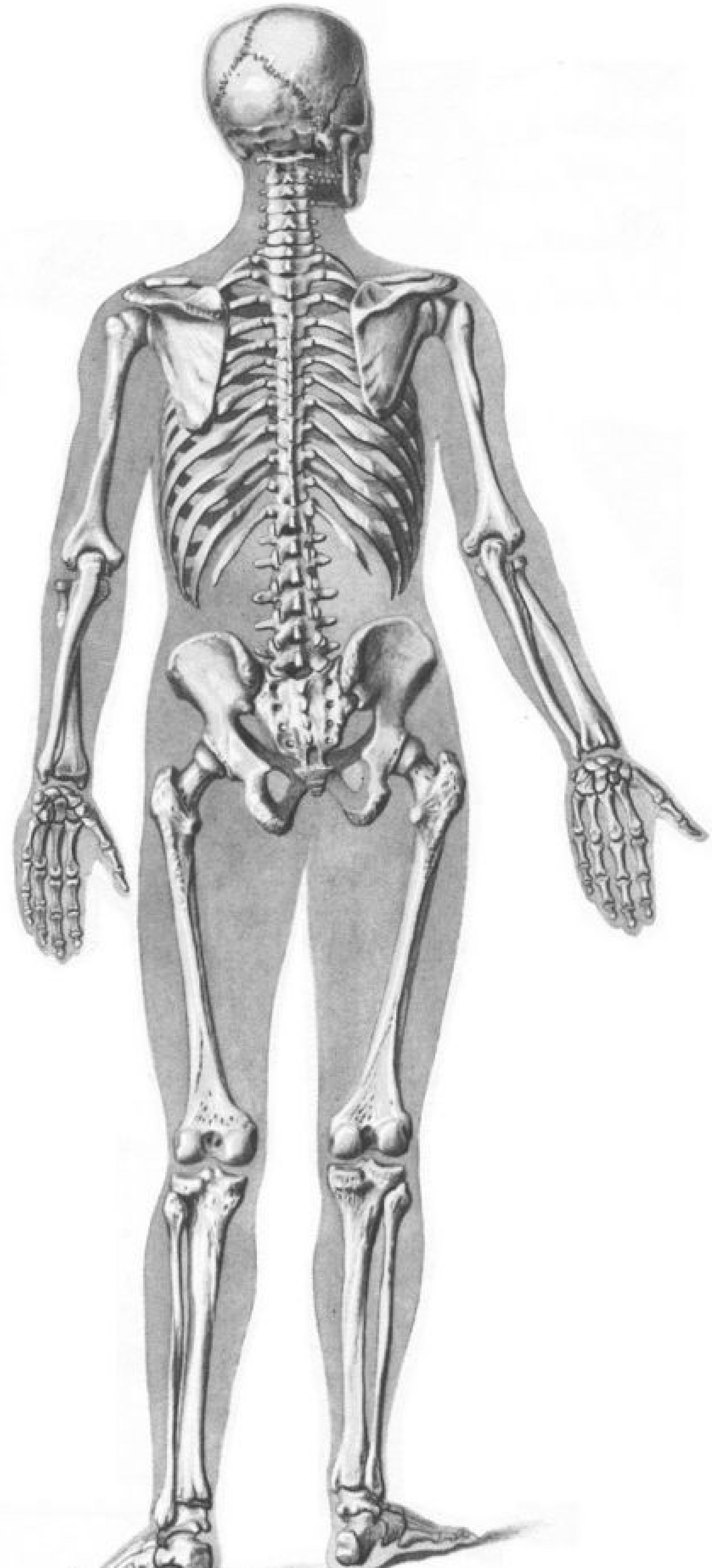
In the flat bones (Fig. 3a) (the bones of the skull cap, shoulder blade, pelvic bone, etc.) the spongy substance, in contrast, usually forms a thinner layer and is surrounded on both sides by plates of the compact substance. In the bones of the skull cap, however, the spongy substance is sufficiently developed. It is known as **diploë** (Fig. 8) and is sandwiched between the **outer** and **inner plates** of the compact substance *(lamina externa* and *lamina interna)*. **Diploetic canals** *(canales diploici)* providing for the passage of venous vessels extend through the spongy substance of the skull-cap bones.

The meshes of the spongy substance and the medullary canal contain the **bone marrow** *(medulla ossium)*. **Red marrow** *(medulla ossium rubra)* and **yellow marrow** *(medulla ossium flava)* are distinguished.

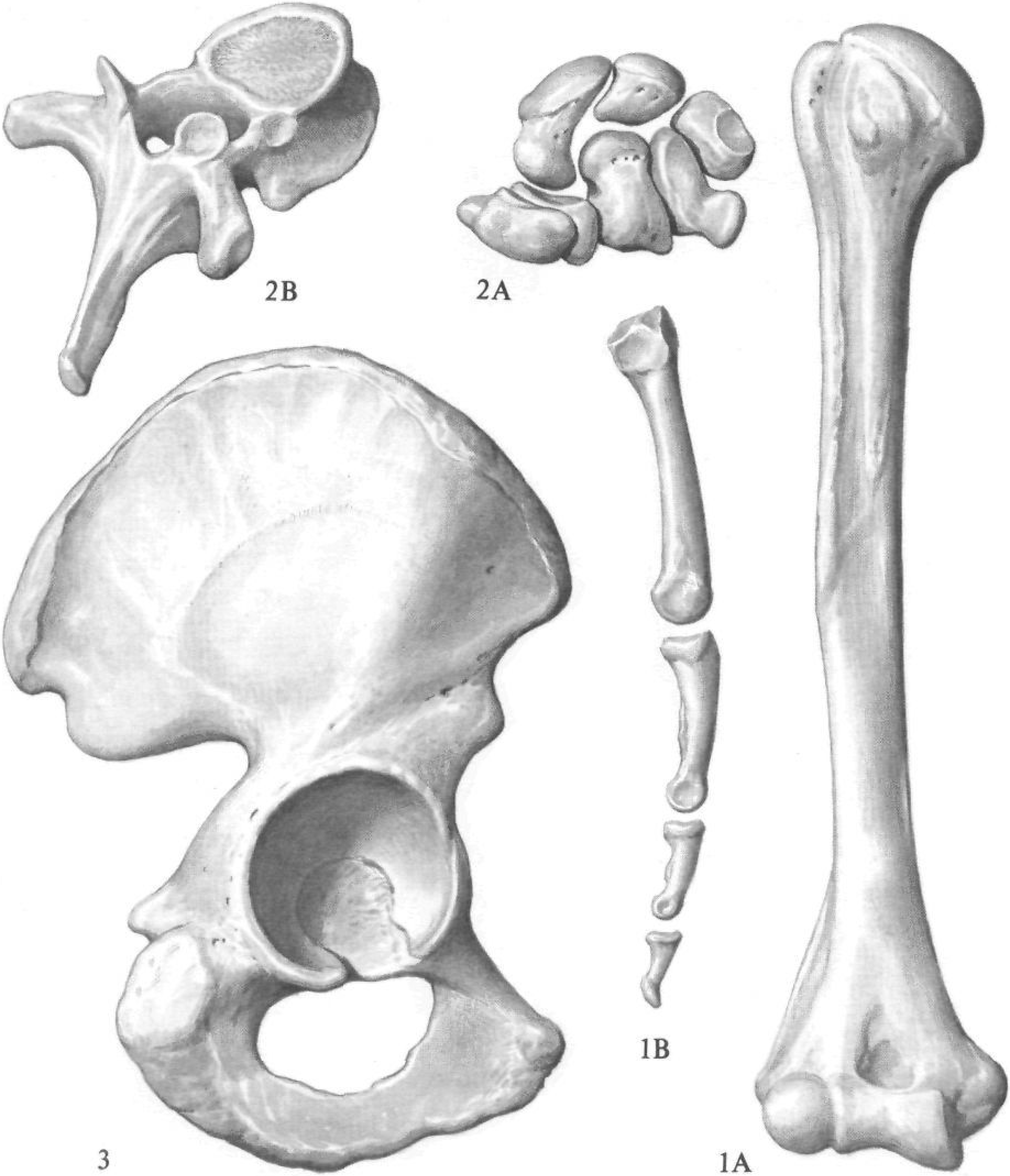
The red marrow possesses high functional activity and is capable of forming blood cells of the myeloid series. With the development and growth of the organism, the red marrow is gradually replaced by the yellow marrow. The yellow marrow is less active and plays a reserve role, but under certain conditions it may be activated.



1. *Skeleton*, anterior aspect ($^1/_{10}$).

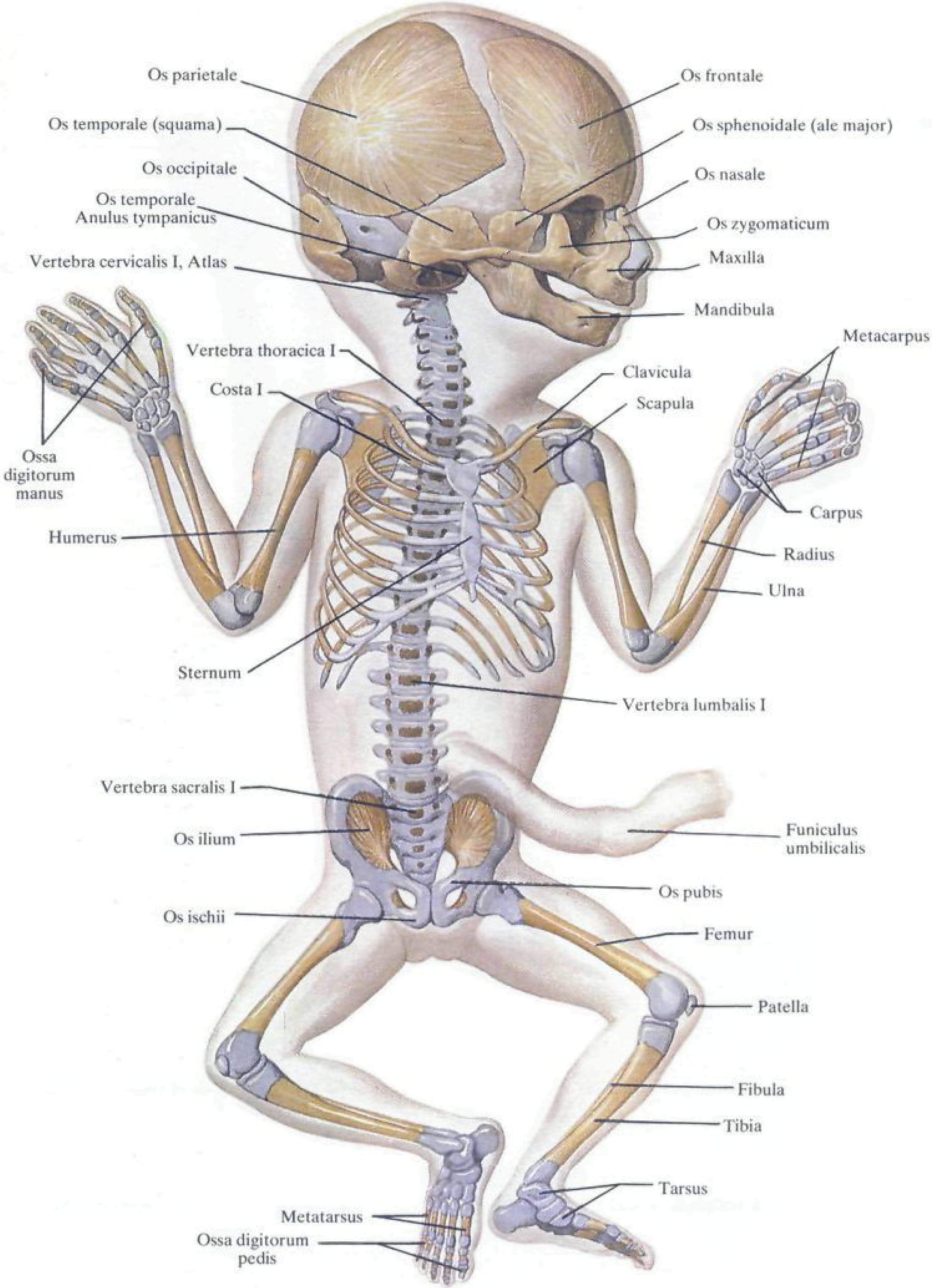


2. *Skeleton*, posterior aspect ($^1/_{10}$).



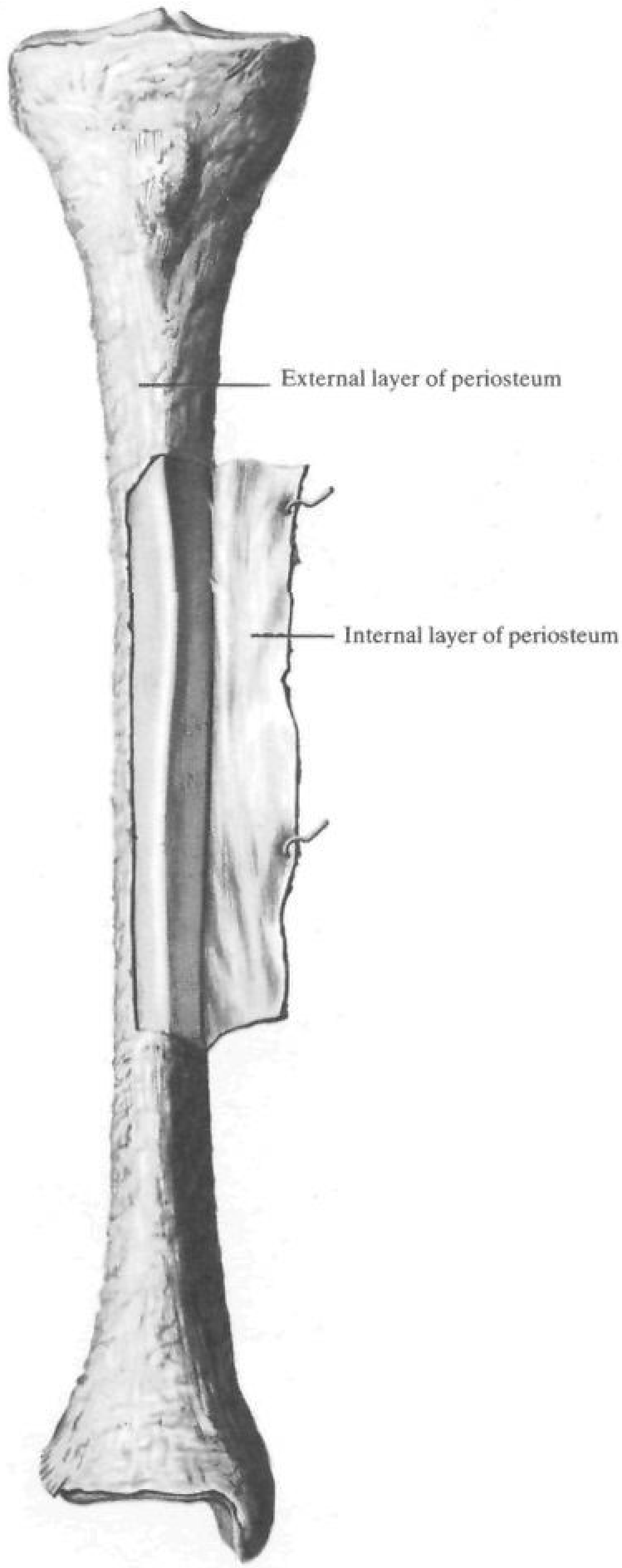
3a. *Bones of different shape.*

1—long bones *(ossa longi)* (1A—humerus; 1B—metacarpal bone and phalanges); 2—short bones *(ossa breves)* (2 A—carpal bones; 2B—vertebra); 3—flat bone *(os planum)* (pelvic bone, *os coxae*).



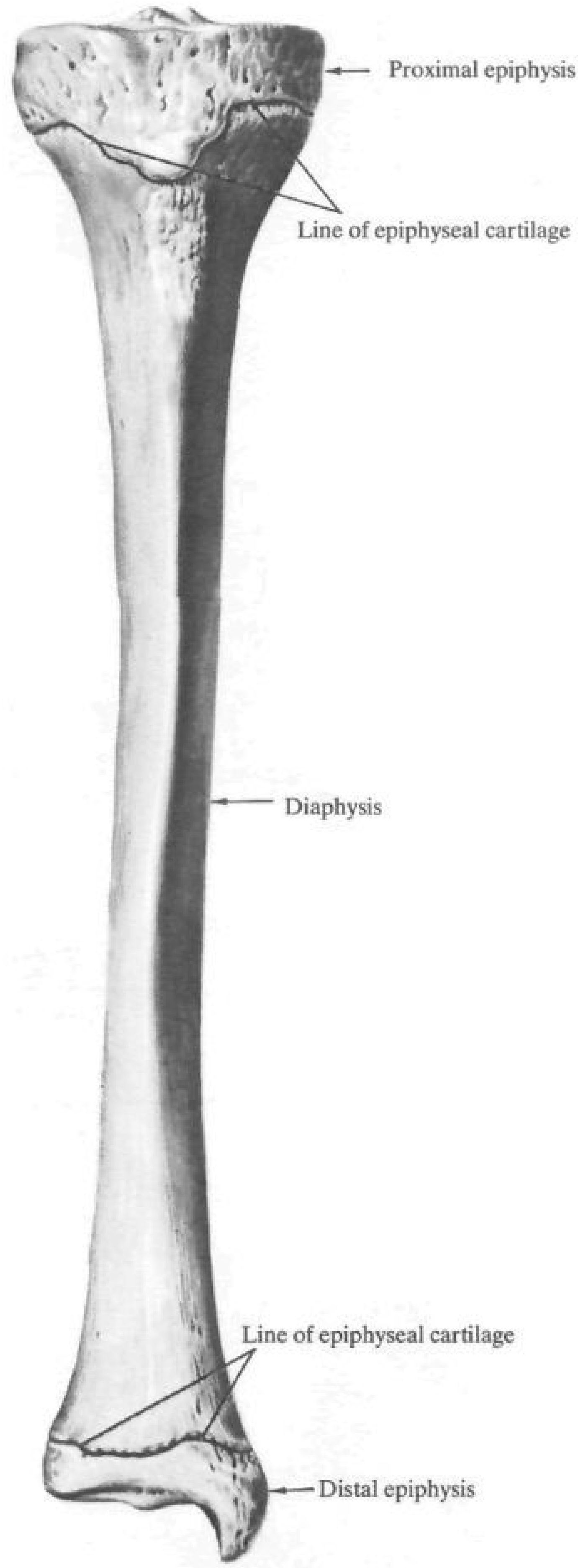
3b. *Four-month-old foetus* (drawing made from a radiograph).

(Brown—bony tissue; blue—cartilaginous tissue; grey—connective tissue between the bones of the skull.)



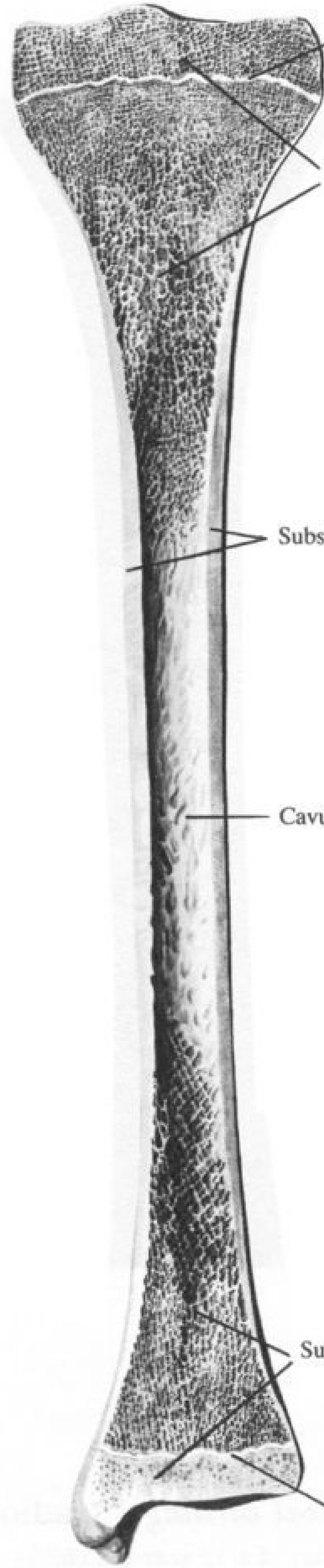
4. *Periosteum* (½).

(Right tibia, front aspect. The periosteum is cut and drawn aside in the middle parts of the bone.)



5. *Diaphysis and epiphyses* (½).

(Right tibia, front aspect. The epiphyses are not fused with the diaphysis.)



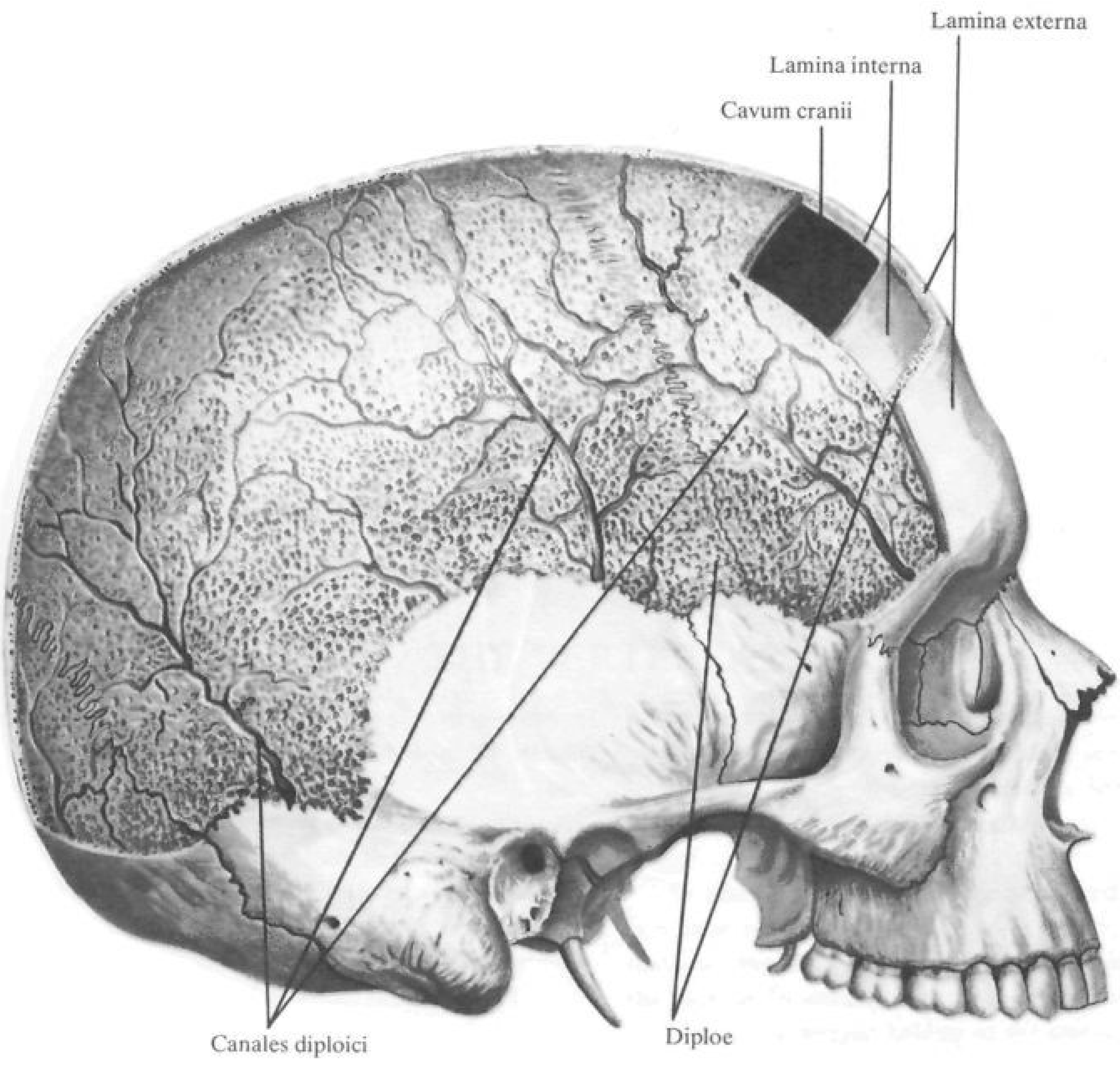
6. *Compact substance of bone (substantia compacta); spongy substance of bone (substantia spongiosa); marrow cavity, or medullary canal (cavum medullare)* (1/2).

(Right tibia, frontal section.)

7. *Epiphyseal cartilages* (radiograph).

(Right knee joint of a 12-year-old child.)

1—femoral diaphysis
2—patella
3—zone of epiphyseal cartilage
4—distal femoral epiphysis
5—proximal tibial epiphysis
6—zone of epiphyseal cartilage
7—tibial diaphysis
8—proximal fibular epiphysis
9—fibular diaphysis



8. *Spongy substance of skull cap (diploë)* ($^3/_5$).

(Skull, from the right side, with the lower jaw removed. The outer table, *lamina externa*, of the skull bones is removed.)

THE BONES OF THE TRUNK

Ossa trunci

The vertebrae, ribs, and the sternum are the bones of the trunk.

THE VERTEBRAE

The **vertebrae**, 33 or 34 in number, are rings placed one above another which form a single column, the **vertebral** or **spinal column** *(columna vertebralis)* (Fig. 9).

The vertebral column has the following parts: the **cervical part** *(pars cervicalis)*, the **thoracic part** *(pars thoracica)*, **the lumbar part** *(pars lumbalis)*, the **sacral part** *(pars sacralis)*, and the **coccygeal part** *(pars coccygea)*. In accordance with this, five groups of vertebrae are distinguished: **cerebral** *(vertebrae cervicae)* (7), **thoracic** *(vertebrae thoracicae)* (12), **lumbar** *(vertebrae lumbales)* (5), **sacral** *(vertebrae sacrales)* (5), and **coccygeal** *(vertebrae coccygeae)* (4 or 5).

The vertebral column of a human adult forms four *curvatures* in the sagittal plane: cervical, thoracic, lumbar (abdominal), and sacral (pelvic). The cervical and lumbar curvatures are concave anteriorly, the condition being known as *lordosis* (Gk); the thoracic and pelvic curvatures are convex anteriorly and are called *kyphosis* (Gk).

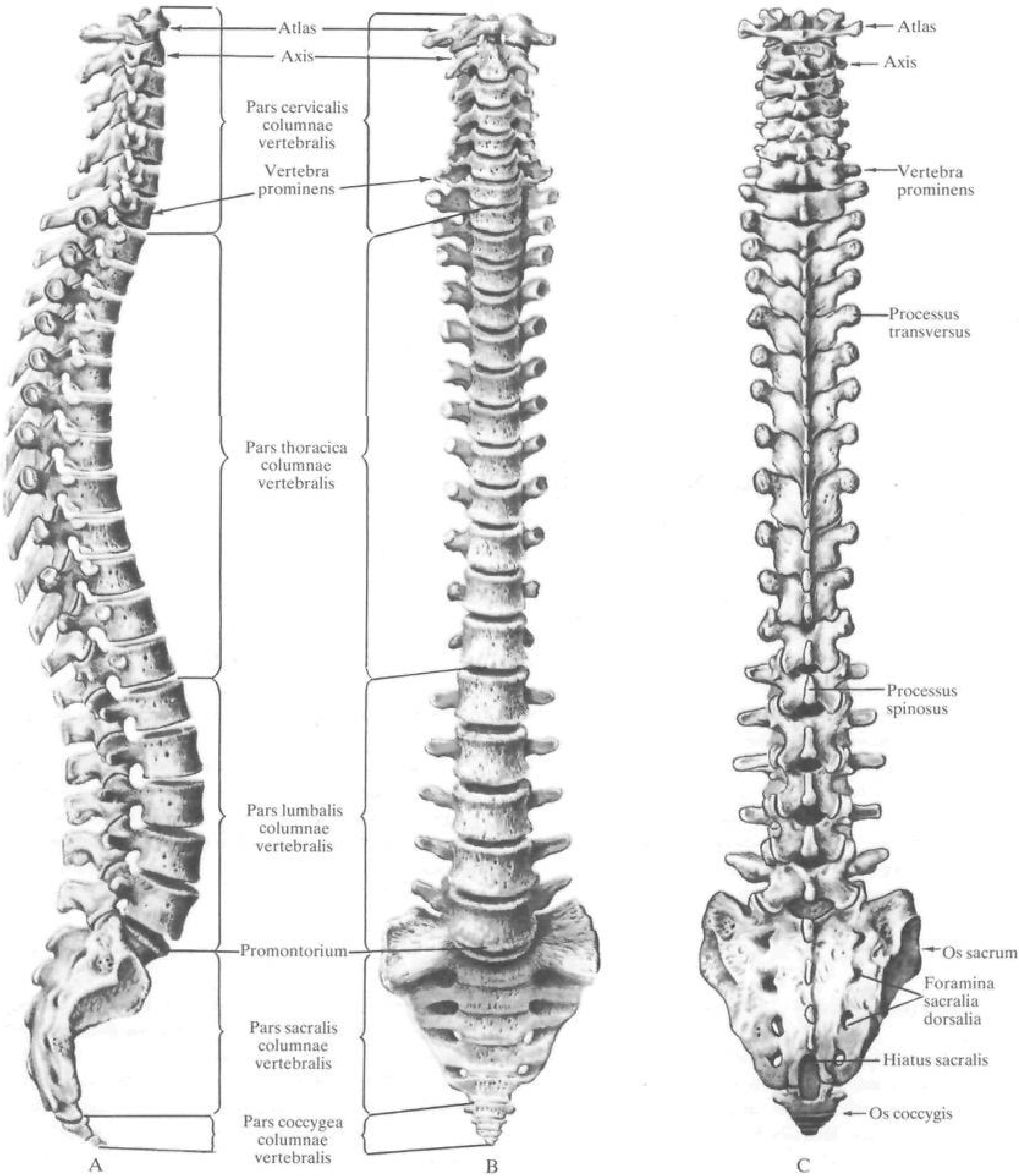
In addition, all vertebrae are separated into two groups—true and false vertebrae; the cervical, thoracic, and lumbar vertebrae make up the first group, while the sacral vertebrae fused to form the **sacrum** *(os sacrum)* and the coccygeal vertebrae fused to form the **coccyx** *(os coccygis)* belong to the second group.

THE VERTEBRA

The vertebra (see Figs 22 and 23) has a body, an arch, and processes.

The **vertebral body** *(corpus vertebrae)* is the anterior, thickened part of the vertebra and is bounded superiorly and inferiorly by surfaces facing, respectively, the adjacent proximal and distal vertebrae, anteriorly and laterally by a slightly concave surface, and posteriorly by a flat surface. The body of the vertebra, its posterior surface in particular, has very many **nutrient foramina** *(foramina nutricia)*, which serve for the passage of vessels and nerves into the bone substance. The bodies of the vertebrae are joined by means of **intervertebral discs** (cartilages), as a result of which a very flexible column, the vertebral column, is formed.

The **vertebral arch** *(arcus vertebrae)* forms the posterior and lateral boundaries of the **vertebral foramen** *(foramen vertebrale)*. The foramina are placed one above the other to form the **vertebral canal** *(canalis vertebralis)* which lodges the spinal cord. The arch arises from the posterolateral edges of the vertebral body as a narrow segment, the **pedicle of the vertebral arch** *(pediculus arcus vertebrae)*. The superior and inferior surfaces of the pedicle bear the **superior vertebral notch** *(incisura vertebralis superior)* and the **inferior vertebral notch** *(incisura vertebralis inferior)*. The superior notch of one vertebra adjoins the inferior notch of the proximally situated vertebra to form the **intervertebral foramen** *(foramen intervertebrale)*, which transmits the spinal nerves and vessels.



9. *Vertebral column (columna vertebralis)* (1/4).
A—from the right side; B—anterior aspect; C—posterior aspect.

The **vertebral processes** *(processus vertebrales)*, seven in number, project from the vertebral arch. One of them, unpaired, extends from the middle of the arch and to the back and is called the **spine of the vertebra** or **spinous process** *(processus spinosus)*. The other processes are paired. One pair, the **superior articular processes** *(processus articulares superiores)* arise from the superior surface of the arch; the other pair, the **inferior articular processes** *(processus articulares inferiores)* project from the inferior surface of the arch; the third pair, the **transverse processes** *(processus transversi)*, extend from the lateral surfaces of the arch (see Figs 24-27).

The superior articular processes have **superior articular facets** *(facies articulares superiores)*; the inferior processes bear similar **inferior articular facets** *(facies articulares inferiores)*. Each vertebra articulates with the adjacent distal vertebra by means of these facets.

CERVICAL VERTEBRAE

The **cervical vertebrae** *(vertebrae cervicales)* (Figs 9-21), seven in number, are characterized by small low bodies (with the exception of the first two vertebrae) which gradually become wider in the direction of the last, seventh vertebra. The superior surface of the body is slightly concave from right to left, while the inferior surface is concave from front to back.

The **vertebral foramen** *(foramen vertebrale)* is wide and almost triangular in shape.

The **articular processes** *(processus articulares)* are relatively short, extend obliquely, and their articular facets are smooth or slightly convex.

The **spines** or **spinous processes** *(processus spinosus)* increase in length gradually from the second to the seventh vertebra. Except in the case of the first and seventh vertebrae the spinous process is bifid and slightly inclined downward.

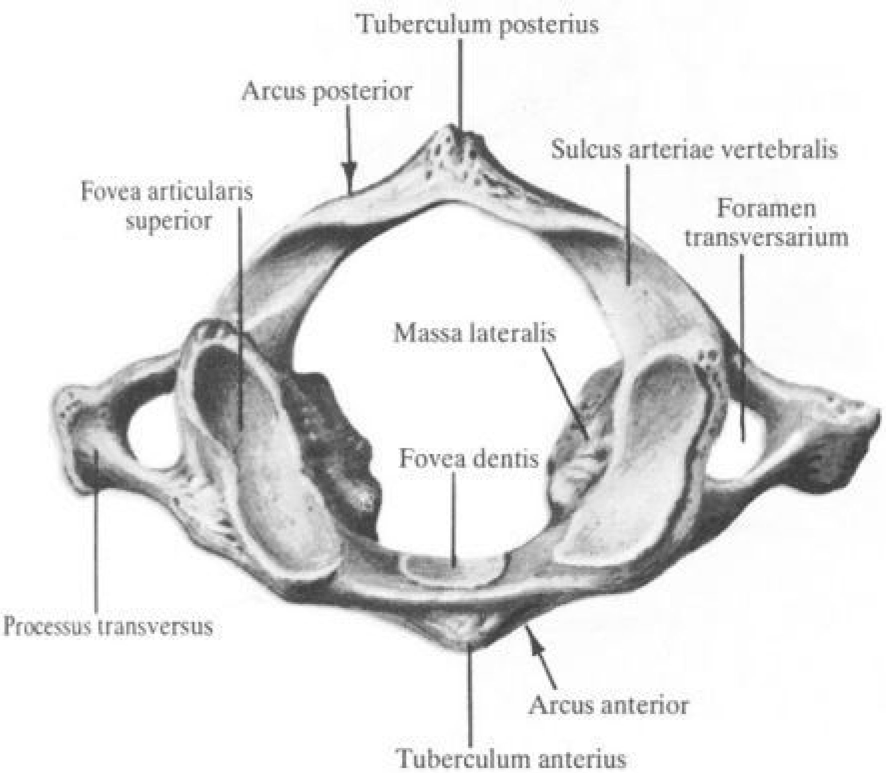
The **transverse processes** *(processus transversus)* are short and project laterally. The superior surface of each process carries a deep **groove for the spinal nerve** *(sulcus nervi spinalis)* (Fig. 13). It separates an **anterior tubercle** from a **posterior tubercle** *(tuberculum anterius* et *tuberculum posterius)* situated on the end of the transverse process.

The sixth vertebra has a particularly developed anterior tubercle. The **common carotid artery** *(arteria carotis communis)* stretches in front of and close to the tubercle and can be pressed to it when haemorrhage occurs. Hence the name **carotid tubercle** *(tuberculum caroticum)*.

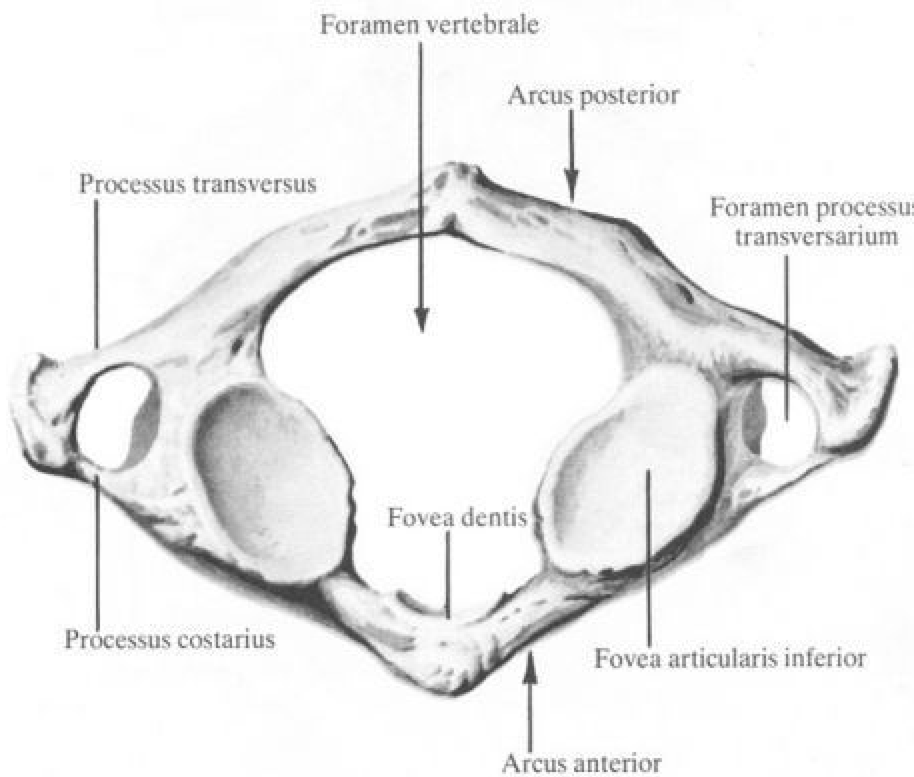
The transverse process of the cervical vertebrae is formed of two processes. The anterior one is the **costal process** *(processus costarius)*, which is a rib rudiment; the posterior one is the **true transverse process** *(processus transversus)*. Together they form the border of the **foramen transversarium** transmitting the vertebral artery, veins, and the attendant sympathetic nerve plexus.

In the cervical spine, the first vertebra, the **atlas**, the second, the **axis**, and the seventh, the **vertebra prominens**, differ from the common type of cervical vertebrae.

The first cervical vertebra, the **atlas** (Figs 10, 11, and 14) has neither a body nor a spine but is a ring formed of two **arches, anterior** and **posterior** *(arcus anterior* et *arcus posterior)*, joined to one another by two more developed **lateral masses** *(massae laterales)*. Each of these masses carries an oval concave **superior articular facet** *(fovea articularis superior)*, on the superior surface for articulation with the occipital bone, and an almost flat **inferior articular facet** *(fovea*



10. *First cervical vertebra (atlas)*; superior aspect ($^1/_1$).



11. *First cervical vertebra (atlas)*; inferior aspect ($^1/_1$).

articularis inferior), on the inferior surface for articulation with the second servical vertebra.

The **anterior arch** *(arcus anterior)* bears an **anterior tubercle** *(tuberculum anterius)* on the anterior surface and a small facet for the **odontoid process** *(fovea dentis)* on the posterior surface which articulates with the dens of the axis.

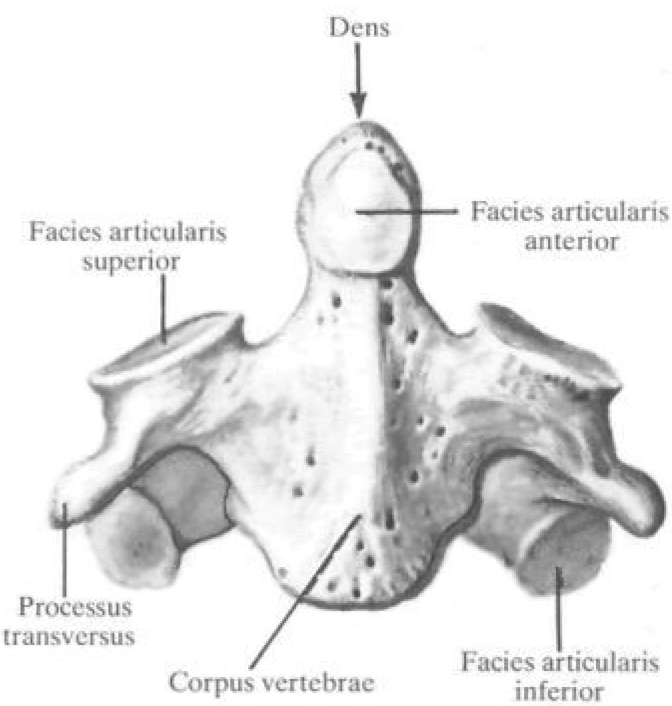
The **posterior arch** *(arcus posterior)* has a **posterior tubercle** *(tuberculum posterius)* representing the spine. On the superior surface of the arch is a **groove for the vertebral artery** *(sulcus arteriae vertebralis)*; the groove is sometimes converted into a canal.

The **second cervical vertebra**, the **axis** (Figs 12–14), carries an **odontoid process** (the *dens*) projecting upward from the body. The atlas together with the skull rotates about the dens like about an axis.

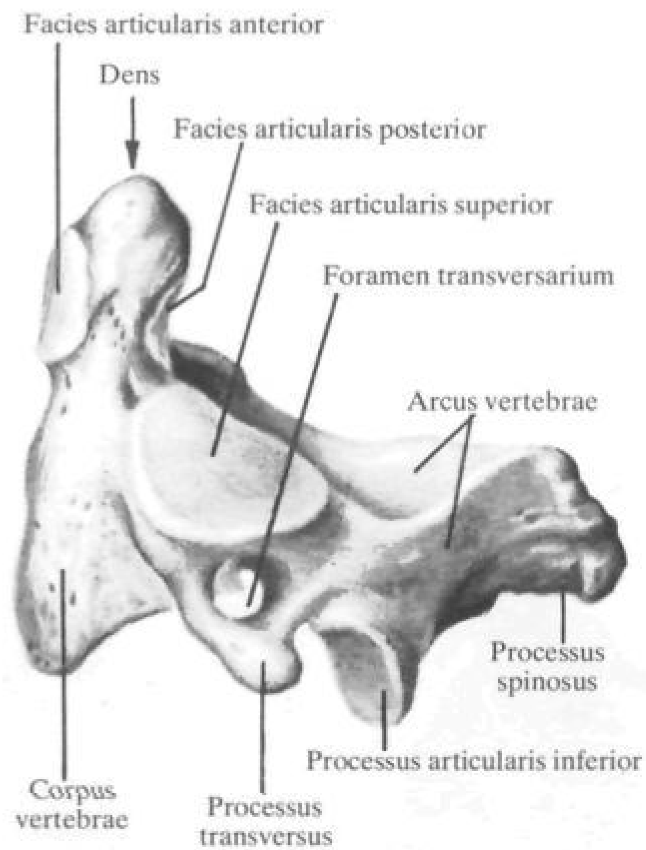
The anterior aspect of the dens carries an **anterior articular facet** *(facies articularis anterior)* for articulation with fovea dentis of the atlas. The posterior surface has a **posterior articular facet** *(facies articularis posterior)*, which the **transverse ligament of the atlas** *(ligamentum transversum atlantis)* adjoins. There are neither anterior and posterior tubercles nor a groove for the spinal nerve on the transverse processes.

The seventh cervical vertebra, **vertebra prominens** (Fig. 19), is distinguished by its long and non-bifid spinous process which is easily palpated under the skin, thus the name. Furthermore, its transverse processes are long, the foramen transversarium is very small (it provides passage for the vertebral vein) and is even absent in some cases.

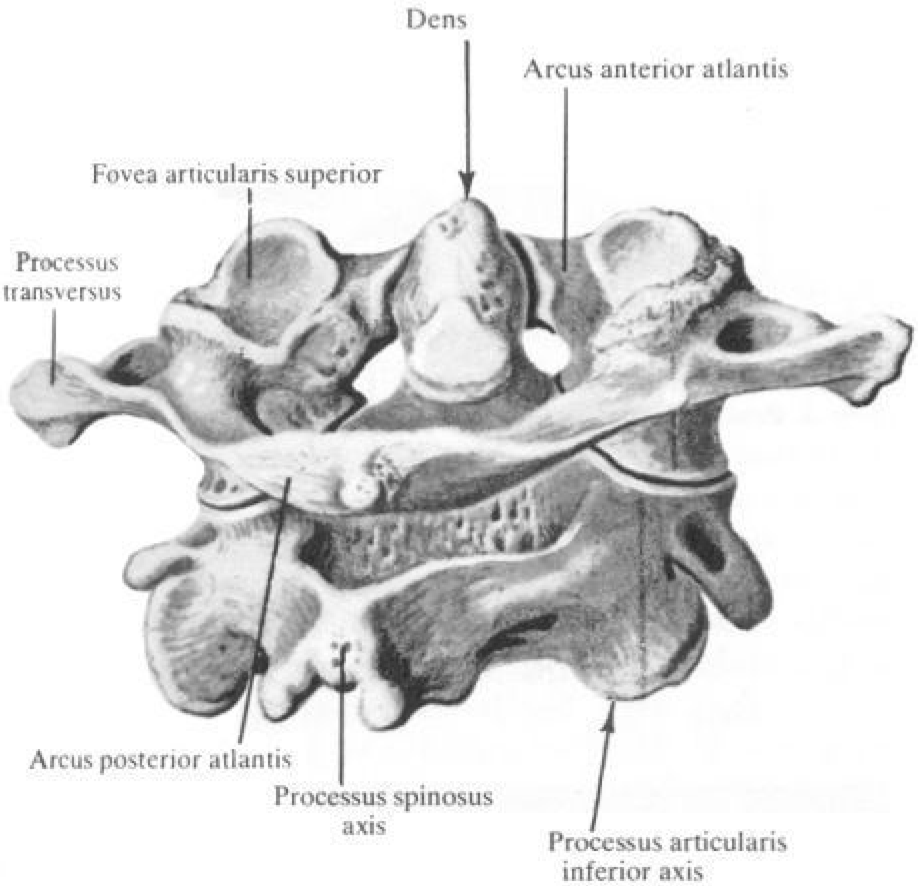
A costal facet *(fovea costalis)*, a mark left by articulation with the head of the first rib, is often present on the lower edge of the lateral surface of the body.



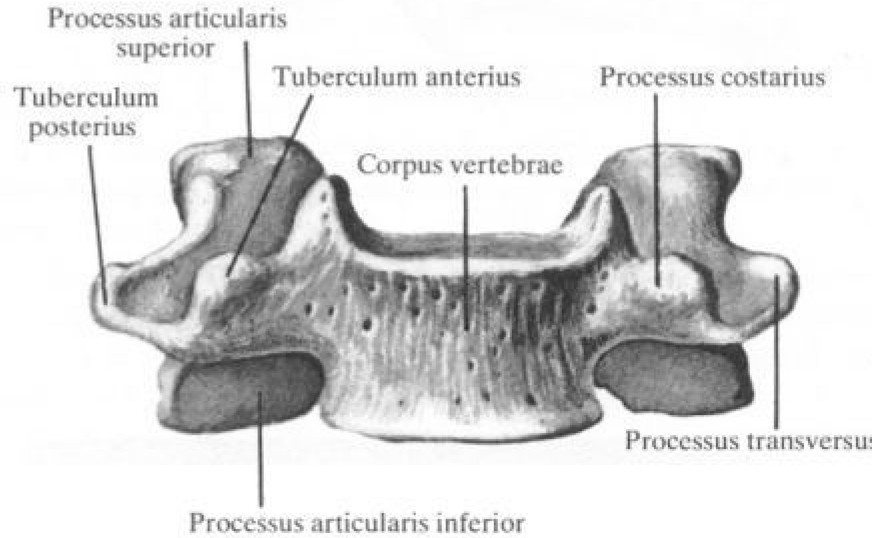
12. *Second cervical vertebra (axis)*; anterior aspect ($^1/_1$).



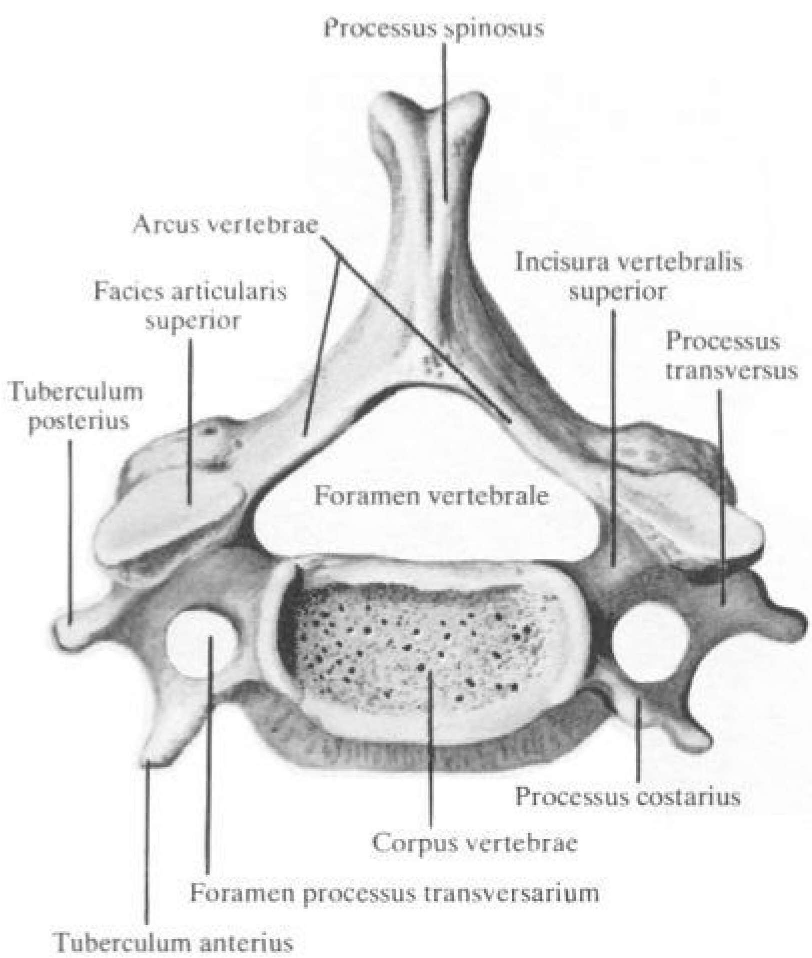
13. *Second cervical vertebra (axis)*; from the left side ($^1/_1$).

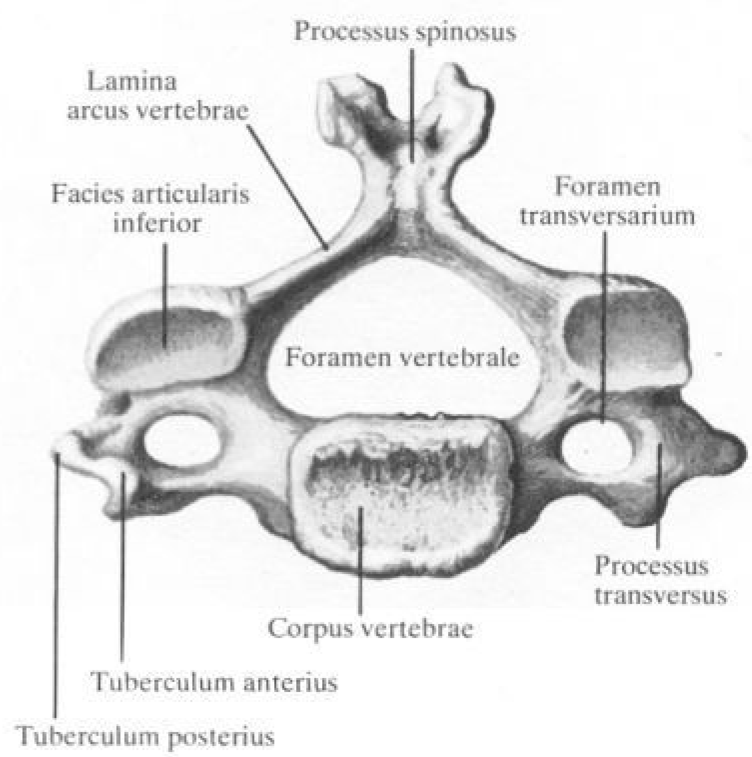


14. *First and second cervical vertebrae*; from the back and right side (1/1).



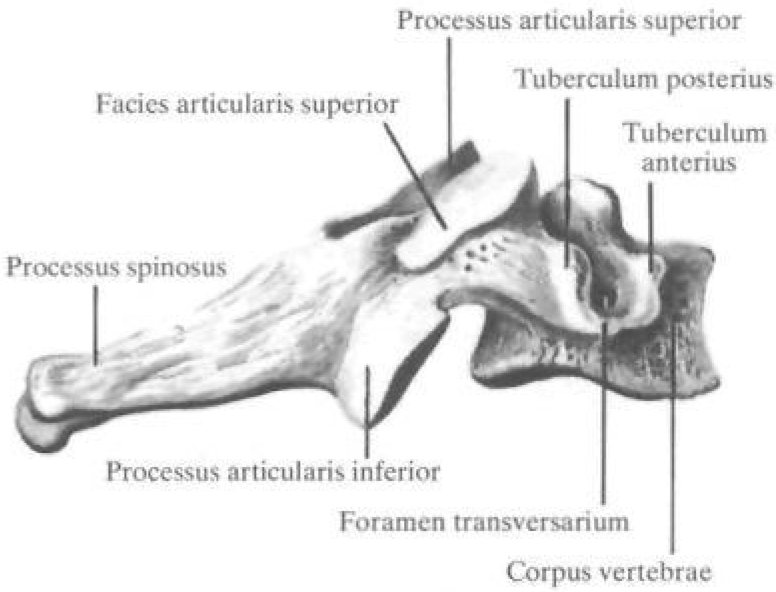
15. *Sixth cervical vertebra (vertebra cervicalis VI)*; anterior aspect (1/1).



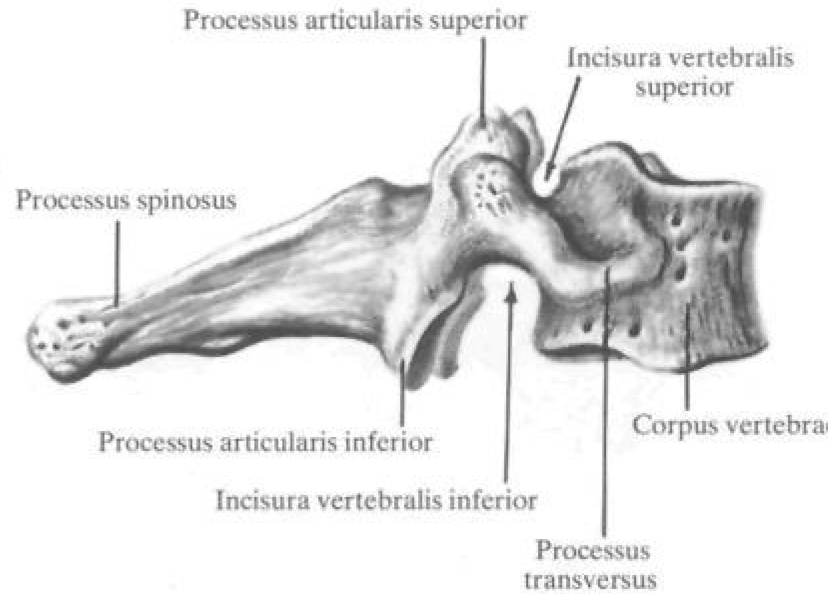


16. *Sixth cervical vertebra (vertebra cervicalis VI)*; superior aspect (1/1).

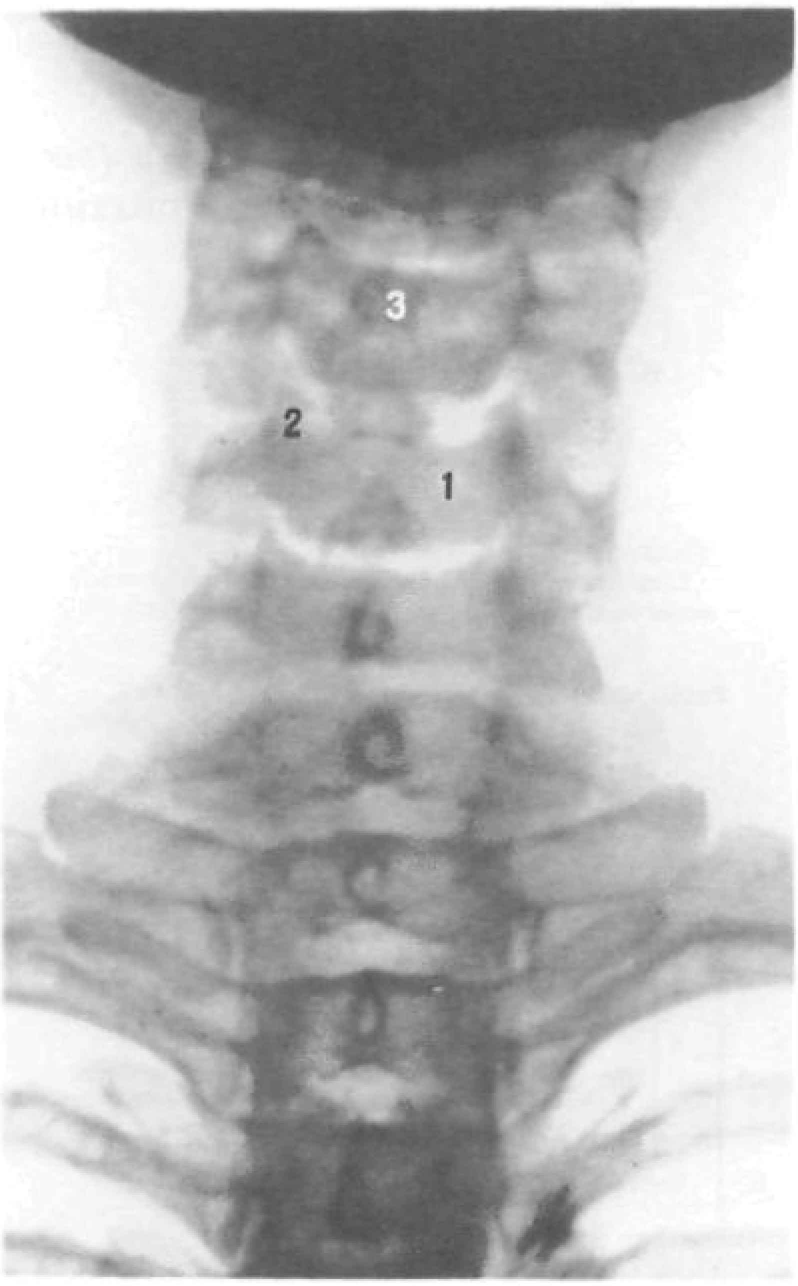
17. *Fourth cervical vertebra (vertebra cervicalis IV)*; inferior aspect (1/1).



18. *Sixth cervical vertebra (vertebra cervicalis VI)*; from the right side ($^1/_1$).

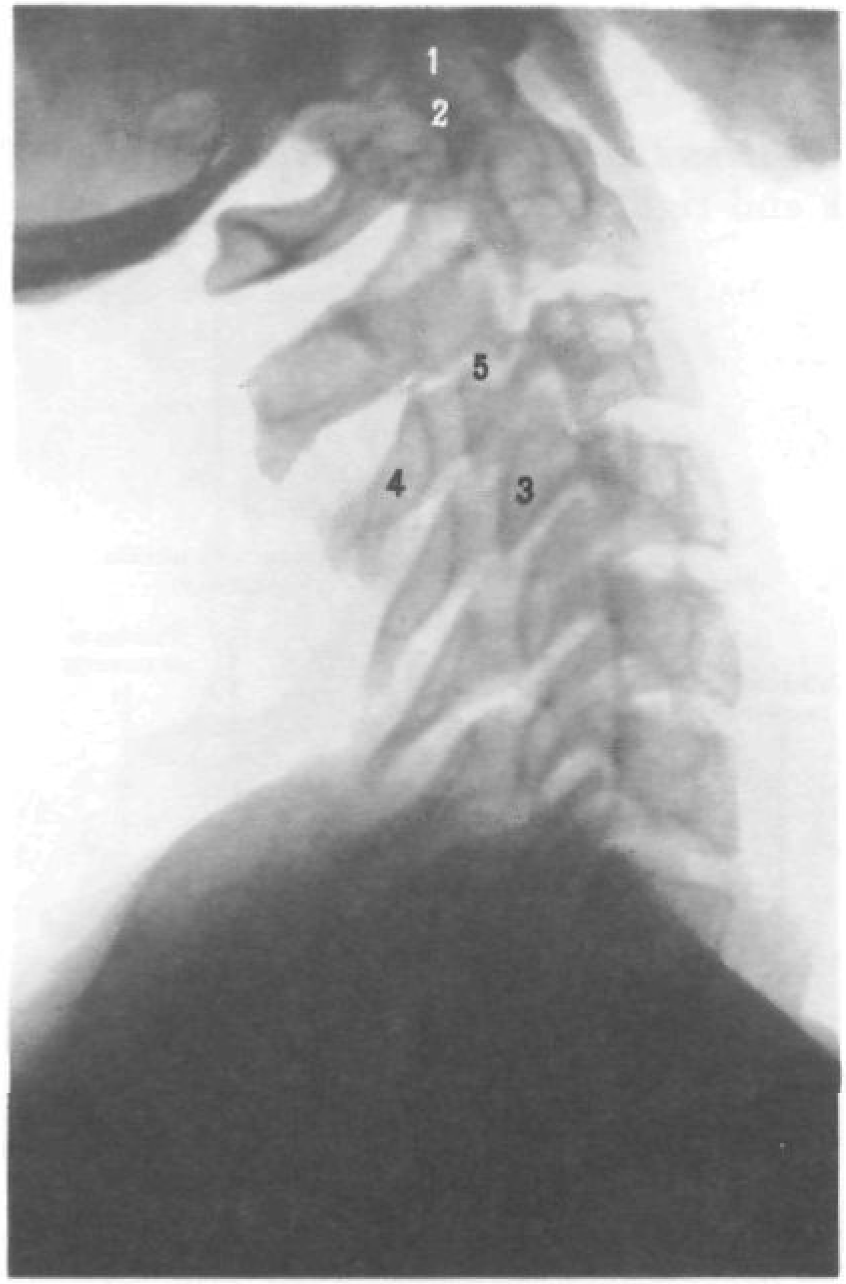


19. *Seventh cervical vertebra (vertebra prominens)*; from the right side ($^1/_1$).



20. *Cervical part of vertebral column* (radiograph).

1—body of fifth cervical vertebra
2—articular process
3—spinous process



21. *Cervical part of vertebral column*; lateral aspect (radiograph).

1—first cervical vertebra
2—second cervical vertebra
3—transverse process
4—spinous process
5—articular process

THORACIC VERTEBRAE

The **thoracic vertebrae** *(vertebrae thoracicae)* (Figs 9, 22-25), 12 in number, are much higher and thicker than the cervical vertebrae; their bodies gradually increase in size downwards toward the lumbar vertebrae.

The posterolateral surface of the body carries two facets, the **superior costal facet** *(fovea costalis superior)*, and the **inferior costal facet** *(fovea costalis inferior)*. The inferior facet of one vertebra joins the superior facet of the adjacent distal vertebra to form a complete articular facet, the site of articulation with the head of the rib. The body of the first thoracic vertebra is an exception; it has a complete costal facet for articulation with the head of the first rib on the superior part of the posterolateral surface and a semifacet for articulation with the head of the second rib on the inferior part. The tenth vertebra has one semifacet on the superior edge of the body. The bodies of the eleventh and twelfth vertebrae each bear only one complete costal facet in the middle of each lateral surface.

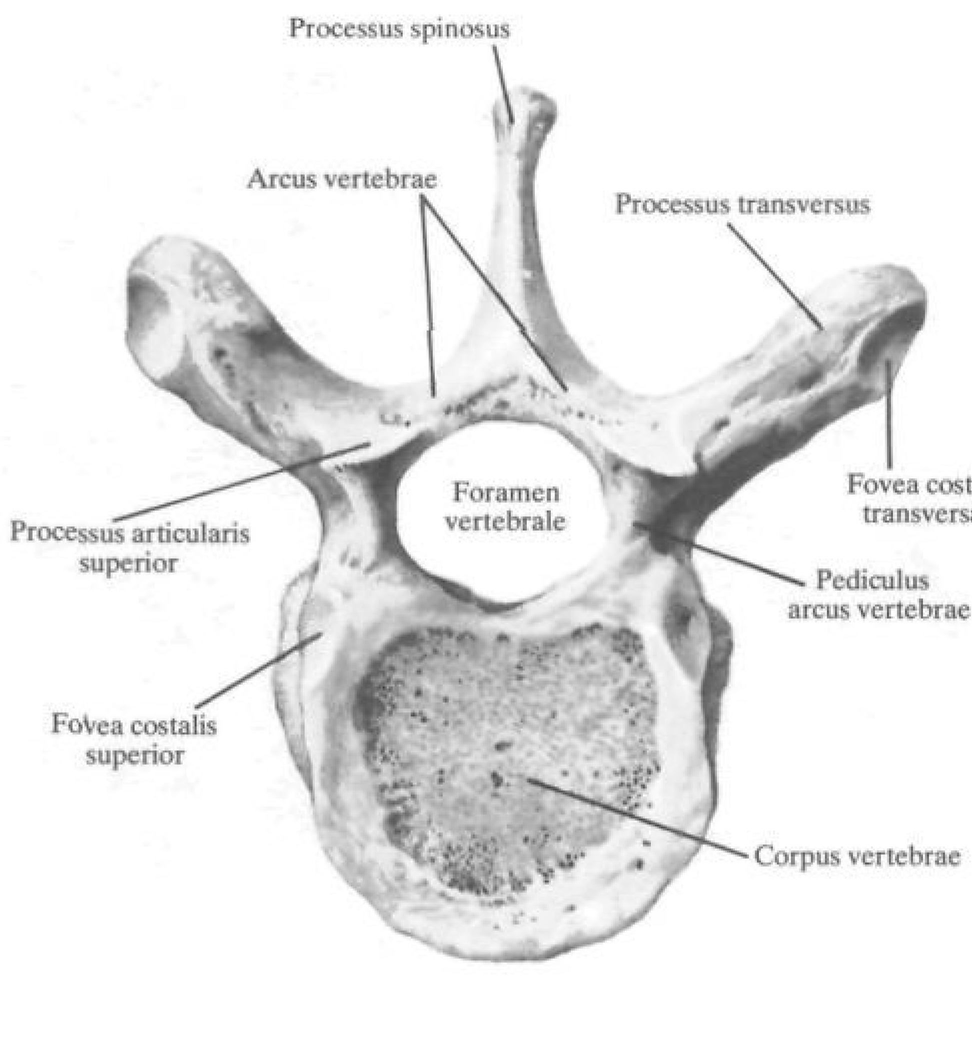
The arches of the thoracic vertebrae form nearly circular vertebral foramina which are, however, relatively smaller than those of the cervical vertebrae.

The transverse process extends laterally and a little to the back and carries a small **costal facet** *(fovea costalis transversalis)* for articulation with the tubercle of the rib.

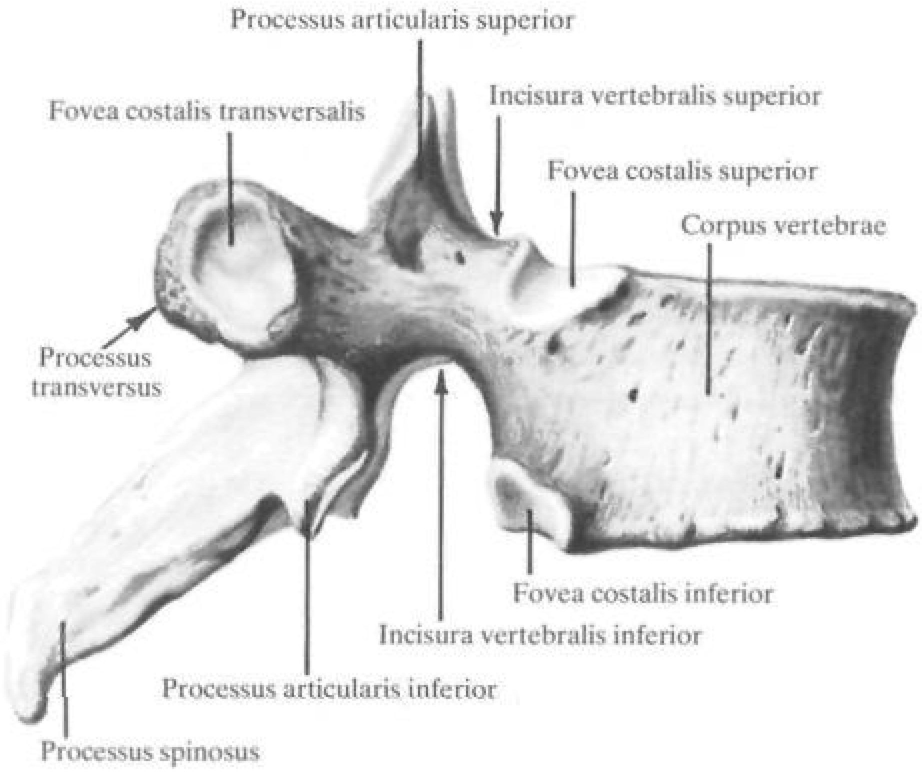
The articular surface of the articular processes lies in the frontal plane and faces backwards on the superior process but forwards on the inferior process.

The spinous processes are long, three-sided, pointed, and slope downwards. Those of the middle thoracic vertebrae fit one over the other like tiles.

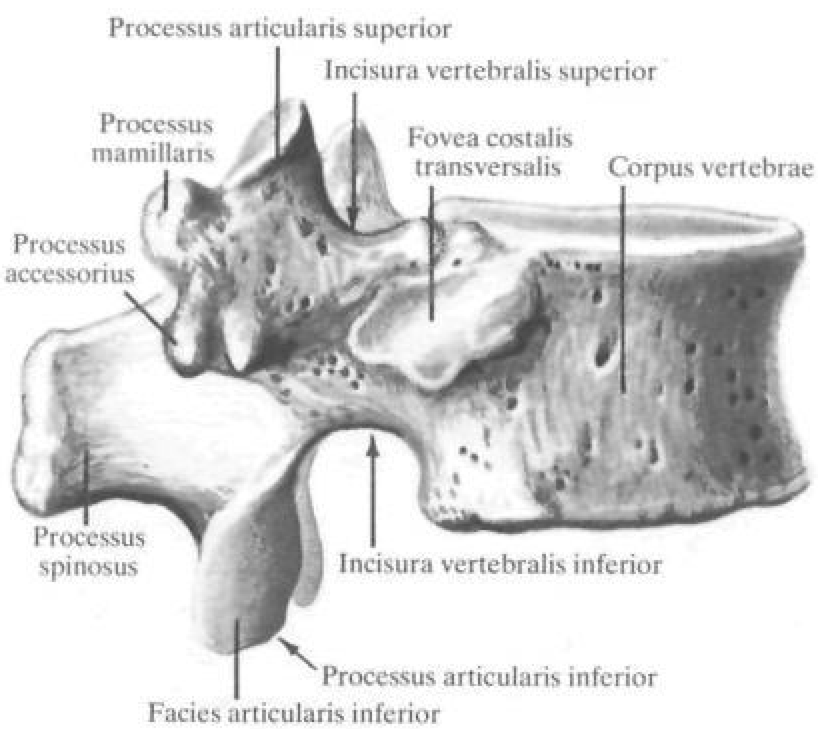
The lower thoracic vertebrae are shaped more like the lumbar vertebrae. The transverse processes of the twelfth thoracic vertebra have on their posterior surface an **accessory process** *(processus accessorius)* and a **mamillary process** *(processus mamillaris)*.



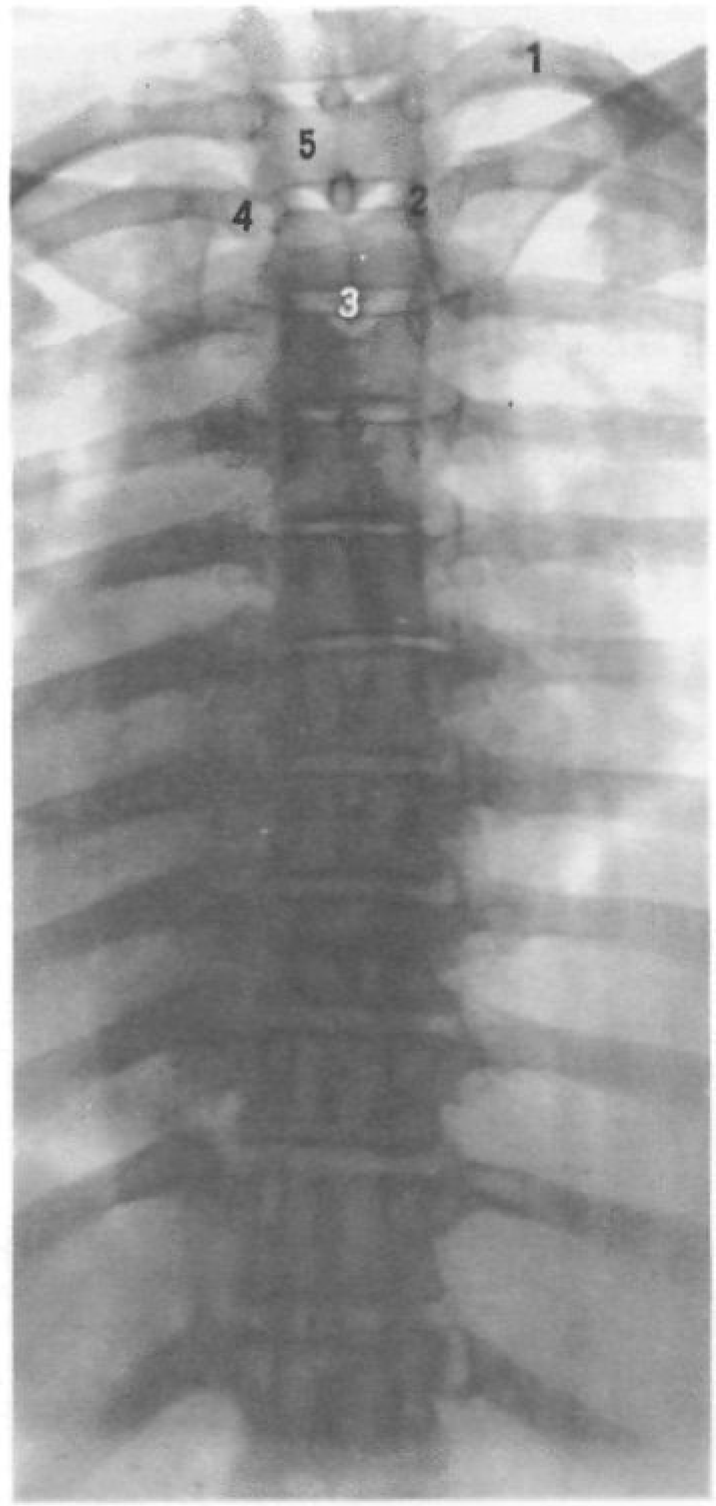
22. *Eighth thoracic vertebra (vertebra thoracica VIII)*; superior aspect ($^1/_1$).



23. *Eighth thoracic vertebra (vertebra thoracica VIII)*; from the right side ($^1/_1$).



24. *Twelfth thoracic vertebra (vertebra thoracica XII)*; from the right side ($^1/_1$).



25. *Thoracic part of vertebral column* (radiograph).

1—first rib
2—costal facet
3—spinous process
4—transverse process
5—body of first thoracic vertebra

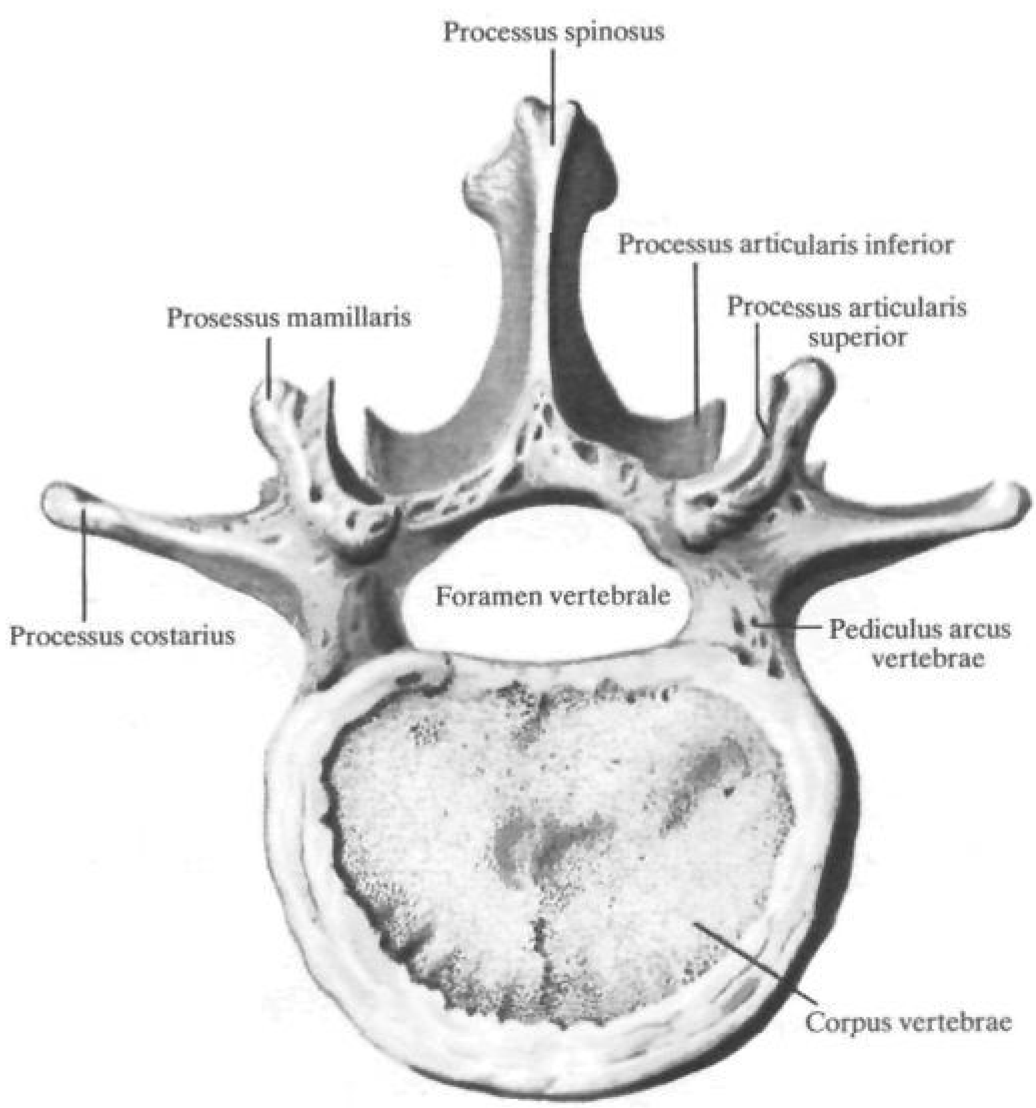
LUMBAR VERTEBRAE

The **lumbar vertebrae** *(vertebrae lumbalis)* (Figs 9, 26–29), five in number, are distinguished from other vertebrae by their large size. The body of these vertebrae is bean-shaped, the arches are strongly developed, and the vertebral foramen is larger than in the thoracic segment and is shaped like an irregular triangle.

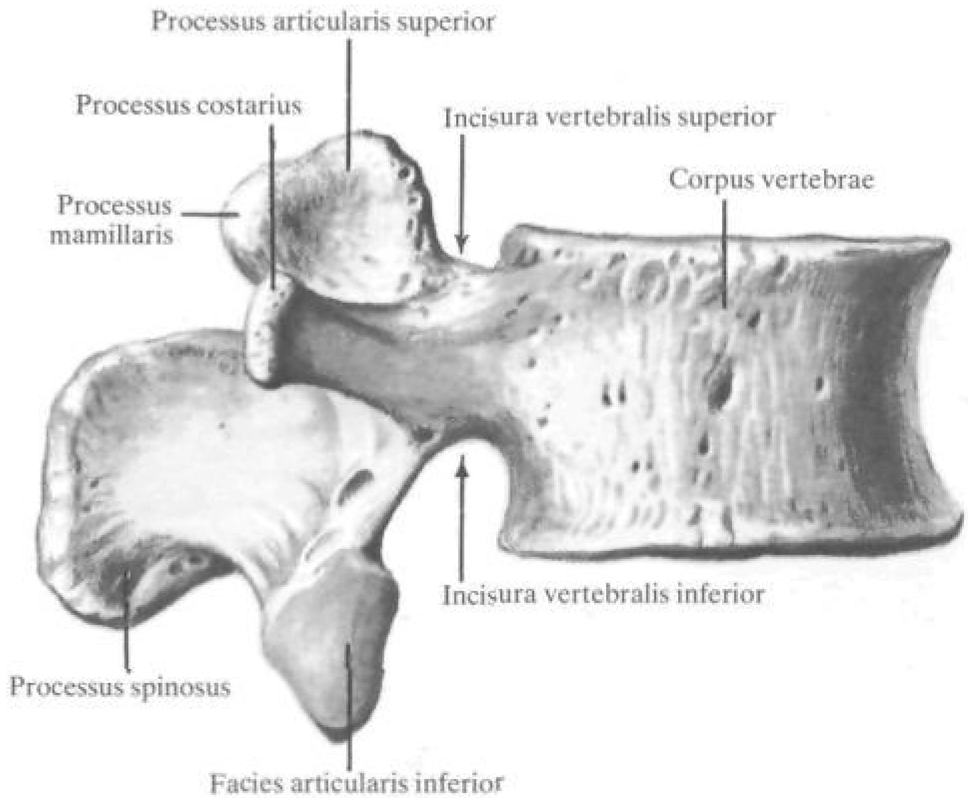
Each transverse process is in front of the articular process; it is compressed from front to back, and projects laterally and a little to the back. Its greater part is a rudiment of the rib and is therefore called the **costal process** *(processus costarius)*. On the posterior surface of the base of the costal surface is a slightly detectable **accessory process** *(processus accessorius)*, which is a rudiment of the transverse process.

The spinous process is short and wide, thickened and rounded at the end. The articular processes arise from the arch, project to the back of the transverse process almost vertically. The articular surfaces lie in the sagittal plane; the superior facet is concave and faces medially, while the inferior surface is convex and faces laterally.

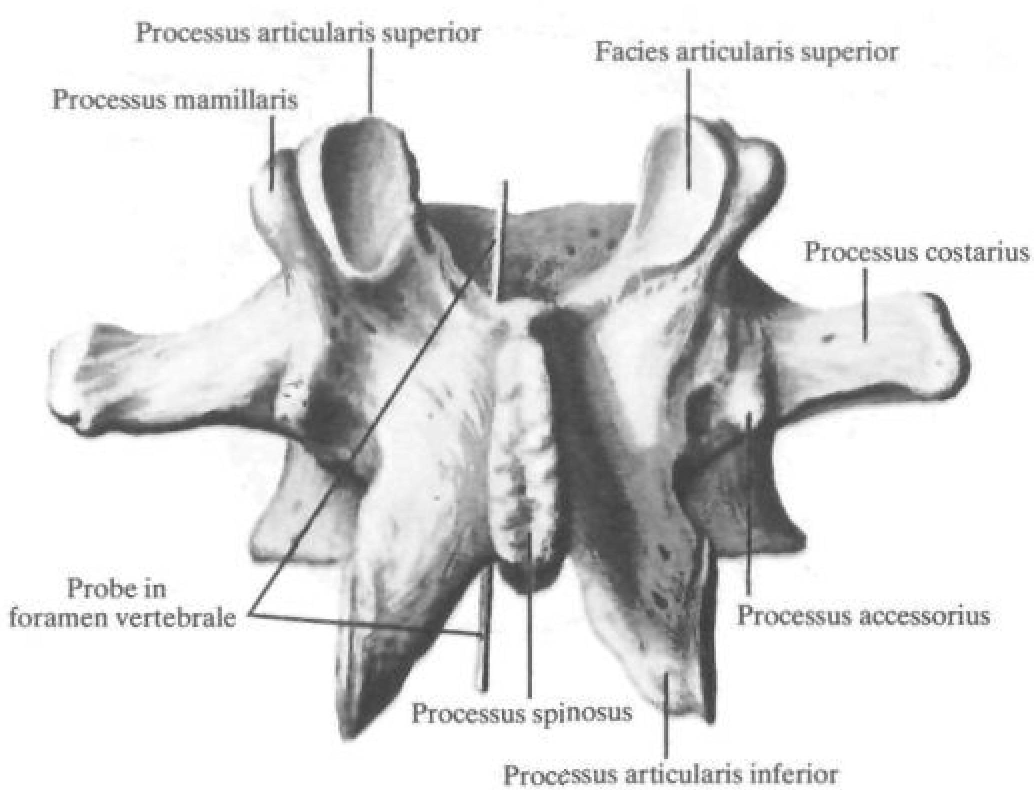
Upon articulation of two adjacent vertebrae, the superior articular processes of one vertebra embrace the sides of the inferior articular processes of the other. The superior articular process bears a small **mamillary process** *(processus mamillaris)* on its posterolateral edge, the site of insertion of muscles.



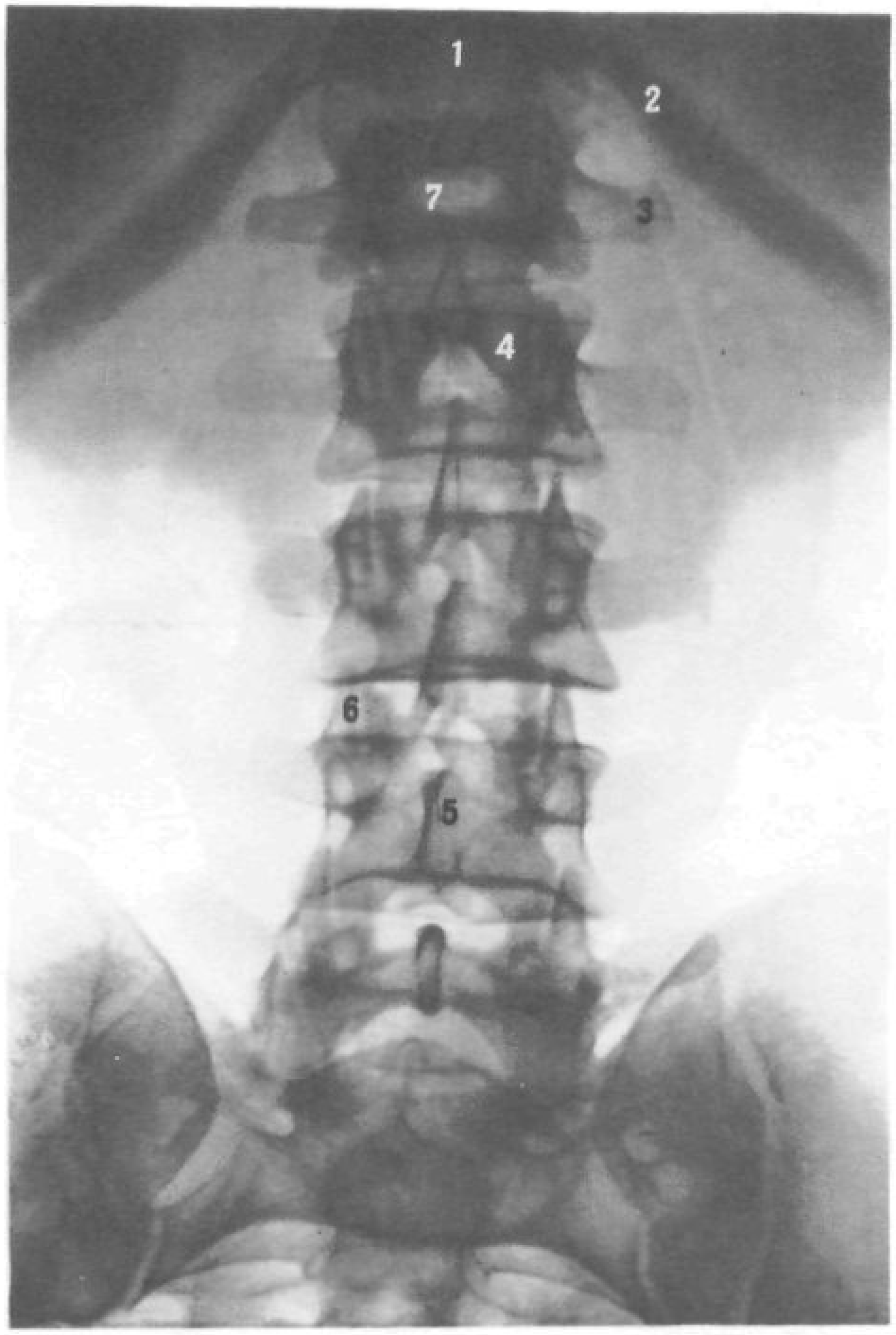
26. *Third lumbar vertebra (vertebra lumbalis III)*; superior aspect ($^1/_1$).



27. *Third lumbar vertebra (vertebra lumbalis III)*; from the right side ($^1/_1$).



28. *Third lumbar vertebra (vertebra lumbalis III)*; posterior aspect ($^1/_1$).



29. *Lumbar segment of vertebral column* (radiograph);

1—twelfth thoracic vertebra
2—twelfth rib
3—costal process
4 and 6—articular process
5—spinous process
7—first lumbar vertebra

THE SACRUM

In an adult the **sacral vertebrae** *(vertebrae sacrales)* five in number, are fused to form a single bone, the sacrum.

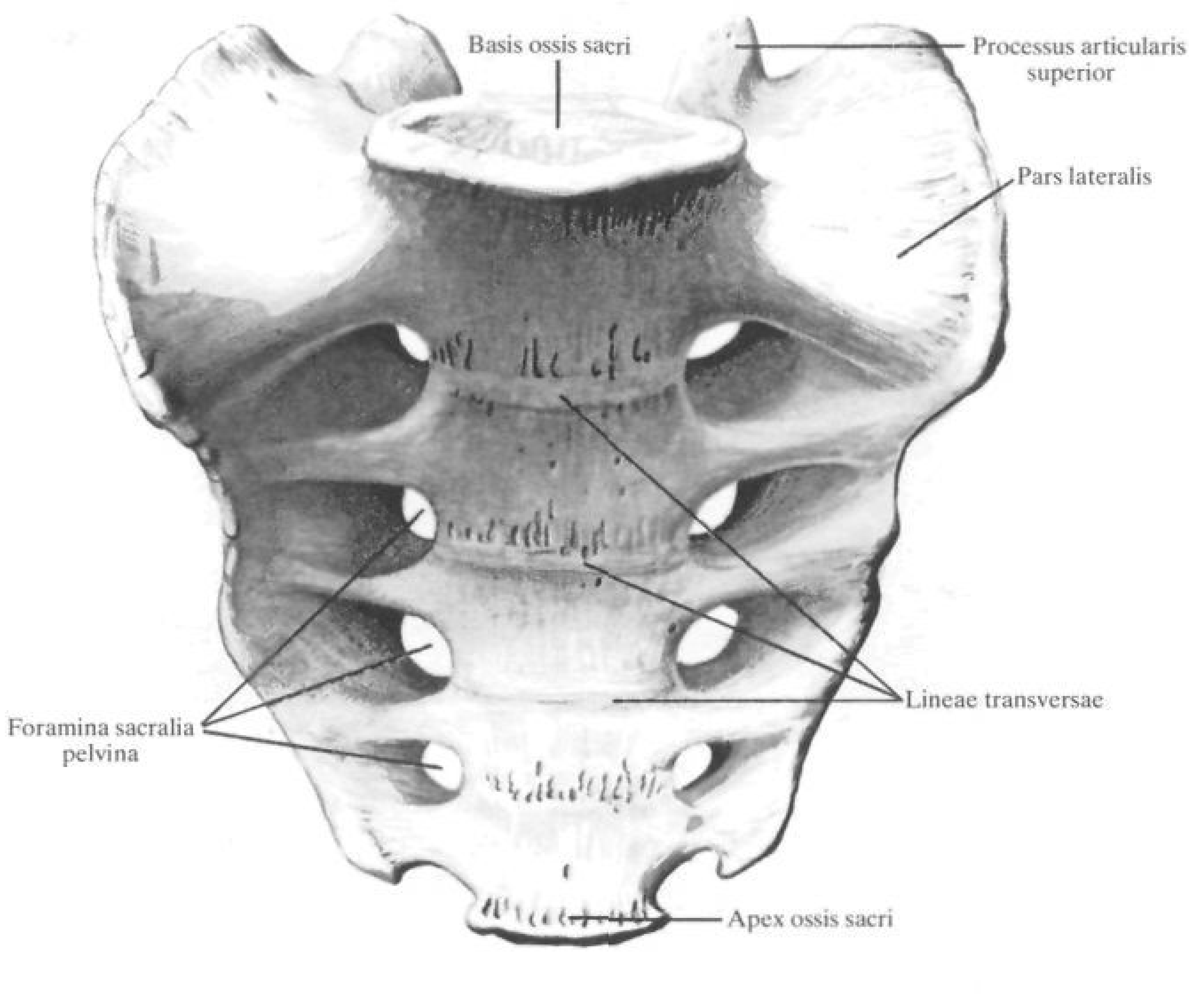
The **sacrum** *(os sacrum)* (Figs 9 and 30–35) is wedge-shaped; it is located below the last lumbar vertebra and contributes to the formation of the posterior wall of the true pelvis. The anterior and posterior surfaces, two lateral borders, a base (with the wide part directed upwards), and an apex (with the narrow part directed downwards) are distinguished in the sacrum. A curved **sacral canal** *(canalis sacralis)* runs through the bone from base to apex (Figs 33–35).

The anterior surface of the sacrum is smooth and concave and faces the pelvic cavity, thus it is called the **pelvic surface** *(facies pelvina).* It has traces of fusion of the bodies of the five sacral vertebrae in the form of four parallel **transverse ridges** *(lineae transversae).* Laterally to these ridges on each side are four **anterior sacral foramina** *(foramina sacralis pelvina)*, which lead posteriorly and medially into the cavity of the sacral canal (they transmit the anterior rami of the sacral spinal nerves and the attendant vessels).

The **dorsal sacral surface** *(facies dorsalis)* (Fig. 31) is convex longitudinally, narrower than the pelvic surface, and rough. It carries five bony tubercles descending one after another. They are formed from fusion of the spinous, transverse, and articular processes of the sacral vertebrae.

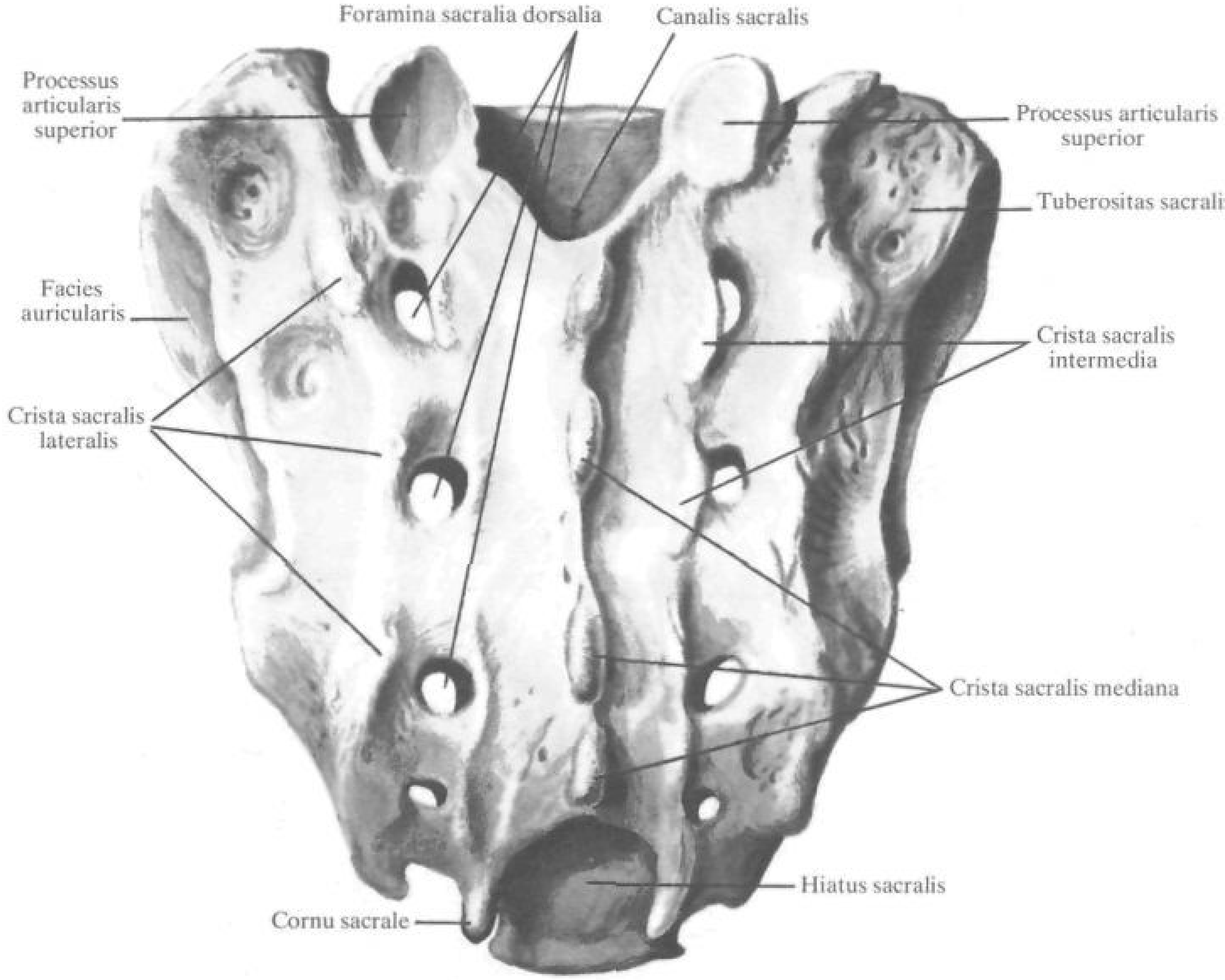
The **spinous tubercles of the sacrum** *(crista sacralis mediana)* are formed as the result of fusion of the spinous processes of the sacral vertebrae and are represented by four tubercles one above the other, sometimes fused to form a single rough crest.

On both sides and lateral to the crista mediana and almost parallel to it stretches a weakly pronounced **articular tubercle of sacrum** *(crista sacralis intermedia)*; it is formed by fusion of the superior and inferior articular processes. Still laterally on each side is a well pronounced series of **transverse tubercles** *(crista sacralis lateralis)*,



30. *Sacrum (os sacrum)*; anterior aspect ($^3/_5$).

(Pelvic surface.)



31. *Sacrum (os sacrum)*; posterior aspect ($^3/_5$).
(Dorsal surface.)

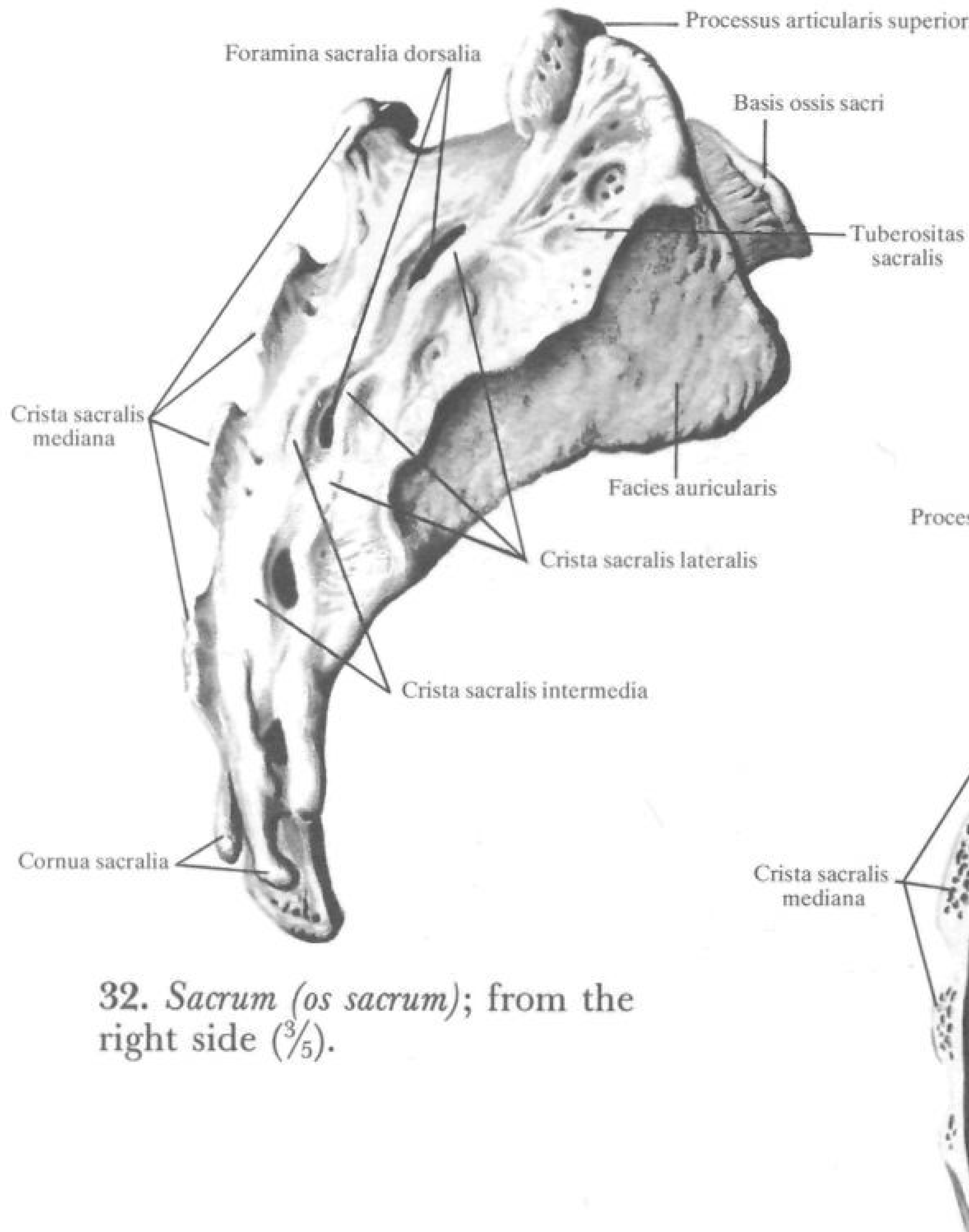
which are formed from fusion of the transverse processes. On each side between the articular and transverse tubercles there are four **dorsal sacral foramina** *(foramina sacralis dorsalia).* They are somewhat smaller than the corresponding pelvic sacral foramina and transmit the posterior rami of the sacral nerves.

The **sacral canal** *(canalis sacralis)* runs along the entire length of the sacrum; it curves and is wider on top and narrower downwards. It is a direct downward continuation of the spinal canal. The sacral canal communicates with the sacral foramina anteriorly and posteriorly via **intervertebral foramina** *(foramina intervertebralia)* lying in the bone.

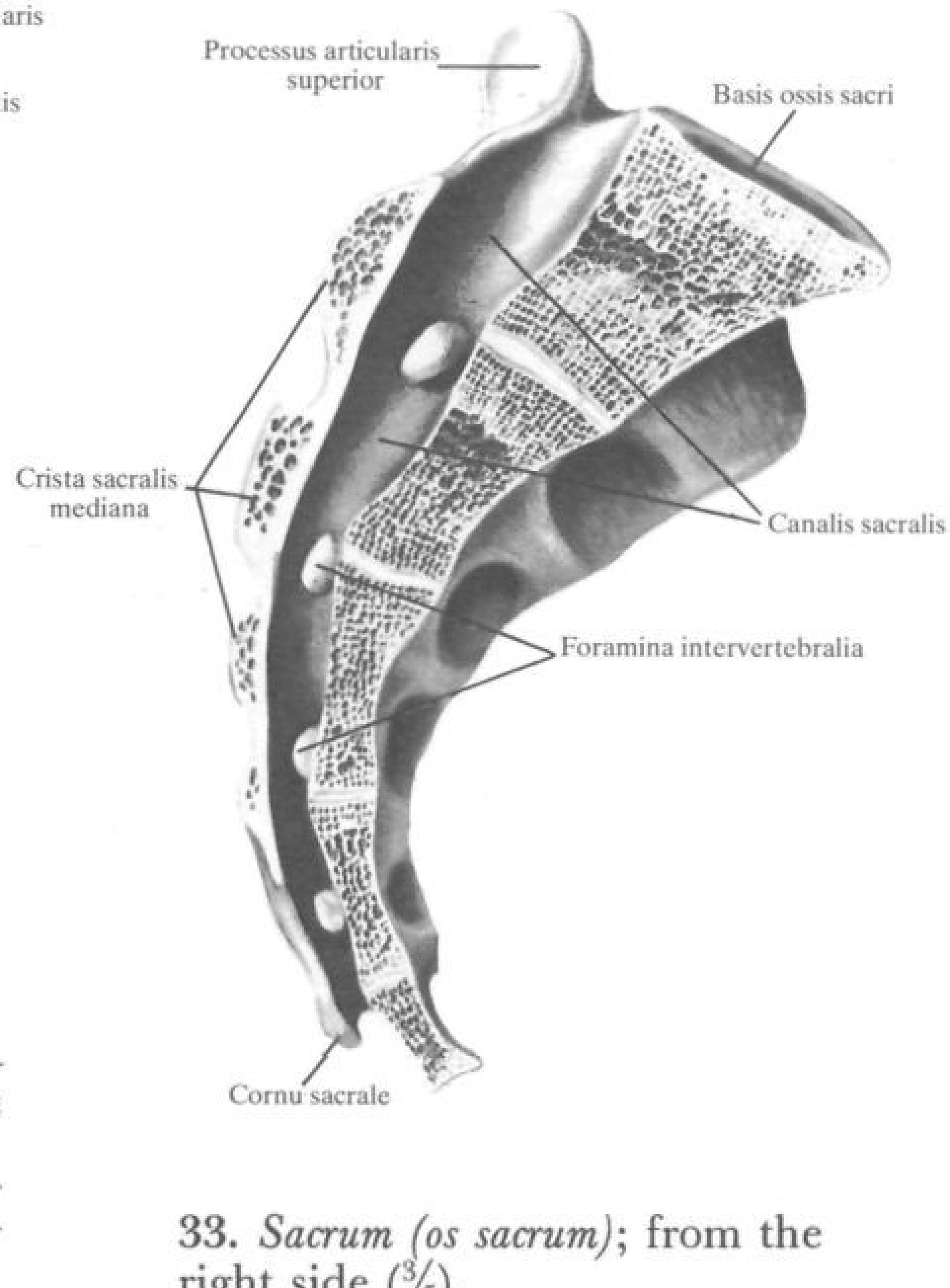
The **base of the sacrum** *(basis ossis sacri)* (Figs 30 and 35) carries a transverse-oval depression for articulation with the inferior surface of the body of the fifth lumbar vertebra. At the site of the articulation the anterior border of the base projects markedly into the pelvic cavity to form the **promontory** *(promontorium).* The **superior articular processes** *(processus articulares superiores)* of the first sacral vertebra project upward from the posterior part of the sacral base. Their **superior articular facets** *(facies articulares superiores)* face backwards and medially and articulate with the inferior articular processes of the fifth lumbar vertebra. The entry into the sacral canal is bounded by the posterior border of the base (arch) of the sacrum with the superior articular processes projecting from it.

The **apex of the sacrum** *(apex ossis sacri)* is narrow, blunt, and has a small oval surface for articulation with the superior surface of the coccyx. Here is the **sacrococcygeal joint** *(junctura sacrococcygea)* (symphysis) (see Fig. 9).

Behind the apex, on the posterior surface of the sacrum, the articular tubercles terminate as two small downward projections, the **sacral cornua** *(cornua sacralia).* The posterior surface of the apex and the sacral cornua form the borders of the opening of the sacral canal, the **sacral hiatus** *(hiatus sacralis).*



32. *Sacrum (os sacrum)*; from the right side ($^3/_5$).



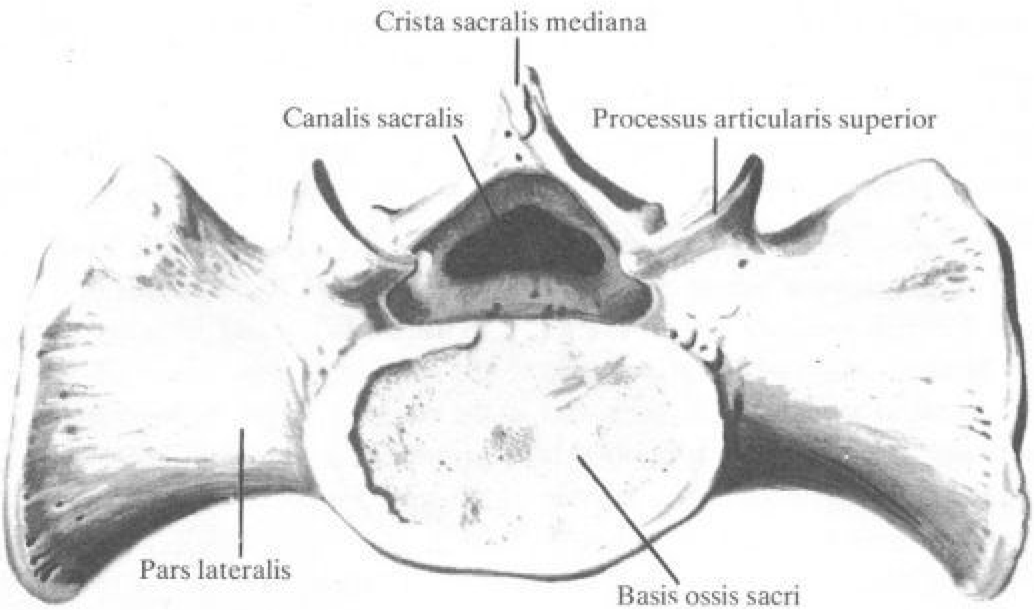
33. *Sacrum (os sacrum)*; from the right side ($^3/_5$).
(Median longitudinal section.)

The superolateral part of the sacrum, **lateral mass** *(pars lateralis)*, is formed by fusion of the transverse processes of the sacral vertebrae.

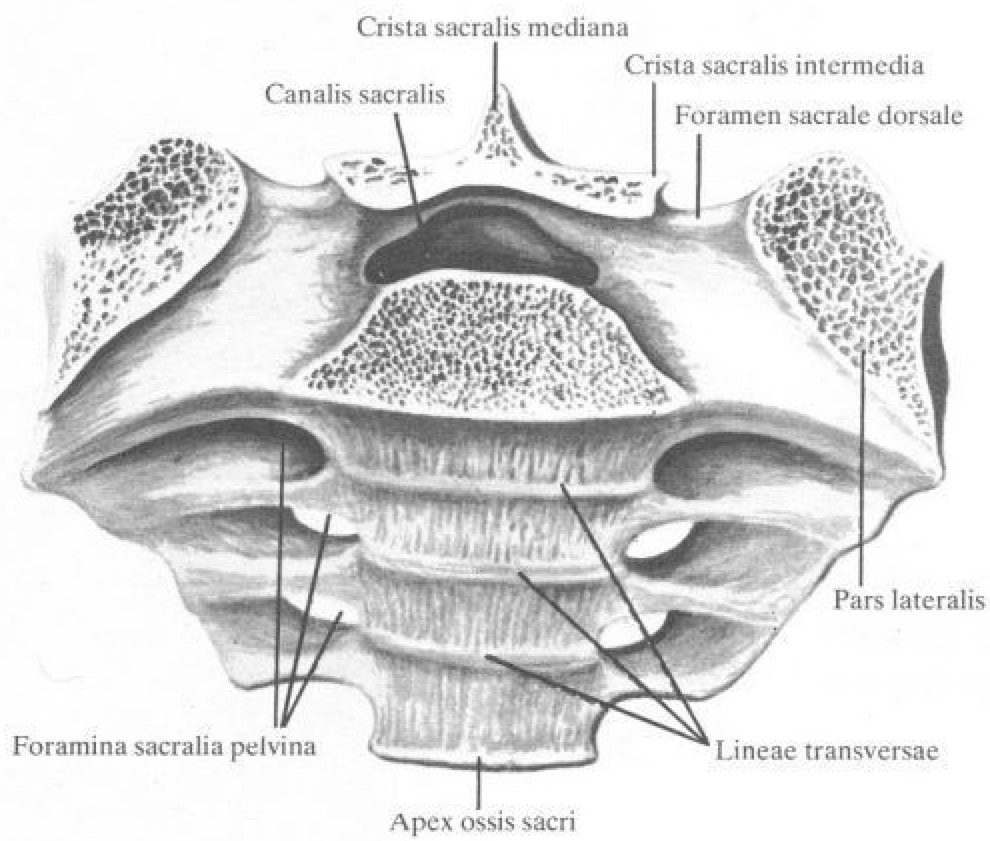
The lateral surface of these parts (Fig. 32) has an articular **auricular surface** *(facies auricularis)*, which articulates with the auricular surface of the ilium (see *The Bones of the Pelvic Girdle*).

To the back and medially of the auricular surface is a well pronounced **sacral tuberosity** *(tuberositas sacralis)*, the site of attachment of the interosseous sacro-iliac ligaments.

The sacrum of a male is longer, narrower, and more curved than that of a female.



34. *Sacrum (os sacrum)*; superior aspect (3/5).



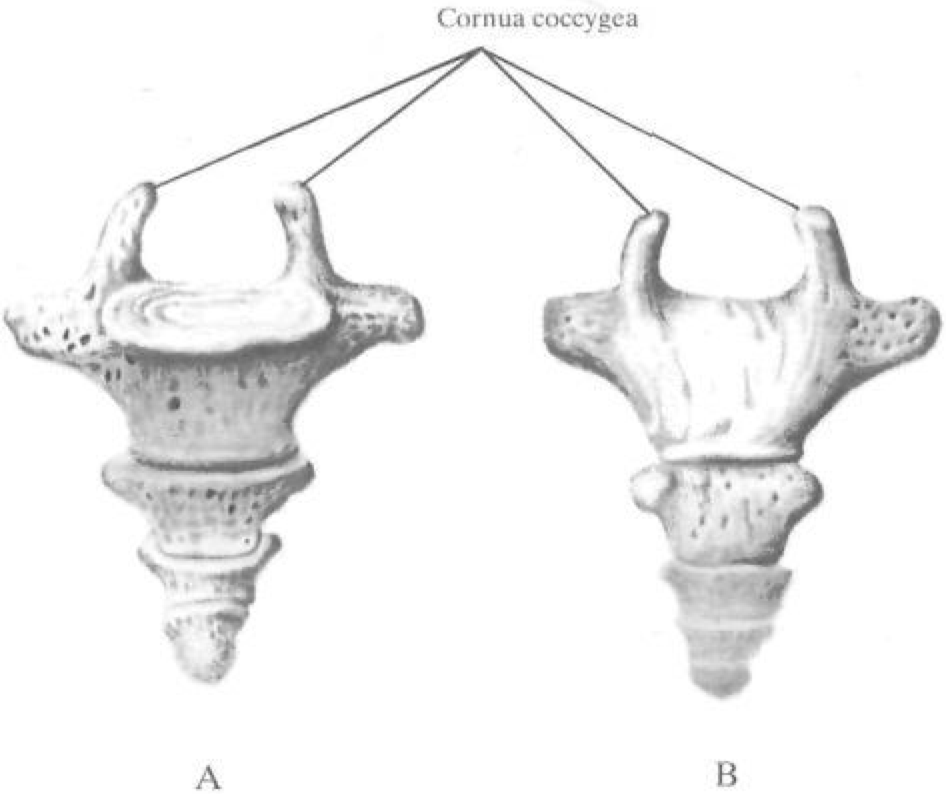
35. *Sacrum (os sacrum)* (3/5).
(Horizontal section through the second sacral vertebra.)

THE COCCYX

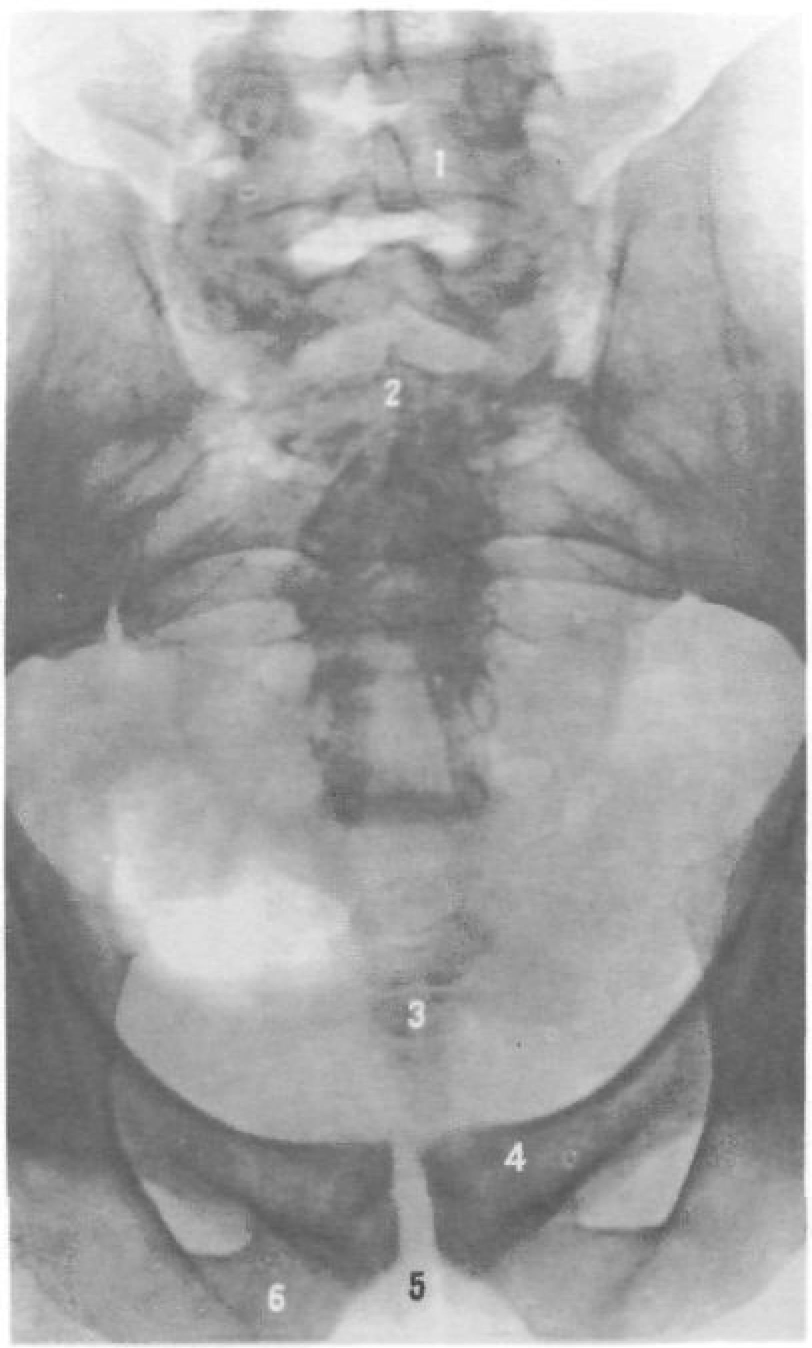
The **coccygeal vertebrae** *(vertebrae coccygeae)*, four or five and less frequently three or six in number, fuse in the adult to form the coccyx.

The **coccyx** *(os coccygis)* (Figs 9, 36 and 37) has the shape of a curved pyramid the base of which faces upwards and the apex downwards. The vertebrae forming it possess only bodies. On each side of the first coccygeal vertebra are the remnants of the superior articular processes in the form of small projections, **coccygeal cornua** *(cornua coccygea)*, extending upwards and articulating with the sacral cornua.

The superior surface of the coccyx has a slightly concave area which articulates with the apex of the sacrum by means of the **sacrococcygeal joint** *(junctura sacrococcygea)*.



36. *Coccyx (os coccygis)* (1/1).
A—anterior aspect;
B—posterior aspect.



37. *Sacral and coccygeal parts of vertebral column* (radiograph).

1—fifth lumbar vertebra
2—sacrum
3—coccyx
4—pubic bone
5—pubic arch
6—ischial bone

THE RIBS

The **ribs** *(costae)* (Figs 38–41) are narrow, curved strips of bone differing in length. There are twelve pairs of them arranged symmetrically on both sides of the thoracic segment of the vertebral column.

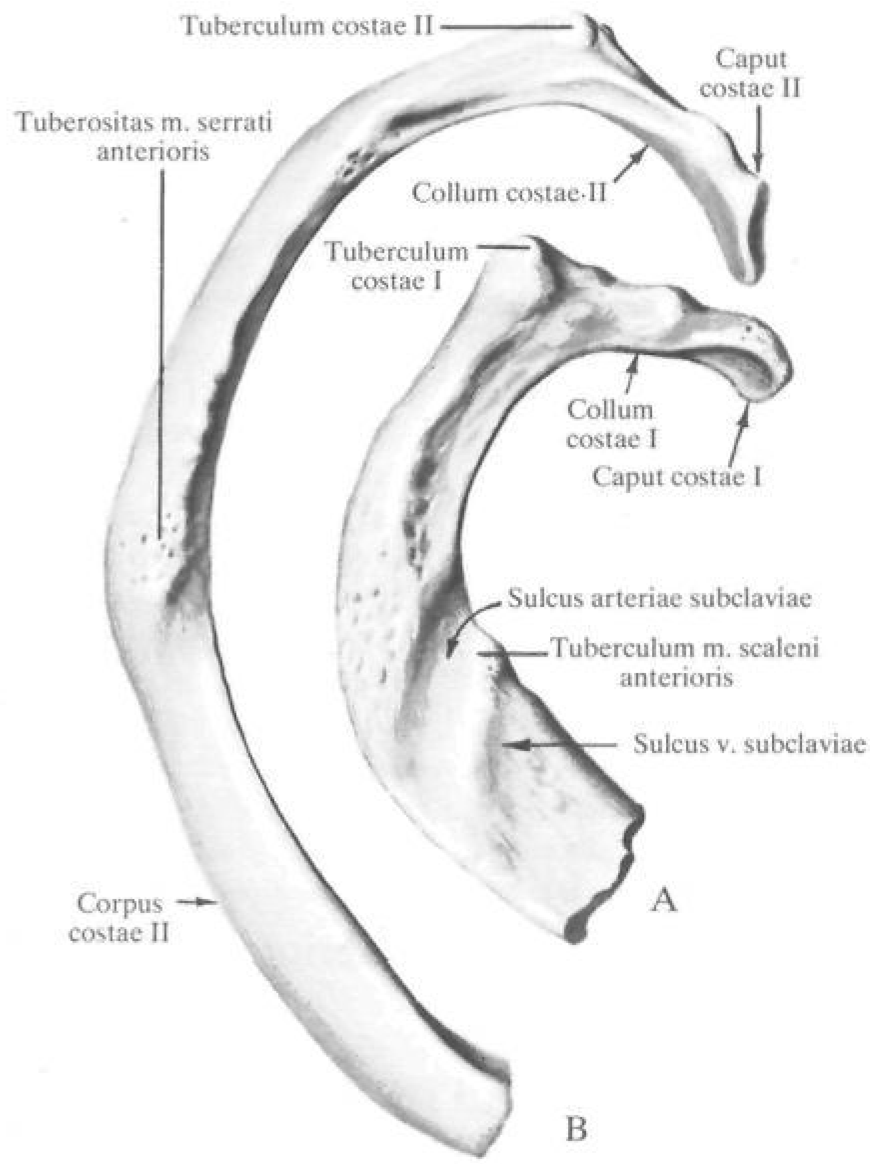
Each rib has a long **bony part** *(os costale)*, a short cartilaginous part, the **costal cartilage** *(cartilago costalis)*, and two **ends**, an **anterior** or **sternal**, and a **posterior** or **vertebral**.

The bony part of the rib has a head, neck, and a body, or shaft. The **head of the rib** *(caput costae)* is at the vertebral end of the rib and is a thickened part carrying the **articular facet of the head of the rib** *(facies articularis capitis costae)*. From the second to tenth rib this facet is separated by a horizontal **crest of the head of the rib** *(crista capitis costae)* into a smaller, superior, and a larger, inferior, part, each articulating correspondingly with the costal facets of the two adjacent vertebrae.

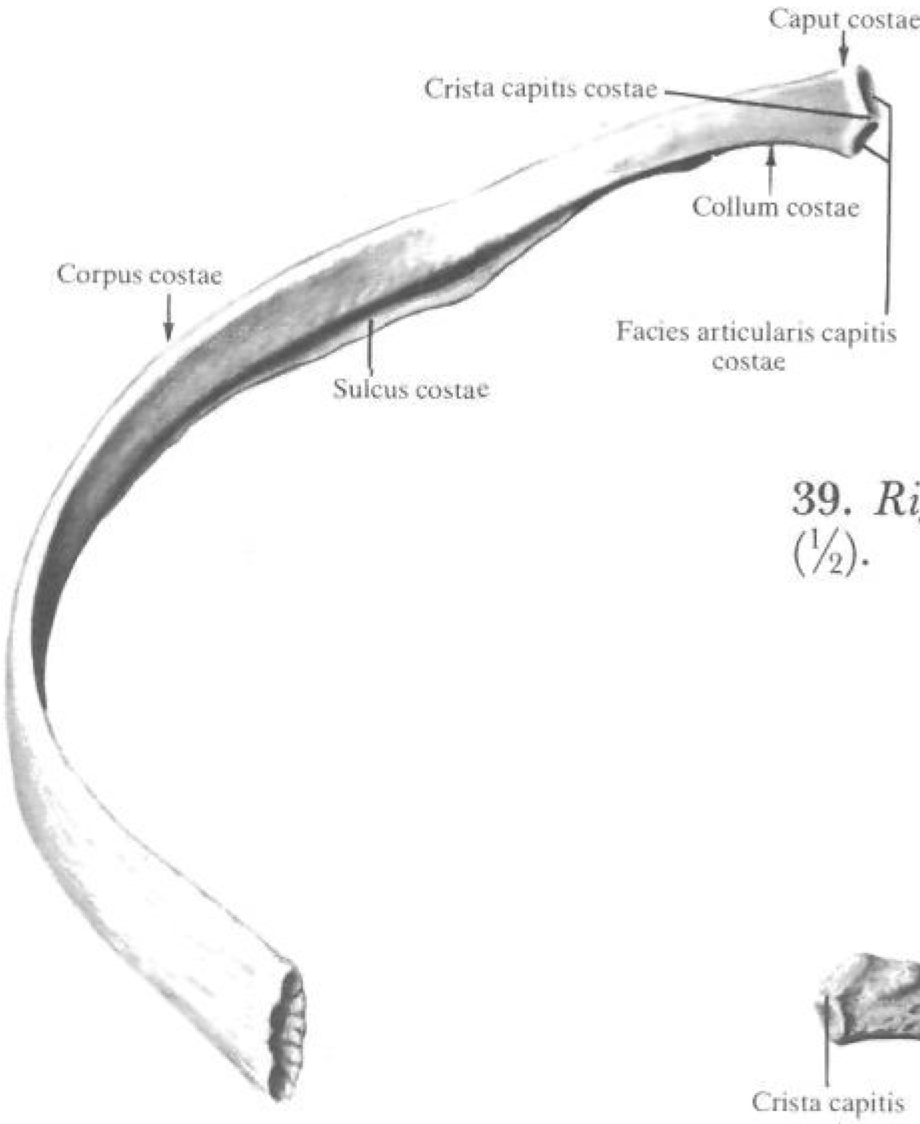
The narrowest and rounded part of the rib, **the neck of the rib** *(collum costae)* carries a **crest** *(crista colli costae)* on its superior border (it is absent on the first and twelfth ribs).

At the junction with the shaft, the neck of the upper ten ribs has a small **tubercle of the rib** *(tuberculum costae)*, which has an **articular facet of tubercle of the rib** *(facies articularis tuberculi costae)* articulating with the transverse costal facet of the corresponding vertebra.

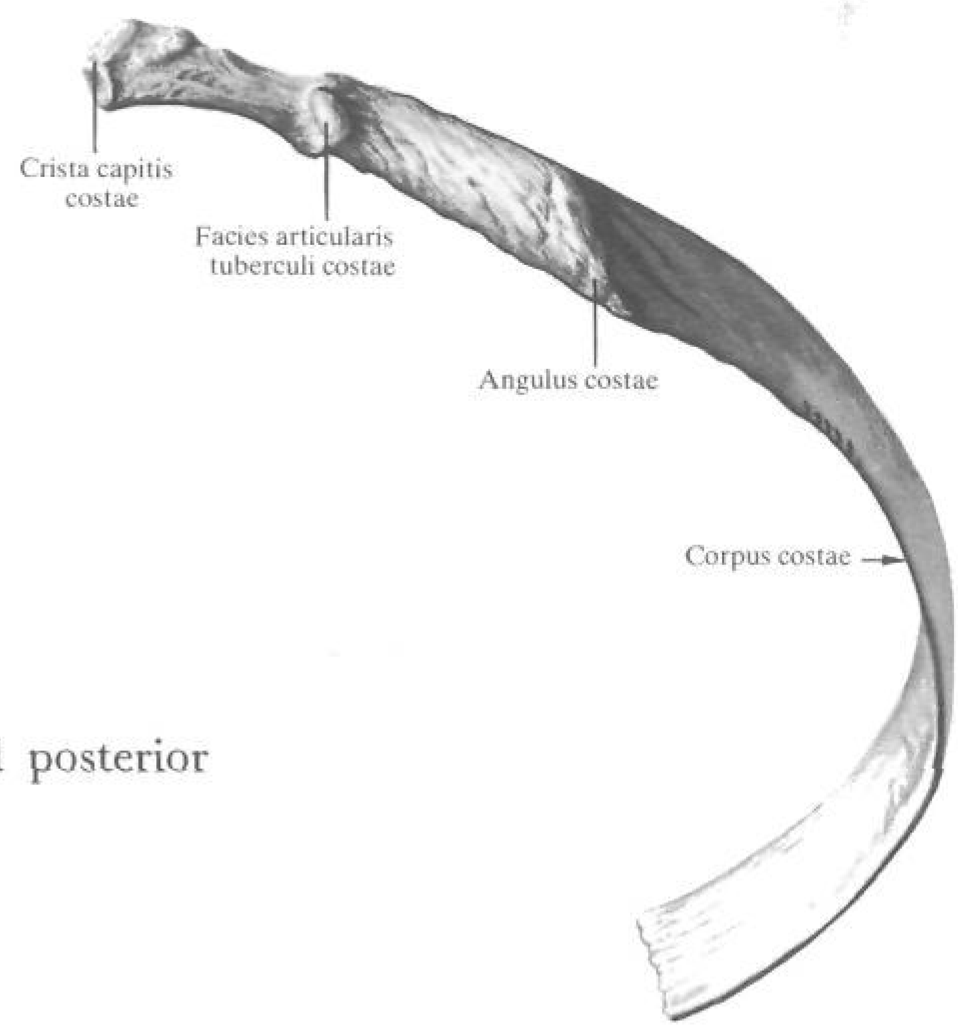
The **shaft of the rib** *(corpus costae)* stretching from the tubercle of the rib to the sternal end, is the longest segment of the bony part of the rib. At some distance from the tubercle the shaft curves considerably to form the **angle of the rib** *(angulus costae)*. The angle coincides only with the tubercle of the first rib, but on the other ribs the distance between these structures increases (down to the eleventh rib); the shaft of the twelfth rib does not form an angle. The shaft of the rib is flattened along its entire distance and therefore two surfaces can be distinguished: an internal concave and an



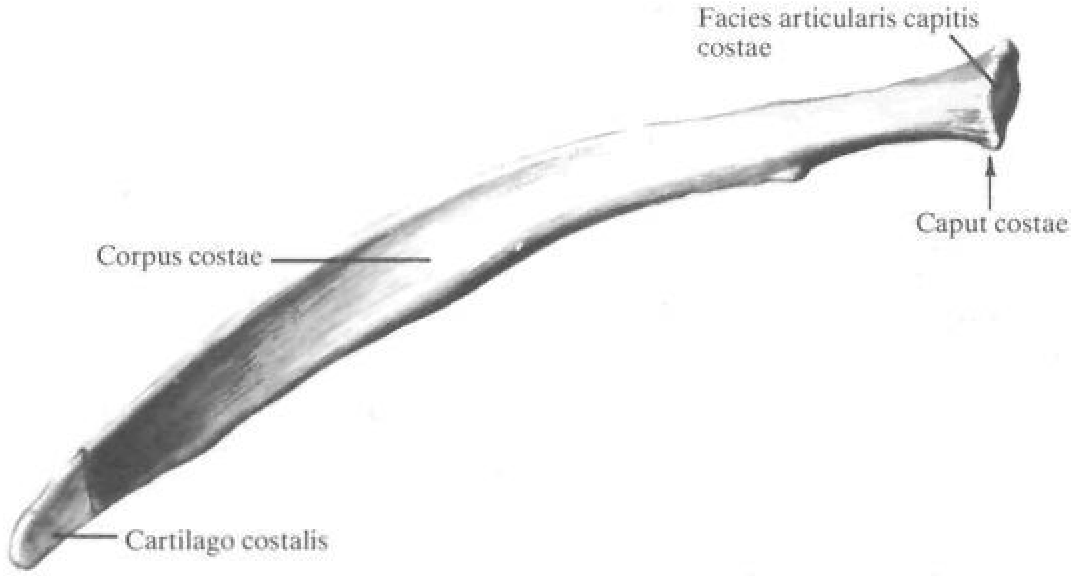
38. *Right ribs (costae)*; superior aspect (⅔).
A—first rib; B—second rib.



39. *Right eighth rib (costa VIII)*; inner aspect ($\frac{1}{2}$).



40. *Right eighth rib (costa VIII)*; outer and posterior aspect ($\frac{1}{2}$).



41. *Right twelfth rib (costa XII)*; inner aspect ($^3/_5$).

external convex surface; and two borders: a rounded upper and a sharp lower border. A **costal groove** *(sulcus costae)* (Fig. 39) lodging the intercostal artery, vein, and nerve stretches on the internal surface along the lower border.

The shape and position of a rib are as follows: the internal surface is concave, the external surface is convex; the upper and lower borders have the shape of a spiral; the rib itself twists about its long axis.

The anterior end of the bony part of the rib bears a facet with a slightly rough surface which is attached to the costal cartilage.

The **costal cartilages** *(cartilagines costales)* are a continuation of the bony parts of the ribs. There are twelve pairs of them also. They become longer gradually from the first to the seventh rib and articulate directly with the sternum. The upper seven pairs of ribs are referred to as **true ribs** *(costae verae)*. The lower five pairs of ribs are called **false ribs** *(costae spuriae)*; the eleventh and twelfth ribs are known as **floating ribs** *(costae fluctuantes)*. The cartilages of the eighth, ninth, and tenth ribs do not reach the sternum directly, but each joins the cartilage of the rib directly above it. The cartilages of the eleventh and twelfth (and sometimes the tenth) ribs do not reach the sternum and their ends lie freely in the muscles of the abdominal wall.

The first two and last two ribs possess some specific features. The **first rib** *(costa I)* (Fig. 38) is shorter but wider than the other ribs and its superior and inferior surfaces lie almost horizontally like the external and internal surfaces of the remaining ribs. The anterior part of the superior surface carries a tubercle for the attachment of the scalenus anterior muscle called the **scalene tubercle** *(tuberculum musculi scaleni anterioris)*. Laterally and posteriorly of the tubercle is a shallow **groove for the subclavian artery** *(sulcus arteriae subclaviae)* to the back of which is a small roughened surface for insertion of the scalenus medius muscle *(musculus scalenus medius)*. To the front and medially of the tubercle is a less distinct **groove for the subclavian vein** *(sulcus venae subclaviae)*. The articular facet on the head of the first rib has no separating crest; the neck is long and thin; the angle of the rib coincides with the tubercle.

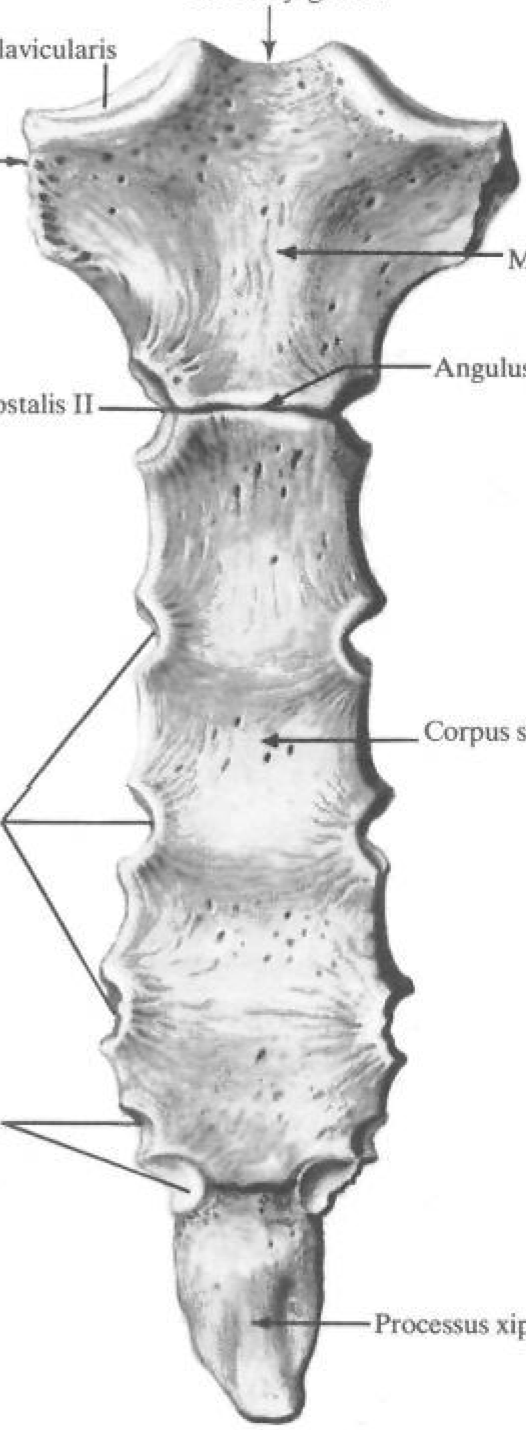
On its external surface the **second rib** *(costa II)* (Fig. 38) has a roughened area, the **tubercle for the serratus anterior muscle** *(tuberositas musculi serrati anterioris)* from which this muscle arises.

The **eleventh** and **twelfth ribs** *(costa XI* et *costa XII)* (Fig. 41) have articular facets which are not separated by a crest. The angle of the rib, neck, tubercle, and costal groove are poorly marked on the eleventh and absent on the twelfth rib.

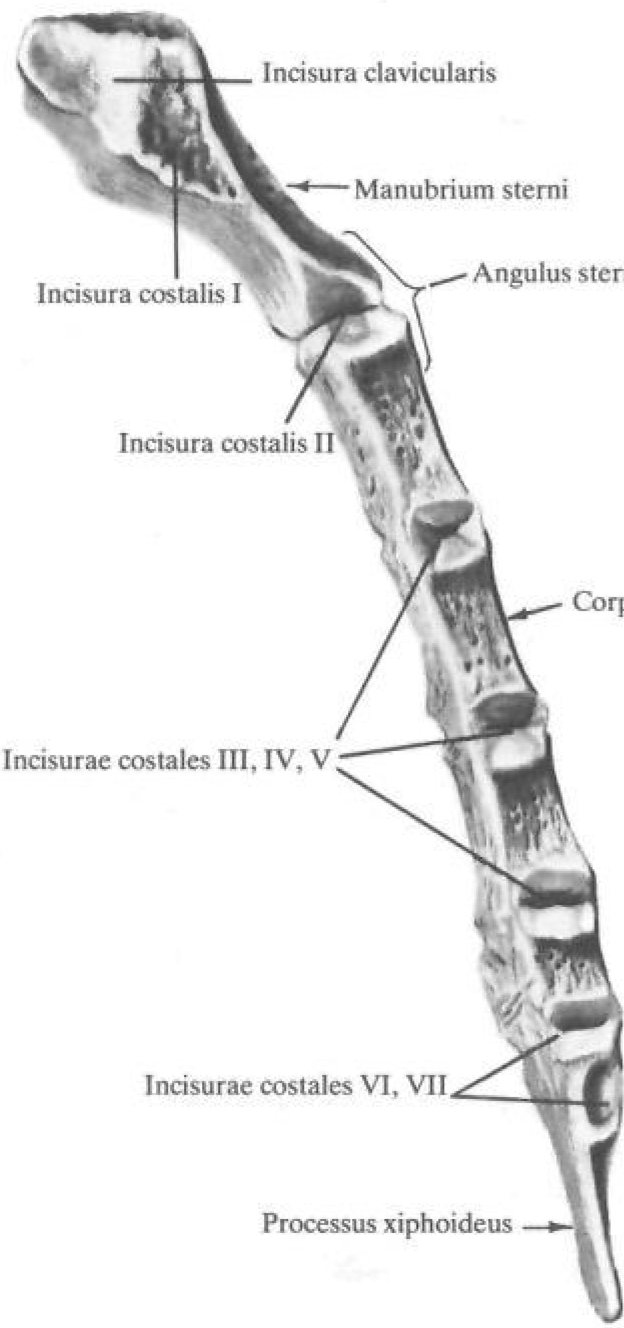
THE STERNUM

The **breast-bone**, or **sternum** (Figs 42–44), is an elongated unpaired bone with a slightly convex anterior surface and a correspondingly concave posterior surface. It occupies part of the anterior wall of the thorax. The manubrium, body, and xiphoid process are distinguished on it. All these parts are joined to one another by layers of cartilage which ossify with age.

The **manubrium sterni** is the widest part of the sternum, thick in its upper part and thinner and narrower below. It bears on the upper border the **jugular notch** *(incisura jugularis)* which is easily palpated through the skin. Lateral to it on each side is the **clavicular notch** *(incisura clavicularis)*, the place of articulation of the sternum with the sternal end of the clavicle.



42. *Sternum*; anterior aspect (3/5).



43. *Sternum*; from the right side (2/3).

A little lower on the lateral border is the **costal notch for the first rib** *(incisura costalis I)* providing for articulation with the cartilage of the first rib. Still lower is a small depression, the upper part of the notch for the second rib. The lower part of this notch is on the body of the sternum.

The **body of the sternum** *(corpus sterni)*, though narrower, is almost three times longer than the manubrium. It is shorter in females than in males.

The anterior surface of the sternum bears poorly marked transverse lines which are traces of fusion during embryonal development.

The cartilaginous union of the upper border of the body with the lower border of the manubrium is called the **manubriosternal joint** *(synchondrosis manubriosternalis)* (see Fig. 195). The body and the manubrium meet at an obtuse open to the back **angle of the sternum** *(angulus sterni)*. This projection is on a level with the articulation of the second rib with the sternum and is easily palpated through the skin.

Four complete and two incomplete **costal notches** *(incisurae costales)* are distinguished on the lateral border of the body. They serve for articulation of the sternum with the cartilages of the second to seventh ribs. One of the incomplete notches is on the top of the lateral border and corresponds to the cartilage of the second rib, while the other is at the bottom of the lateral border and corresponds to the cartilage of the seventh rib. The four complete notches are arranged between them and correspond to the third to sixth ribs.

The areas of the lateral borders between two adjacent costal notches are shaped like crescentic depressions.

The **xiphoid process** *(processus xiphoideus)* is the shortest part of the sternum and varies in size and shape. Its pointed or blunt apex faces either forwards or backwards and has a bifid end or is perforated in the middle. A half-notch for articulation with the cartilage of the seventh rib is located in the superolateral part of the process.

By old age the xiphoid process undergoes ossification and becomes fused with the body of the sternum.

THE THORACIC CAGE

The **thoracic cage** *(thorax)* (Figs 44–47, a and b) is formed by the thoracic segment of the spine, the ribs, and the sternum.

The thorax has the shape of a truncated cone with the wide base facing downwards and the truncated apex upwards. An anterior, posterior, and lateral walls and an upper (inlet) and lower (outlet) apertures are distinguished in the thorax.

The anterior wall is shorter than the other walls and is formed by the sternum and the costal cartilages. It slopes and therefore its lower parts project forwards more than the upper parts. The posterior wall, which is almost vertical, is longer than the anterior one and is formed by the thoracic vertebrae and the parts of the ribs from the heads to the angles.

On both sides of the external surface of the posterior wall, between the vertebral spines and the angles of the ribs, there is a groove, the dorsal sulcus, accommodating the deep dorsal muscles. On the internal surface of the wall, between the projecting vertebral bodies and the angles of the ribs, there are grooves, the **pulmonary sulci** *(sulci pulmonale)* (Fig. 46). The posterior borders of the lungs adjoin these sulci.

The lateral walls are longer than either the anterior or posterior wall. They are formed by the shafts of the ribs and are more or less convex, depending on the individual features.

The spaces bounded by two adjacent ribs superiorly and inferiorly, by the lateral border of the sternum anteriorly, and by the vertebrae posteriorly, are called **intercostal spaces** *(spatia intercostalia)*. They are filled by ligaments, intercostal muscles, and membranes.

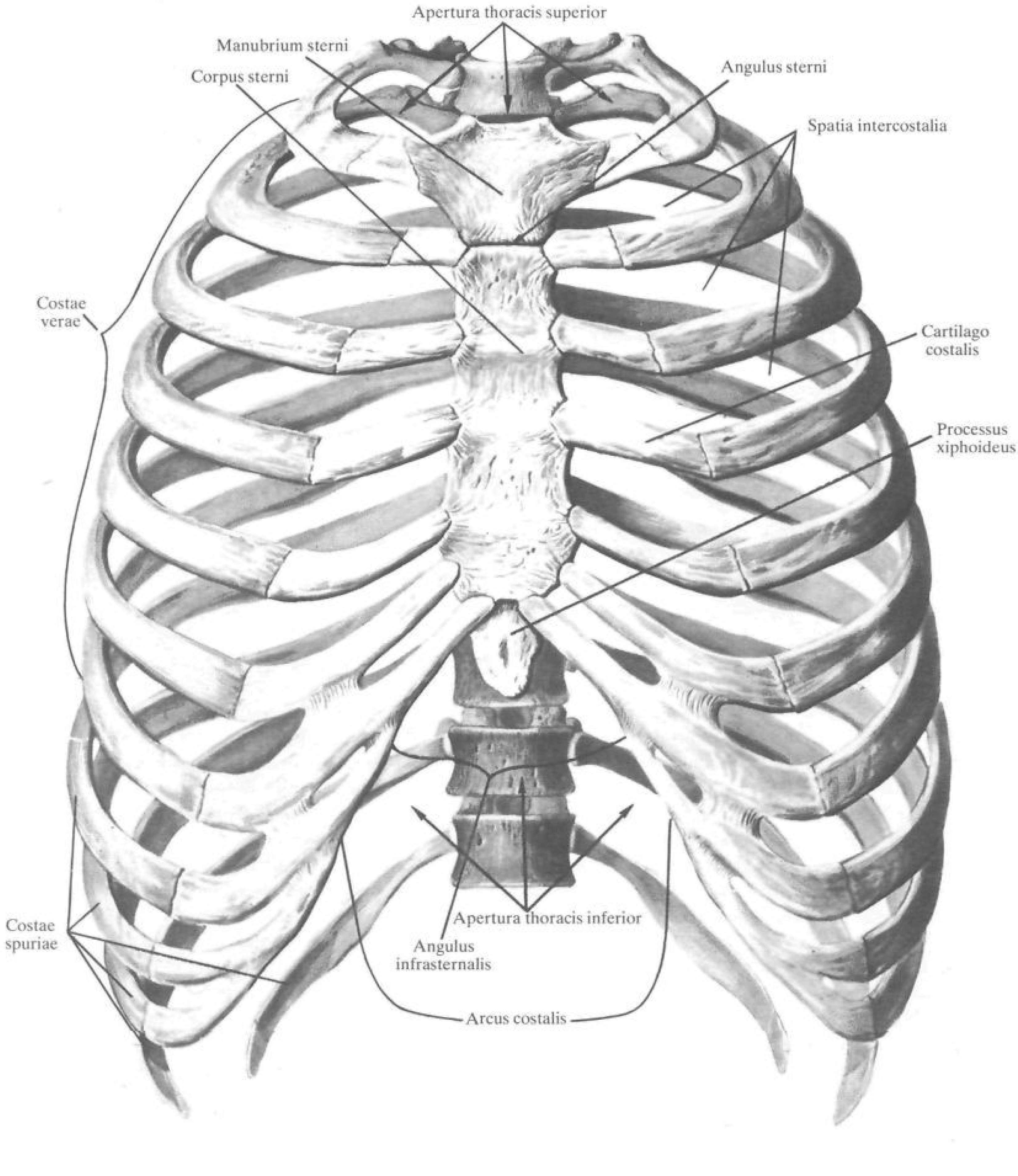
The **thoracic cavity** *(cavum thoracis)* is bounded by the thoracic walls and has two apertures (inlet and outlet).

The **inlet of the thorax** *(apertura thoracis superior)* is smaller than the outlet and is bounded by the upper border of the manubrium anteriorly, by the first ribs laterally, and by the body of the first thoracic vertebra posteriorly. It is transversely-oval in shape and lies in a plane sloping from back to front and downwards. The upper border of the manubrium sterni is on a level with the space between the second and third thoracic vertebrae.

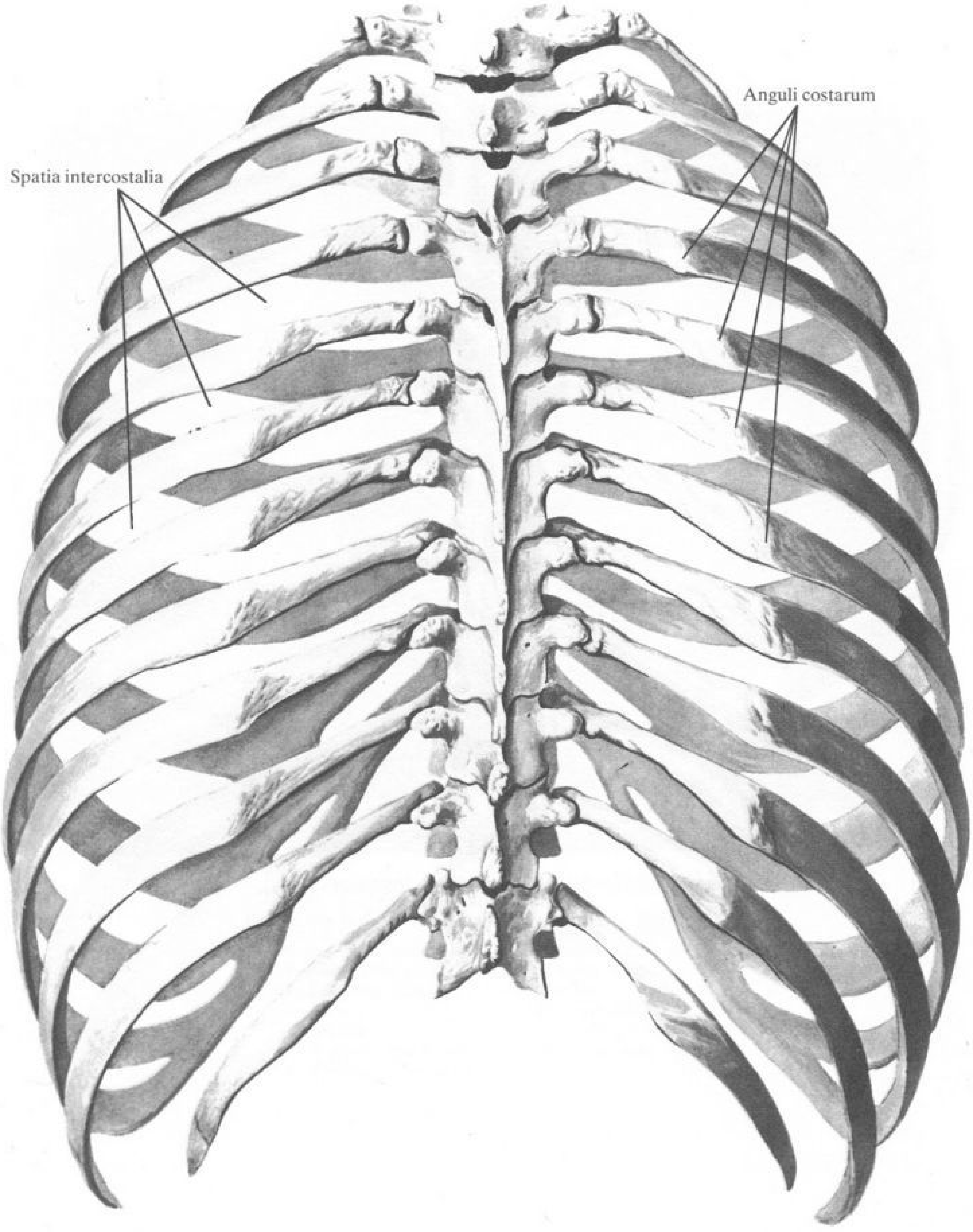
The **outlet of the thorax** *(apertura thoracis inferior)* is bounded by the xiphoid process and the costal arch formed by the ends of the false ribs anteriorly, by the free ends of the eleventh and twelfth ribs laterally, and by the lower borders of the twelfth ribs and the body of the twelfth vertebra posteriorly.

At the xiphoid process the **costal arch** *(arcus costalis)* forms the **infrasternal angle** *(angulus infrasternalis)* which is open downwards.

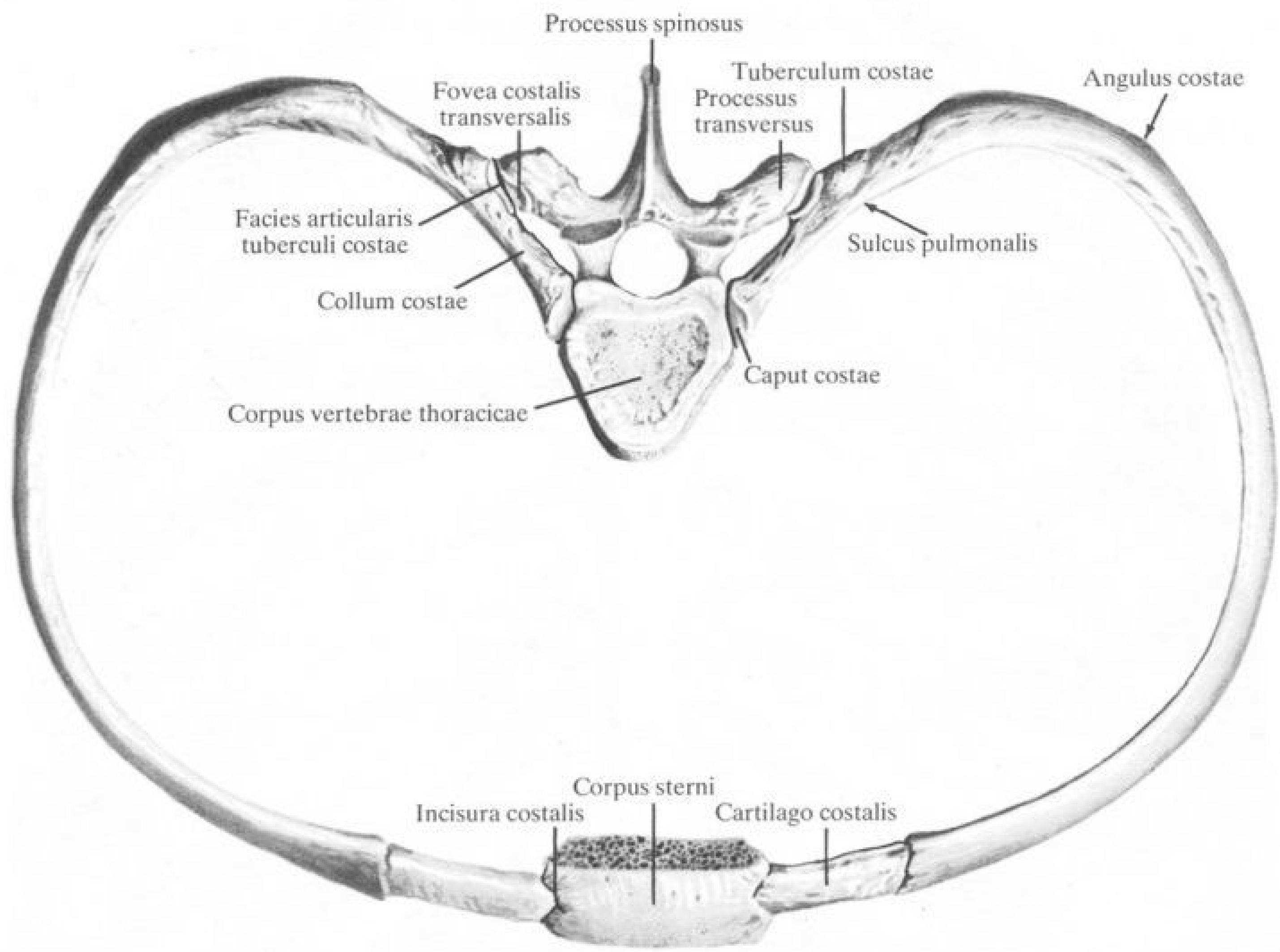
The thorax of different individuals varies in shape (it may be flat, cylindrical or conical). A narrow thoracic cage is longer than a wide one, its infrasternal angle is more acute, and the intercostal spaces are wider. The thorax of males is longer, wider, and more conical than that of females. Furthermore the shape of the thorax depends on the individual's age.



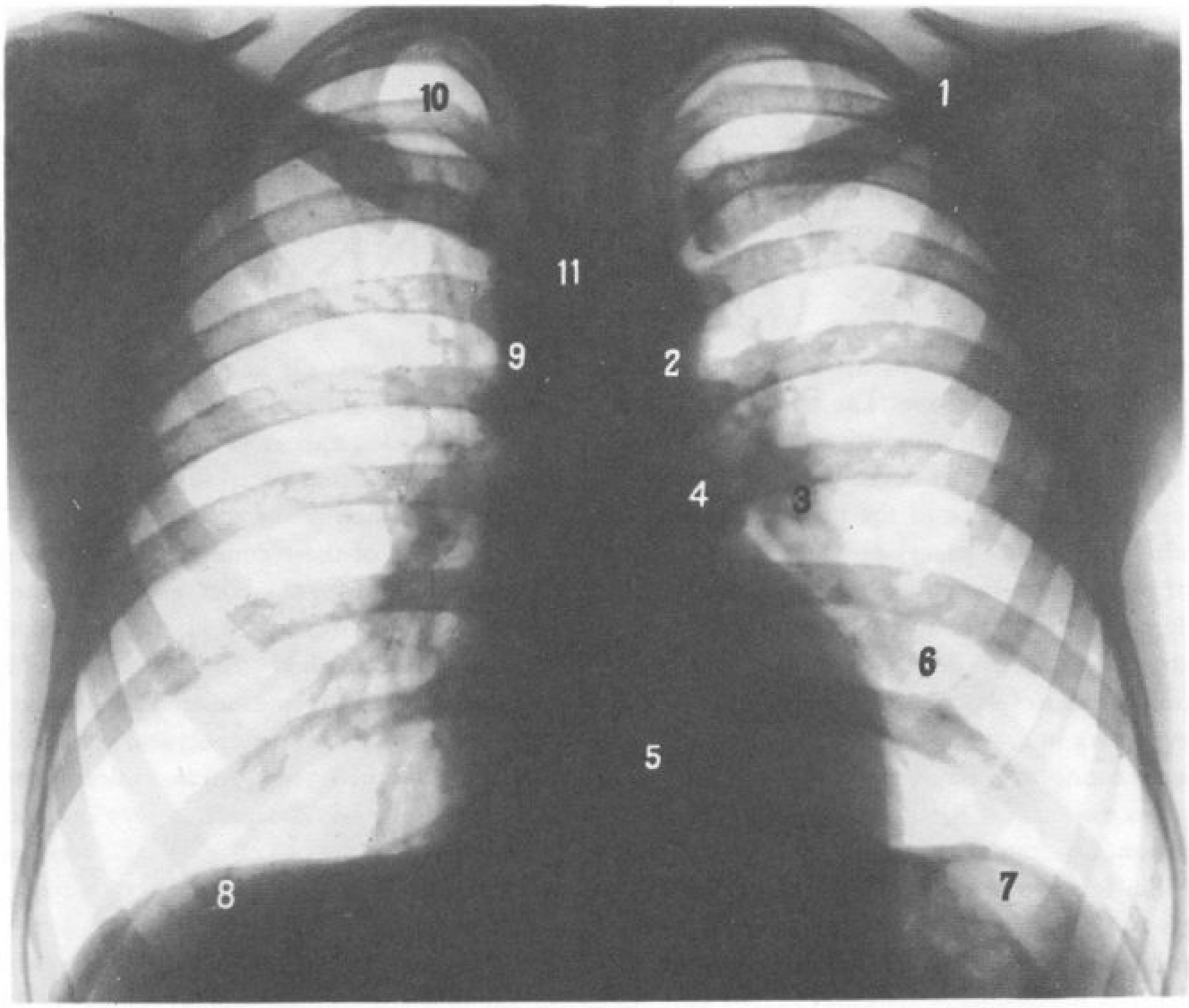
44. *Thorax*; anterior aspect (2/5).



45. *Thorax*; posterior aspect (2/5).



46. *Skeleton of thoracic segment* ($\frac{1}{2}$).
(Relation of ribs to vertebra [fourth] and sternum.)



47. *Chest* (radiograph).

1—left clavicle
2—descending aorta
3—hilum of lung
4—pulmonary trunk
5—heart
6—left lung
7—diaphragm (left dome)
8—diaphragm (right dome)
9—ascending aorta
10—apex of right lung
11—arch of aorta
12—ribs
13—right clavicle
14—right scapula
15—left scapula

DEVELOPMENT OF BONES AND AGE FEATURES OF THE TRUNK SKELETON[1]

The skeleton develops from the mesenchyme which is poorly differentiated embryonic connective tissue. The bones of the calvaria and those of the face develop in connective tissue (endesmal or intramembranous ossification), others develop in cartilage, perichondrally (later, with the appearance of the periosteum, periosteally) or endochondrally. All these processes begin at the end of the second month of the intrauterine period, when all other types of tissues are already present in the body of the embryo.

The bones forming in connective tissue are known as primary bones and pass through two developmental stages: membranous and bony. Bones developing in cartilage are called secondary and go through three stages: connective-tissue, cartilaginous, and bony.

In intramembranous ossification, islets of ossification appear at the site of the future bones as condensations of mesenchymal cells (which take part in the formation of fibrous fibres) and a great number of blood vessels. Osteoblasts differentiate from the mesenchymal cells and produce intercellular substance consisting of ossein and calcium salts. The fibrous fibres are impregnated with this substance and the osteoblasts are embedded in them. After that the osteoblasts develop into mature cells of bony tissue, the osteocytes. Perichondral (periosteal) ossification occurs in a similar manner at the expense of the cells of the perichondrium (periosteum). Endochondral ossification takes place through growth of blood vessels from the surrounding mesenchyme into the cartilaginous germs of the bones. Mesenchyme adjoining the forming bone develops into the periosteum. The external layer of the dura mater serves as the periosteum for the internal surface of the skull bones.

The process of osteogenesis continues with the formation of osteoclasts (bone destroyers) from mesenchymal cells surrounding the vessels.

Cartilaginous tissue with a great number of ossification nuclei called primary prevails in the skeleton of a newborn (Fig. 47a). Secondary ossification nuclei appear later. The primary, like the secondary nuclei, appear earlier in girls than in boys. In tubular bones, the ossification nuclei first appear in the central parts of the diaphysis and then in the epiphyses.

At the end of the second month of the embryonic period the vertebrae (except for the coccygeal vertebrae) have two nuclei in their arch, which form from the fusion of several nuclei, and one main nucleus in the body. In the first year of life, the nuclei of the arch develop dorsally and unite. This process occurs more rapidly in the cervical than in the coccygeal vertebrae. The arches usually fuse by the age of 7 years. An exception is the first sacral vertebra (sometimes the sacral segment does not close until the age of 15-18 years). At the age of 3-6 years, bony union of the nuclei in the arch with the nucleus in the body occurs, first in the thoracic vertebrae.

Epiphyseal rings appear on the borders of the vertebral body at the age of 8 years in girls and at the age of 10 in boys. The vertebral spines and transverse processes which have additional secondary ossification nuclei on the apices are completely ossified in the pubertal period or a little later.

The atlas and axis develop in a different manner. The anterior and posterior arches of the atlas fuse to form a single bone at the age of 5-6 years. Before the anterior bony arch forms, an area with its own paired ossification nucleus appears in the cartilaginous germ of the arch and fuses with the axis to form the dens at the age of 4-5 years. The dens articulates with the internal surface of the anterior arch of the atlas by means of the atlanto-axial articulation.

The five sacral vertebrae fuse to form the sacrum quite late, in the 18-25th year of life. The three lower vertebrae begin to fuse from the age of 15, the two upper vertebrae fuse by the age of 25.

The rudimentary coccygeal vertebrae are distinguished by the extremely irregular appearance of the ossification nuclei: in the 2nd-3rd week after birth in the first vertebra, at the age of 4-8 years in the second, at 9-13 years of age in the third, and, finally, at the age of 15 in the fourth vertebra. Their fusion, first the lower and then the upper vertebrae, continues after the age of 30 years.

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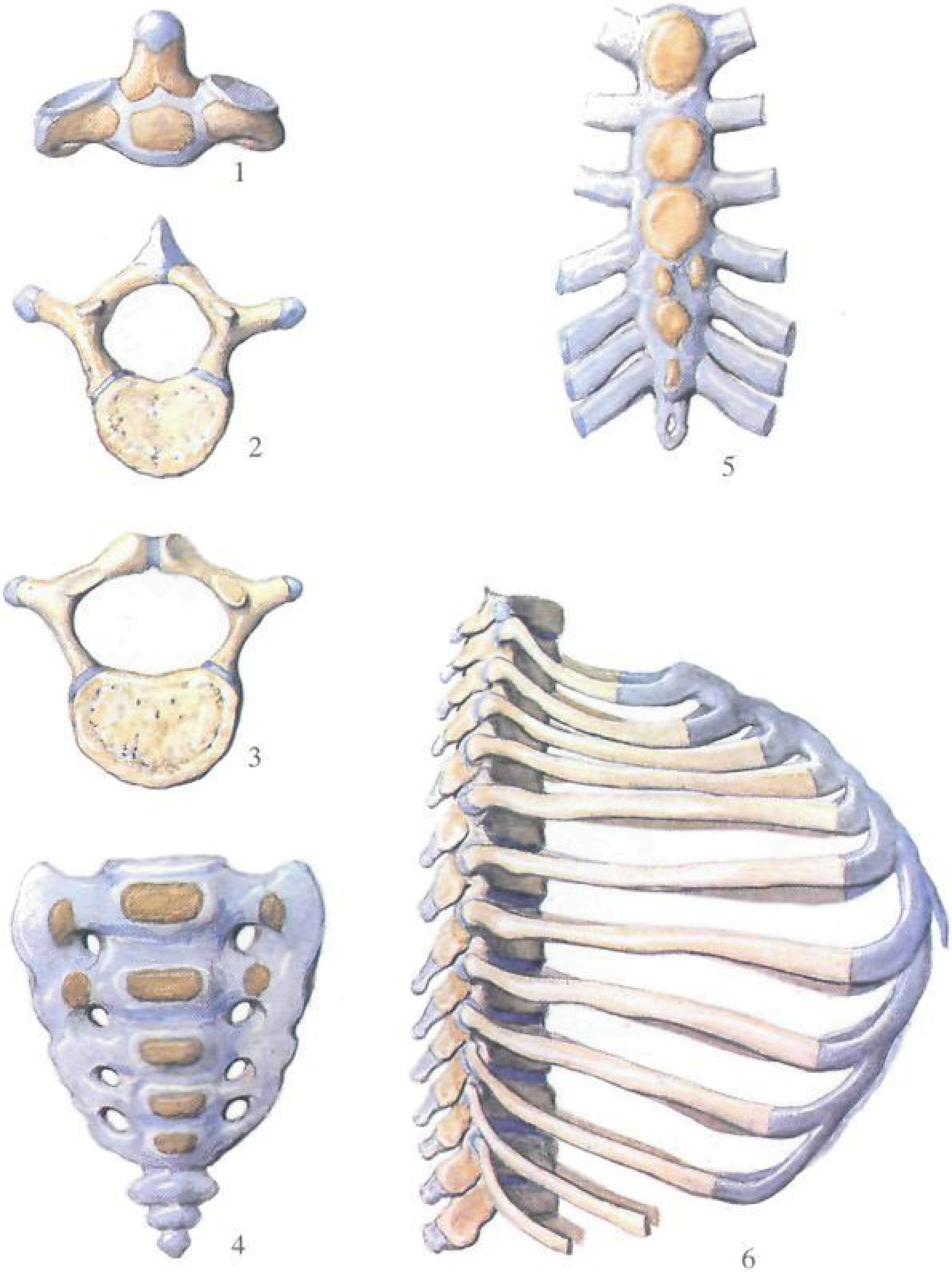
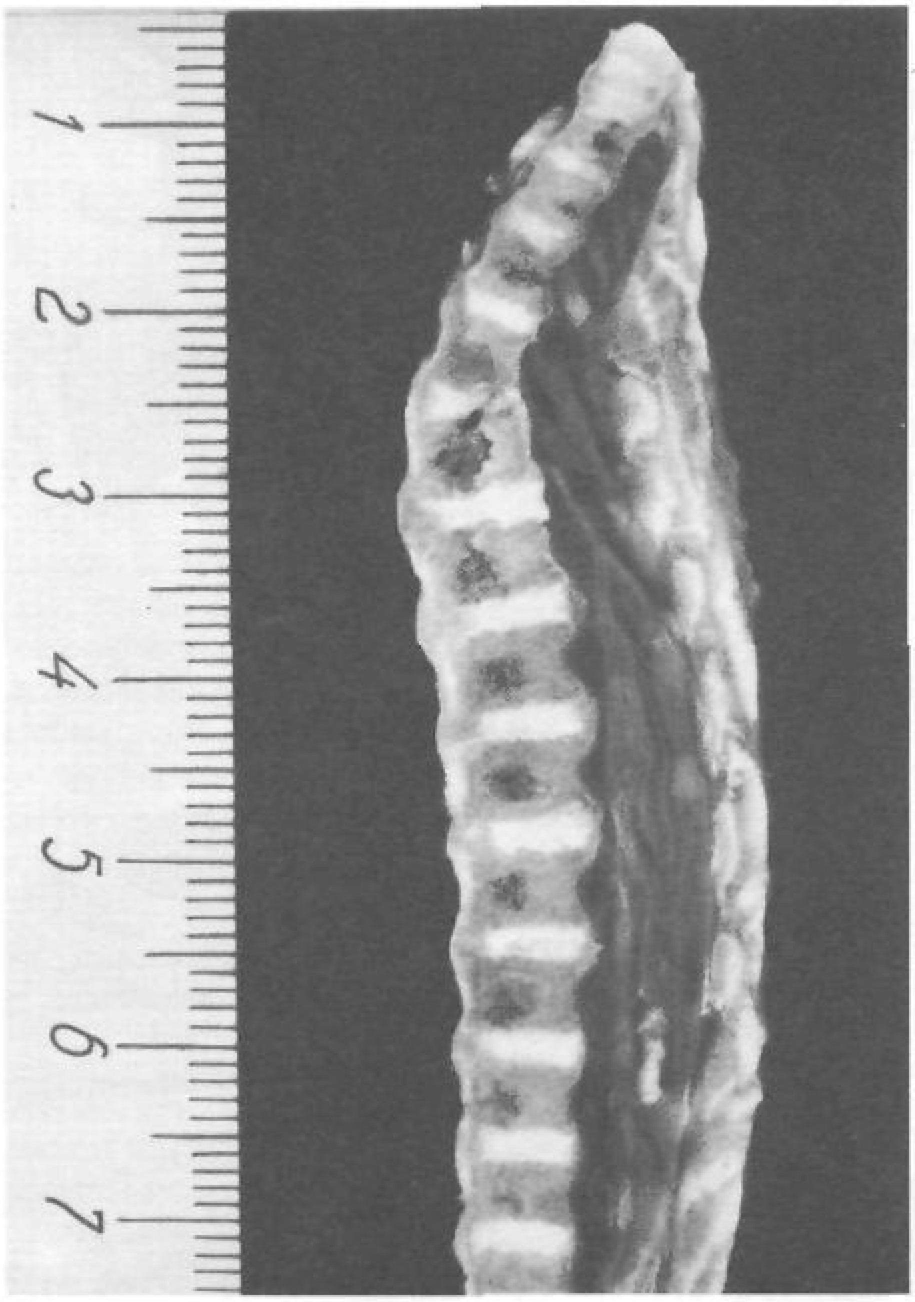
[1] In view of the fact that students will study the age features after they are acquainted in detail with the anatomy of a human adult, in this section as well as in other similar sections we dwell only on some age peculiarities. For details of development we refer the reader to a textbook of embryology.



47a. ***Bones of trunk*** **(of a newborn).**

1—second cervical vertebra
2—third thoracic vertebra
3—second lumbar vertebra
4—sacrum
5—sternum
6—thorax



47b. *Sagittal section through lumbar segment of vertebral column of a child* (photograph).

With age the vertebral column as a whole goes through different stages of changes in size and shape. It grows particularly intensively during the first two years of life, it almost doubles in length; until the age of 16 growth in length is slower, after which the spinal column grows again actively and in an adult its length is more than three times the length of a newborn's spinal column. It is believed that until the age of 2 years the vertebrae grow just as intensively as the intervertebral discs, but after the age of 7 the relative size of the disc diminishes markedly. The nucleus pulposus contains a lot of water and is much larger in a child than in an adult. The vertebral column of a newborn is straight in the anteroposterior direction. Later, as the result of a number of factors (the effect of the work of muscles, independently maintained sitting posture, the weight of the head, etc.), curvatures form in it. The cervical curvature (cervical lordosis) forms in the first 3 months of life. The thoracic curvature (thoracic kyphosis) appears by the age of 6-7 months, the lumbar curvature (lumbar lordosis) is expressed sufficiently by the end of the first year of life.

The ribs are laid down as mesenchyme which lies between the muscle segments and is then replaced by cartilage. Perichondral ossification of the ribs begins from the second month of the intrauterine period, endochondral ossification occurs some time later. The bone tissue in the shaft of the rib grows anteriorly, the ossification nuclei appear in the region of the angle and head at the age of 15-20 years.

The anterior ends of the upper nine ribs are joined on both sides by cartilaginous sternal bands which, approaching one another first in the upper and then in the lower parts, unite to form the sternum. This process takes place in the 3rd-4th month of intrauterine life. The sternum contains primary ossification nuclei for the manubrium and body and secondary nuclei for the clavicular notches and the xiphoid process. Ossification occurs irregularly in the different parts of the sternum. In the manubrium, for instance, the primary ossification nucleus appears in the 6th intrauterine month, the parts of the body fuse by the 10th year of life and unite finally by the age of 18. The xiphoid process often remains cartilaginous even though a secondary ossification nucleus appears in it by the age of 6 years. The sternum as a whole ossifies at the age of 30 to 35 years, sometimes still later or even not at all.

The thorax, formed by twelve pairs of ribs, twelve thoracic vertebrae, and the sternum together with the articular-ligamentous apparatus, goes through a series of developmental stages. The development of the lungs, heart, and liver, and the position of the body (lying down, sitting, walking) alter in respect to age and function and thus cause changes in the thorax. The main parts of the thorax (the dorsal sulci, lateral walls, upper and lower apertures, costal arch, and infrasternal angle) alter during the various periods of development acquiring each time more and more features of the thorax of an adult. It is believed that the development of the thorax occurs in four main periods: from birth to the age of 2 years it develops very intensively; in the second stage, between the ages of 3 and 7, its development is quite rapid, though slower than in the first period; the third stage, from 8 to 12 years of age, is characterized by rather slow development; the fourth stage, the pubertal period, is also marked sometimes by intensive development. After this, slow growth continues to the age of 20-25 and then stops.

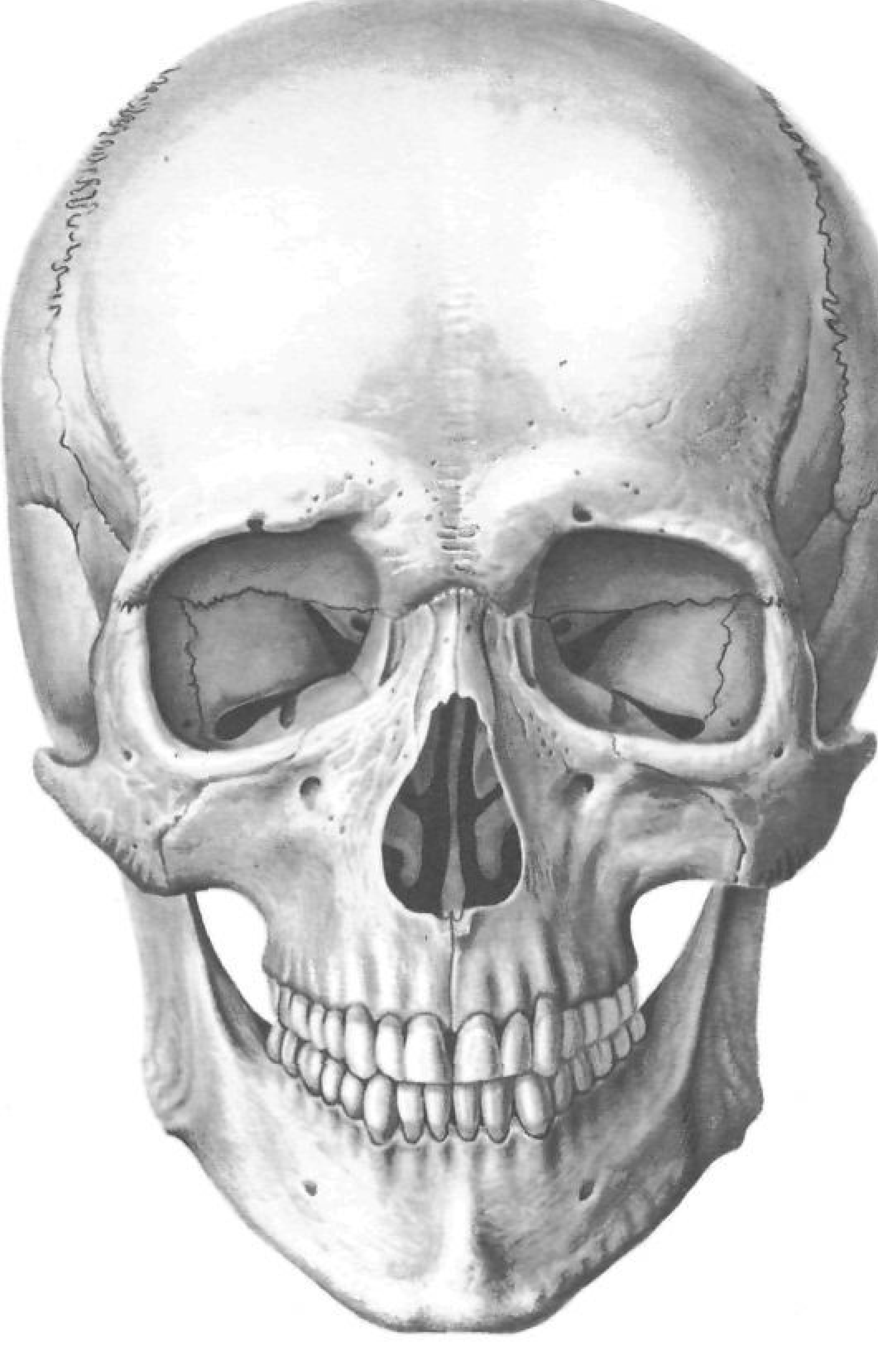
THE BONES OF THE HEAD

Ossa capitis

The **skull** *(cranium)* (Figs 48–53) is the skeleton of the head. The **bones of the cranium** *(ossa cranii)* and the **bones of the face** *(ossa faciei)* are distinguished in it. The skull is the receptacle for the brain and organs of sense (visual, acoustic, and olfactory organs).

The facial bones form the framework of the face and the initial parts of the alimentary tube and respiratory tract.

Both parts of the skull are composed of individual bones joined to one another by means of **sutures** *(suturae)* and **cartilagi-**



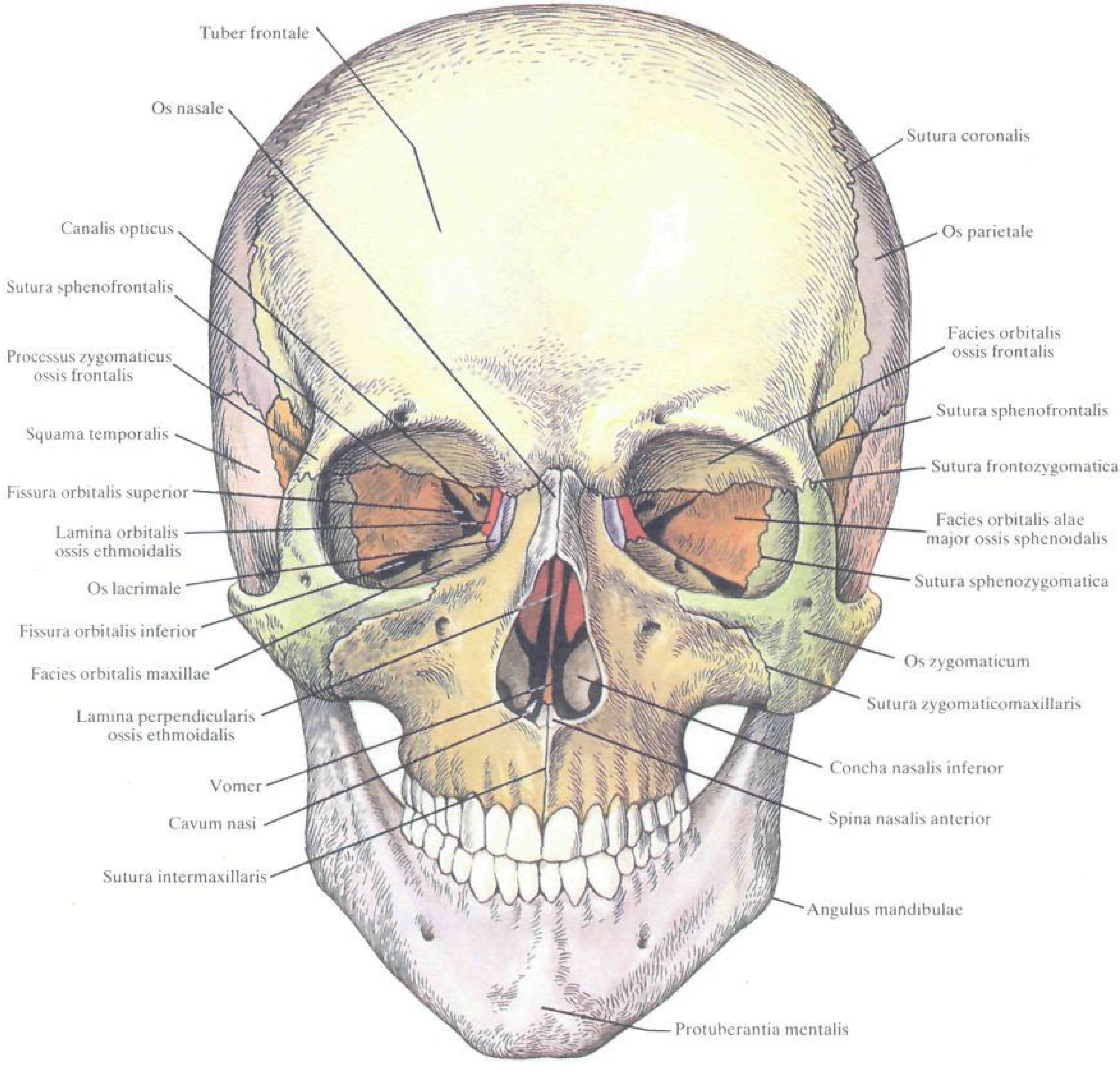
48. *Skull (cranium)*; anterior aspect (2/3).

nous articulations, or joints *(synchondroses)*, which allow no movement. The lower jaw is an exception, its joint is movable.

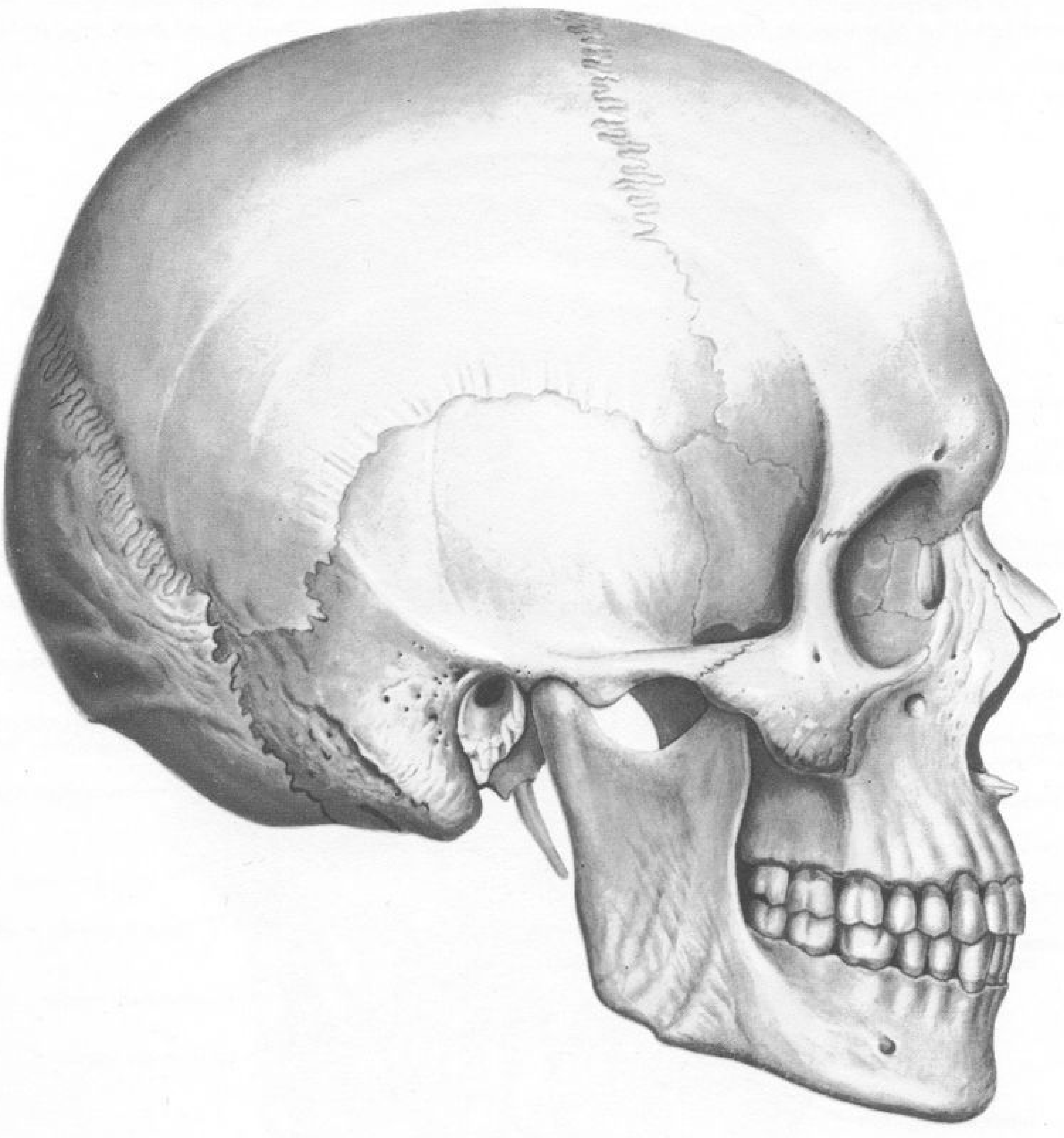
The occipital, parietal, frontal, sphenoid, temporal, and ethmoid bones are topographically referred to the bones of the cranium; the bones of the face are the inferior nasal conchae, the lacrimal and nasal bones, the vomer, the maxilla, the palatine and zygomatic bones, the mandible, and the hyoid bone.

The following bones are related to the **bones of the cranium** *(ossa cranii)* in terms of its development: unpaired bones: **occipital** *(os occipitale)*, **sphenoid** *(os sphenoidale)*, **frontal** *(os frontale)*, **ethmoid** *(os ethmoidale)*, **vomer**; paired bones: **temporal** *(os temporale)*, **parietal** *(os parietale)*, **inferior nasal concha** *(concha nasalis inferior)*, **lacrimal** *(os lacrimale)*, **nasal** *(os nasale)*.

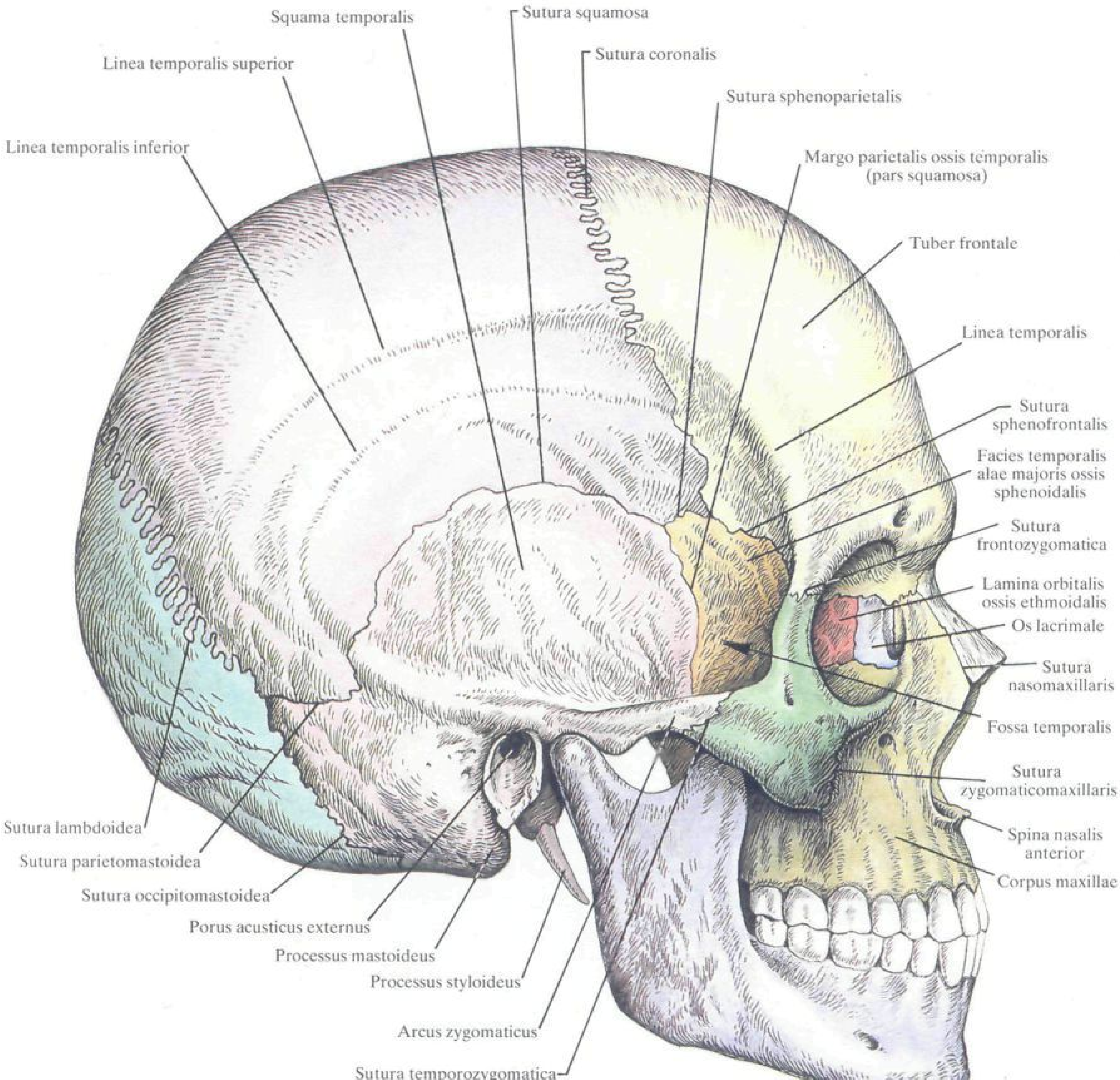
The **bones of the face** *(ossa faciei)* are the paired **maxilla, palatine** *(os palatinum)*, and **zygomatic** *(os zygomaticum)* bones and the unpaired **mandible** *(mandibula)* and **hyoid bone** *(os hyoideum)*.



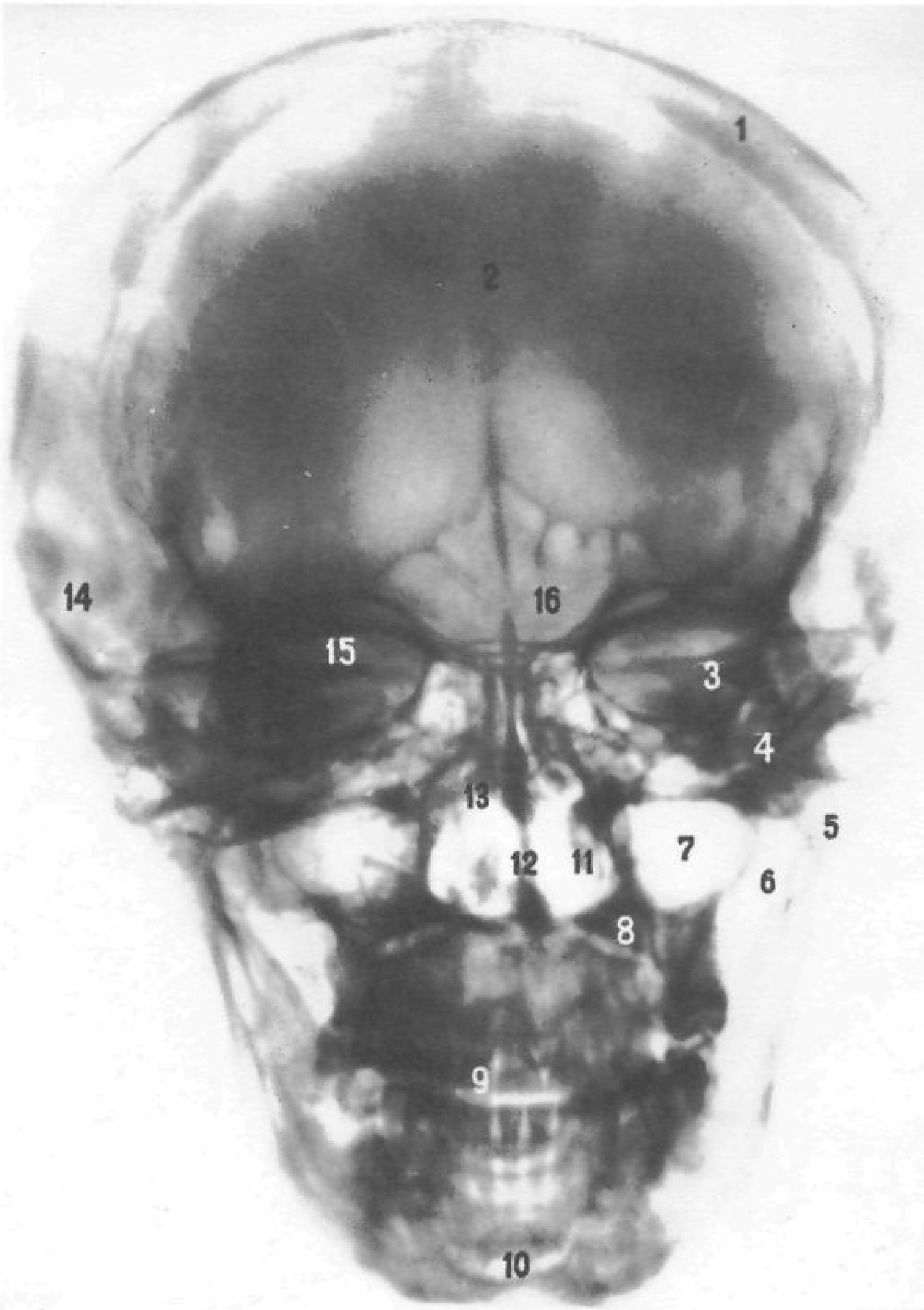
49. *Skull (cranium)*; anterior aspect (semischematical representation) ($\frac{2}{3}$).



50. *Skull (cranium)*; from the right side (⅔).

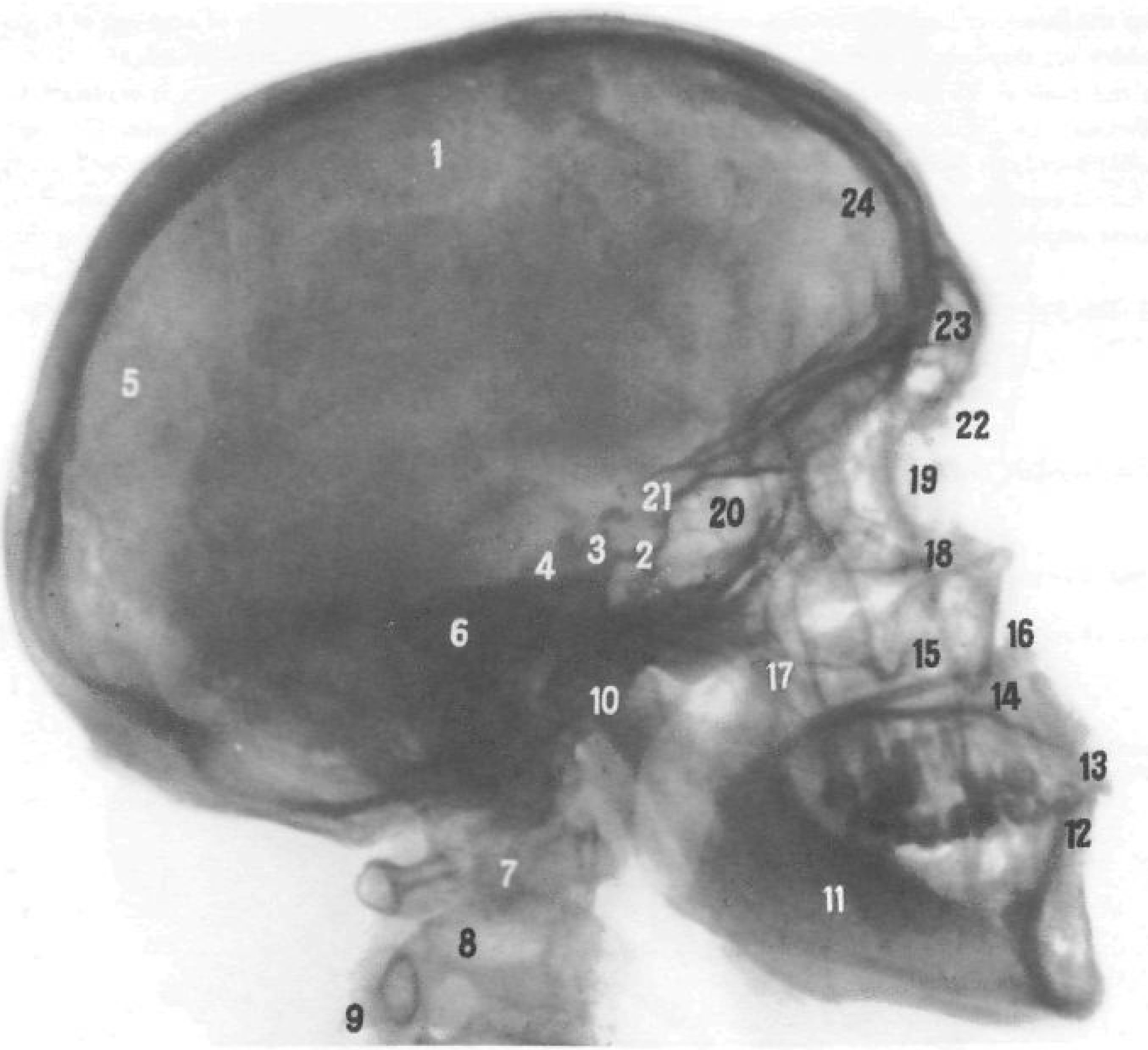


51. *Skull (cranium)*; from the right side (semischematical representation); (⅔).



52. *Skull* (posteroanterior view radiograph).

1—parietal bone
2—frontal bone
3—temporal bone (petrous part)
4—zygomatic bone
5—condyloid process of mandible
6—coronoid process of mandible
7—maxillary sinus
8—maxilla
9—tooth (upper lateral incisor)
10—mandible
11—inferior nasal concha
12—osseous nasal septum
13—middle nasal concha
14—temporal bone
15—orbit
16—frontal sinus



53. *Skull* (lateral view radiograph).

1—parietal bone
2—sella turcica
3—dorsum sellae
4—clivus
5—occipital bone
6—temporal bone (petrous part)
7—second cervical vertebra
8—transverse process
9—spinous process (spine)
10—condyloid process of mandible
11—mandible
12—mandibular incisors
13—maxillary incisors
14—maxilla
15—maxillary sinus
16—anterior nasal spine
17—coronoid process of mandible
18—infra-orbital margin
19—orbit
20—sphenoidal sinus
21—anterior clinoid process
22—nasal bone
23—frontal sinus
24—frontal bone

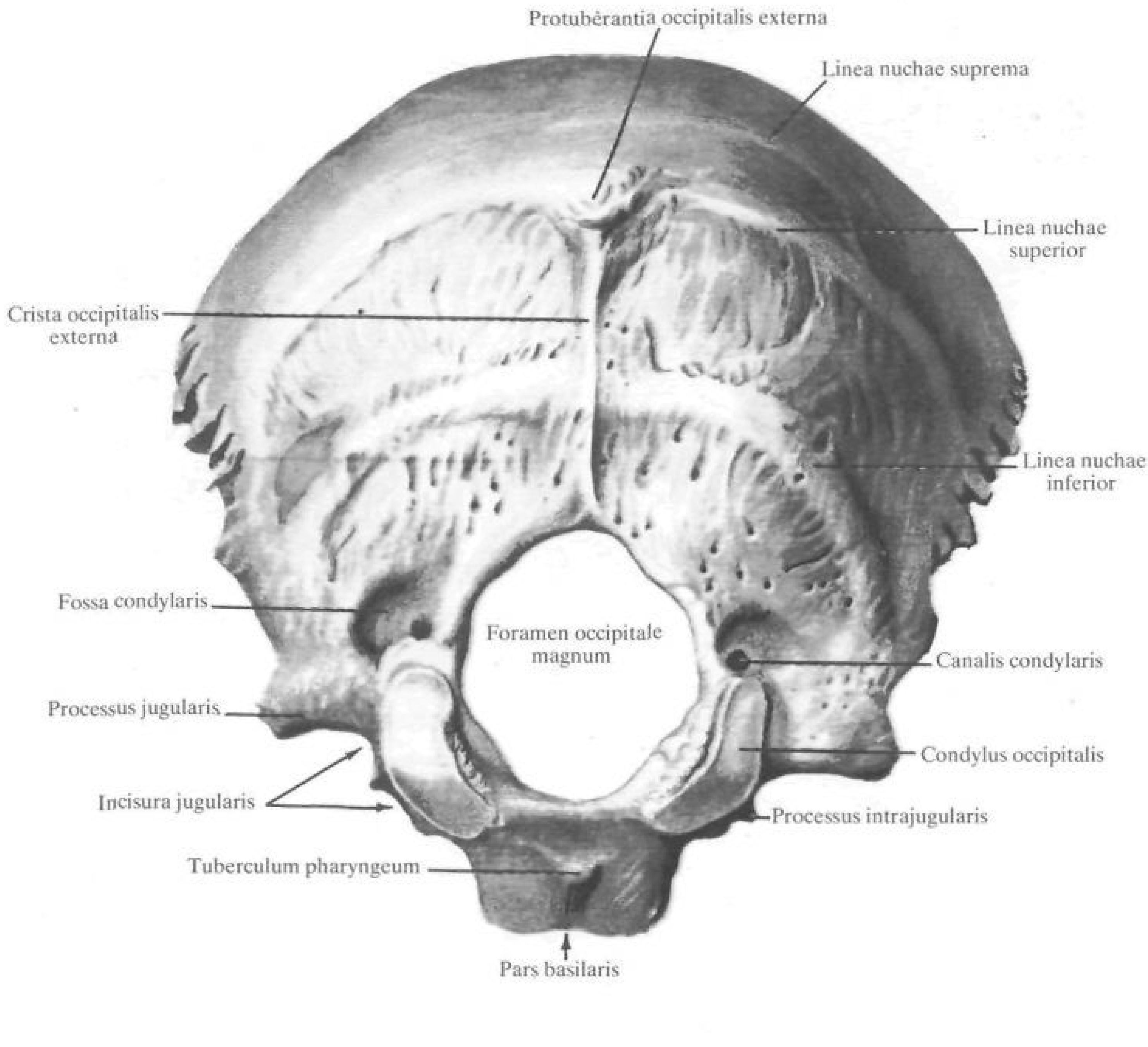
THE BONES OF THE CRANIUM

THE OCCIPITAL BONE

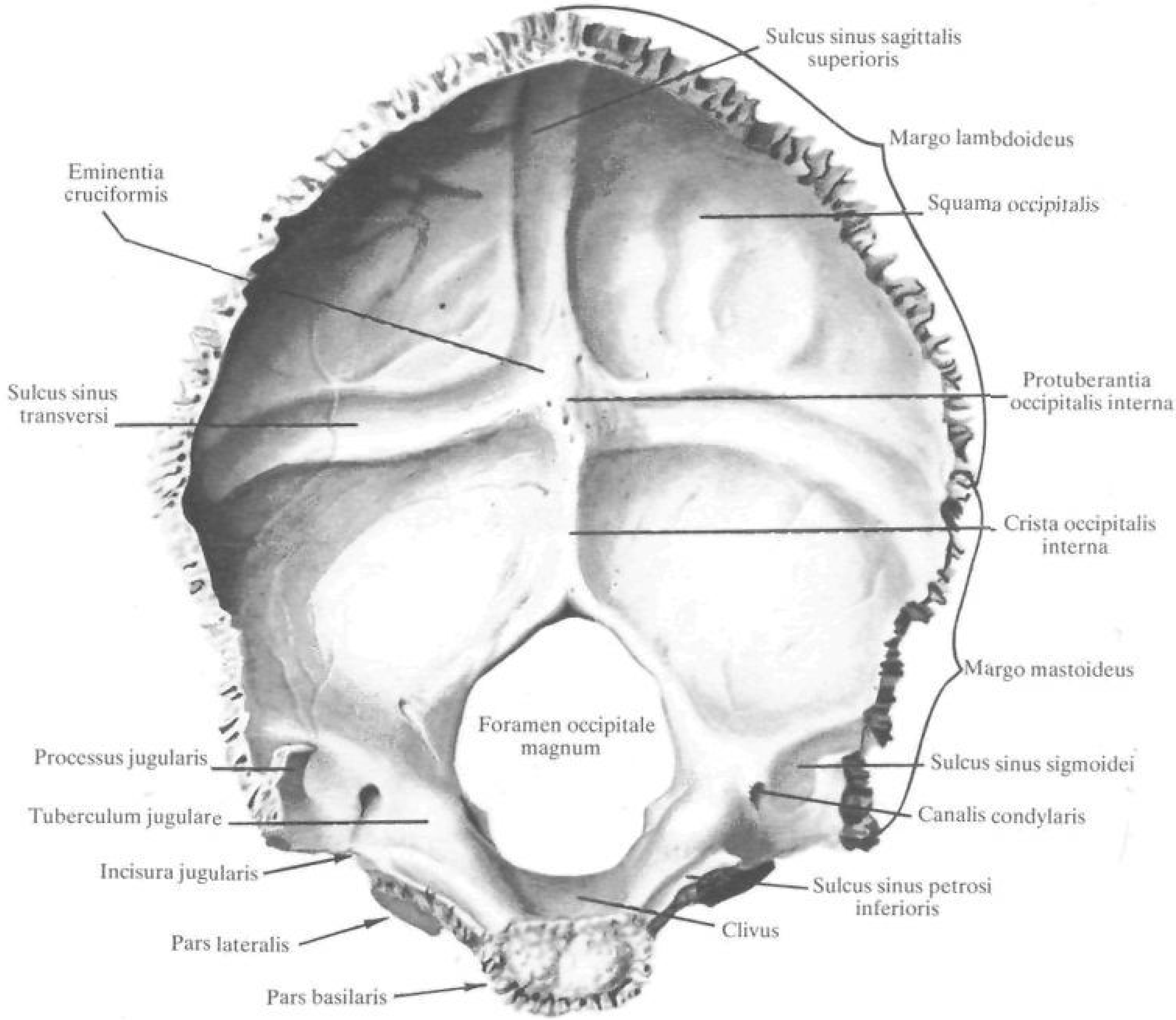
The **occipital bone** *(os occipitale)* (Figs 54-56) is an unpaired bone forming the posteroinferior part of the skull. Its external surface is convex, the internal (cerebral) surface is concave. Its anteroinferior part contains the **foramen magnum** *(foramen occipitale magnum)* by means of which the cranial cavity communicates with the vertebral canal. On the basis of development, the following four parts surrounding foramen magnum are distinguished in the occipital bone: the **basilar part** *(pars basilaris)* situated in front of the foramen magnum, paired **condylar parts** *(partes laterales)*, and the **squamous part** *(squama occipitalis)* situated to the back of the foramen.

The **basilar part** *(pars basilaris)* is short, thick, and quadrangular in shape. Its posterior border is free, smooth, and slightly tapered, and forms the anterior border of the foramen magnum. Its anterior border is thick and rough and articulates with the body of the sphenoid bone by means of cartilage to form the **spheno-occipital joint** *(synchondrosis sphenooccipitalis)*.

In adolescence the cartilage is replaced by bone tissue and both bones fuse to form a single bone. The superior surface of the basilar part facing the cranial cavity is smooth and slightly concave. Together with the part of the sphenoid bone situated in front of it, the basilar part forms the **clivus** facing the foramen magnum (it lodges the medulla oblongata, the pons, and the basilar artery and its branches). On the middle of the inferior external, slightly



54. *Occipital bone (os occipitale)*; outer aspect (4/5).



55. *Occipital bone (os occipitale)*; inner aspect ($\frac{4}{5}$).

convex, surface of the basilar part are a small **pharyngeal tubercle** *(tuberculum pharyngeum)*—the site of attachment of the anterior longitudinal ligament and the fibrous membrane of the pharynx called **pharyngobasilar fascia** *(fascia pharyngobasilaris)*, and rough lines marking the insertion of the rectus capitis anterior and longus capitis muscles.

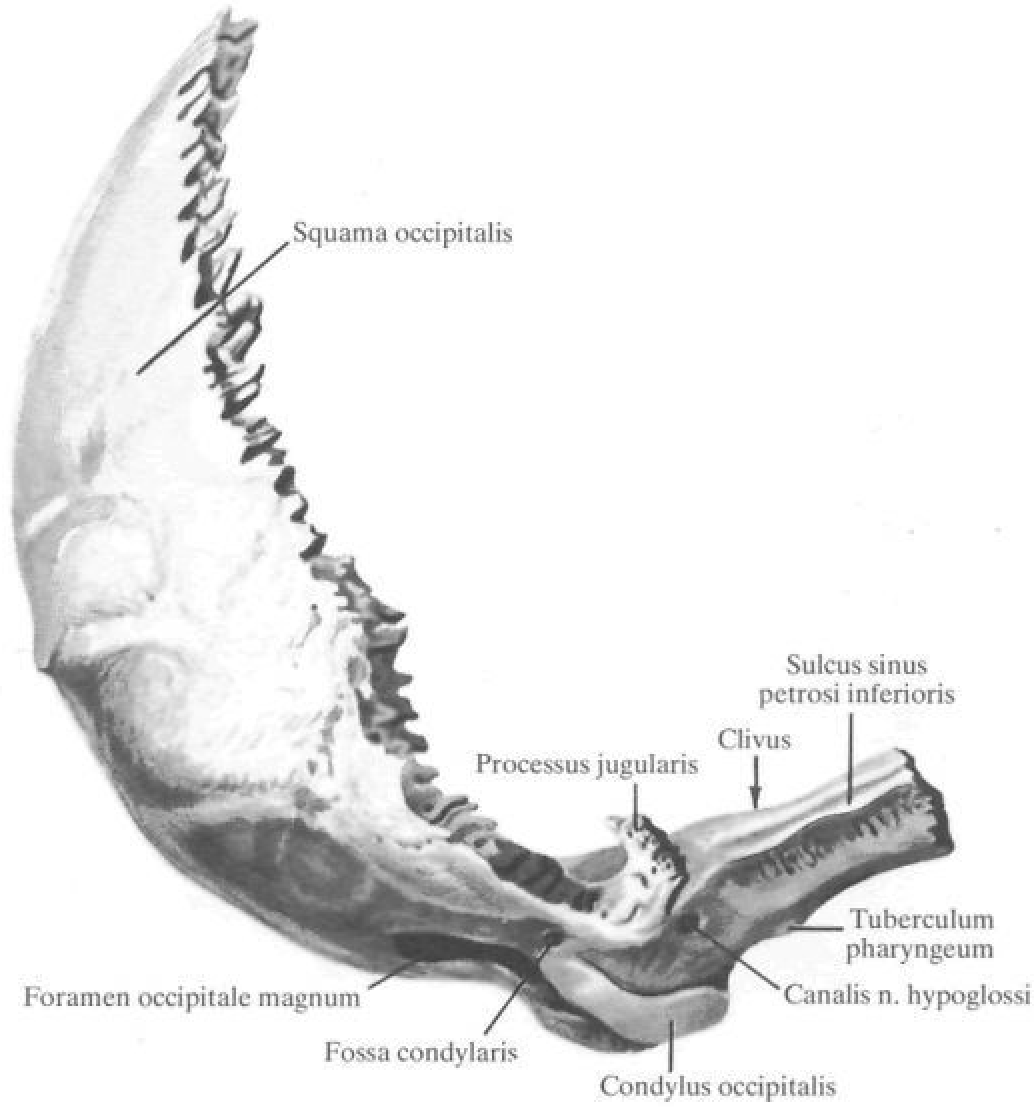
The external slightly uneven border of the basilar part and condylar parts of the occipital bone adjoin the posterior margin of the petrous part of the temporal bone. Between them is the **petro-occipital fissure** *(fissura petrooccipitalis)*, which in an unmacerated skull is filled with cartilage forming the **petro-occipital joint** *(synchondrosis petrooccipitalis)* that as a remnant of the cartilaginous skeleton ossifies with age.

The **condylar parts** *(partes laterales)* of the occipital bone are slightly elongated, thickened in the posterior parts and narrowed a little in the anterior parts. They form the lateral borders of the foramen magnum and fuse anteriorly with the basilar part and posteriorly with the squamous part.

On the external border of the internal (cerebral) surface (Fig. 55) is a narrow **groove for the inferior petrosal sinus** *(sulcus sinus petrosi inferioris)* which meets the inferior border of the petrous part of the temporal bone and joins the similarly named groove on the temporal bone to form a sort of canal in which the venous **inferior petrosal sinus** *(sinus petrosus inferior)* lies.

On the inferior, external, surface of either condylar part is an elongated oval in shape and convex articular process, the **occipital condyle** *(condylus occipitalis)*; both condyles with the articular surface converge anteriorly but diverge posteriorly; they articulate with the superior facets of the atlas. To the back of the occipital condyle is a **condylar fossa** *(fossa condylaris)* lodging the posterior condylar emissary vein *(vena emissaria condylaris)*.

The external border of the condylar part bears a large **jugular**



56. *Occipital bone (os occipitale)*; from the right side (4/5).

notch *(incisura jugularis)* with smooth edges. A small **intrajugular process** *(processus intrajugularis)* projects on the notch.

The jugular notch of the occipital bone and the jugular notch of the petrous part of the temporal bone form the **jugular foramen** *(foramen jugulare)*.

The intrajugular processes of both bones separate this foramen into two parts: a larger posterior part lodging the upper bulb of the internal jugular vein *(bulbus superior vena jugularis internae)*, and a smaller anterior part transmitting the glossopharyngeal, vagus, and accessory nerves *(nervi glossopharyngeus, vagus* et *accessorius)*.

The jugular notch is bounded by the **jugular process** *(processus jugularis)* posteriorly and laterally. On the external surface of its base is a small **paramastoid process** *(processus paramastoideus)* into which the rectus capitis lateralis muscle is inserted.

A wide **sigmoid groove** *(sulcus sinus sigmoidei)* stretches behind the jugular process on the internal surface of the skull; it is a continuation of the sigmoid groove of the temporal bone. A smooth **jugular tubercle** *(tuberculum jugulare)* is located anteriorly and medially.

To the back of and downwards from the jugular tubercle, between the jugular process and the occipital condyle the **hypoglossal canal** *(canalis nervi hypoglossi)* passes through the bone; it transmits the hypoglossal nerve.

The **squamous part of the occipital bone** *(squama occipitalis)* forms the posterior border of the foramen magnum and makes up the greater part of the occipital bone. This is a wide triangular curved plate with a concave internal (cerebral) surface and a convex external surface.

The edge of the squamous part is separated into two parts: a larger strongly serrated superior part called the **lambdoid border** *(margo lambdoideus)* which articulates with the occipital border of the parietal bones to form the **lambdoid suture** *(sutura lambdoidea)*; a smaller less serrated inferior part called the **mastoid border** *(margo mastoideus)* which unites with the edge of the mastoid process of the temporal bone by means of the **occipitomastoid suture** *(sutura occipitomastoidea)*.

The **external occipital protuberance** *(protuberantia occipitalis externa)* (Fig. 54) is in the middle of the external surface of the squama where it is most convex. The protuberance is easily palpated through the skin. Laterally from it diverge paired raised **su-**

perior nuchal lines *(linea nuchae superiores)*, above and parallel to which are encountered accessory **highest nuchal lines** *(linea nuchae supremae)*.

The **external occipital crest** *(crista occipitalis externa)* descends from the external occipital protuberance to the foramen magnum.

In the middle of the distance between the foramen magnum and the external occipital protuberance, the crest gives rise to the **inferior nuchal lines** *(linea nuchae inferiores)*, which diverge laterally and pass to the edges of the squamous part parallel to the superior lines. All these lines mark the insertion of muscles. The surface of the squamous part below the superior nuchal lines is the site of attachment of muscles terminating on the occipital bone.

The **cerebral surface** *(facies cerebralis)* of the squamous part bears the **eminentia cruciata** *(eminentia cruciformis)* in the middle of which is the **internal occipital protuberance** *(protuberantia occipitalis interna)* (Fig. 55). It corresponds to the external occipital protuberance on the external surface.

The cruciate eminence gives rise to a **groove for the transverse sinus** *(sulcus sinus transversi)* passing laterally on either side, an ascending **superior groove for the sagittal sinus** *(sulcus sinus sagittalis superioris)*, and an **internal occipital crest** *(crista occipitalis interna)* descending to the posterior semicircumference of the foramen magnum.

Processes of the dura mater with the venous sinuses embedded in them are attached to the borders of the transverse and sagittal grooves and the internal occipital crest.

THE PARIETAL BONE

The **parietal bone** *(os parietale)* (Figs 50, 51, 57, 58) is a paired bone forming the superior and lateral parts of the skull cap (calvaria). It is a quadrangular plate convex on the outer surface. Two surfaces, external and internal, and four borders, superior, inferior, anterior, and posterior, are distinguished in it.

The **external surface** *(facies externa)* is even and convex. The most convex part is called the **parietal eminence**, or **tuber** *(tuber parietale)*. Below the tuber is a rough horizontal arched **superior temporal line** *(linea temporalis superior)* which arises from the anterior border of the bone and, being a continuation of the superior temporal line of the frontal bone, stretches along the entire surface of the parietal bone to its posteroinferior angle. Below this line and parallel to the inferior border of the parietal bone stretches another, more defined line, the **inferior temporal line** *(linea temporalis inferior)*. The superior line gives attachment to the temporal fascia, the inferior line is the site of insertion of the temporal muscle.

The **internal surface** *(facies interna)* is concave and bears poorly defined depressions corresponding to the gyri of the brain which are called **impressions for the cerebral gyri** *(impressiones digitatae)*, cerebral ridges and dendriform branching **arterial sulci** *(sulci arteriosi)* which are marks of the branches of the middle meningeal artery.

On the superior border of the cerebral surface of the bone passes an incomplete **sagittal groove** *(sulcus sinus sagittalis superioris)* and, together with the groove on the contralateral parietal bone, forms a complete groove (the sickle-shaped process of the dura mater, *falx cerebri*, is attached to the margins of the groove).

In the posterior part of the superior border of the bone is a small **parietal foramen** *(foramen parietale)* which is an **emissary** *(emissarium)* transmitting a branch of the occipital artery to the dura mater and the parietal emissary vein. Deep in the sagittal groove and next to it (particularly on the parietal bones at an elderly age) can be seen most of the small **granular pits** *(foveolae granulares)* (granulations of the arachnoid mater of the brain project here).

A small deep **sigmoid groove** *(sulcus sinus sigmoidei)*, an impression of the venous sigmoid sinus of the dura mater, is found on the cerebral surface at the posteroinferior angle. It is continuous with the sigmoid groove on the temporal bone anteriorly and with the groove for the transverse sinus on the occipital bone posteriorly.

The superior, **sagittal border** *(margo sagittalis)* runs straight and is strongly serrated. It is longer than the other borders and articulates with the sagittal border of the contralateral parietal bone by means of the **sagittal suture** *(sutura sagittalis)*.

The inferior, **squamous border** *(margo squamosa)* is tapered and arched and its anterior area is covered by the posterior part of the upper border of the greater wing of the sphenoid bone. Further to the back, the parietal border of the squamous part of the temporal bone is superimposed on it; the extreme posterior area articulates by means of notches with the mastoid process of the temporal bone. According to these three areas, the following three sutures form: the **squamous suture** *(sutura squamosa)*, the **parietomastoid suture** *(sutura parietomastoidea)*, and the **sphenoparietal suture** *(sutura sphenoparietalis)*.

The anterior, **frontal border** *(margo frontalis)* is serrated. It articulates with the parietal border of the squama of the frontal bone to form the **coronal suture** *(sutura coronalis)*.

The posterior, **occipital border** *(margo occipitalis)* is serrated and articulates with the lambdoid border of the occipital bone to form the **lambdoid suture** *(sutura lambdoidea)*.

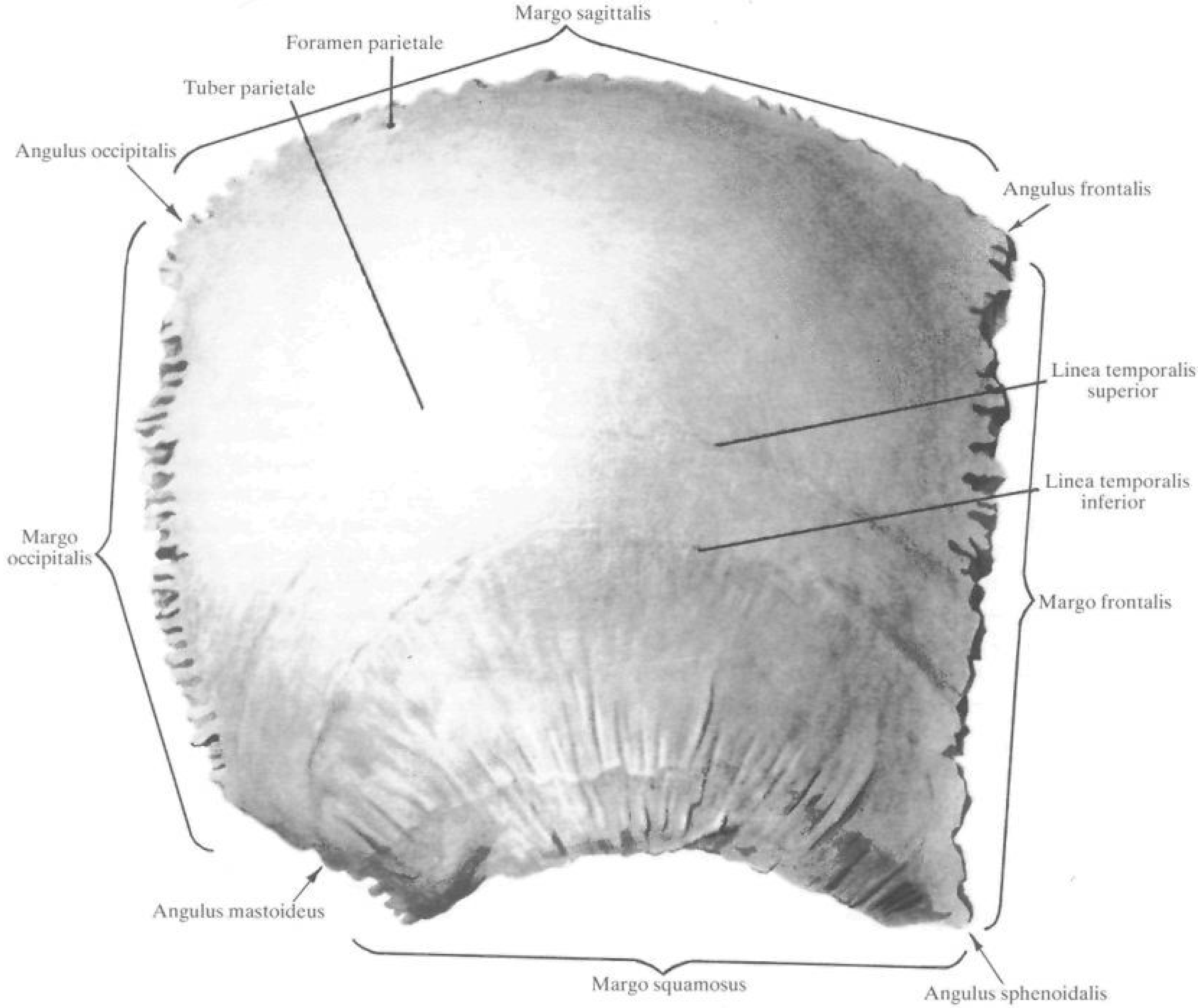
In accordance with the four borders, the parietal bone has four angles.

The anterosuperior, **frontal angle** *(angulus frontalis)* is almost straight (it is bounded by the coronal and sagittal sutures).

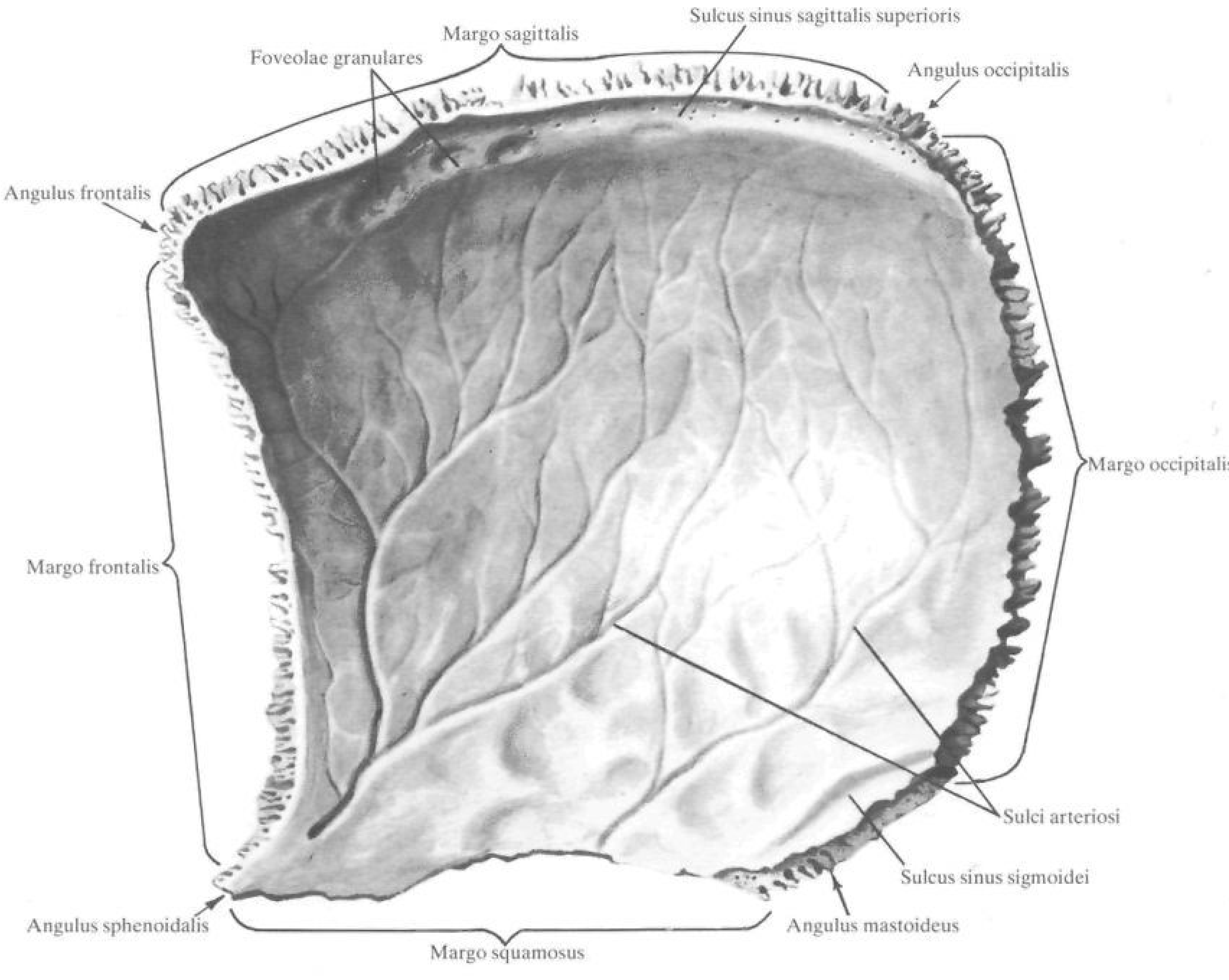
The anteroinferior, **sphenoidal angle** *(angulus sphenoidalis)* is acute (it is bounded by the coronal and sphenoparietal sutures).

The posterosuperior, **occipital angle** *(angulus occipitalis)* is obtuse (it is bounded by the lambdoid and sagittal sutures).

The posteroinferior, **mastoid angle** *(angulus mastoideus)* is more obtuse than the posterosuperior angle (it is bounded by the lambdoid and parietomastoid sutures). Its anterior part fits into the **parietal notch** *(incisura parietalis)* of the temporal bone.



57. *Right parietal bone (os parietale)*; outer aspect (⅘).



58. *Right parietal bone (os parietale)*; inner aspect ($^4/_5$).

THE FRONTAL BONE

The **frontal bone** *(os frontale)* (Figs 48-53, 59-61) of a human adult forms the anterior part and partly the base of the skull cap. It consists of four parts: **frontal squama** *(squama frontalis)*, two **orbital plates** *(partes orbitales)*, and the **nasal part** *(pars nasalis)*.

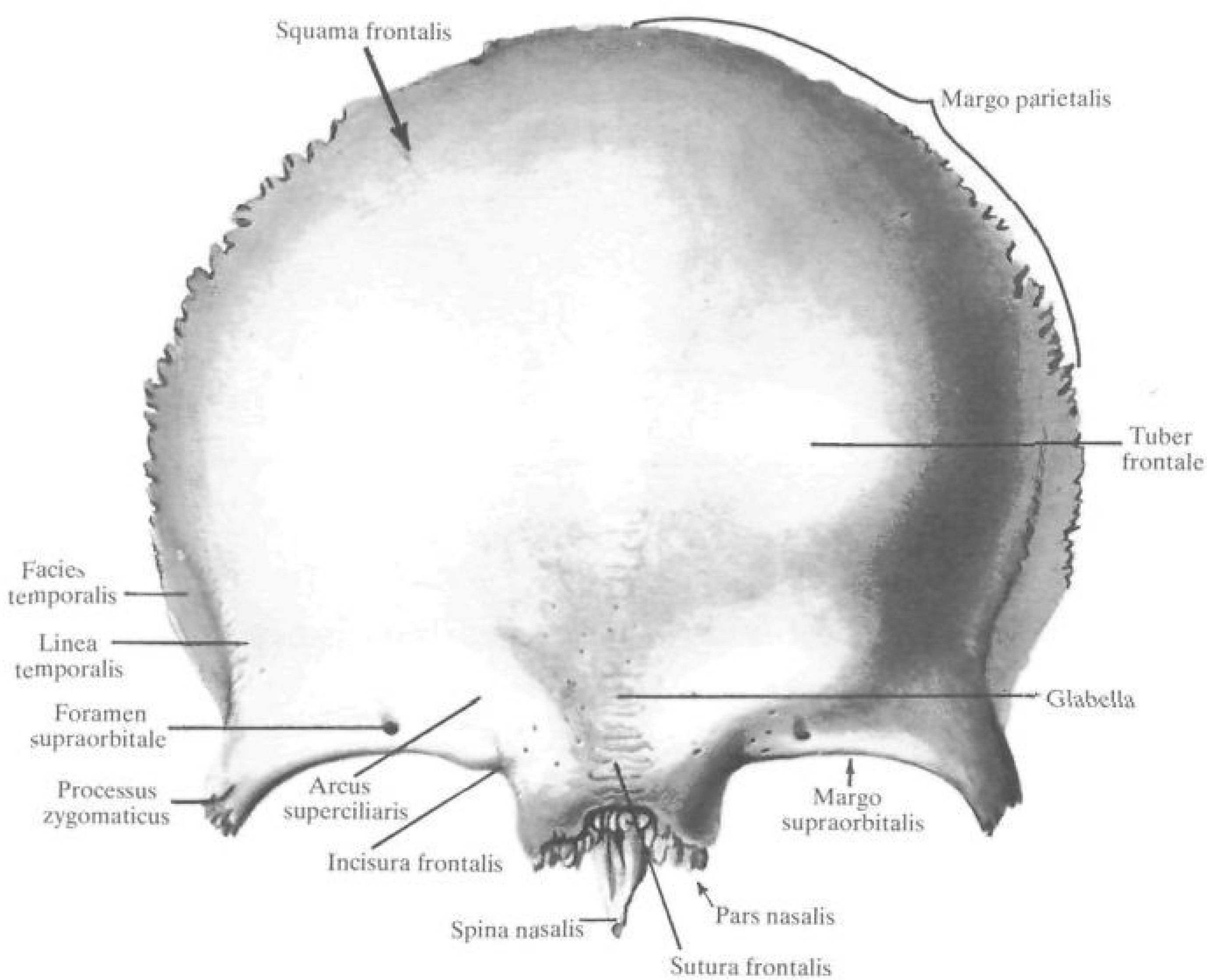
The **frontal squama** *(squama frontalis)* is convex to the front and has the following surfaces: an external (frontal), two lateral (temporal) surfaces, and an internal (cerebral surface).

The **frontal surface** *(facies externa)* is smooth, convex anteriorly and has an eminence on the median line. This eminence is not detectable in some cases. This is the line of the **frontal suture** *(sutura metopica)* marking the union of the halves of the frontal bone in early childhood. In the anterior parts, the frontal surface of the squama is continuous with the **orbital surface** *(facies orbitalis)* and forms the **supraorbital margin** *(margo supraorbitalis)* on both sides. Above and parallel to this margin is a more or less defined arched eminence, the **superciliary arch** *(arcus superciliaris)*. Above each arch is a rounded **frontal eminence** *(tuber frontale)*. Between and slightly above the superciliary arches the surface of the squama has a depressed area, the **glabella**. The supraorbital margin has a small **supraorbital notch** *(incisura supraorbitalis)* in its medial third. This notch varies greatly and may be present as a **supraorbital foramen** *(foramen supraorbitale)*. Nearer to the median line, i.e. medially, is located a no less defined **frontal notch** *(incisura frontalis)*. The supraorbital notch transmits the lateral branch of the supraorbital nerve and vessels, the frontal notch transmits the medial branch of this nerve and vessels. A **frontal foramen** *(foramen frontale)* may be found in place of the notch.

The supraorbital margin is continuous laterally with a blunt triangular **zygomatic process** *(processus zygomaticus)*, whose serrated edge unites with the frontal process of the zygomatic bone by means of the **frontozygomatic suture** *(sutura frontozygomatica)*.

An arched **temporal line** *(linea temporalis)* ascends posteriorly from the zygomatic process. It separates the frontal surface of the squama from its **temporal surface** *(facies temporalis)* which is the anterosuperior area of the temporal fossa where part of the temporal muscle arises.

The **cerebral surface** *(facies interna)* of the frontal squama (Fig. 60) is concave. It has poorly defined **impressions for the gyri**



59. *Frontal bone (os frontale)*; outer aspect ($^4/_5$).

(impressiones girorum), **cerebral ridges** *(juga cerebralia)*, and inconstantly present and indistinct **arterial sulci** *(sulci arteriosi)* which are markings for the brain and vessels lodged here.

The **sagittal groove** *(sulcus sinus sagittalis superioris)* runs in the middle of the superior parts of the internal surface. Both its edges pass upwards and to the back to unite with the sagittal groove of the parietal bone, while downwards they join to form a single sharp **frontal crest** *(crista frontalis)* (to which the process of the dura mater, falx cerebri, is attached). At its lowest part the crest together with the **ala of the crista galli** *(ala cristae galli ossis ethmoidalis)* form the **foramen caecum** *(foramen cecum)*, a blind opening occupied by a process of the dura mater.

The superior, or posterior, thickened border of the frontal squama is called the **parietal margin** *(margo parietalis)*. Its serrated border unites with the frontal border of the parietal bone to form the **coronal suture** *(sutura coronalis)*. The inferior triangular areas of the squama unite with the frontal border of the greater wings of the sphenoid bone.

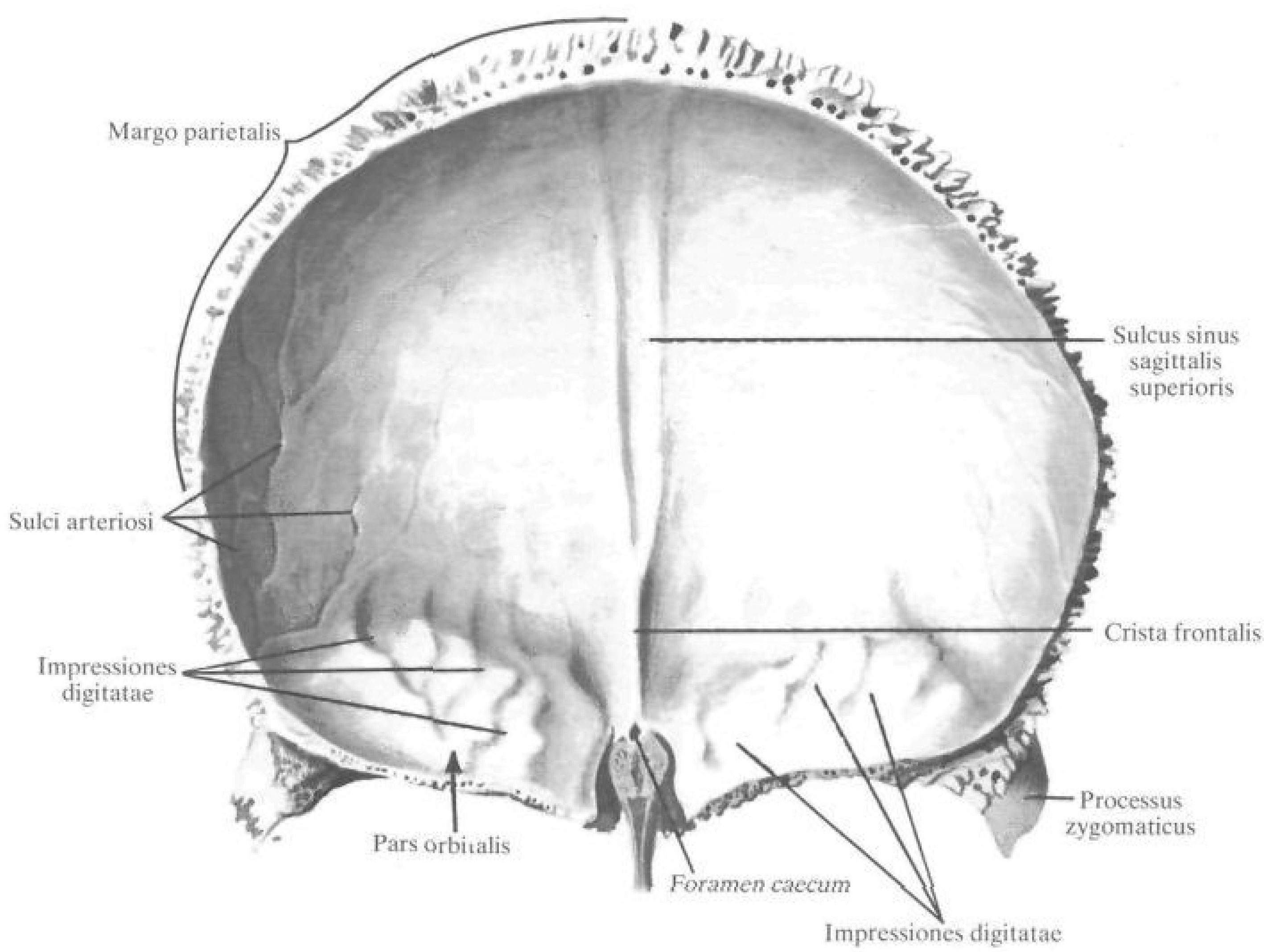
Each **orbital plate** *(pars orbitalis)* (Fig. 61) of the frontal bone contributes to the formation of the superior wall of the orbit. It stretches posteriorly and horizontally from the supraorbital margin of the squama. Inferior (orbital) and superior (cerebral) surfaces are distinguished in it.

The **orbital surface** *(facies orbitalis)* faces the cavity of the orbit and is smooth and concave. In its lateral part at the base of the zygomatic process it has a small shallow **fossa for the lacrimal gland** *(fossa glandulae lacrimalis)*.

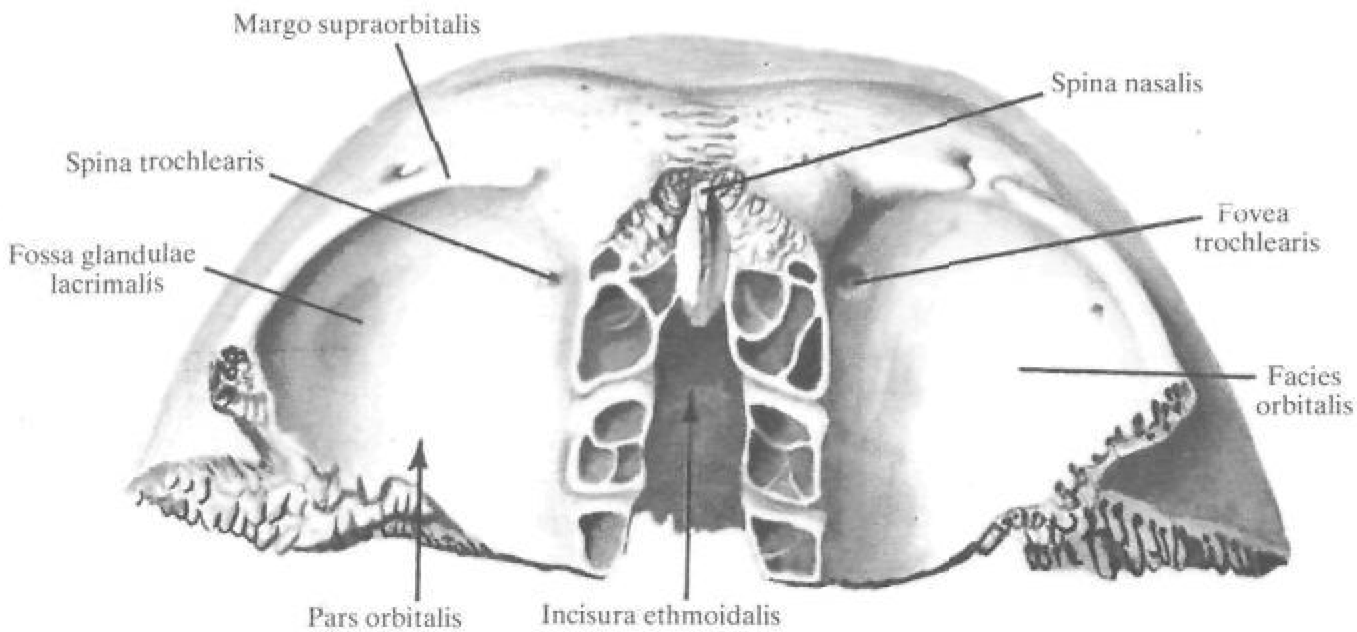
The medial part of the orbital surface bears a poorly defined **trochlear fossa** *(fovea trochlearis)*, near to which a cartilaginous **trochlear spine** *(spina trochlearis)* is often found (it serves for attachment of a cartilaginous ring which is a pulley, the trochlea, for the tendon of the superior oblique muscle of the eyeball).

The **cerebral surface** *(facies interna)* of the orbital part has clearly defined markings for the frontal lobes of the brain in the form of **impressions for the gyri** *(impressiones girorum)* and **cerebral ridges of the cranium** *(juga cerebralia)*.

The orbital plates are separated from one another by the **ethmoidal notch** *(incisura ethmoidalis)* into which fits the **cribriform plate** *(lamina cribrosa)* of the ethmoid bone. The notch is bounded on the sides by a border lateral of which are a series of small pits



60. *Frontal bone (os frontale)*; inner aspect (3/4).



61. *Frontal bone (os frontale)*; inferior aspect (3/4).

(Fig. 61). They roof in the open ethmoidal cells of the superior part of the ethmoid bone to form their superior wall. Two ethmoidal grooves, anterior and posterior, stretch transversely between the ethmoidal cells and together with the ethmoidal grooves of the labyrinth of the ethmoid bone form small canals which have small openings on the medial wall of the orbit: the **anterior ethmoidal foramen** *(foramen ethmoidale anterius)* (see Figs 106 and 109) which transmits the anterior ethmoidal vessels and nerve, and the **posterior ethmoidal foramen** *(foramen ethmoidale posterius)* which transmits the nerves and posterior ethmoidal vessels. The margin of the ethmoidal notch articulates with the superior margin of the **orbital plate** *(lamina orbitalis)* of the ethmoid bone to form the **frontoethmoid suture** *(sutura frontoethmoidalis)*. Anteriorly the notch unites with the lacrimal bone by means of the **frontolacrimal suture** *(sutura frontolacrimalis)*.

The posterior border of the orbital plate is thin and serrated, and articulates with the lesser wing of the sphenoid bone to form the internal part of the **sphenofrontal suture** *(sutura sphenofrontalis)*.

The lateral border of the orbital plate is rough, triangular, and articulates with the frontal border of the greater wing of the sphenoid bone to form the external part of the sphenofrontal suture. Still laterally the border terminates at the zygomatic process.

The **nasal part** *(pars nasalis)* of the frontal bone closes the ethmoidal notch anteriorly in an arch-like fashion. In the middle of its anterior part, the **nasal spine** *(spina nasalis)* (sometimes a double one) projects obliquely downwards and forwards. It has a tapering end and flattened sides and is surrounded in front and on the sides by a serrated **nasal margin** *(margo nasalis)*. The anterior parts of the margin unite with the superior border of the nasal bone to form the **frontonasal suture** *(sutura frontonasalis)*, the posterior parts join the **frontal process of the maxilla** *(processus frontalis)* by means of the **frontomaxillary suture** *(sutura frontomaxillaris)*. Posteriorly, the inferior surface of the nasal part bears shallow ethmoidal pits which, as pointed out above, roof in the cells of the ethmoidal labyrinths.

On either side of the nasal spine is the **aperture of the frontal sinus** *(apertura sinus frontalis)*. It stretches upwards and forwards and leads into the cavity of the respective frontal sinus.

The **frontal sinus** *(sinus frontalis)* (see Figs 94 and 103) is a paired cavity lodged between both plates of the frontal bone in its anteroinferior parts. It is an air **paranasal sinus** *(sinus paranasalis)*. The right and left sinuses are separated by a vertical **septum of the frontal sinuses** *(septum sinuum frontalium)*. The septum deviates to one or the other side as a result of which the sinuses differ in size. The borders of the sinuses vary considerably. Sometimes they reach upwards to the frontal eminence, downwards to the supraorbital margin, backwards to the lesser wings of the sphenoid bone, and laterally to the zygomatic processes. By means of its aperture the frontal sinus communicates with the **middle meatus of the nose** *(meatus nasi medius)*. The cavity of the sinus is lined with a mucous membrane.

THE SPHENOID BONE

The **sphenoid bone** *(os sphenoidale)* (Figs 62-64, 94, 96, 102) is unpaired and forms the central part of the base of the skull.

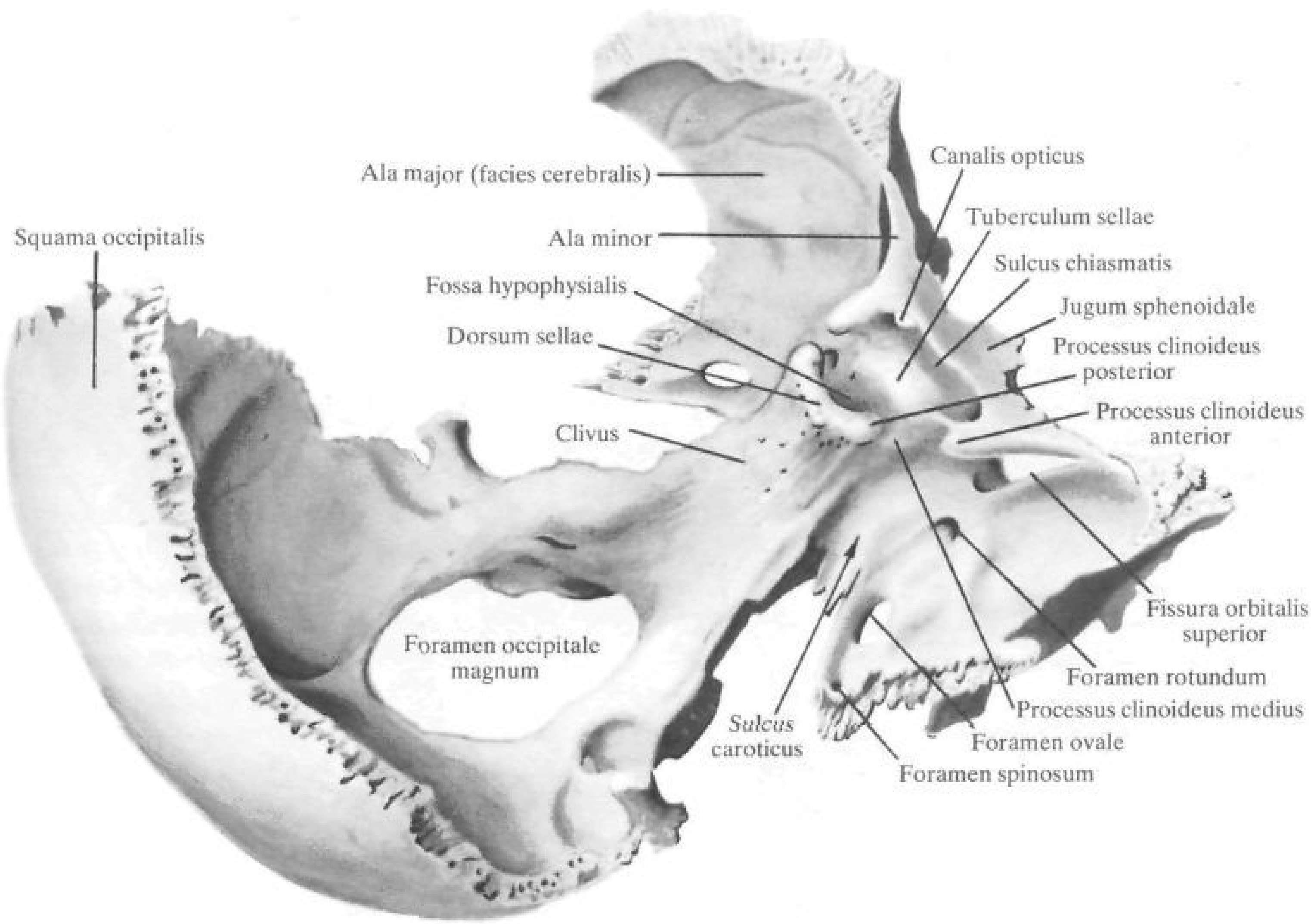
The **body** *(corpus ossis sphenoidalis)* is the middle part of the sphenoid bone, it is cuboid in shape and has six surfaces.

In its middle part the superior surface facing the cranial cavity has a depression, the **sella turcica**, in the centre of which is the **hypophyseal fossa** *(fossa hypophysialis)* (Fig. 62) in which the hypophysis is lodged. The size of the fossa is determined by the size of the hypophysis. The sella turcica is bounded by the **tuberculum sellae** anteriorly. To the back of it, on the lateral surface of the sella is an inconstantly present **middle clinoid process** *(processus clinoideus medius)*.

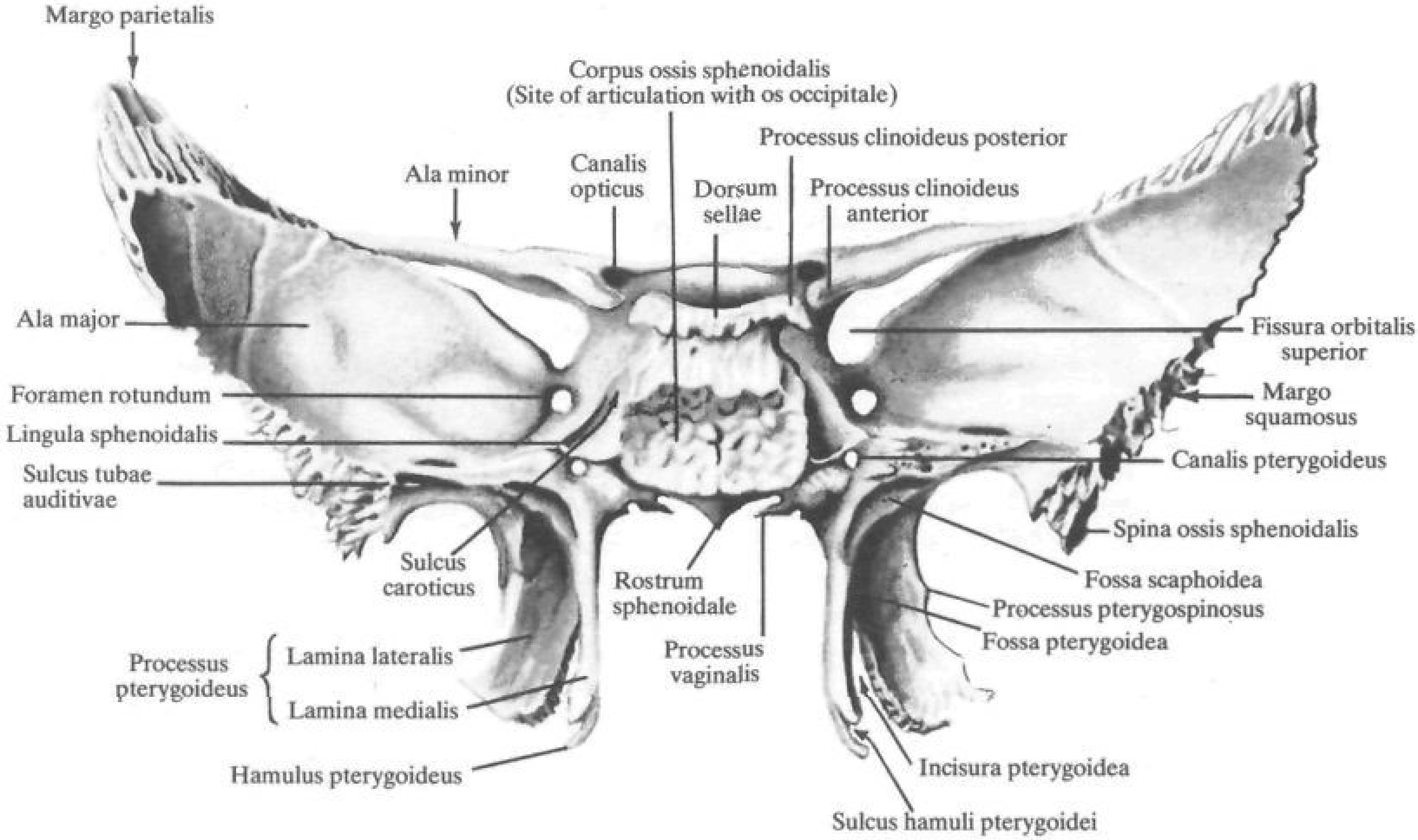
A shallow transverse **optic groove** *(sulcus chiasmatis)* passes to the front of the sella and lodges the **optic chiasma** *(chiasma opticum)*. On both sides the groove is continuous with the **optic foramen** *(canalis opticus)*. In front of the groove is a smooth surface, **jugum sphenoidale,** that connects the lesser wings of the sphenoid bone. The anterosuperior border of the body is serrated, projects forwards slightly, and unites with the posterior border of the **cribriform plate** *(lamina cribrosa)* of the ethmoid bone to form the **sphenoethmoidal suture** *(sutura sphenoethmoidalis)*. The sella turcica is bounded posteriorly by the **dorsum sellae** terminating on both sides by a small **posterior clinoid process** *(processus clinoideus posterior)*.

The **carotid groove** *(sulcus caroticus)* stretches laterally from front to back of the sella (it is an impression of the internal carotid artery and the attendant nerve plexus which are lodged here). A sharp process called the **lingula of the sphenoid bone** *(lingula sphenoidalis)* projects at the posterior edge of the groove on its lateral side.

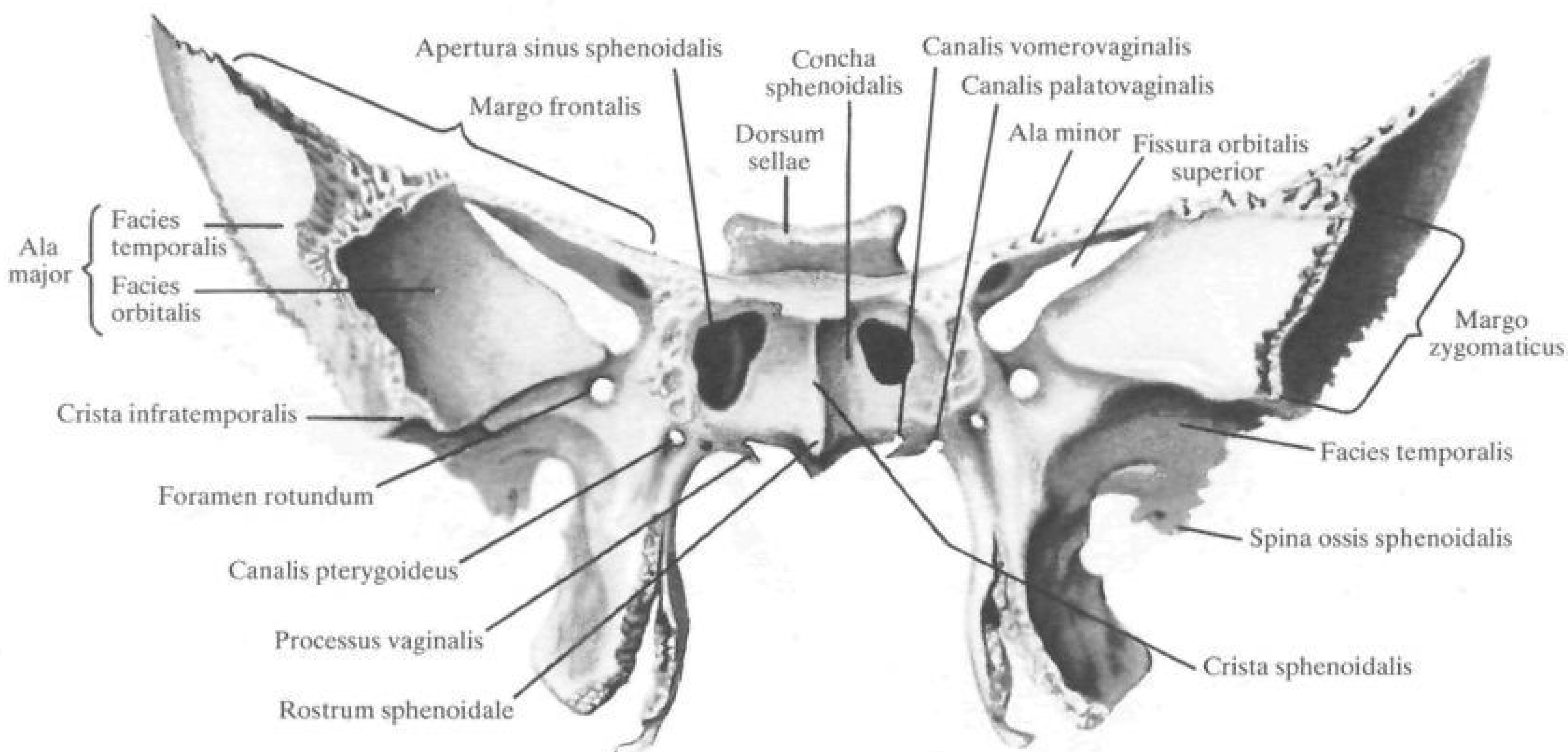
The posterior surface of the dorsum sellae is continuous with the superior surface of the basilar part of the occipital bone to form the **clivus** (on which the pons, the medulla oblongata, the basilar artery and its branches are lodged). The posterior surface of the body is rough. It is joined to the anterior surface of the basilar part of the occipital bone by means of a cartilaginous layer to form the **spheno-occipital joint** *(synchondrosis sphenooccipitalis)*. The cartilage is replaced by bony tissue with age and both bones fuse.



62. *Sphenoid bone (os sphenoidale)* and *occipital bone (os occipitale)*; superior aspect (3/4).



63. *Sphenoid bone (os sphenoidale)*; posterior aspect ($^1/_1$).



64. *Sphenoid bone (os sphenoidale)*; anterior aspect ($^1/_1$).

The anterior and part of the inferior surface of the body face the nasal cavity. A vertical **crest of the sphenoid** *(crista sphenoidalis)* projects into the middle of the anterior surface. Its anterior edge adjoins the **perpendicular plate** *(lamina perpendicularis)* of the ethmoid bone. The lower segment of the crest is tapered and stretches downwards to form the **rostrum of the sphenoid** *(rostrum sphenoidale)* which is wedged in-between the **alae of the vomer** *(alae vomeris)*. To both sides of the crest is a thin curved plate called the **sphenoidal concha** *(concha sphenoidalis)* (Fig. 64) which forms the anterior and partly the inferior walls of the **sphenoidal sinus** *(sinus sphenoidalis)* and has a small **aperture of the sphenoidal sinus** *(apertura sinus sphenoidalis)*. Lateral to the aperture are small pits which roof in the cells of the posterior part of the ethmoid bone labyrinth. The external margins of these pits unite partially with the orbital plate of the ethmoid bone to form the **sphenoethmoidal suture** *(sutura sphenoethmoidalis)*, while the inferior margins unite with the **orbital process** *(processus orbitalis)* of the palatine bone.

The **sphenoidal sinus** *(sinus sphenoidalis)* (see Fig. 94) is a paired cavity, occupies a large part of the body of the sphenoid bone, and is a paranasal air cavity. Both the right and left cavities are separated by the **septum of the sphenoidal sinuses** *(septum sinuum sphenoidalium)* which is anteriorly continuous with the crest of the sphenoid. Just like in the case of the frontal sinuses, the septum sometimes deviates to one side as a result of which the sinuses may differ in size. Each sinus communicates with the nasal cavity by means of its aperture described above. The cavity of the sinus is lined with a mucous membrane.

The **lesser wings** *(alae minores)* of the sphenoid bone arise from the anterosuperior angles of the body and project laterally as two horizontal plates at the base of which is a small round opening leading into a bony 5-6 mm long **optic foramen** *(canalis opticus)*. It transmits the optic nerve and the ophthalmic artery. The lesser wings have a superior surface facing the cranial cavity and an inferior surface which faces the orbital cavity and forms the superior border of the **superior orbital fissure** *(fissura orbitalis superior)*.

The anterior border of the lesser wing is thick and serrated and unites with the orbital plate of the frontal bone. The posterior concave and smooth border projects into the cranial cavity freely and is the border between the **anterior** and **middle cranial fossae** *(fossae cranii anterior* et *media)* (see Figs 101 and 102). The posterior border terminates medially by a projecting well-defined **anterior clinoid process** *(processus clinoideus anterior)* to which part of the dura mater is attached, forming the **diaphragma sellae**.

The **greater wings** *(alae majores)* arise from the lateral surfaces of the body of the sphenoid bone and stretch laterally.

The greater wing has five surfaces and three borders.

The superior, **cerebral surface** *(facies cerebralis)* is concave and faces the cranial cavity. It forms the anterior part of the middle cranial fossa and bears **impressions for the gyri** *(impressiones digitatae)*, **cerebral juga**, or **ridges** *(juga cerebralia)*, and **arterial sulci** *(sulci arteriosi)* which are markings for the brain surface and middle meningeal arteries lodged here.

There are three openings at the base of the wing: the **foramen rotundum** (Figs 63 and 64) transmitting the maxillary nerve is situated medially and anteriorly; laterally and posteriorly of the foramen rotundum is the **foramen ovale** transmitting the mandibular nerve and the vascular network of the foramen ovale; still more laterally and to the back of the foramen ovale is the **foramen spinosum** transmitting the middle meningeal artery, vein, and nerve.

The anterosuperior, **orbital surface** *(facies orbitalis)* is smooth, rhomboid, and faces the orbital cavity. It forms the greater part of the lateral wall of the orbit. A gap is left between the inferior border of this surface and the posterior border of the orbital surface of the maxillary body to form the **inferior orbital fissure** *(fissura orbitalis inferior)* (Figs 48 and 49).

The anterior, **maxillary surface** *(facies maxillaris)* is a small triangular surface bounded by the orbital surface superiorly and by the root of the pterygoid process of the sphenoid bone laterally and inferiorly. It contributes to the formation of the posterior wall of the **pterygopalatine fossa** *(fossa pterygopalatina)* (see Figs 109 and 110) in which the foramen rotundum is located.

The superolateral, **temporal surface** *(facies temporalis)* is slightly concave and participates in the formation of the wall of the **temporal fossa** *(fossa temporalis)* from which the temporal muscle arises. This surface is bounded inferiorly by the **infratemporal crest** *(crista infratemporalis)* below which is an area with the **foramen ovale** and the **foramen spinosum**. This area forms the superior wall of the **infratemporal fossa** *(fossa infratemporalis)* in which part of the lateral pterygoid muscle originates. The superior, **frontal border** *(margo frontalis)* is widely serrated and articulates with the orbital plate of the frontal bone by means of the **sphenofrontal suture** *(sutura sphenofrontalis)*. The lateral parts of the frontal border terminate as a sharp **parietal border** *(margo parietalis)* which unites with the sphenoid angle of the parietal bone to form the **sphenoparietal suture** *(sutura sphenoparietalis)*. The medial parts of the frontal border are continuous with a thin free border which binds the **superior orbital fissure** *(fissura orbitalis superior)* inferiorly because of a gap left between this border and the inferior surface of the lesser wing.

The anterior, **zygomatic border** *(margo zygomaticus)* is serrated and articulates with the frontal process of the zygomatic bone to form the **sphenozygomatic suture** *(sutura sphenozygomatica)*.

The posterior, **squamous border** *(margo squamosus)* unites with the **sphenoidal border** *(margo sphenoidalis)* of the temporal bone by means of the **sphenosquamous suture** *(sutura sphenosquamosa)*. Posteriorly and laterally the squamous border terminates as the **spine of the sphenoid** *(spina ossis sphenoidalis)* to which are attached the sphenomandibular ligaments and a bunch of muscles tensing the soft palate, the tensor palati muscle.

Medially of the spine of the sphenoid, the posterior border of the greater wing stretches anteriorly of the **petrous part** *(pars petrosa)* of the temporal bone and binds the **sphenopetrosal fissure** *(fissura sphenopetrosa)* which is medially continuous with the **foramen lacerum** (see Figs 96 and 102). In a nonmacerated skull this fissure is filled with cartilaginous tissue to form the **sphenopetrous joint** *(synchondrosis sphenopetrosa)*.

The **pterygoid processes** *(processus pterygoidei)* (Figs 63 and 64) spring downwards from the junction of the greater wings and the body of the sphenoid bone. They are formed of two plates, lateral and medial. The **lateral pterygoid plate** *(lamina lateralis processus pterygoidei)* is wider but thinner and shorter than the medial plate (the lateral pterygoid muscle originates from its lateral surface). The **medial pterygoid plate** *(lamina medialis processus pterygoidei)* is narrower, thicker and slightly longer than the lateral plate. Both plates fuse by means of their anterior borders and diverge to the back to form the **pterygoid fossa** *(fossa pterygoidea)* in which the medial pterygoid muscle arises. In the inferior parts, the plates do not fuse but bind the **pterygoid notch** *(incisura pterygoidea)* into which the **pyramid process,** or **tubercle** *(processus pyramidalis)* of the palatine bone fits. The free end of the medial plate terminates as the **pterygoid hamulus** *(hamulus pterygoideus)* which projects downwards and laterally and has on its lateral surface the **sulcus of the pterygoid hamulus** *(sulcus hamuli pterygoidei)* (this sulcus lodges the tendon of the tensor veli palatini muscle).

The posterosuperior border of the medial plate becomes wider at the base to form an elongated **scaphoid fossa** *(fossa scaphoidea)* in which the tensor veli palatini muscle originates.

Laterally of the scaphoid fossa is a shallow **groove for the pharyngotympanic tube** *(sulcus tubae auditivae)* (Fig. 63) which passes onto the greater wing laterally to reach the **spine of the sphenoid** *(spina ossis sphenoidalis).* This groove lodges the cartilaginous part of the auditory tube. Above and medially of the scaphoid fossa is an opening leading into the **pterygoid canal** *(canalis pterygoideus)* which transmits vessels and nerves. The canal stretches sagittally in the depth of the pterygoid process and opens on the maxillary surface of the greater wing on the posterior wall of the pterygopalatine fossa.

Under the opening along the anterior edge of the fossa is the pterygopalatine groove.

From the base of the medial plate a flat horizontal **vaginal process** *(processus vaginalis)* projects medially, it is situated below the body of the sphenoid bone and covers the **ala of the vomer** *(ala vomeris)* from the lateral side. As a result the groove of the vaginal process, the **vomerovaginal sulcus** *(sulcus vomerovaginalis),* which faces the wing is transformed into the **vomerovaginal canal** *(canalis vomerovaginalis).*

A small **palatinovaginal sulcus** *(sulcus palatinovaginalis)* sometimes stretches sagittally lateral of the process, in which case the sphenoid process of the palatine bone lying directly below the sulcus closes it to form the **palatinovaginal canal** *(canalis palatinovaginalis)* (both canals transmit nerves arising from the pterygopalatine ganglion, while the palatinovaginal canal transmits in addition branches of the sphenopalatine artery).

The **pterygospinous process** *(processus pterygospinosus)* extends sometimes from the posterior border of the lateral plate towards the spine of the sphenoid which it may reach to form an opening.

THE TEMPORAL BONE

The **temporal bone** *(os temporale)* (Figs 51-53, 65-71, 102) is a paired bone which contributes to the formation of the base of the skull and the side of the skull. The organ of hearing and equilibrium is lodged in it. The temporal bone articulates with the mandible and is a support for the masticatory apparatus.

On the external surface of the bone is the **lateral orifice of the external auditory meatus** *(porus acusticus externus)* around which the three parts of the temporal bone are arranged: the **squamous part** *(pars squamosa)* superiorly, **the petrous part (pyramid)** *(pars petrosa)* medially and posteriorly, and the **tympanic part** *(pars tympanica)* anteriorly and inferiorly.

The **squamous part** *(pars squamosa)* has the shape of a plate situated almost sagittally. Its outer **temporal surface** *(facies temporalis)* is rather rough and slightly convex. In its posterior part it bears a vertical **groove for the middle temporal artery** *(sulcus arteriae temporalis mediae),* which is a mark of the artery of the same name.

In the posteroinferior portion of the squamous part is an arched line which is continuous with the inferior temporal line of the parietal bone.

Above and slightly in front of the external acoustic meatus, the squamous part gives rise to a horizontally projecting **zygomatic process** *(processus zygomaticus)* which has a wide root but becomes gradually narrower. The process has a medial and a lateral surfaces and two margins, a longer superior and a shorter inferior margin. The anterior end of the zygomatic process is serrated and joins the **temporal process of the zygomatic bone** *(processus temporalis)* to form the **zygomatic arch** *(arcus zygomaticus)* (see Figs 50 and 51).

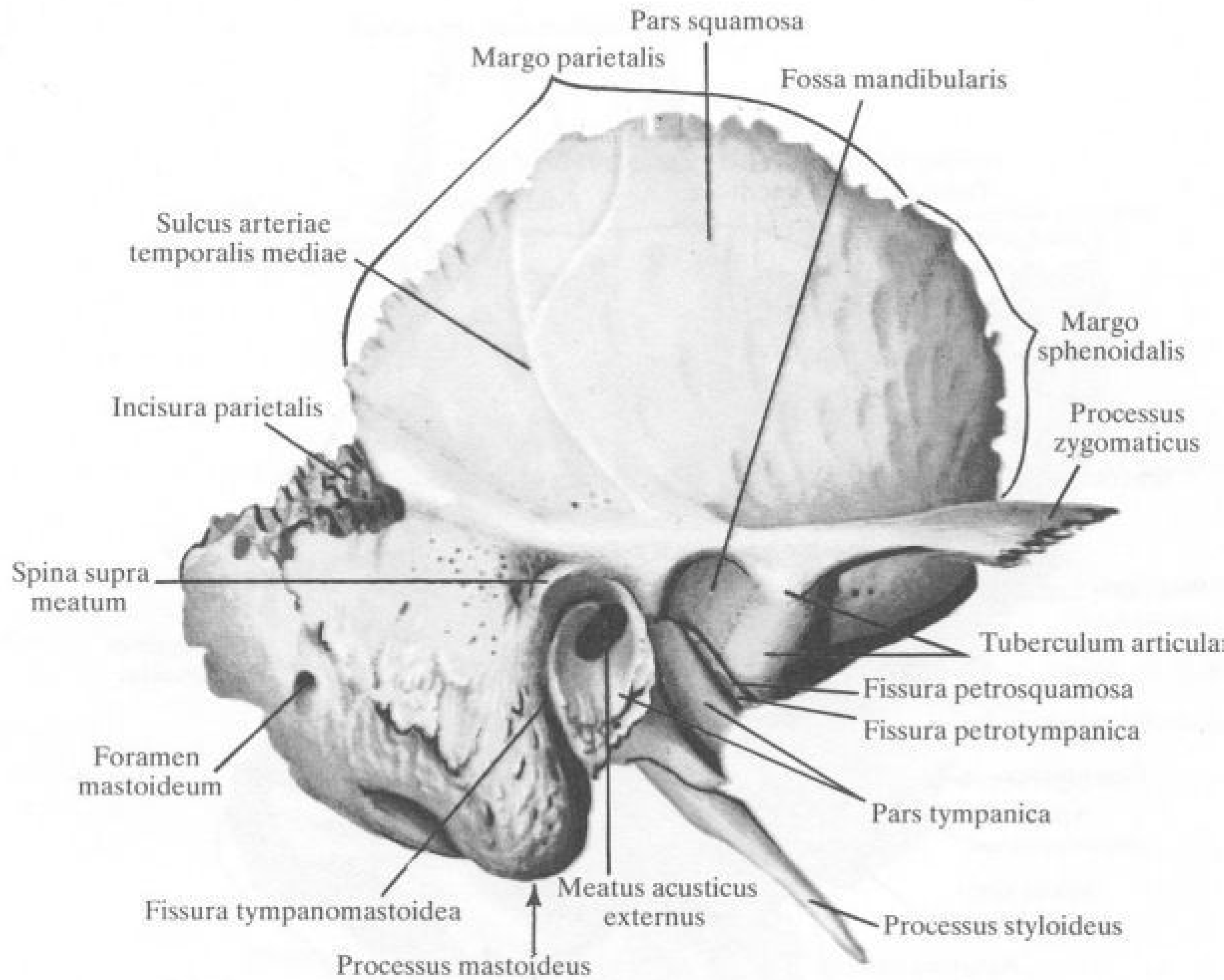
On the inferior surface of the root is a transversely-oval **articular fossa** *(fossa mandibularis)* for articulation with the head of the mandible. The fossa is bounded anteriorly by the **eminentia articularis** *(tuberculum articulare)* (Fig. 65).

The outer surface of the squamous part contributes to the formation of the **temporal fossa** *(fossa temporalis)* in which bundles of the temporal muscle originate.

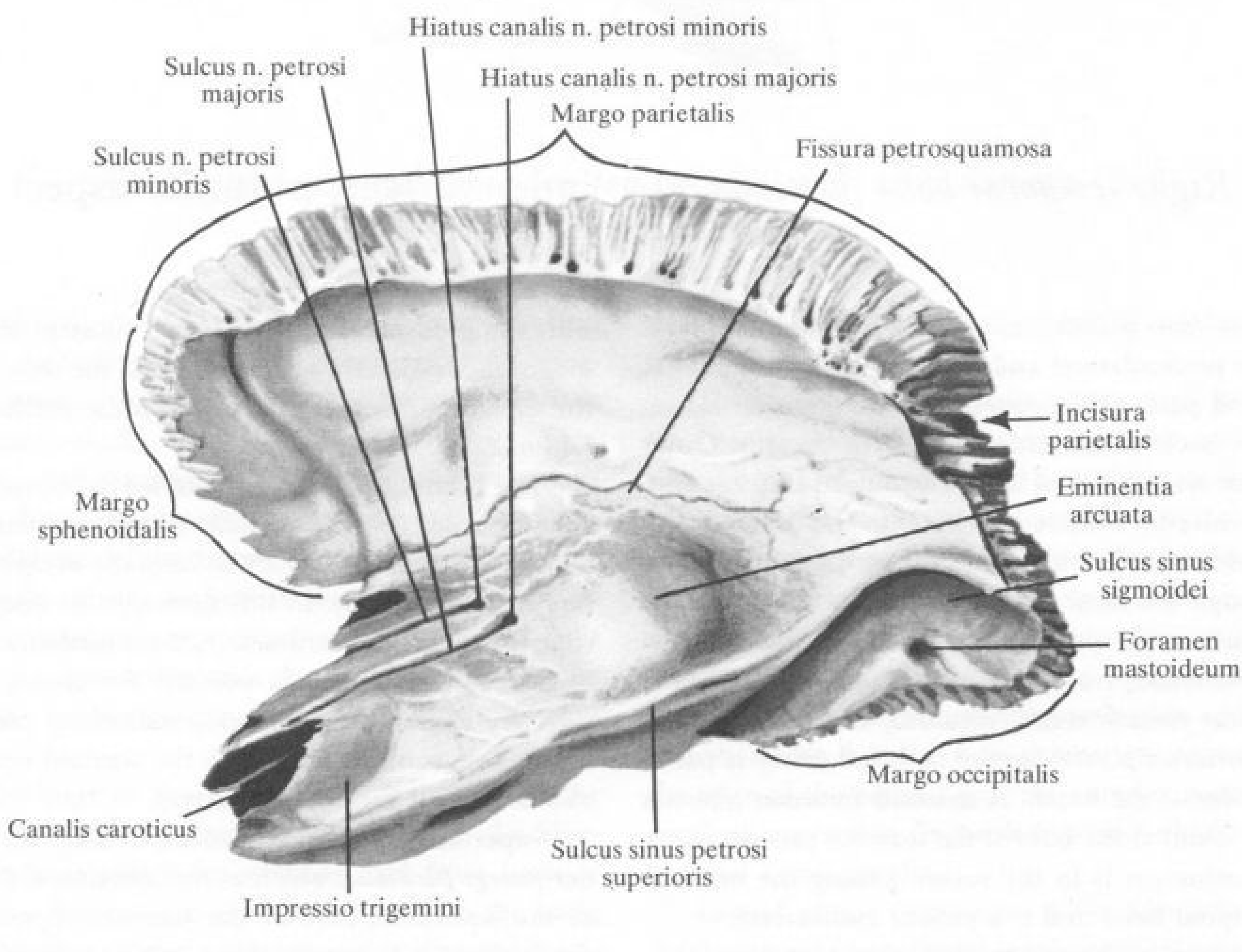
The inner, **cerebral surface of the squamous part** *(facies cerebralis)* is slightly concave and carries **impressions for the gyri** *(impressiones digitatae),* **cerebral juga** *(juga cerebralia),* and an **arterial sulcus** *(sulcus arteriosus)* lodging the middle meningeal artery.

The squamous part of the temporal bone has two free borders, sphenoidal and parietal.

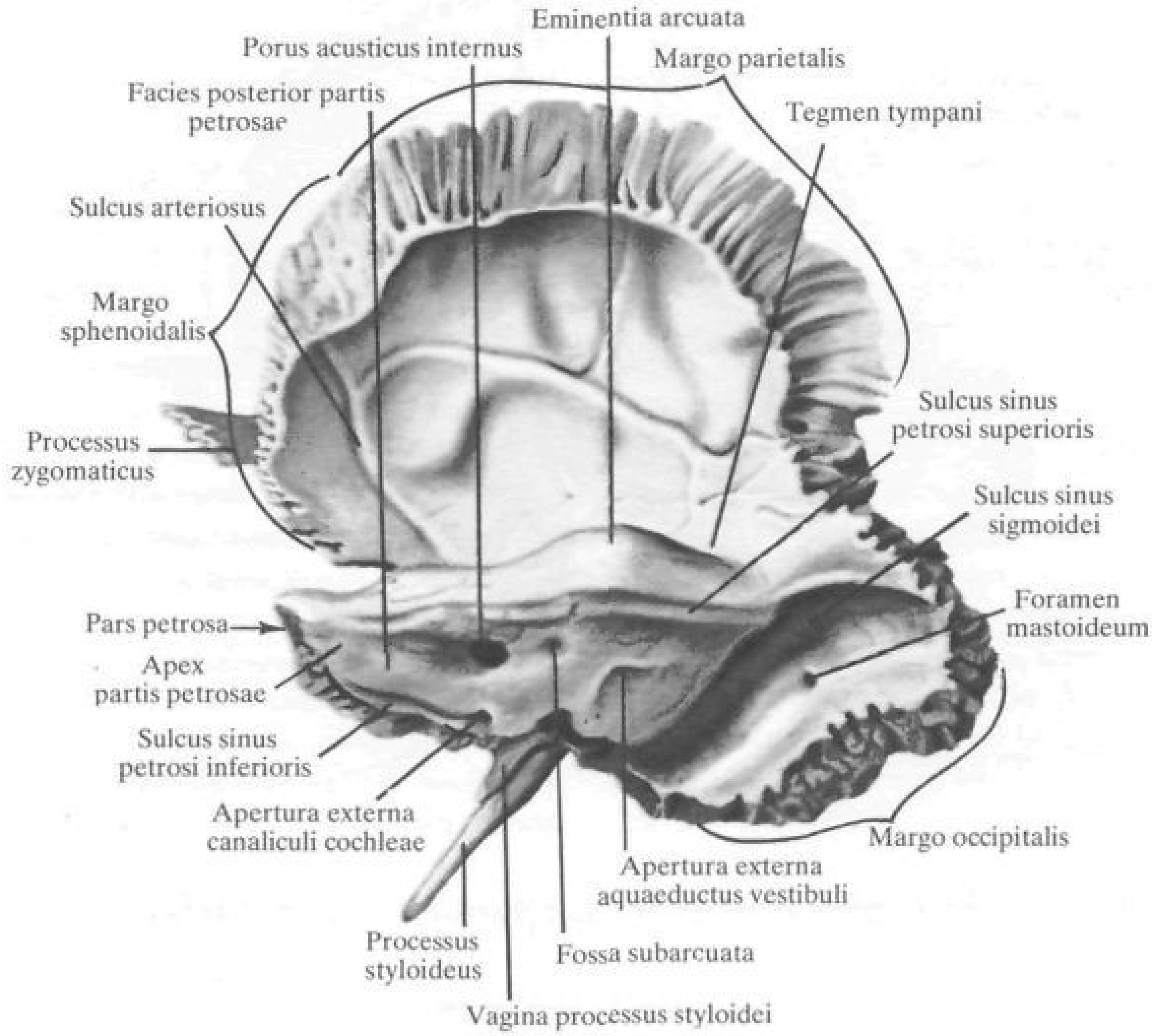
The anteroinferior, **sphenoidal border** *(margo sphenoidalis)* is wide, serrated and articulates with the squamous border of the greater wing of the sphenoid bone to form the **sphenosquamous suture** *(sutura sphenosquamosa).* The superoposterior, **parietal border** *(margo parietalis)* is sharp and is longer than the sphenoidal border; it articulates with the squamous border of the parietal bone.



65. *Right temporal bone (os temporale)*; outer surface (1/1).



66. *Right temporal bone (os temporale)*; inner surface, superior aspect (1/1).



67. *Right temporal bone (os temporale)*; inner surface, posterior aspect ($^1/_1$).

The **petrous part** *(pars petrosa)*, or **pyramid**, of the temporal bone consists of the posterolateral and anteromedial parts.

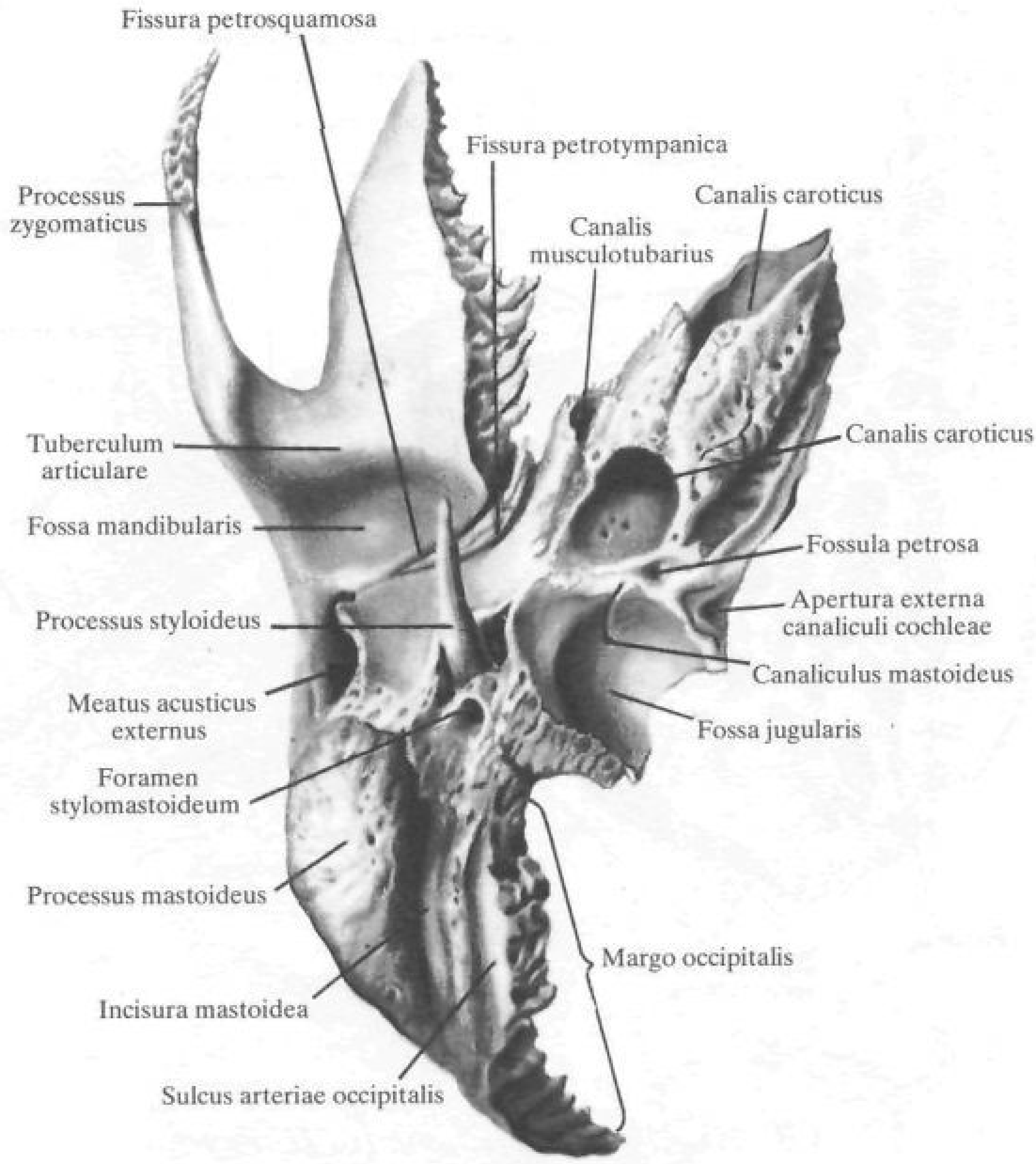
The posterolateral part is the **mastoid process** *(processus mastoideus)* situated to the back of the external acoustic meatus. Outer and inner surfaces are distinguished in it. The outer surface is convex, rough, and provides for muscle attachment. The mastoid process is continuous downwards with a conical projection which is easily palpated through the skin.

On the inner surface, the process is bounded by a deep **mastoid notch** *(incisura mastoidea)* from which the **posterior belly of the digastric muscle** *(venter posterior musculi digastrici)* arises. The **occipital groove** *(sulcus arteriae occipitalis)* for the occipital artery is parallel to and slightly behind the notch. A **mastoid foramen** *(foramen mastoideum)* is often found at the base of the mastoid process on its lateral surface. Sometimes it is in the suture joining the mastoid process and the occipital bone and is a venous emissarium.

On the inner, cerebral surface of the mastoid process is a wide S-shaped **sigmoid groove** *(sulcus sinus sigmoidei)* which is continuous upwards with the sigmoid groove of the parietal bone and then with the groove for the transverse sinus of the occipital bone (it lodges the transverse venous sinus of the dura mater). Downwards the sigmoid sinus is continuous with the similar sinus of the occipital bone.

The mastoid process is bounded posteriorly by a serrated **occipital border** *(margo occipitalis)* which articulates with the mastoid border of the occipital bone to form the **occipitomastoid suture** *(sutura occipitomastoidea)*. In this suture, in its middle part or occipital edge is the **mastoid foramen** *(foramen mastoideum)* (sometimes more than one) which, as it is pointed out above, lodges the mastoid emissary veins *(venae emissariae mastoideae)* connecting the subcutaneous veins of the head with the sigmoid venous sinus and mastoid branch of the occipital artery.

Superiorly the mastoid process is bounded by the **parietal border** *(margo parietalis)* which at the junction with the parietal border of the squamous part of the temporal bone forms the **parietal notch** *(incisura parietalis)*; the mastoid angle of the parietal bone is wedged into it to form the **parietomastoid suture** *(sutura parietomastoidea)*.



68. *Right temporal bone (os temporale)*; inferior aspect ($^1/_1$).

At the junction of the outer surface of the mastoid process and the outer surface of the squamous part the remnants of the **squamomastoid suture** *(sutura squamosomastoidea)* can be detected; it is well defined on a child's skull.

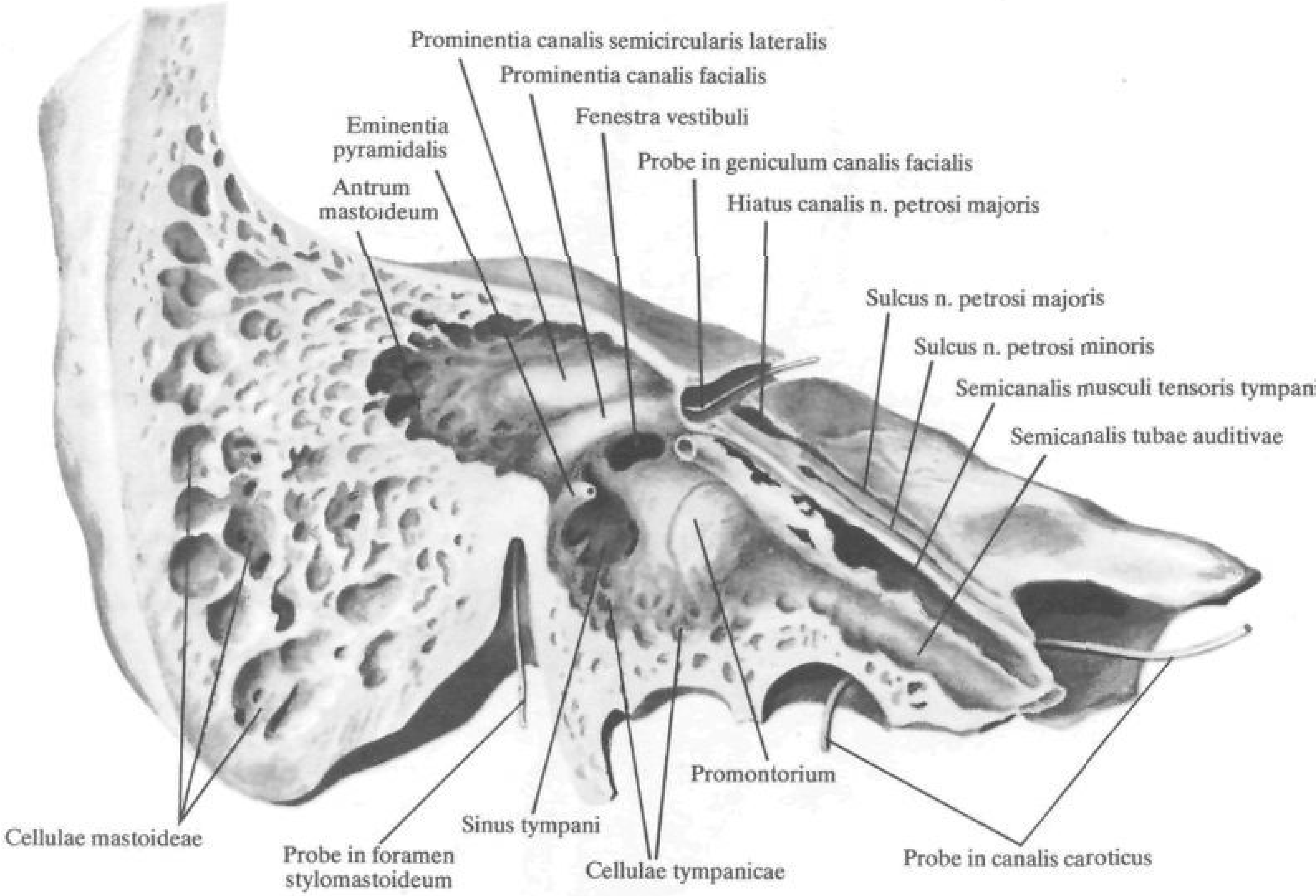
Bony air sinuses called the **mastoid air cells** *(cellulae mastoideae)* (Fig. 69) located in the mastoid process and separated from one another by bony walls are demonstrated on a cross-section of the process. The **tympanic antrum** *(antrum mastoideum)* is a cavity always found in the central part of the process; the mastoid cells open into it and it communicates with the tympanic cavity. The mastoid cells and the tympanic antrum are lined with a mucous membrane.

The anteromedial part of the pars petrosa is medial of the squamous part and the mastoid process. It has the shape of a trihedral pyramid whose long axis runs medially and from back to front. The base of the petrous part faces laterally and to the back; *the* **apex of the petrous part** *(apex partis petrosae) is directed medially* and forwards.

Three surfaces (anterior, posterior, and inferior) and three borders *(superior, anterior, and posterior) are distinguished in the petrous* part.

The **anterior surface** *(facies anterior partis petrosae)* (Fig. 66) faces the cranial cavity. It is smooth and wide and stretches obliquely downwards and forwards and is continuous with the cerebral surface of the squamous part from which it is sometimes separated by the **petrosquamous fissure** *(fissura petrosquamosa).* Almost in the middle of the anterior surface is an **arcuate eminence** *(eminentia arcuata)* formed by the underlying anterior semicircular canal of the labyrinth. A small area called the roof of tympanum, or **tegmen tympani** is situated between the eminence and the petrosquamous fissure; under it is the **tympanic cavity** *(cavum tympani).* Close to the apex of the petrous part the anterior surface bears a small **trigeminal impression** *(impressio trigemini)* which is a mark for the trigeminal nerve ganglion.

Lateral of the impression is the **hiatus for the greater superficial petrosal nerve** *(hiatus canalis nervi petrosi majoris)* from which a narrow **groove for the greater superficial petrosal nerve** *(sulcus nervi petrosi majoris)* branches off medially. A small **hiatus for the lesser**



69. *Right temporal bone (os temporale)* ($^2/_1$).

(Vertical section made parallel to the axis of the petrous part.)

superficial petrosal nerve *(hiatus canalis nervi petrosi minoris)* is found in front and a little laterally of the opening; it gives rise to the **groove for the lesser superficial petrosal nerve** *(sulcus nervi petrosi minoris).*

The **posterior surface of the petrous part** *(facies posterior partis petrosae)* (Fig. 67), like the anterior surface, faces the cranial cavity but stretches upwards and backwards where it is continuous with the mastoid process. Almost in the middle of this surface is a round **porus acusticus internus** which leads into the **internal auditory meatus** *(meatus acusticus internus).* The porus transmits the facial, intermediate, and vestibulocochlear nerves and the artery and vein of the labyrinth. A shallow **subarcuate fossa** *(fossa subarcuata)* is present a little above and lateral to the porus acusticus internus. It is well defined in the newborn; it lodges a process of the dura mater.

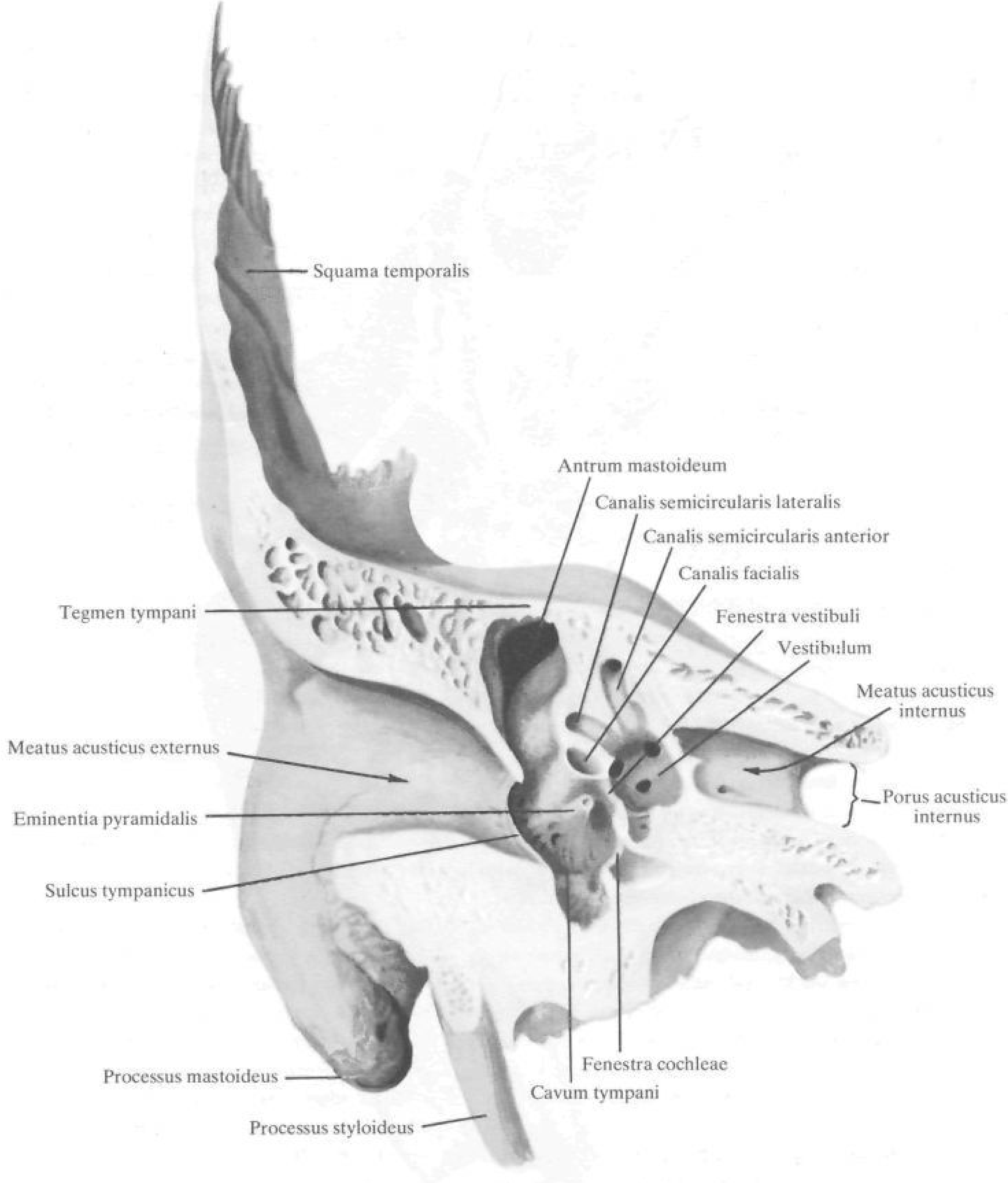
Still laterally to porus acusticus internus is a slit-like **external opening of the aqueduct of the vestibule** *(apertura externa aqueductus vestibuli)* transmitting the endolymphatic duct from the cavity of the internal ear.

The **inferior surface of the petrous part** *(facies inferior partis petrosae)* (Fig. 68) is rough and uneven; it lies on the inferior aspect of the cranial base. It carries a round or oval **jugular fossa** *(fossa jugularis)* lodging the upper bulb of the internal jugular vein.

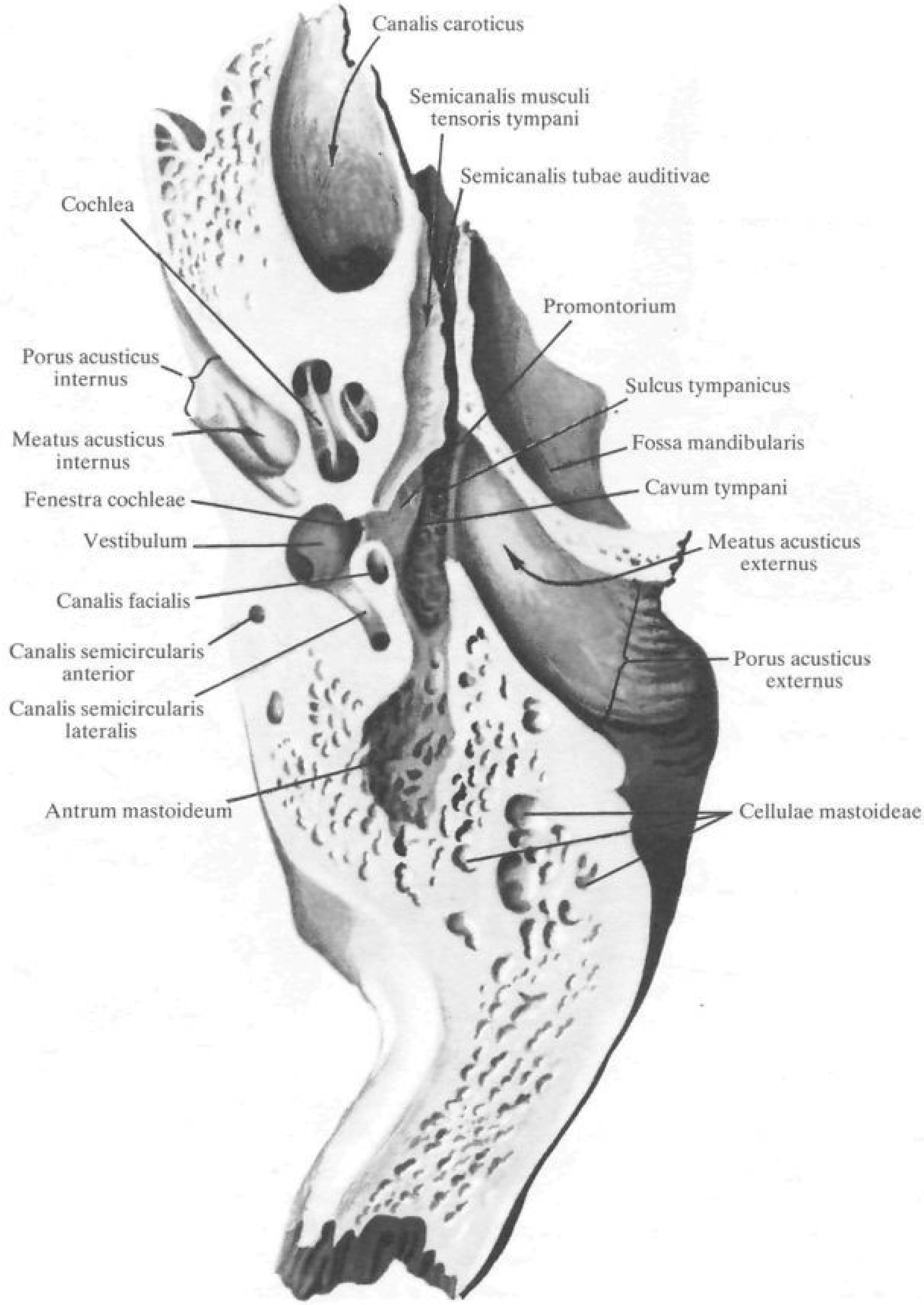
The floor of this fossa has a small groove for the auricular branch of the vagus nerve. The groove leads into the orifice of the **mastoid canaliculus** *(canaliculus mastoideus)* which opens into the **tympanomastoid fissure** *(fissura tympanomastoidea).*

The posterior margin of the jugular fossa is bounded by the **jugular notch** *(incisura jugularis)* which is divided into two parts, an anteromedial part and a posterolateral part, by a small **intrajugular process** *(processus intrajugularis).* To the front of the jugular fossa is a round orifice leading into the **carotid canal** *(canalis caroticus)* which has another orifice on the apex of the petrous part.

A small **petrosal fossa** *(fossula petrosa)* lies between the anterior circumference of the jugular fossa and the external orifice of the carotid canal; the inferior ganglion of the glosso-pharyngeal nerve is lodged in it. Deep in the fossa is an opening into the **canaliculus for the tympanic nerve** *(canaliculus tympanicus)* in which the inferior



70. *Right temporal bone (os temporale)* ($^2/_1$).
(Vertical section made through external auditory meatus.)



71. *Right temporal bone (os temporale)* ($^5/_2$).

(Horizontal section through external auditory meatus.)

tympanic artery also passes. The canaliculus opens into the **middle ear** *(auris media)* or the **tympanic cavity** *(cavum tympani)*.

The **styloid process** *(processus styloideus)* projects downwards and slightly forwards lateral of the jugular fossa. It varies in length and is the site of origin of muscles and ligaments.

A bony projection of the tympanic part, called the **sheath of the styloid process** *(vagina processus styloidei)* descends in front of and lateral to the root of the process.

To the back of the root of the process is the **stylomastoid foramen** *(foramen stylomastoideus)* which is the external opening of the **canal for the facial nerve** *(canalis facialis)*.

The **superior border of the petrous part** *(margo superior partis petrosae)* separates the anterior surface from the posterior surface. It carries the **groove for the superior petrosal sinus** *(sulcus sinus petrosi superioris)* (a mark of the superior petrosal venous sinus); the tentorium cerebelli which is a part of the dura mater is also attached to the groove. The groove is continuous posteriorly with the sigmoid groove of the mastoid process of the temporal bone.

The **posterior border of the petrous part** *(margo posterior partis petrosae)* is the junction of its posterior and inferior surfaces. It carries on its cerebral surface the **groove for the inferior petrosal sinus** *(sulcus sinus petrosi inferioris)* (a mark of the inferior petrosal venous sinus). A triangular funnel-like depression bearing the **external opening of the cochlear canaliculus** *(apertura externi canaliculi cochleae)* is almost in the middle of the posterior border near the jugular notch.

The **anterior border of the petrous part** *(margo anterior partis petrosae)* is on the lateral side of its anterior surface and is shorter than either the superior or posterior border. It is separated from the squamous part of the temporal bone by the **petrosquamous fissure** *(fissura petrosquamosa)*. Lateral of the internal opening of the carotid canal the anterior border carries the orifice of the **musculotubal canal** *(canalis musculotubarius)* which opens into the tympanic cavity (see *The Musculotubal Canal*).

CANALS AND CAVITIES OF THE PETROUS PART OF THE TEMPORAL BONE

1. The **carotid canal** *(canalis caroticus)* (Figs 68 and 69) originates in the middle of the inferior surface of pars petrosa as an external orifice. At first it ascends anteriorly of the cavity of the middle ear, then, curving, it passes forwards and medially and opens on the apex of the petrous part by means of an internal orifice. The carotid canal transmits the internal carotid artery and the attendant veins and plexus of sympathetic nerve fibres.

2. The **caroticotympanic canaliculi** *(canaliculi caroticotympanici)* are two small canaliculi branching off from the carotid canal and leading into the tympanic cavity. They transmit the caroticotympanic nerves.

3. The **canal for the facial nerve** *(canalis facialis)* (Fig. 69) originates on the floor of the **internal auditory meatus** *(meatus acusticus internus)* in the facial nerve area *(area nervi facialis)*; (see Vol. III. *The Organ of Hearing*). It stretches laterally almost at a right angle to the axis of the petrous part and passes to the anterior surface of this part to the **hiatus for the greater superficial petrosal nerve** *(hiatus canalis nervi petrosi majoris)*. It bends here at a right angle to form the **geniculum of the canal for the facial nerve** *(geniculum canalis facialis)* and passes over to the posterior part of the medial wall of the tympanic cavity which bears a corresponding **prominence of the facial nerve canal** *(prominentia canalis facialis)*. Further the canal stretches posteriorly along the axis of the petrous part till it reaches the **pyramid of the tympanum** *(eminentia pyramidalis)* and then descends vertically to form the **stylomastoid foramen** *(foramen stylomastoideum)*. The canal transmits the facial and intermediate nerves, arteries, and veins.

4. The **anterior canaliculus for the chorda tympani** *(canaliculus chordae tympani)* runs off the lateral wall of the canal for the facial nerve a few millimetres above the stylomastoid foramen. It stretches forwards and upwards and enters the tympanic cavity by an opening on the posterior wall. The canaliculus transmits a branch of the intermediate nerve called the **chorda tympani** which leaves the tympanic cavity through the petrotympanic fissure.

5. The **canaliculus for the tympanic nerve** *(canaliculus tympanicus)* originates on the inferior surface of the petrous part deep in the **petrosal fossa** *(fossula petrosa)*. It then passes to the inferior wall of the tympanic cavity, perforates it, and enters the cavity. The canaliculus stretches on the medial wall of the cavity in the **groove of the promontory** *(sulcus promontorii)* and then passes to the superior wall of the cavity where it opens by means of the **hiatus for the lesser petrosal superficial nerve** *(hiatus canalis nervi petrosi minoris)*.

6. The **musculotubal canal** *(canalis musculotubarius)* (see Figs 68, 69 and 71) is a continuation of the anterosuperior part of the tympanic cavity. Its external opening originates at the notch between the petrous and squamous parts of the temporal bone at the anterior end of the petrosquamous fissure and reaches the superior part of the anterior wall of the tympanic cavity. It stretches laterally and slightly to the back of the horizontal part of the carotid canal, almost on the axis of the petrous part. The horizontal **septum of the musculotubal canal** *(septum canalis musculotubarii)* separates the canal into a superior, smaller **canal for the tensor tympani** *(semicanalis musculi tensoris tympani)* and an inferior, larger **canal of the pharyngotympanic tube** *(semicanalis tubae auditivae)* connecting the tympanic cavity with the pharyngeal cavity (see Vol. III. *The Organ of Hearing*).

7. The **mastoid canaliculus** *(canaliculus mastoideus)* (see Fig. 68) originates deep in the jugular fossa, crosses the inferior part of the canal for the facial nerve, and opens into the tympanomastoid fissure. The canaliculus transmits the auricular branch of the vagus nerve.

8. The **tympanic cavity** *(cavum tympani)* (see Fig. 69) is elongated, compressed on the sides, and lined with a mucous membrane. Inside it are three auditory ossicles: the **malleus, incus,** and

stapes which articulate with one another to form a chain. (The structure of the canals listed and of the tympanic cavity, auditory ossicles and labyrinth is described in detail in Vol. III. *The Organ of Hearing*.)

The **tympanic part** *(pars tympanica)* (Figs 65 and 68) is the smallest part of the temporal bone. It is a slightly bent annular plate forming the anterior, inferior, and partly the posterior walls of the **external auditory meatus** *(meatus acusticus externus)*. The lateral edge of the tympanic part is limited superiorly by the squama of the temporal bone and borders the **porus acusticus externus.** A **suprameatal spine** *(spina suprameatum)* is found at the posterosuperior lateral margin of the porus. The **tympanic groove** *(sulcus tympanicus)* is at the junction of the larger, medial and smaller, lateral parts of the external acoustic meatus. It gives attachment to the tympanic membrane. Superiorly the tympanic groove terminates as two projections: the **greater tympanic spine** *(spina tympanica major)* in front and the **lesser tympanic spine** *(spina tympanica minor)* at the back. Between these spines is the **tympanic notch** *(incisura tympanica)* which opens into the **epitympanic recess** *(recessus epitympanicus)* (see Vol. III. *The Organ of Hearing*).

The inferior process of the tegmen tympani is wedged in between the medial portion of the tympanic and the squamous parts of the temporal bone. To both sides of the process stretch, respectively, the **petrosquamous fissure** *(fissura petrosquamosa)* and the **squamotympanic fissure** *(fissura petrotympanica)* which transmits the chorda tympani and small vessels.

The lateral part of the pars tympanica is continuous with a bony crest whose elongated portion forms the **sheath of the styloid process** *(vagina processus styloidei)*. The external auditory meatus is absent in the newborn and the tympanic part is represented by the **tympanic ring** *(anulus tympanicus)* (see Fig. 99).

The medial surface of the greater tympanic spine carries a clearly defined spinous crest on the ends of which are an anterior and posterior tympanic processes; along the crest passes a groove for the malleus.

THE ETHMOID BONE

The **ethmoid bone** *(os ethmoidale)* (Figs 72-74a, 74b, 103-106) is an unpaired bone. Its larger part is situated in the superior portions of the nasal cavity, the smaller part is in the anterior areas of the base of the skull.

It is shaped like an irregular cube and is formed of air cells and is therefore a **pneumatic bone** *(ossa pneumatica)*.

A cribriform or horizontal plate, a perpendicular or vertical plate, and two labyrinths, one on each side of the perpendicular plate, are distinguished.

The **cribriform plate** *(lamina cribrosa)* is the superior wall of the nasal cavity and fits horizontally into the ethmoidal notch of the frontal bone to form the **frontoethmoid suture** *(sutura frontoethmoidalis)*. It is pierced by 30-40 small openings transmitting nerves (fibres of the olfactory nerves) and vessels.

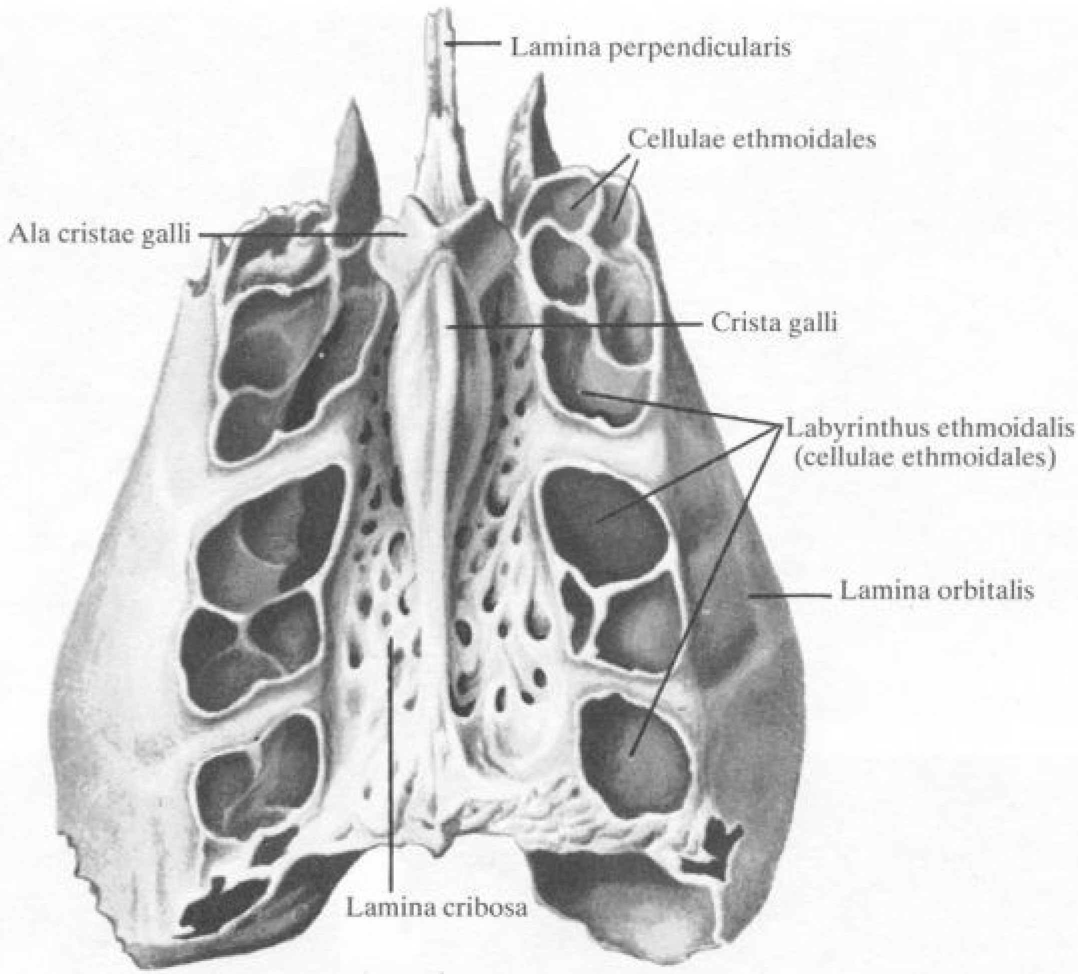
The **perpendicular plate** *(lamina perpendicularis)* (Figs 73 and 74) is separated into two parts, a smaller, superior part above the cribriform plate, and the other larger, inferior part below this plate. The superior part forms the **crista galli** and faces the cranial cavity; the falx cerebri, a process of the dura mater, attaches to it.

The anteroinferior margin of the crista galli is bounded on each side by an inconstantly found projection, the **ala of crista galli** *(ala cristae galli)*. Both projections border the **foramen caecum** of the frontal bone posteriorly and superiorly. The lower part of the perpendicular plate has an irregular quadrangular shape and descends vertically into the nasal cavity to form the anterosuperior part of the nasal septum. Superiorly it meets the **nasal spine** *(spina nasalis)* of the frontal bone, anteriorly the bones of the nose, posteriorly the **crest of the sphenoid** *(crista sphenoidalis)*, inferiorly the **vomer**, and anteroinferiorly the cartilaginous part of the nasal septum. The whole perpendicular plate or only part of it often deviates to the side.

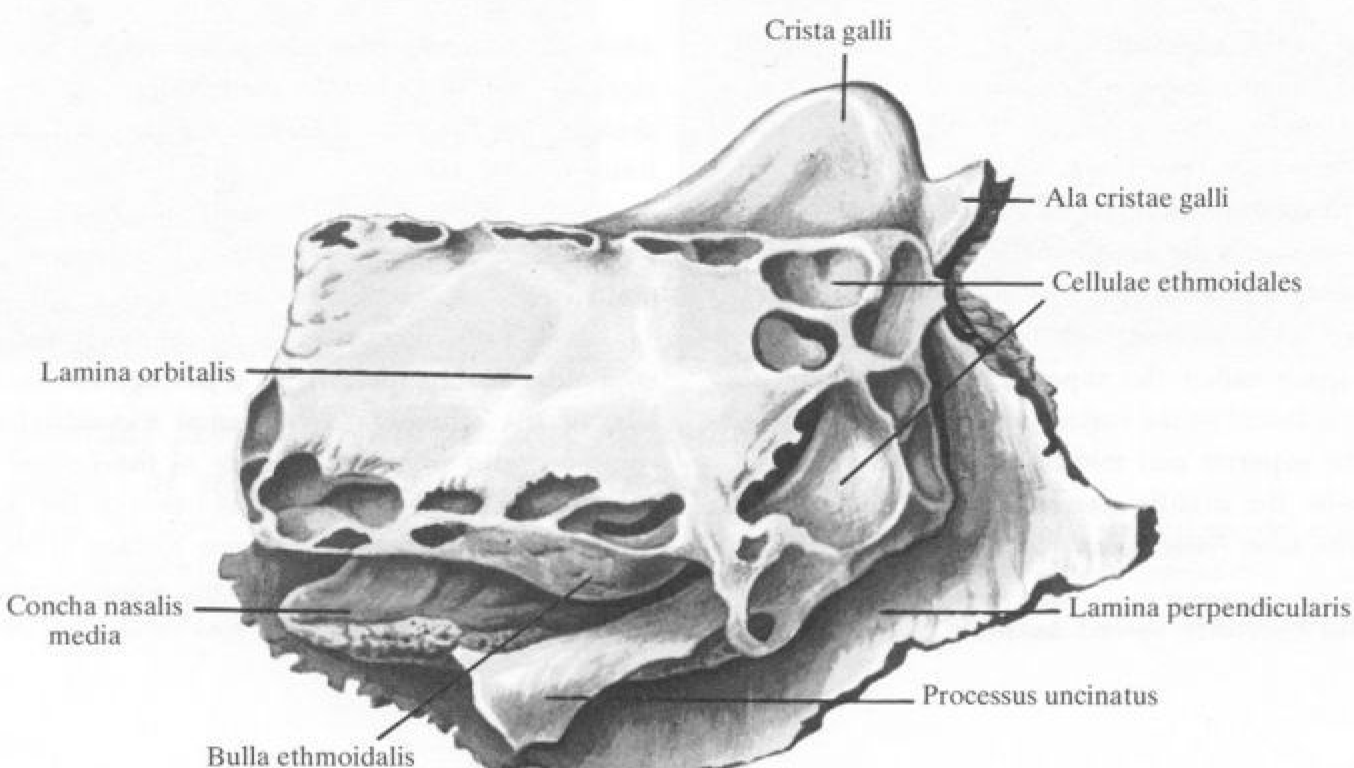
The **ethmoidal labyrinth** *(labyrinthus ethmoidalis)* is a paired structure situated on each side of the perpendicular plate and adjoining the inferior surface of the cribriform plate. Each labyrinth consists of a great number of air **ethmoidal cells** *(cellulae ethmoidales)* (Fig. 72) communicating with one another as well as with the nasal cavity through a series of openings. The cells are lined with a mucous membrane which is a continuation of the nasal mucosa.

The cells are divided into **anterior ethmoidal cells** *(cellulae ethmoidales anteriores)* opening into the middle meatus of the nose and **middle** and **posterior ethmoidal cells** *(cellulae ethmoidales mediae* et *posteriores)* communicating with the superior meatus of the nose.

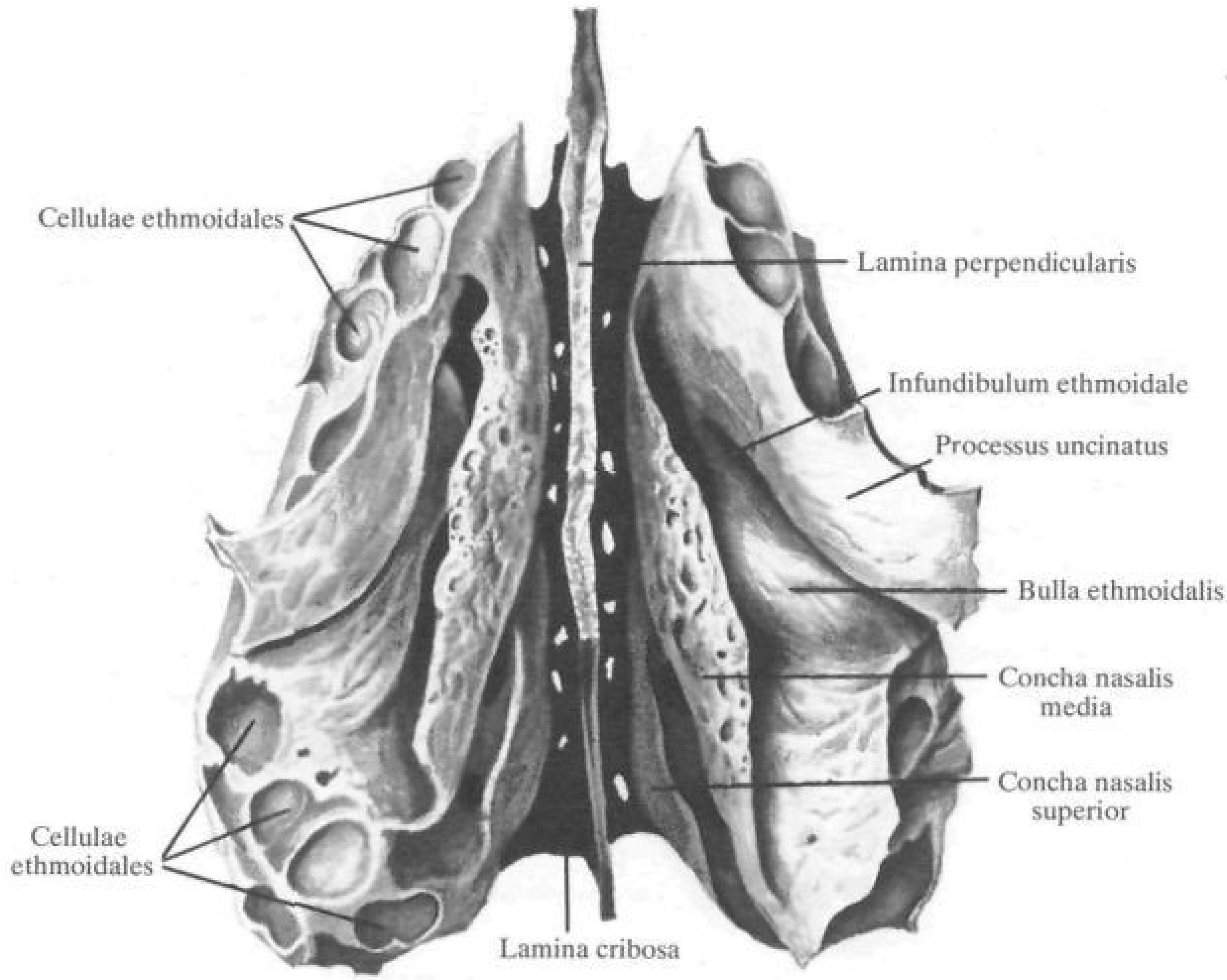
The lateral wall of the labyrinth is a thin, smooth **orbital plate** *(lamina orbitalis)* (Figs 51, 72, 73, 109) forming the greater part of the medial orbital wall. The plate joins the frontal bone superiorly to form the **frontoethmoid suture** *(sutura frontoethmoidalis)*, the maxilla and orbital process of the palatine bone inferiorly to form, respectively, the **ethmoidomaxillary suture** *(sutura ethmoideomaxillaris)* and the **palatoethmoidal suture** *(sutura palatoethmoidalis)*, with the lacrimal bone anteriorly to form the **lacrimoethmoidal suture,** and with the sphenoid bone posteriorly to form the **sphenoethmoidal suture** *(sutura sphenoethmoidalis)* (see Fig. 109). The superior border of the labyrinth carries two small ethmoidal grooves, anterior and posterior, which join similar grooves of the frontal bone to form canals opening by means of the **anterior** and **posterior ethmoidal foramina** *(foramina ethmoidalis anterius* et *posterius)* which transmit, respectively, the anterior and posterior ethmoidal nerves and vessels.



72. *Ethmoid bone (os ethmoidale)*; superior aspect (3/2).



73. *Ethmoid bone (os ethmoidale)*; from the right side (3/2).



74a. *Ethmoid bone (os ethmoidale)*; inferior aspect (3/2).

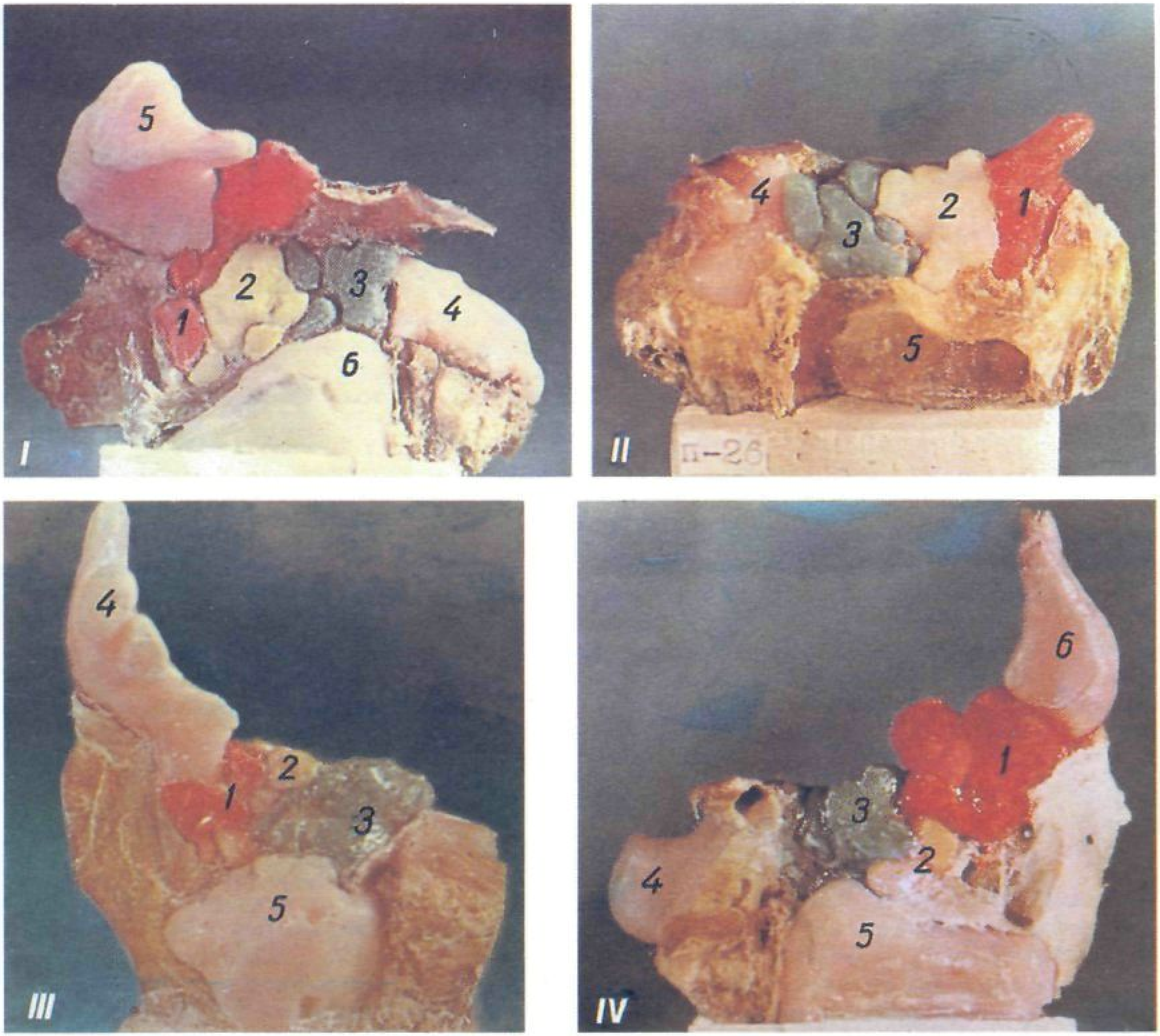
The medial wall of the labyrinth (Figs 74, 103, and 104) is a rough grooved plate forming the greater part of the lateral wall of the nasal cavity. Its surface facing the perpendicular plate bears two thin laterally curled processes with slightly curved margins; the upper process is called the **superior nasal concha** *(concha nasalis superior)* and the lower one is the **middle nasal concha** *(concha nasalis media)*. A rudimentary process is occasionally found above the superior concha; this is the **highest nasal concha** *(concha nasalis suprema)*. A slit-like space called the **superior meatus of the nose** *(meatus nasi superior)* is found in the superoposterior part of the medial wall between the superior and middle nasal conchae.

The passage under the middle nasal concha is known as the **middle meatus of the nose** *(meatus nasi medius)* (see Figs 103 and 105).

A posteriorly and inferiorly curved **uncinate process** *(processus uncinatus)* projects from the inferoanterior surface of each labyrinth in front of and below the middle nasal concha. On the intact skull it joins the **ethmoidal process** *(processus ethmoidalis)* of the inferior nasal concha.

To the back of and above the uncinate process (Figs 73 and 74) is one of the largest cells which is bulged and called the **ethmoidal bulla** *(bulla ethmoidalis)*.

Between the uncinate process inferiorly and anteriorly and the ethmoidal bulla superiorly is a passage known as the **infundibulum of the ethmoid** *(infundibulum ethmoidale)* whose upper end communicates with the aperture of the frontal sinus. The **hiatus semilunaris** (see Fig. 104) forms between the posterior margin of the uncinate process and inferior surface of the ethmoidal bulla, by means of which the maxillary sinus communicates with the middle meatus of the nose.



74b. *Ethmoidal labyrinth (labyrinthus ethmoidalis).*
(Plastic models of ethmoidal cells. N. Skripnikov's preparation.)

I. Ethmoidal cells, *left side*:
1—anterior cells 4—sphenoidal sinus
2—middle cells 5—frontal sinus
3—posterior cells 6—maxillary sinus

II. Ethmoidal cells, *right side*:
1—anterior cells 4—frontal sinus
2—middle cells 5—maxillary sinus
3—posterior cells

III. Ethmoidal cells, *left side*:
1—anterior cells 4—sphenoidal sinus
2—middle cells 5—maxillary sinus
3—posterior cells

IV. Ethmoidal cells, *right side*:
1—anterior cells 4—sphenoidal sinus
2—middle cells 5—maxillary sinus
3—posterior cells 6—frontal sinus

THE BONES OF THE FACE

THE INFERIOR NASAL CONCHA

The **inferior nasal concha** *(concha nasalis inferior)* (Figs 75, 103 and 104) is a paired curved bony plate with three processes: maxillary, lacrimal, and ethmoidal.

The **maxillary process** *(processus maxillaris)* projects from the bone at an acute angle into which fits the inferior border of the hiatus of the maxillary sinus. The process is seen distinctly from the opened maxillary sinus.

The **lacrimal process** *(processus lacrimalis)* joins the inferior concha to the lacrimal bone.

The **ethmoidal process** *(processus ethmoidalis)* arises at the junction of the maxillary process and the body of the bone and projects into the maxillary sinus. It is often fused with the uncinate process of the ethmoid bone.

The anterior part of the superior border of the inferior concha articulates with the conchal crest of the maxilla, the posterior part of the concha articulates with the conchal crest of the perpendicular plate of the palatine bone. The longitudinal slit-like space beneath the inferior nasal concha is called the **inferior meatus of the nose** *(meatus nasi inferior)*.

THE NASAL BONE

The **nasal bone** *(os nasale)* (Figs 76, 49-51) is paired, quadrangular, slightly elongated and slightly convex anteriorly. The superior margin of each bone articulates with the nasal part of the frontal bone, the lateral margin articulates with the anterior margin of the **frontal process of the maxilla** *(processus frontalis maxillae)*.

The anterior surface of the bone is smooth and perforated by one or more openings transmitting vessels and nerves. The posterior surface is slightly concave and bears the **ethmoidal groove** *(sulcus ethmoidalis)* lodging the anterior ethmoidal nerve. Both nasal bones articulate by mildly serrated medial borders to form the **internasal suture** *(sutura internasalis)* which is grooved longitudinally. The inner surfaces of both bones adjoin the **nasal spine** *(spina nasalis)* of the frontal bone and the **perpendicular plate** *(lamina perpendicularis)* of the ethmoid bone.

THE LACRIMAL BONE

The **lacrimal bone** *(os lacrimale)* (Figs 77, 49-51) is a paired elongated quadrangular plate situated in the anterior part of the medial orbital wall. Its superior border articulates with the orbital part of the frontal bone to form the **frontolacrimal suture** *(sutura frontolacrimalis)*, the posterior border with the anterior border of the orbital plate of the ethmoid bone; the inferior border meets the orbital surface of the maxilla posteriorly to form the **lacrimomaxillary suture** *(sutura lacrimomaxillaris)* and the lacrimal process of the inferior concha anteriorly to form the **lacrimoconchal suture** *(sutura lacrimoconchalis)*. Anteriorly the bone articulates with the frontal process of the maxilla to form the **lacrimomaxillary suture** *(sutura lacrimomaxillaris)*.

The bone covers the anterior cells of the ethmoid bone and carries on its lateral surface the **crest of the lacrimal bone** *(crista lacrimalis posterior)* which separates it into a larger posterior and a smaller anterior parts. The crest terminates as a projection called the **lacrimal hamulus** *(hamulus lacrimalis)* which reaches the lacrimal groove on the frontal process of the maxilla. The anterior part is flat, while the posterior part is concave to form the **lacrimal groove** *(sulcus lacrimalis)*. Inferiorly the groove adjoins the **lacrimal groove of the maxillary frontal process** *(sulcus lacrimalis processus frontalis maxillae)* to form the **fossa of the lacrimal sac** *(fossa sacci lacrimalis)*. The fossa is continuous downwards with the **nasolacrimal canal** *(canalis nasolacrimalis)* which drains into the inferior meatus of the nose.

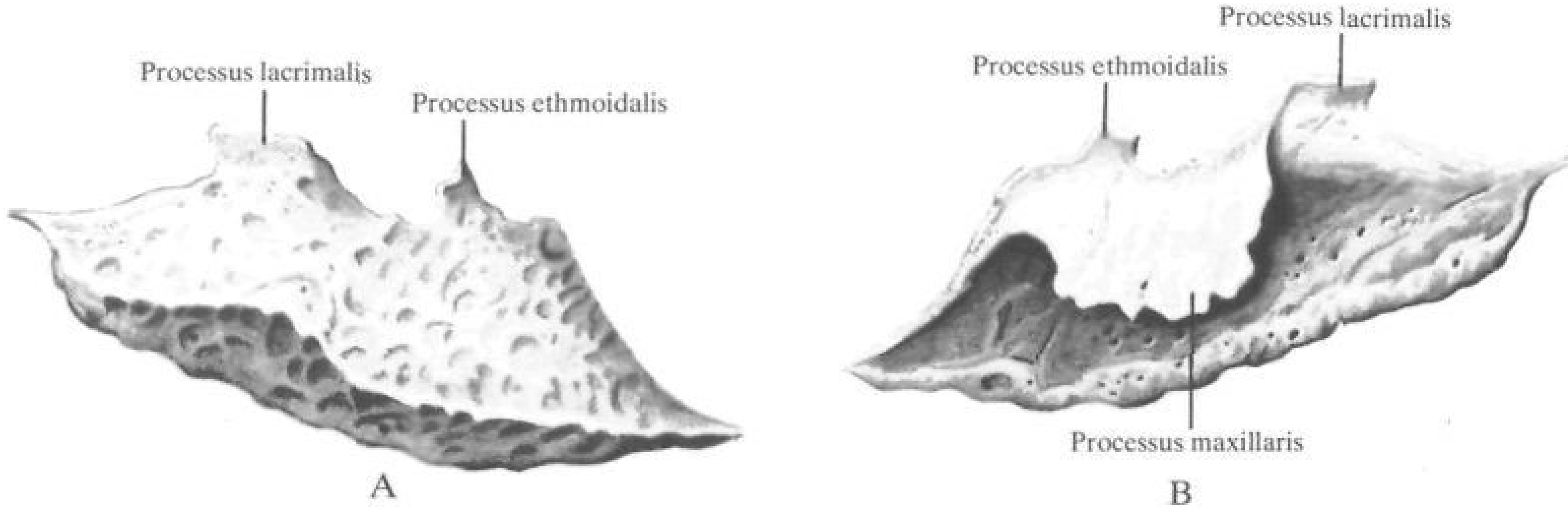
THE VOMER

The **vomer** (Figs 78, 79, and 94) is an unpaired, elongated rhomboid plate forming the posterior part of the nasal septum.

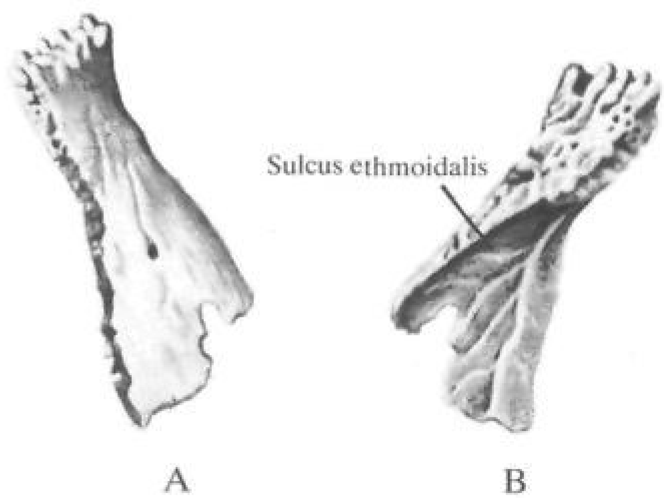
It is usually slightly curved (except for the posterior edge).

The superior edge of the vomer is thicker than the other edges and is split into two everted processes called the **alae of the vomer** *(alae vomeris)*. They adjoin the inferior surface of the body of the sphenoid bone and embrace its rostrum.

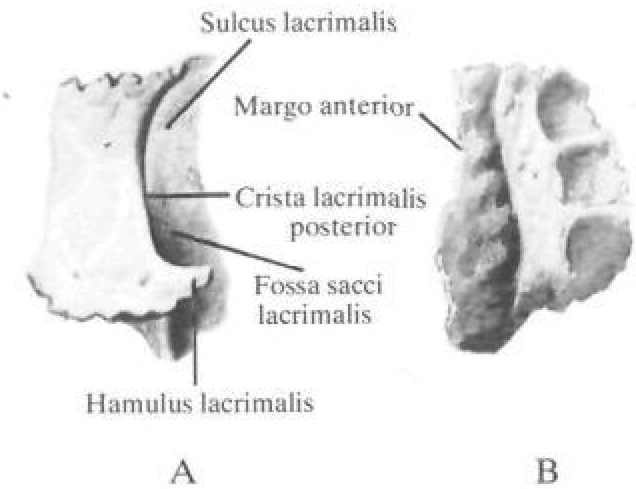
The posterior edge of the bone is free, slightly tapered, and



75. *Right inferior nasal concha (concha nasalis inferior)* ($^3/_2$).
A—inner aspect; B—outer aspect.



76. *Right nasal bone (os nasalis)* ($^1/_1$).
A—outer aspect; B—inner aspect.



77. *Right lacrimal bone (os lacrimale)* ($^1/_1$).
A—outer aspect; B—inner aspect.

78. *Vomer*; from the right side ($^2/_1$).

79. *Vomer*; superior aspect (2/1).

separates the **posterior apertures of the nose** *(choanae)* one from the other.

The anterior and inferior edges are rough; the inferior one articulates with the **nasal crests** *(crista nasalis)* of the maxilla and palatine bone, while the anterior edge is bevelled and articulates with the **perpendicular plate** *(lamina perpendicularis)* of the ethmoid bone superiorly and with the cartilaginous nasal septum inferiorly.

THE MAXILLA

The **maxilla** (Figs 80-83, 49 and 51) is a paired bone situated in the superoanterior part of the visceral cranium. It is a pneumatic bone *(ossa pneumatica)* because it contains a large cavity, the **maxillary sinus** *(sinus maxillaris)* which is lined by mucous membrane.

A body and four processes are distinguished in the bone.

The **body of the maxilla** *(corpus maxillae)*, in which the maxillary sinus is lodged, has four surfaces: superior, or orbital; anterior; medial, or nasal; posterior, or infratemporal.

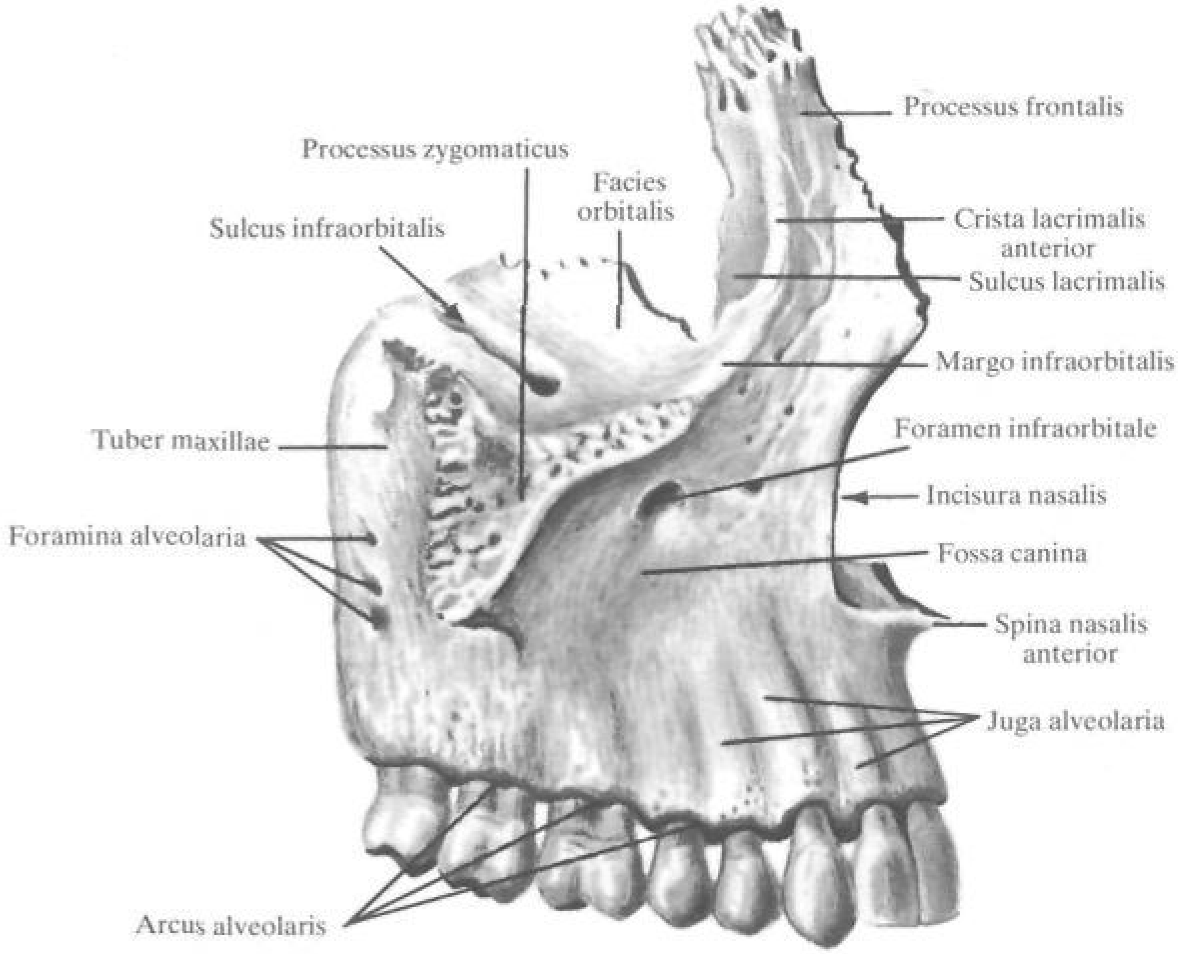
The processes of the bone are as follows: frontal, zygomatic, alveolar, and palatine.

The **orbital surface** *(facies orbitalis)* is smooth, triangular, and slightly inclined forwards, laterally, and downwards. It forms the inferior wall of the **orbit** *(orbita)*.

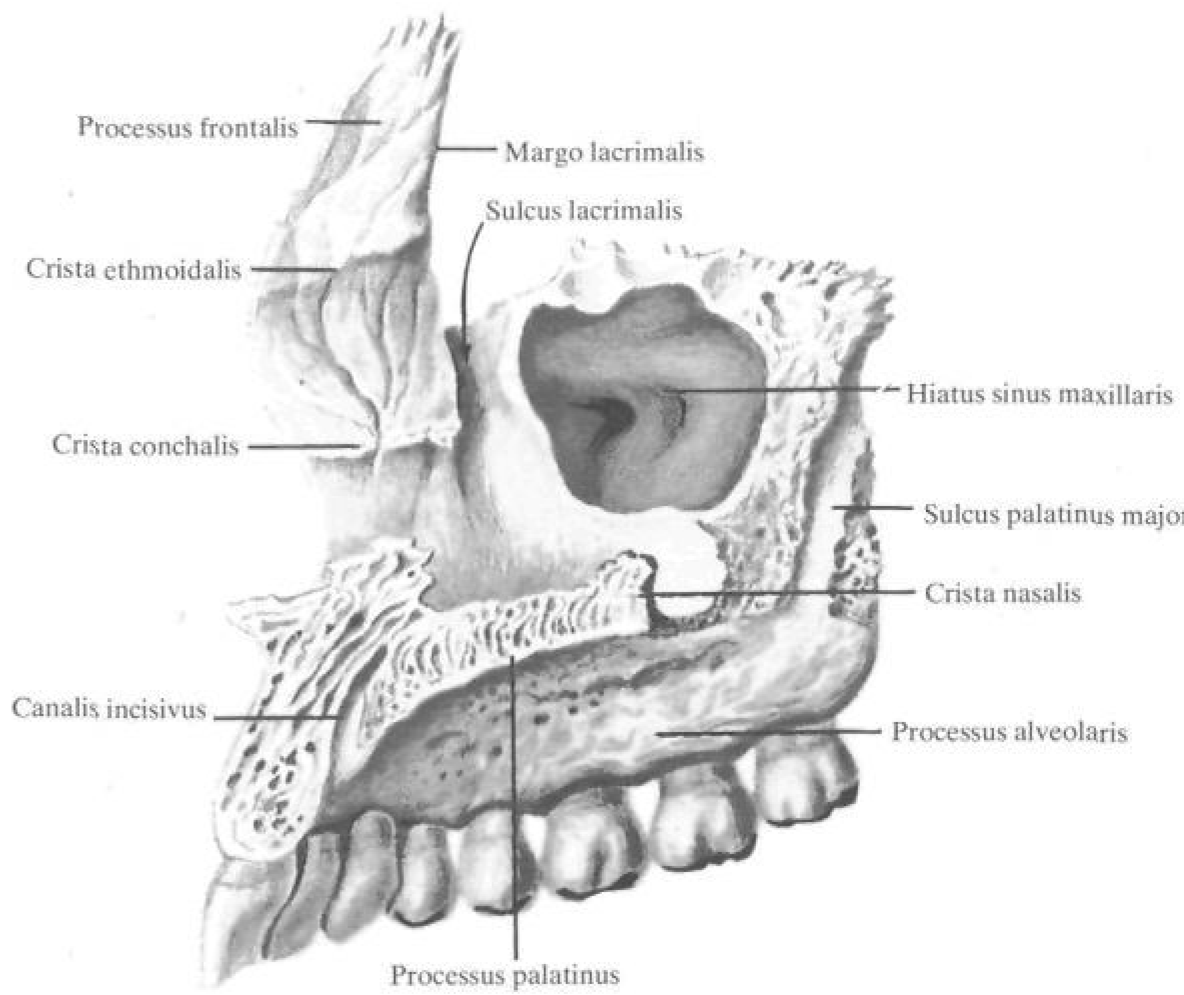
The medial border of the orbital surface articulates anteriorly with the lacrimal bone to form the **lacrimomaxillary suture** *(sutura lacrimomaxillaris)*; posteriorly of the lacrimal bone it articulates with the orbital plate of the ethmoid bone to form the **ethmoidomaxillary suture** *(sutura ethmoidomaxillaris)*, and still further posteriorly, it joins the orbital process of the palatine bone to form the **palatomaxillary suture** *(sutura palatomaxillaris)*.

The anterior border of the orbital surface is smooth and forms the free **infraorbital margin** *(margo infraorbitalis)*. It is serrated laterally and is continuous with the **zygomatic process** *(processus zygomaticus)*. Medially the infraorbital margin curves upwards, tapers, and is continuous with the frontal process on which stretches longitudinally the **lacrimal crest** *(crista lacrimalis anterior)*.

The posterior border of the superior (orbital) surface, together with the inferior border of the orbital surface of the greater wings of the sphenoid bone, which runs parallel with it, forms the **infe-**



80. *Right maxilla*; anterolateral aspect ($^1/_1$).



81. *Right maxilla*; medial aspect ($^1/_1$).

rior orbital fissure *(fissura orbitalis inferior)*. In the middle of its distance the inferior wall of the fissure bears a small **infraorbital groove** *(sulcus infraorbitalis)* which stretches forwards and becomes deeper to be gradually continuous with the **infraorbital canal** *(canalis infraorbitalis)*. The groove and the canal transmit the infraorbital nerve, arteries, and veins. The canal describes an arch and opens on the anterior surface of the body of the maxilla. The inferior wall of the canal has small openings of the anterior dental canals which are called anterior dental foramina (Fig. 82); they transmit nerves to the anterior maxillary teeth.

The **posterior surface** *(facies infratemporalis)* faces the infratemporal and pterygopalatine fossae. It is uneven, often convex, and forms the **maxillary tuberosity** *(tuber maxillae)*. Two or three small openings of the dental canals, the **dental foramina** *(foramina alveolaria)* (Figs 80 and 82), can be seen on it; they transmit nerves to the posterior maxillary teeth.

The **anterior surface** *(facies anterior)* is slightly curved. A rather large **infraorbital foramen** *(foramen infraorbitale)* opens on it below the infraorbital margin and still further below is a small depression called the **canine fossa** *(fossa canina)* which is the site of origin of the levator anguli oris muscle.

The anterior surface is continuous downwards with the anterior (buccal) surface of the **alveolar process** *(processus alveolaris)*. The alveolar process has a series of depressions between ridges, which are called the **alveolar juga** *(juga alveolaria)*.

Medially and forwards, towards the nose, the anterior surface of the body of the maxilla continues as a sharp edge of the **nasal notch** *(incisura nasalis)*. The notch terminates below as the **anterior nasal spine** *(spina nasalis anterior)*. The nasal notches of both maxillae limit the **anterior bony aperture of the nose** *(apertura piriformis)* which leads into the nasal cavity.

The **nasal surface** *(facies nasalis)* of the maxilla (Fig. 81) has a more complex structure. In its superoposterior angle is the **hiatus of the maxillary sinus** *(hiatus sinus maxillaris)* leading into the sinus maxillaris. To the back of the hiatus the rough nasal surface articulates with the perpendicular plate of the palatine bone by means of a suture and carries a vertical **greater palatine groove** *(sulcus palatinus major)* contributing to the formation of the walls of the **greater palatine canal** *(canalis palatinus major)*. In front of the hiatus of the maxillary sinus stretches the **nasolacrimal groove** *(sulcus lacrimalis)* which is limited by the posterior border of the frontal process anteriorly. The groove closes to form the **nasolacrimal canal** *(canalis nasolacrimalis)*; the groove meets the lacrimal bone superiorly and the lacrimal process of the inferior concha inferiorly. Still further to the front the nasal surface carries a horizontal eminence called the **conchal crest** *(crista conchalis)* to which the inferior nasal concha is attached.

From the superior border of the nasal surface at its junction with the anterior surface projects upwards the **frontal process** *(processus frontalis)*. It has a medial (nasal) and lateral (facial) surfaces. The lateral surface is separated into an anterior and posterior parts by the **lacrimal crest** *(crista lacrimalis anterior)*. The posterior part is continuous downwards with the **nasolacrimal groove** *(sulcus lacrimalis)*. The inner, **lacrimal border** *(margo lacrimalis)* of the frontal process articulates with the lacrimal bone to form the **lacrimomaxillary suture** *(sutura lacrimomaxillaris)*. The **ethmoidal crest** *(crista ethmoidalis)* stretches from front to back on the medial surface. The superior border of the frontal process is serrated and articulates with the nasal part of the frontal bone to form the **frontomaxillary suture** *(sutura frontomaxillaris)*. The anterior border of the frontal process unites with the nasal bone to form the **nasomaxillary suture** *(sutura nasomaxillaris)*.

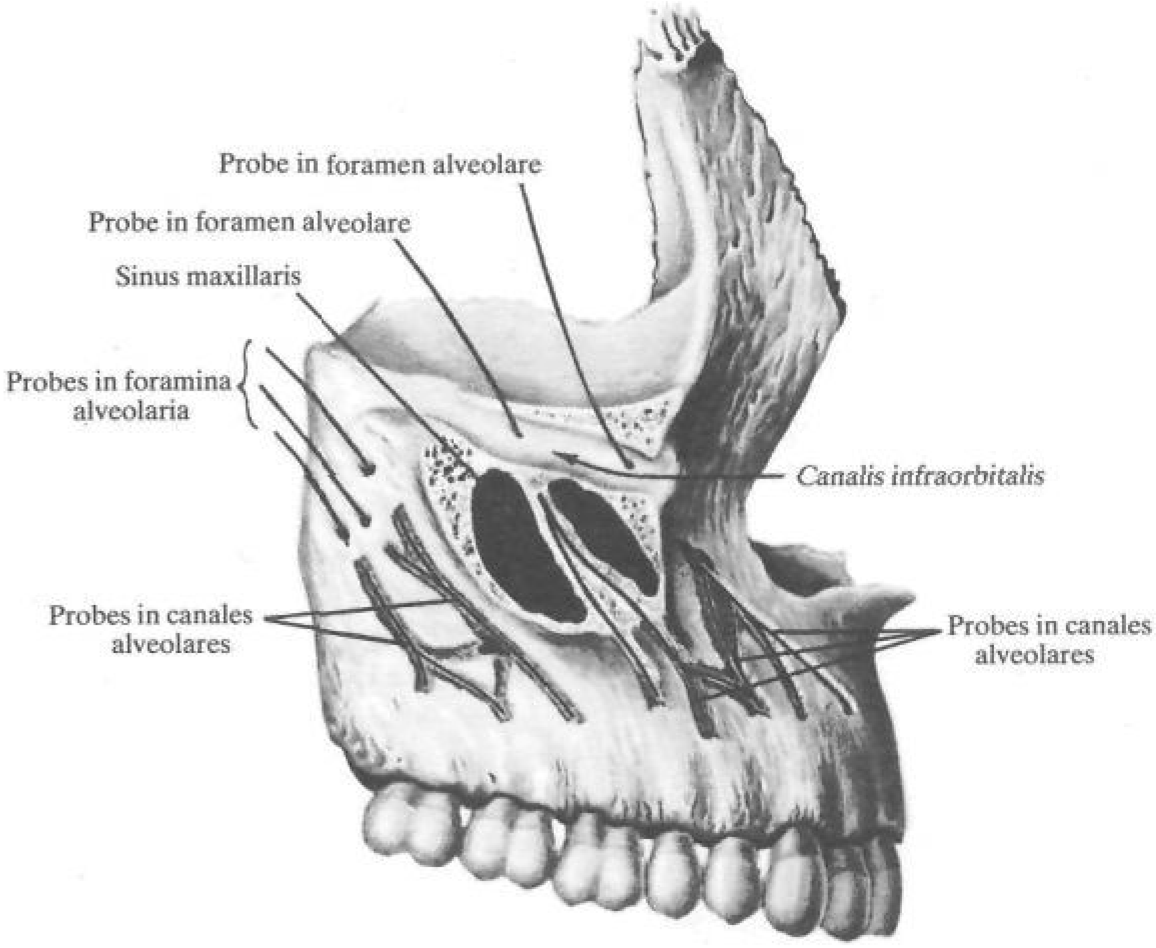
The **zygomatic process** *(processus zygomaticus)* projects from the laterosuperior angle of the body. Its rough end unites with the **zygomatic bone** *(os zygomaticum)* to form the **zygomaticomaxillary suture** *(sutura zygomaticomaxillaris)*.

The **palatine process** *(processus palatinus)* (Figs 81 and 83) is a horizontal bony plate extending medially from the inferior border of the nasal surface of the body of the maxilla and together with the horizontal plate of the palatine bone forms the bony septum between the nasal cavity and the cavity of the mouth. Both maxillae unite by means of the rough medial borders of their palatine processes to form the **median palatine suture** *(sutura palatina mediana)*.

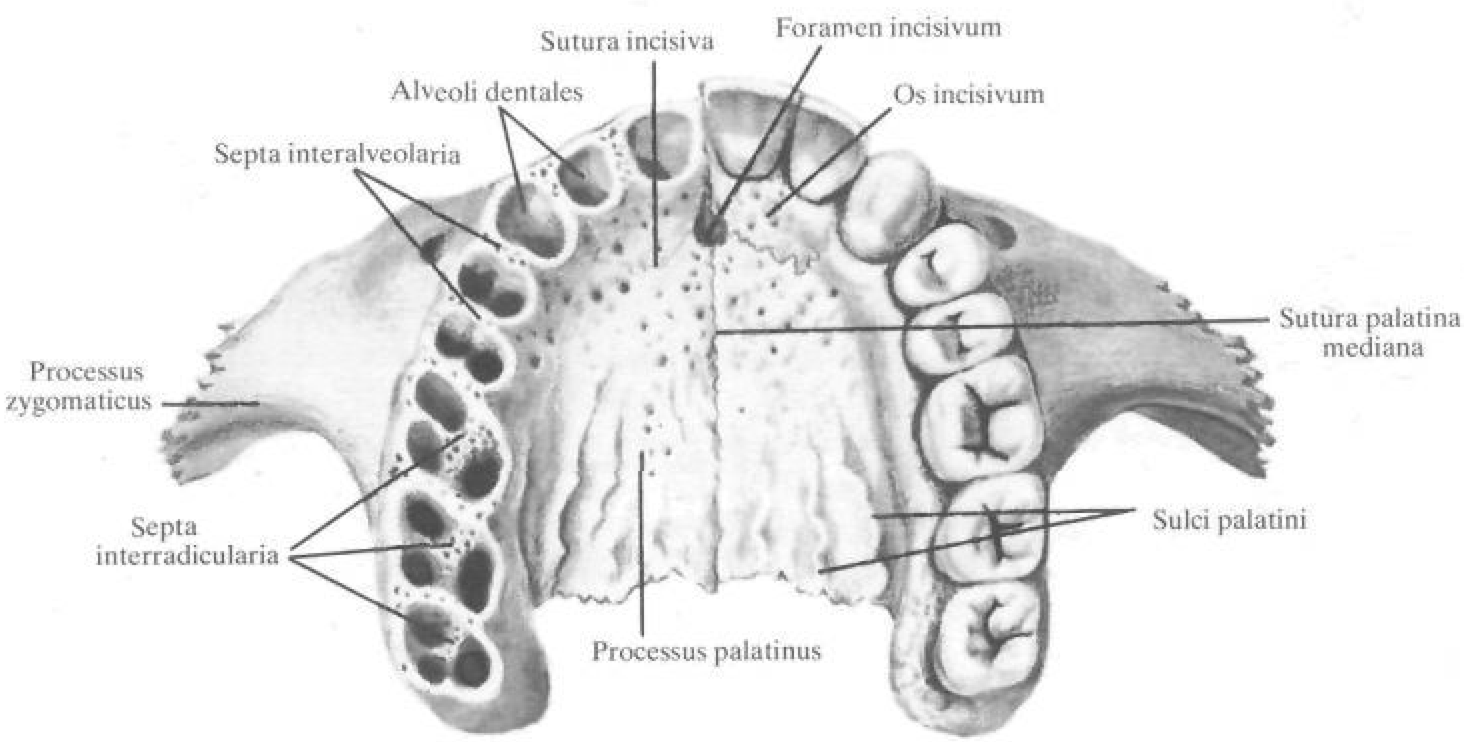
The palatine processes form a sharp marginal projection facing the nasal cavity; this is the **nasal crest** *(crista nasalis)* which adjoins the inferior border of the vomer and the cartilaginous nasal septum. The posterior border of the palatine process meets the anterior border of the horizontal part of the palatine bone to form the **transverse palatine suture** *(sutura palatina transversa)*. The superior surface of the palatine processes is smooth and slightly concave. The inferior surface is rough and carries two **palatine grooves** *(sulci palatini)* close to its posterior end; the sulci are separated from one another by small **palatine spines** *(spinae palatinae)*; both transmit vessels and nerves. An **incisive canal** *(canalis incisivus)* forms between the right and left palatine processes at the anterior border. The **incisive foramen** *(foramen incisivum)* may be found on one of the processes, in which case an incisive groove is seen on the contralateral process.

The **alveolar process** *(processus alveolaris)* (Figs 80 and 83) whose development is associated with the development of the teeth, projects downwards from the inferior border of the body of the bone and describes an arch which is convex anteriorly and laterally. The inferior surface of this region, the **alveolar arch** *(arcus alveolaris)*, has a row of **tooth sockets** *(alveoli dentales)* for the roots of eight teeth on both sides. The sockets are separated from one another by **interalveolar septa** *(septa interalveolaria)*. Some of the sockets are in turn divided by **interradicular septa** *(septa interradicularia)* into smaller sockets according to the number of roots which the tooth has.

The anterior surface of the alveolar process bears longitudinal ridges called **alveolar juga** *(juga alveolaria)* corresponding to the five anterior sockets. In the foetus, part of the alveolar process with the sockets for the two anterior incisors is a separate **incisive bone** *(os incisivum)* which fuses early with the rest of the maxillary alveolar process. Both alveolar processes meet in the middle to form the **intermaxillary suture** *(sutura intermaxillaris)*.



82. *Right maxilla*; anterolateral aspect (1/1).
(The dental canals are opened.)



83. *Maxillae*; inferior aspect (1/1).

THE PALATINE BONE

The **palatine bone** *(os palatinum)* (Figs 84-86; 108) is a paired bone. It is a curved plate situated in the back of the nasal cavity. The bone forms part of the floor (the hard palate) and the lateral wall of the nasal cavity. A **horizontal plate** *(lamina horizontalis)* and a **perpendicular plate** *(lamina perpendicularis)* are distinguished in the palatine bone. The horizontal plates of both palatine bones meet on the midline of the hard palate to form the posterior part of the **median palatine suture** *(sutura palatina mediana)* and articulate with the two palatine processes of the maxillae, which are located in front of them, to form the **transverse palatine suture** *(sutura palatina transversa)*.

The horizontal plate carries a **posterior nasal spine** *(spina nasalis posterior)* on the posteromedial end and a **nasal crest** *(crista nasalis)* on the medial border. The superior surface of the horizontal plate is slightly concave and smooth, the inferior surface is rough.

A thick tubercle *(processus pyramidalis)* projects backwards from the lateral part of the base of the perpendicular plate. It is wedged into the notch between the plates of the pterygoid process of the sphenoid bone and limits the **pterygoid fossa** *(fossa pterygoidea)* from below.

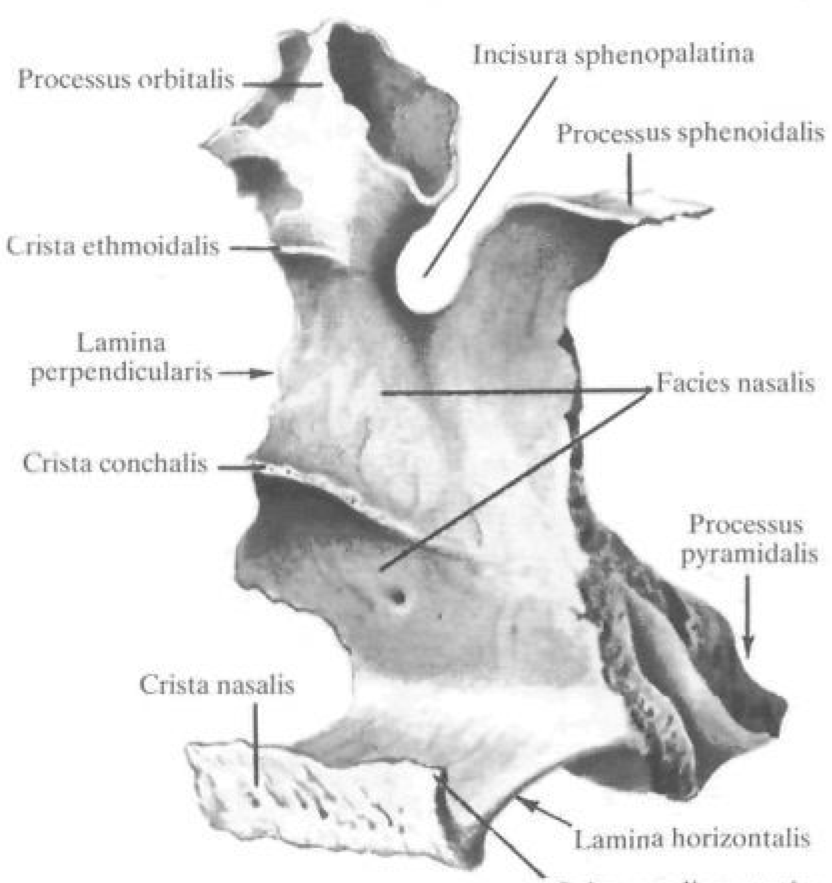
The inferior surface of the tubercle carries one or two **lesser palatine foramina** *(foramina palatina minora)* (see Fig. 108). In front of them, on the inferior surface of the lateral border of the horizontal plate is the **greater palatine foramen** *(foramen palatinum majus)* which is lodged in the suture between the palatine bone and the maxilla.

The thin bony perpendicular plate of the palatine bone arises at a right angle and adjoins the anterior margin of the medial surface of the pterygoid process and the posterior part of the nasal surface of the body of the maxilla. Its lateral surface carries the **greater palatine groove** *(sulcus palatinus major)* which together with the palatine groove of the maxilla and the pterygoid process forms the **greater palatine canal** *(canalis palatinus major)*. The canal opens on the hard palate by the **greater palatine foramen** *(foramen palatinum majus)*.

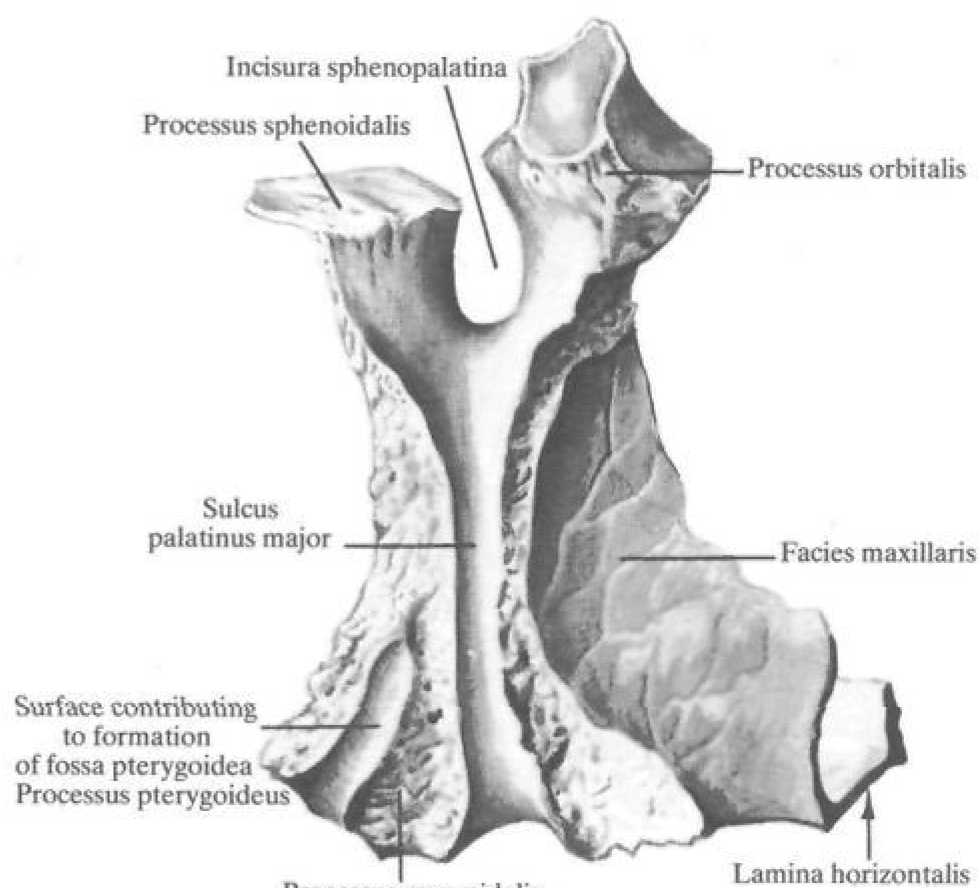
The medial surface of the perpendicular plate bears the **conchal crest** *(crista conchalis)* which is a marking of fusion of the plate with the posterior part of the inferior nasal concha.

Slightly above it is the **ethmoidal crest** *(crista ethmoidalis)* for attachment of the middle nasal concha of the ethmoid bone.

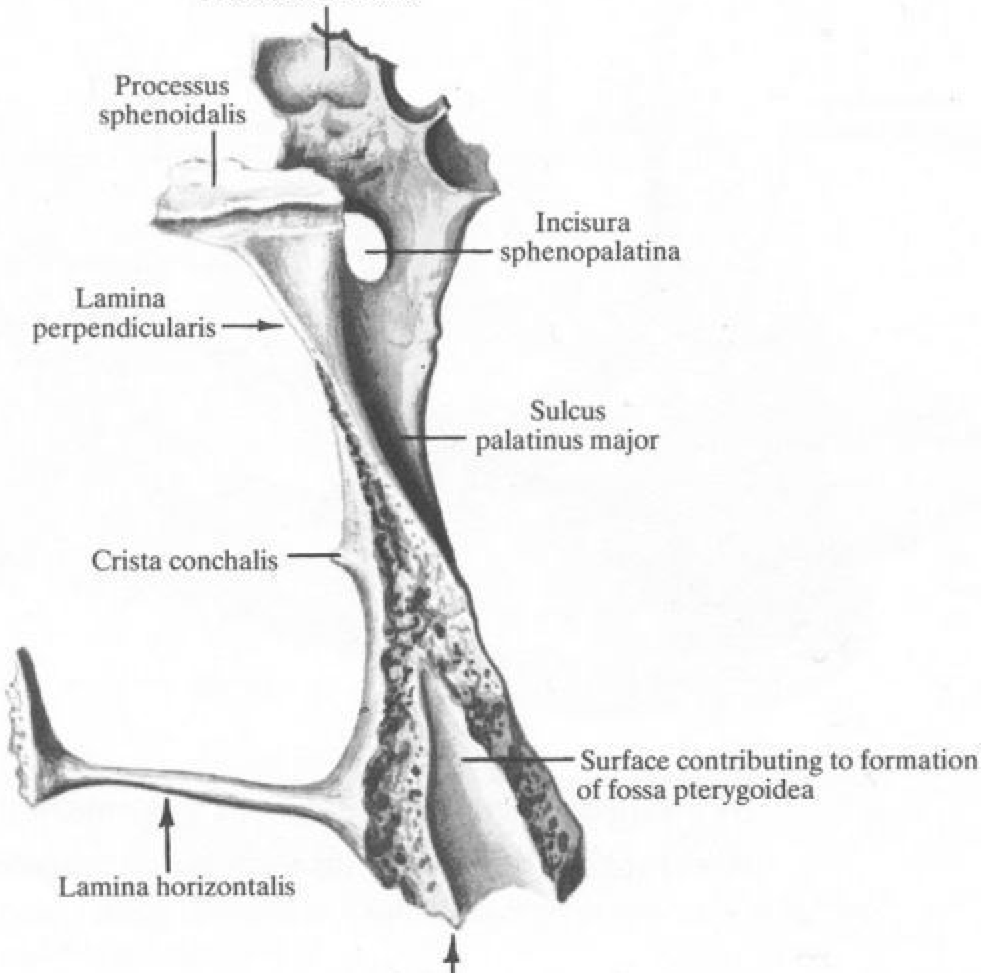
The superior border of the perpendicular plate terminates as two processes: one is the **orbital process** *(processus orbitalis)* (Fig. 85)



84. *Right palatine bone (os palatinum);* medial and posterior aspect (5/3).



85. *Right palatine bone (os palatinum);* lateral aspect (5/3).



86. *Right palatine bone (os palatinum)*; posterior aspect (2/1).

and the other is the **sphenoidal process** *(processus sphenoidalis)*. The processes are separated by the **sphenopalatine notch** *(incisura sphenopalatina)*. The notch with the body of the sphenoid bone adjacent to it forms the **sphenopalatine foramen** *(foramen sphenopalatinum)*.

The **orbital process** *(processus orbitalis)* adjoins the orbital surface of the maxilla; it often carries an air cell which is connected with the posterior cells of the ethmoid bone.

The **sphenoidal process** *(processus sphenoidalis)* reaches the inferior surface of the body of the sphenoid bone, its concha, and the wings of the vomer.

THE ZYGOMATIC BONE

The **zygomatic bone** *(os zygomaticum)* (Figs 49-52 and 87) is a paired bone and a component of the lateral parts of the visceral cranium. Three surfaces are distinguished on it. Its **lateral surface** *(facies lateralis)* is shaped like an irregular quadrangle and is convex, particularly in the region of the protuberance.

The **orbital surface** *(facies orbitalis)* stretching medially and forwards is concave. It forms part of the lateral and inferior walls of the orbit and meets the lateral surface by means of a sharp and curved margin which contributes inferiorly to the **infraorbital margin** *(margo infraorbitalis)*.

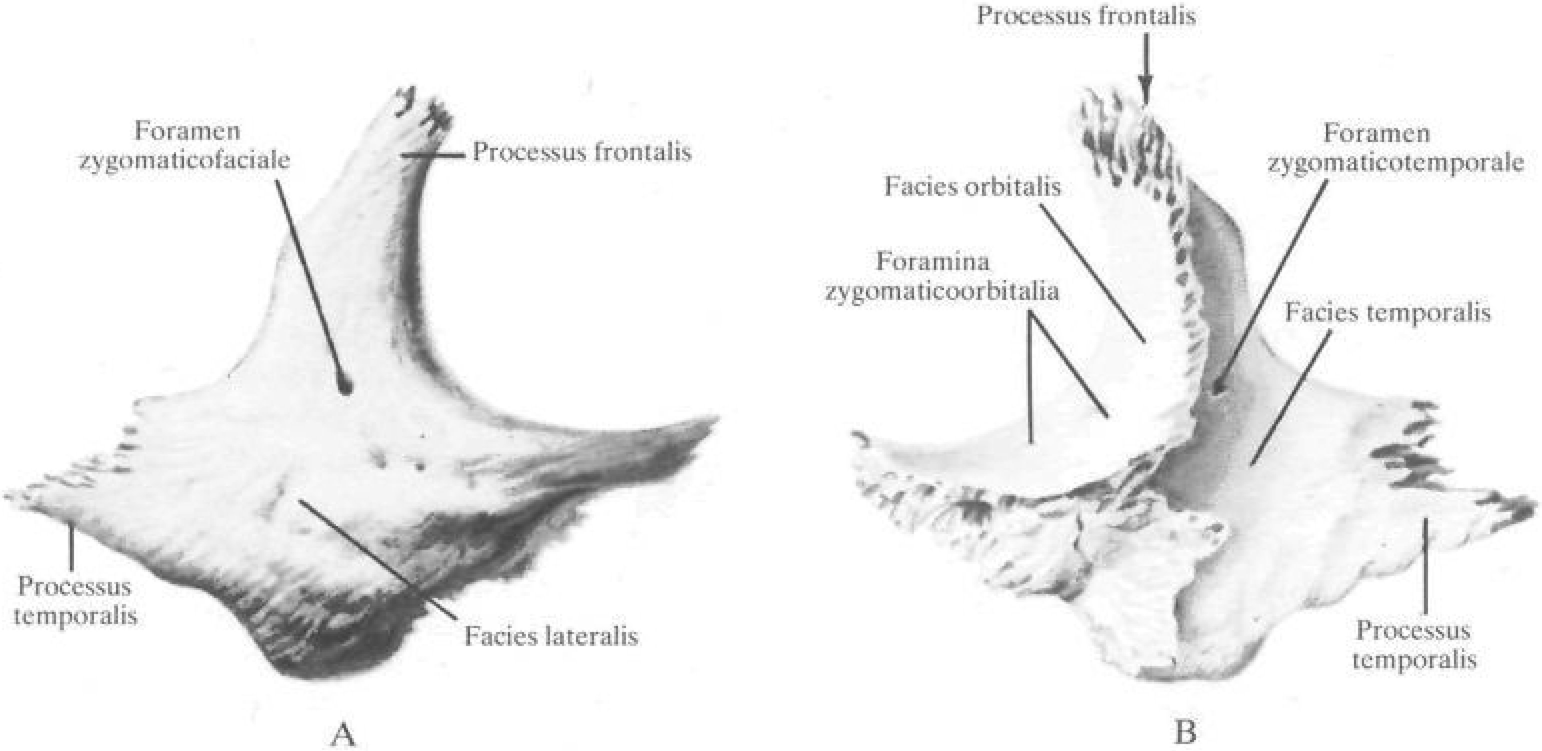
The **temporal surface** *(facies temporalis)* faces the temporal fossa.

The **frontal process** *(processus frontalis)* arises from the superior angle of the body of the bone. It articulates with the zygomatic process of the frontal bone to form the **frontozygomatic suture** *(sutura frontozygomatica)* and with the greater wing of the sphenoid bone to form the **sphenozygomatic suture** *(sutura sphenozygomatica)*.

The zygomatic bone unites with the maxilla to form the **zygomaticomaxillary suture** *(sutura zygomaticomaxillaris)*.

The orbital surface of the bone bears the **zygomatico-orbital foramen** *(foramen zygomaticoorbitale)* leading into a canal which bifurcates in the bone. One branch of the canal opens on the anterior surface of the bone as the **zygomaticofacial foramen** *(foramen zygomaticofaciale)*, the other—on the temporal surface as the **zygomaticotemporal foramen** *(foramen zygomaticotemporale)*. These canals transmit nerves.

The posterior angle of the bone gives rise to the **temporal process** *(processus temporalis)* which meets the zygomatic process of the temporal bone to form the **zygomatic arch** *(arcus zygomaticus)*.



87. *Right zygomatic bone (os zygomaticum)*; (1/1).
A—lateral aspect; B—medial aspect.

THE MANDIBLE

The **mandible** *(mandibula)* (see Figs 48-53; 88-91) is an unpaired bone forming the lower part of the visceral skull. A **body** *(corpus mandibulae)* and two processes called **rami** *(rami mandibulae)* projecting upwards from its posterior end are distinguished.

The **body** *(corpus)* is formed from two halves of the bone which fuse on the midline to form a single bone during the first year of life. The outer surface of each half is convex, and the height of the body is greater than its width. A lower margin, or the **base of the mandible** *(basis mandibulae)* and an upper margin formed by the **alveolar part** *(pars alveolaris)* are distinguished in the lower jaw.

On the outer surface of the middle part of the body is the **mental protuberance** *(protuberantia mentalis)* directly lateral of which on each side is the **mental tubercle** *(tuberculum mentale)*. The **mental foramen** *(foramen mentale)* transmitting vessels and nerves is above and lateral of the tubercle. This foramen corresponds to the position of the root of the second premolar. To the back of the mental foramen is the **oblique line** *(linea obliqua)* which runs upwards and is continuous with the anterior border of the ramus of the mandible.

The development of the **alveolar part** *(pars alveolaris)* is determined by the teeth which it carries; it is bounded superiorly by the **alveolar arch** *(arcus alveolaris)*. This border bears 16 (8 on each side) **tooth sockets** *(alveoli dentales)* (see Fig. 89) separated from one another by **interalveolar septa** *(septa interalveolaria)*. A multi-rooted socket lodging a tooth with two roots is divided by an **inter-radicular septum** *(septum interradicularia)*.

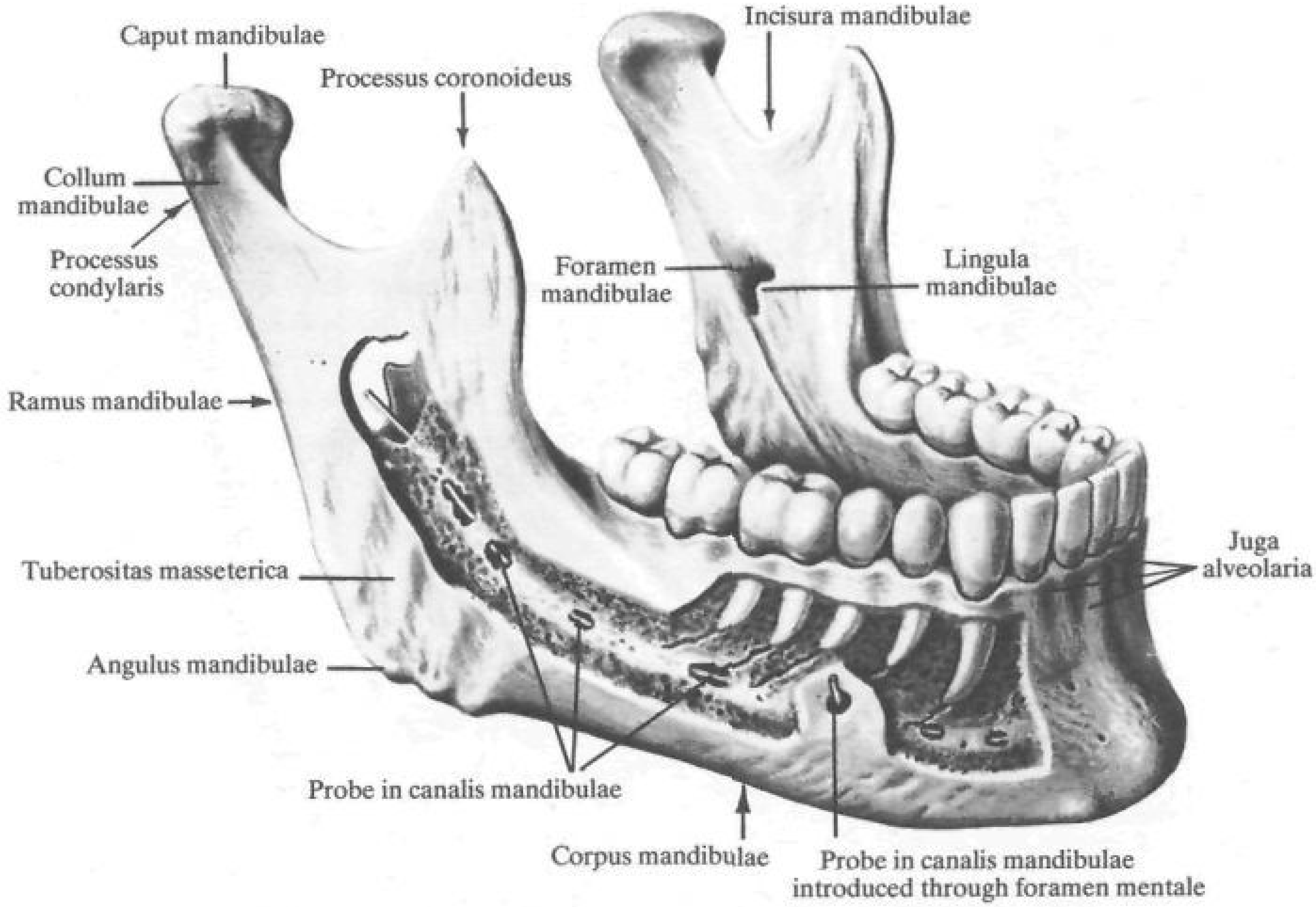
The superior margin of the outer surface of the body has a series of ridges and depressions called **alveolar juga** *(juga alveolaria)*.

A solitary or double **mental spine**, or **genial tubercle** *(spina mentalis)* is located on the inner surface of the body of the mandible near the midline; the geniohyoideus and genioglossus muscles originate here. On the lower margin is a depression called the **digastric fossa** *(fossa digastrica)* which serves for attachment of the digastric muscle. A **mylohyoid line** *(linea mylohyoidea)* passes obliquely on each side of the inner surface of the body towards the ramus; the mylohyoid muscle and part of the superior constrictor muscle of the pharynx arise here.

Above this line in its anterior parts is the **sublingual fossa** *(fovea sublingualis)* lodging the sublingual gland; under the posterior part of the line is the **submandibular fossa** *(fovea submandibularis)* which is often poorly defined; it lodges the submandibular gland. Under the posterior part of the mylohyoid line also stretches the **mylohyoid groove** *(sulcus mylohyoideus)* which lodges the mylohyoid vessels and nerves.

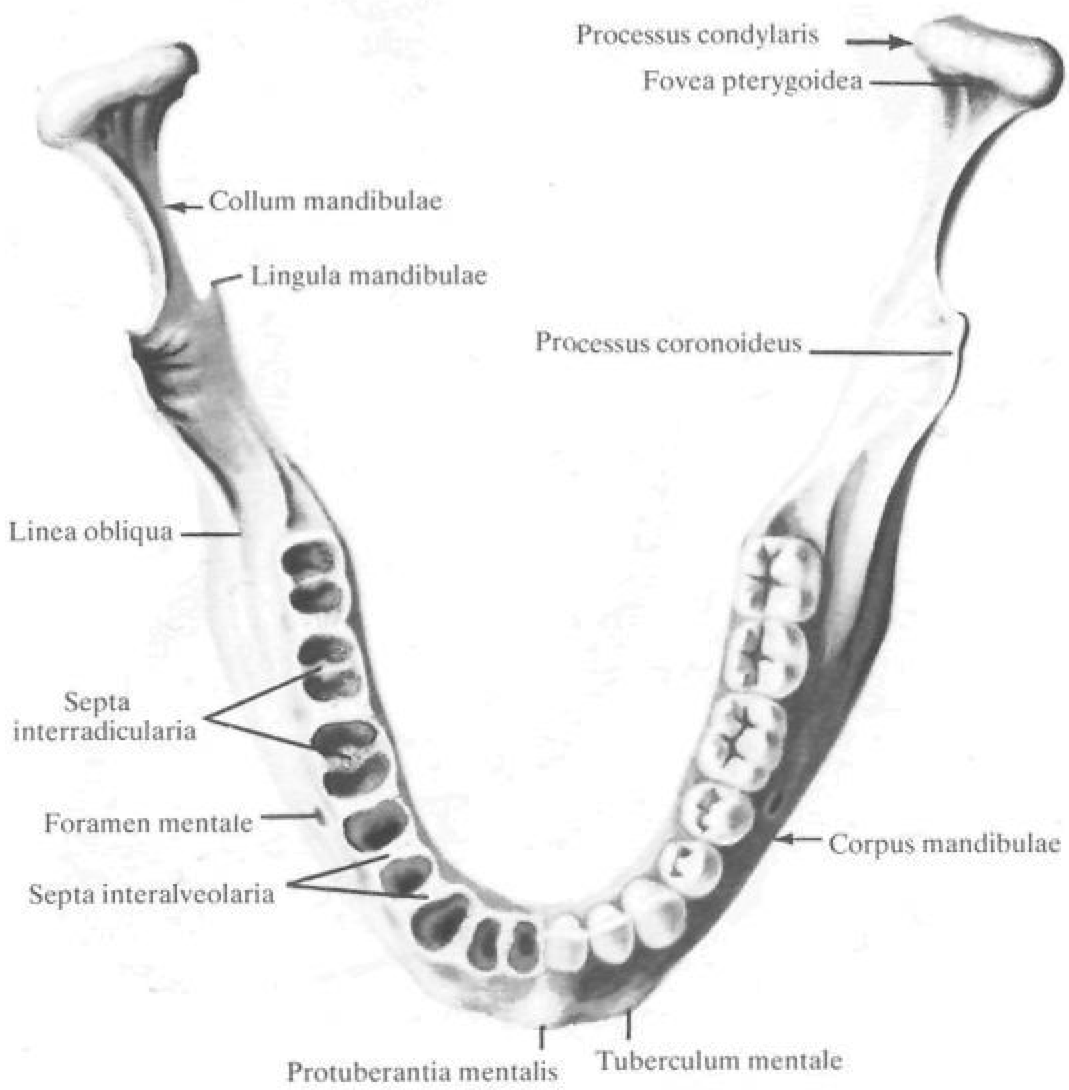
The **ramus of the mandible** *(ramus mandibulae)* (Figs 88 and 91) is a wide bony plate arising from the posterior end of the body obliquely and posteriorly to form the **angle of the mandible** *(angulus mandibulae)* with the lower margin of the body.

A rough area called the **masseteric tuberosity** *(tuberositas masseterica)* is located on the outer surface of the ramus in the region of the angle; it serves for attachment of the masseter muscle. In line with this tuberosity but on the inner surface is a smaller, **pterygoid**

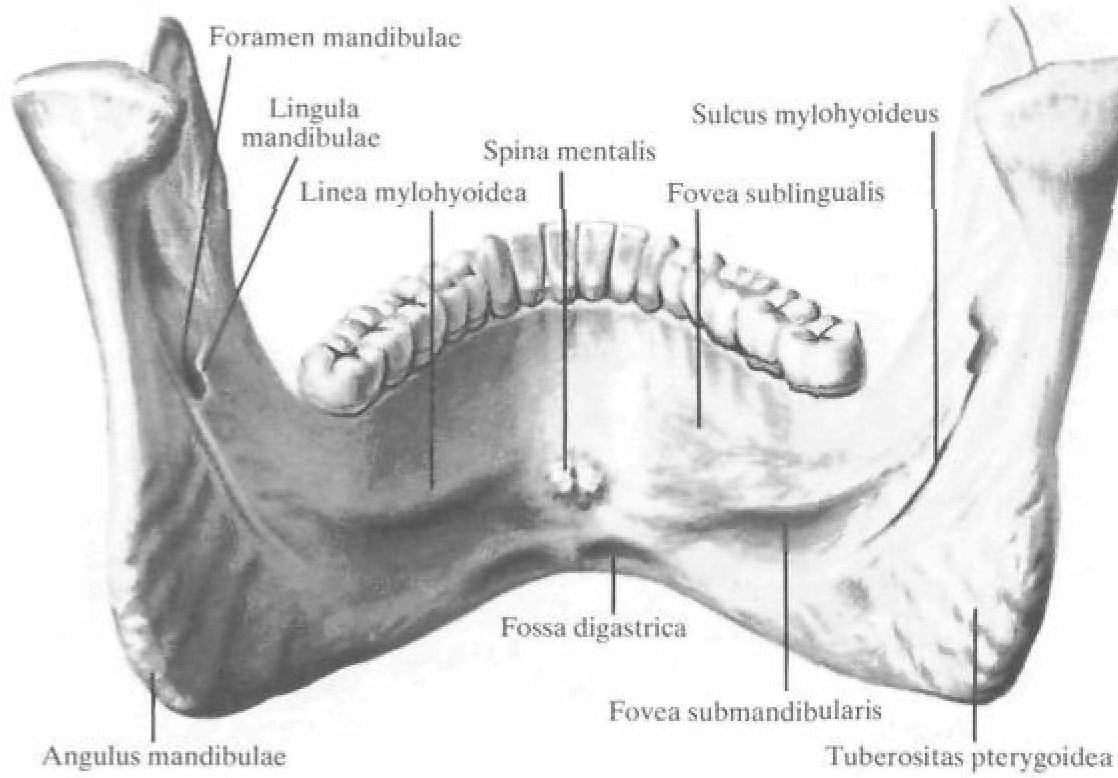


88. *The mandible (mandibula)*; outer aspect ($\frac{4}{5}$).

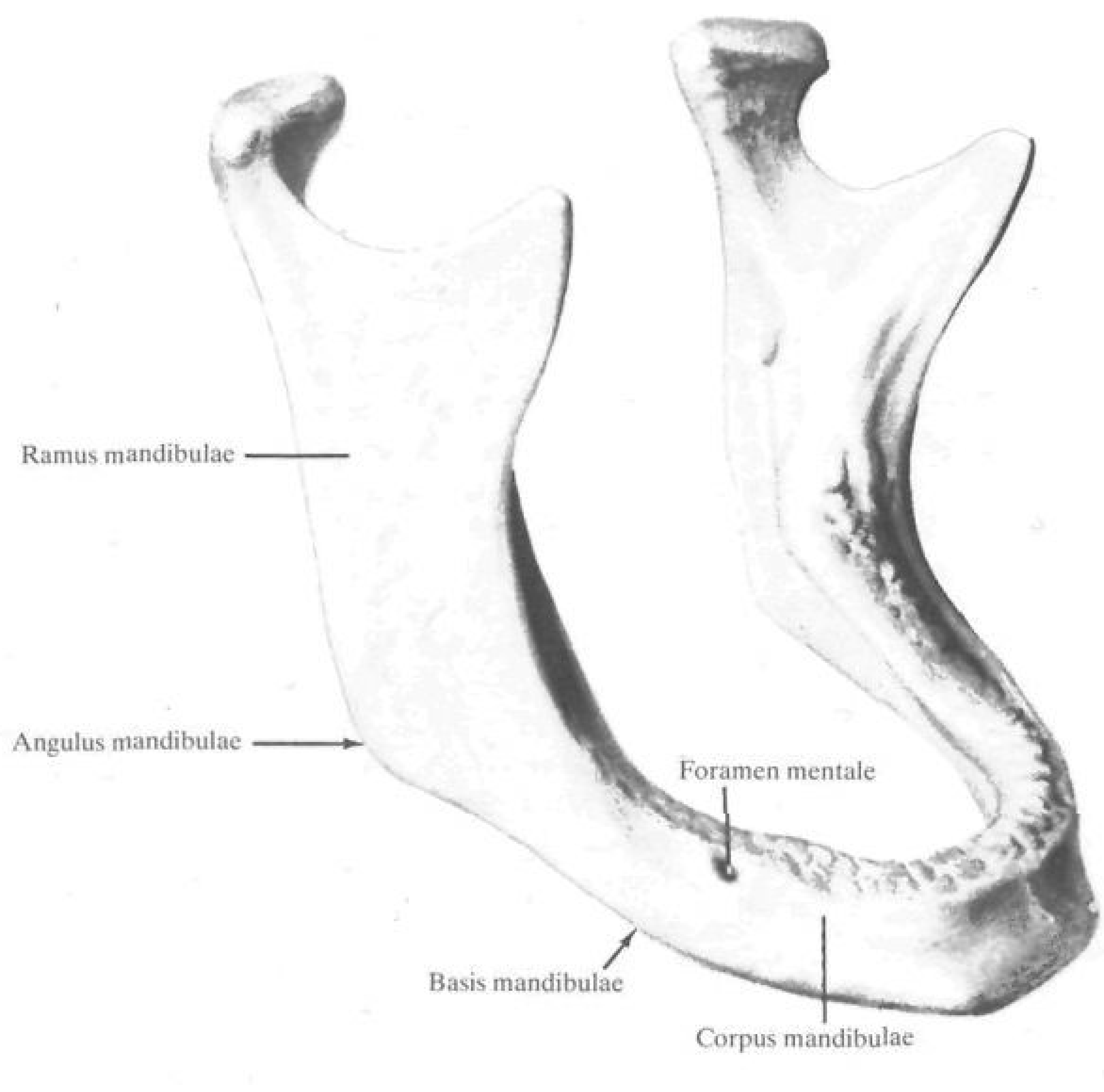
(The external lamina of the compact bone substance is removed; a probe is introduced into the mandibular canal.)



89. *Mandible (mandibula)*; superior aspect ($\frac{4}{5}$).



90. *Mandible (mandibula)*; inner aspect (4/5).



91. *Mandible (mandibula)* of an old man (4/5).

(The teeth and alveolar part of the mandible are absent.)

tuberosity *(tuberositas pterygoidea)* which is the site of origin of the middle pterygoid muscle.

The **mandibular foramen** *(foramen mandibulae)* is located in the middle of the inner surface of the ramus; it is bounded medially and anteriorly by a small bony projection called the **lingula of the mandible** *(lingula mandibulae)*. The foramen leads into the **mandibular canal** *(canalis mandibulae)* (Fig. 88) transmitting vessels and nerves. The canal is lodged in the spongy substance of the bone; it curves downwards and to the front and reaches almost the middle of the mandible and opens on the anterior surface of its body by means of the **mental foramen** *(foramen mentale)*.

On the superior end of the ramus are two processes which are separated by the **mandibular notch** *(incisura mandibulae)*. The anterior process, called the **coronoid process** *(processus coronoideus)* often has a rough area giving attachment to the temporal muscle; the posterior, **condyloid process** *(processus condylaris)* articulates with the skull by means of the **head of the mandible** *(caput mandibulae)* which is covered by cartilage.

The head is continuous with the **neck of the mandible** *(collum mandibulae)* on whose inner surface is seen a **pterygoid pit** *(fovea pterygoidea)* which gives attachment to the lateral pterygoid muscle.

THE HYOID BONE

The **hyoid bone** *(os hyoideum)* (Fig. 92) is situated below the tongue. It is shaped like a horse-shoe and can be felt through the skin in a lean person. It is attached to other bones by means of ligaments. The hyoid bone consists of a **body** *(corpus)* and **greater** and **lesser horns** *(cornua majora* et *minora)*.

The body is a convex plate and carries a transverse and a vertical crests. The superior border of the plate is sharp, the inferior border is thickened. The lateral borders of the body are joined to the greater horns by means of articular surfaces or fibrous or hyaline cartilage.

The greater horns project from the body to the back and laterally. They are thinner and longer than the body and are slightly thickened on the ends.

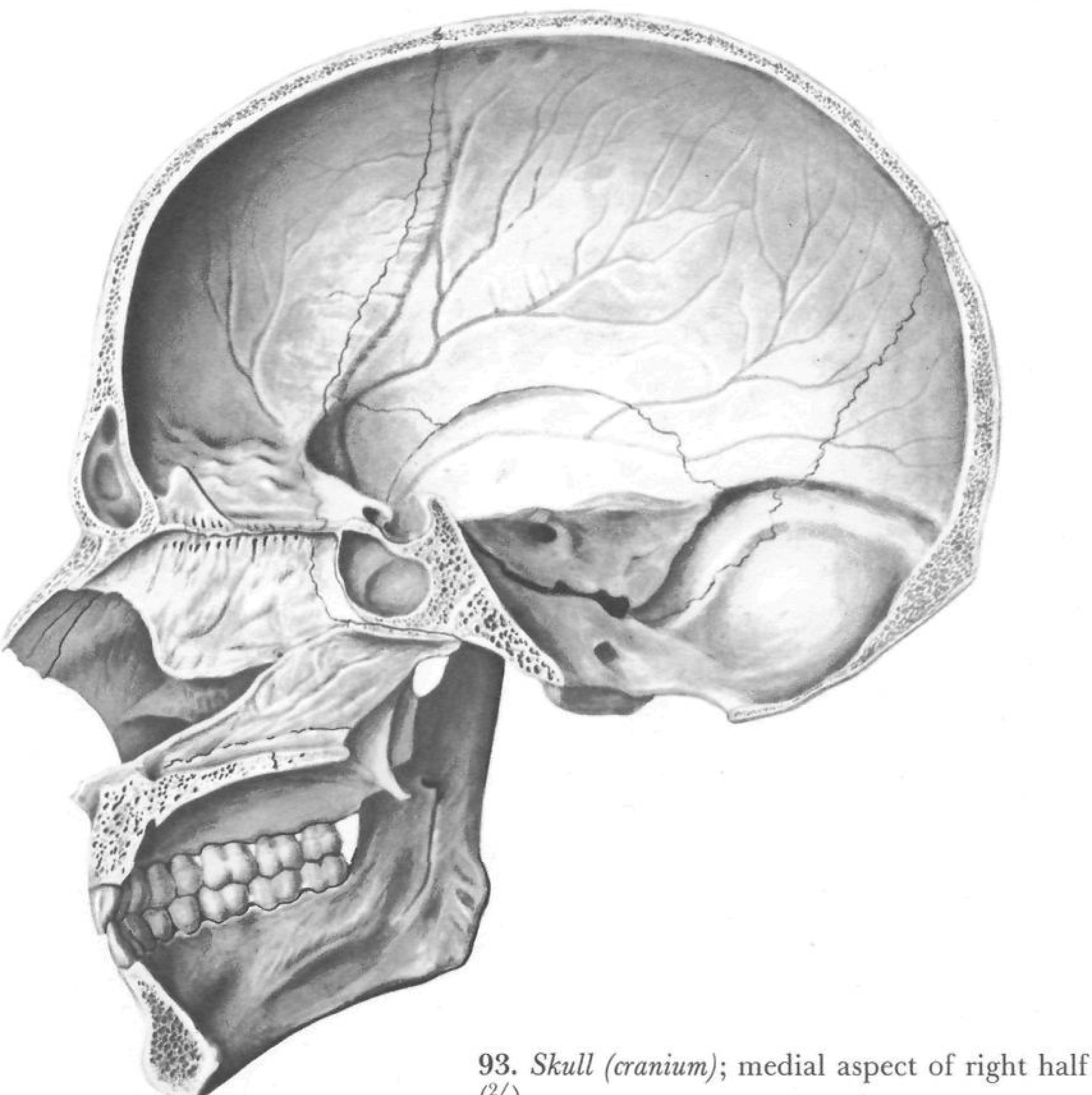
The lesser wings arise at the junction of the body and the greater wings. In some cases they remain cartilaginous. They are joined to the body either by means of a joint with a weakly tightened capsule or by means of connective tissue. Their ends are embraced by the **stylohyoid ligament** *(ligamentum stylohyoideum)* which sometimes contains one or more small bones.

92. *Hyoid bone (os hyoideum)*; superior and outer aspect ($^3/_2$).

THE SKULL AS A WHOLE

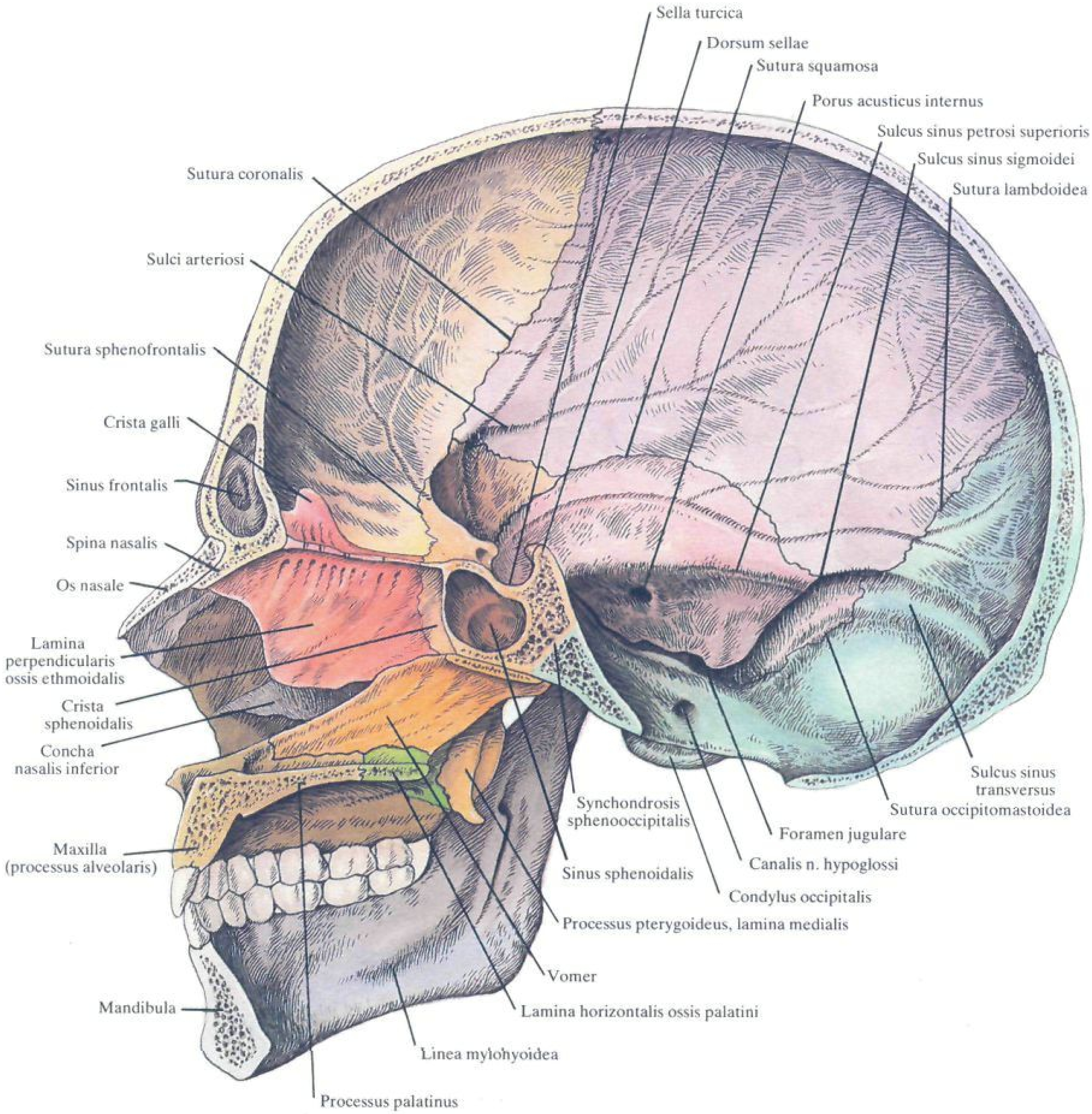
The **skull** *(cranium)* (see Figs 48-53; 93-96) is separated into two large parts which are continuous with one another. The upper part is the **skull cap**, or **calvaria** *(fornix cranii)*, the lower part is called the **base** *(basis)*.

The border separating these two large parts passes on a conventional line through the following structures: (1) external occipital protuberance; (2) superior nuchal line; (3) base of the mastoid process; (4) superior margin of the porus acusticus externus; (5) root of the zygomatic process of the temporal bone; (6) infratemporal crest of the greater wing of the sphenoid bone; (7) sphenozygomatic suture; (8) zygomatic process of the frontal bone; (9) supra-orbital margin, and (10) nasal margin of the frontal bone. Above this line drawn through the structures named is the calvaria, below the line is the base of the skull.

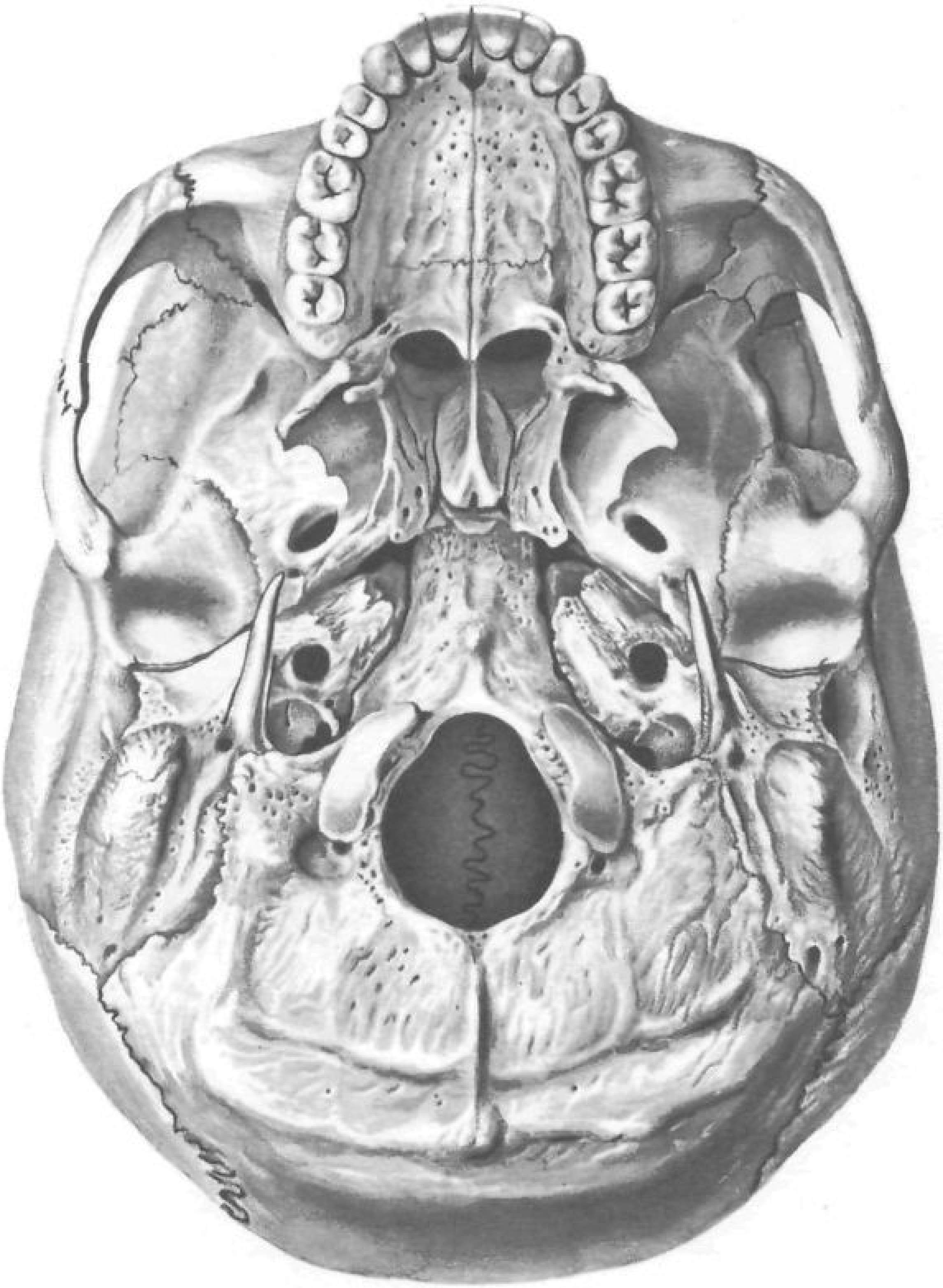


93. *Skull (cranium)*; medial aspect of right half (2/3).

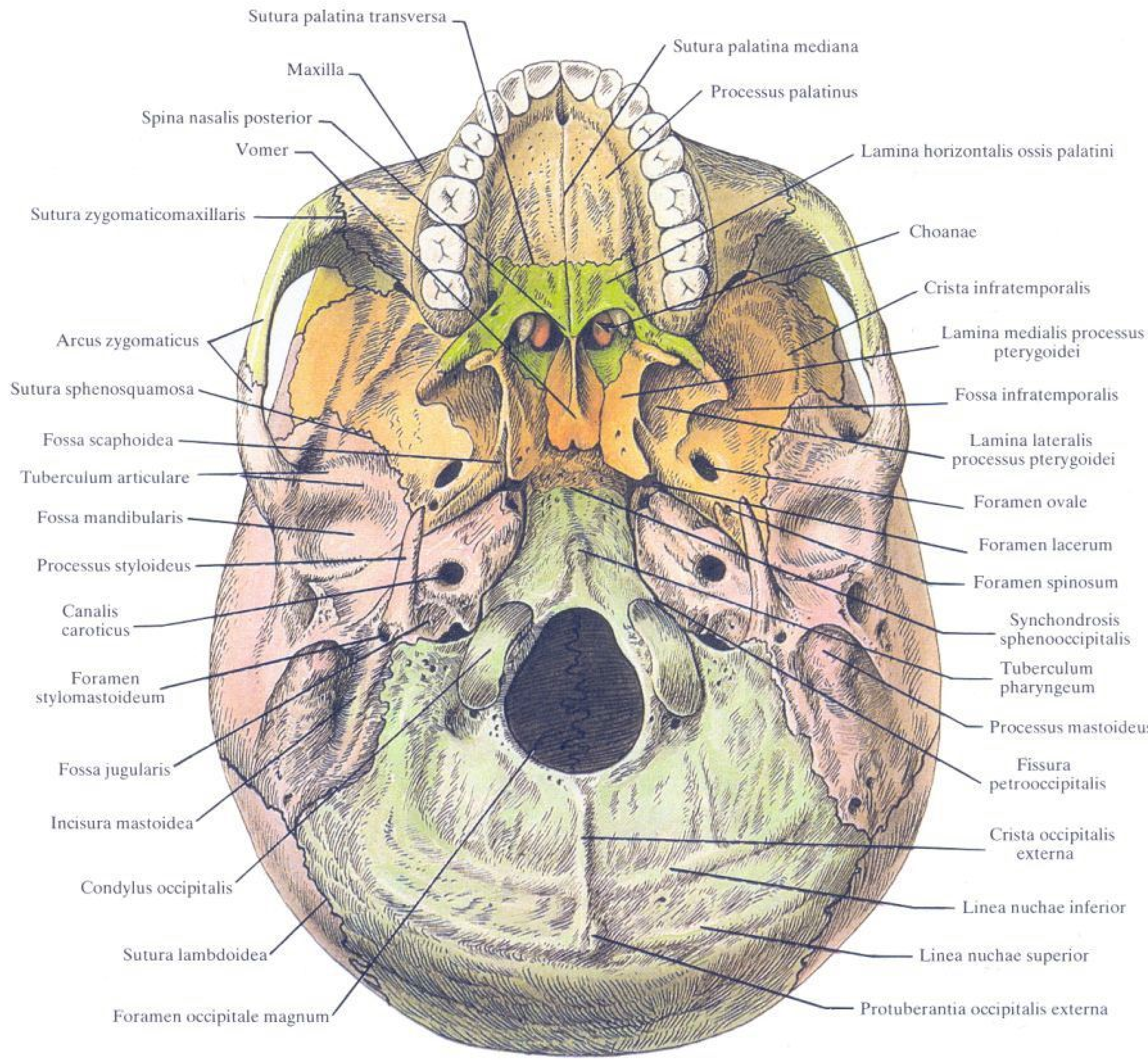
(Sagittal section made to the left of the median plane.)



94. *Skull (cranium)*; medial aspect (represented semischematically).



95. *Skull (cranium)*; inferior aspect ($\frac{2}{3}$).
(Lower surface of base of skull, basis cranii externa.)



96. *Skull (cranium)*; inferior aspect (semischematical representation).

THE SKULL CAP

On examining the convex (external) surface of the **skull cap**, or **calvaria** (Figs 97 and 98) one can easily see that it is formed of bones joined by means of **sutures** *(suturae)*.

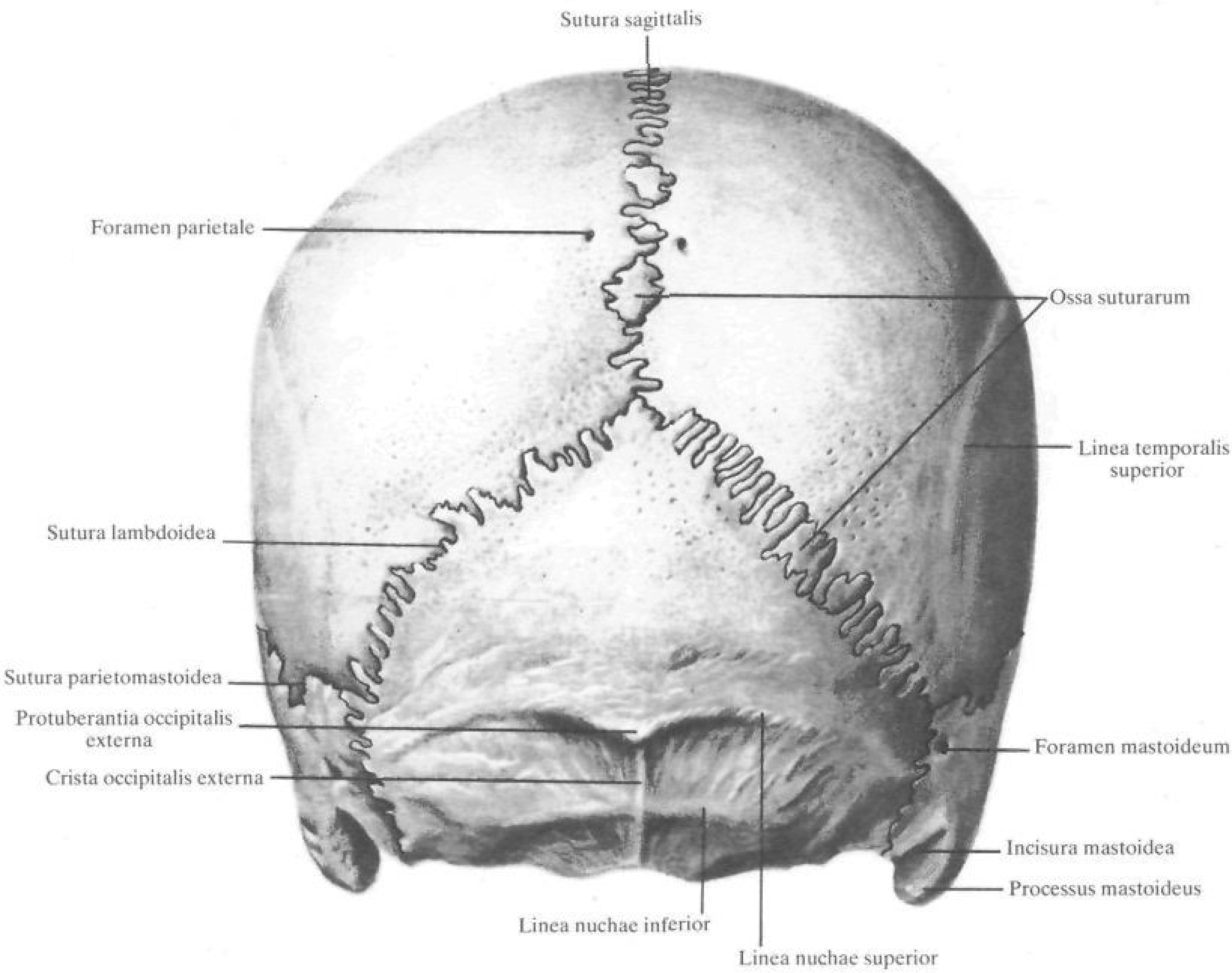
They articulate by means of **connective tissue** *(syndesmosis)*.

Sutures are one of the types of bone union. The bones contributing to the formation of the skull cap are joined by various types of sutures, some forming a serrated line, others an even line. A suture with a serrated line is called a **serrated suture** *(sutura serrata)*. One in which the bones unite to form an even line may be called either a **squamous suture** *(sutura squamosa)*, when the edges of one bone overlap the edge of the other bone (like the scales of fish), or a **flat suture** *(sutura plana)* when the edges of the united bones are even and in simple apposition.

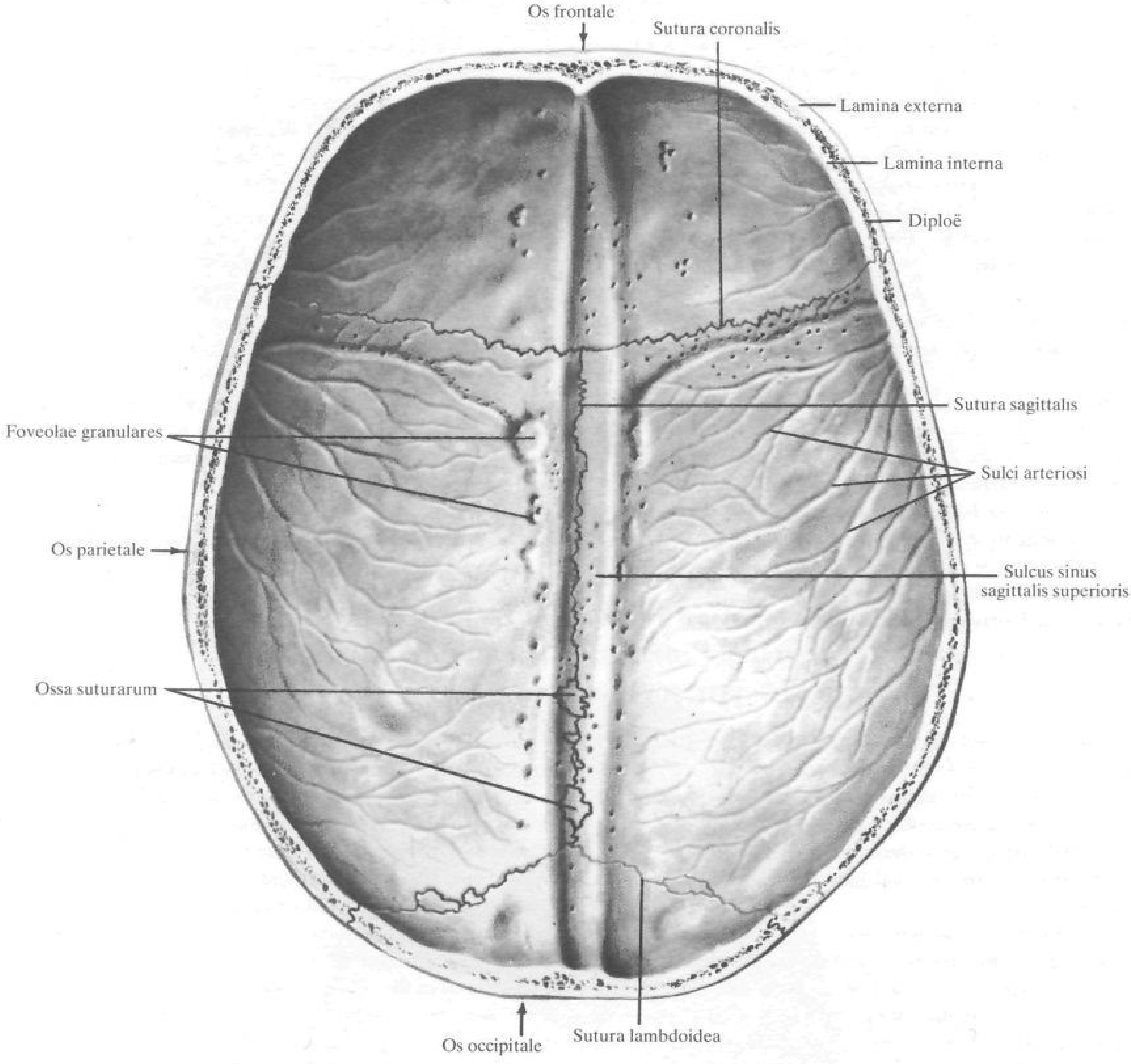
The sutures formed between the bones are usually named after the articulating bones.

Some sutures of the calvaria are named according to direction or shape: the **coronal suture** *(sutura coronalis)* is the union between the frontal and parietal bones; the **sagittal suture** *(sutura sagittalis)* is that between the parietal bones; the **lambdoid suture** *(sutura lambdoidea)* is the junction between the occipital and parietal bones.

On the lateral surface of the skull cap, below the **inferior temporal line** *(linea temporalis inferior)* is the temporal area which is continuous downwards with the **temporal fossa** *(fossa temporalis)* bounded laterally by the **zygomatic process of the temporal bone** *(processus zygomaticus ossis temporalis)*.



97. *Skull (cranium)*; posterior aspect (⅔).
(Without the mandible.)



98. *Skull cap* or *calvaria*; internal aspect (2/3).

The anterior convexity of the calvaria is the **forehead** *(frons)*. The posterior part of the calvaria has three eminences: the two lateral ones are called **parietal eminences** *(tubera parietalia)*, the posterior eminence is the **occiput.** Between these three eminences is the utmost upwardly projecting point of the roof, the **top** or **crown of the skull** *(vertex)*.

The cerebral surface of the skull cap bears grooves and ridges which reflect the relief of the brain and are its markings.

In addition, the cerebral surface of the calvaria carries the markings of vessels and grooves of the venous sinuses. The largest groove stretches on the midline of the calvaria and is called the **sagittal groove for the superior sagittal sinus** *(sulcus sinus sagittalis superioris)*. On the margins of the groove are seen small but deep **granular pits** *(foveolae granulares)* occupied by arachnoidal outgrowths. In addition to these pits, two or three **nutrient foramina** *(foramina nutricia)* are seen in the posterior parts of the sagittal groove, usually not in the groove itself but at some distance from its edges.

THE FONTANELLES

One of the specific features of the skull of a newborn are **fontanelles** *(fonticuli cranii)* (see Figs 3, 99 and 100). These are unossified areas of the **membranous cranium** *(desmocranium)* which are located in places of future sutures.

It is general knowledge that the calvaria undergoes structural changes during intrauterine life, i.e. it is a membranous structure covering the top of the brain at first but is gradually replaced by bony tissue later without going through the stage of cartilage. This period is characterized by the appearance of bone nuclei (in the second or the beginning of the third intrauterine month) as islets in this or that bone. These islets merge later to form large bony plates which are the bony framework of the various bones of the calvaria.

By the time of birth, however, areas of the membranous skull remain between the bones as narrow bands and wider spaces called fontanelles. Due to their elasticity they may retract or protrude depending on the intracranial pressure; hence their name (dim. of Fr. *fontaine* fountain). Six fontanelles are distinguished on the skull of a newborn; among them two are paired and two unpaired. The unpaired are the anterior and posterior fontanelles, the paired—the sphenoidal and mastoid fontanelles.

The **anterior fontanelle** *(fonticulus anterior)* (Fig. 100) is usually diamond-shaped and located at the junction of the sagittal, coronal, and frontal sutures. It is normally ossified by the age of about two years.

The **posterior fontanelle** *(fonticulus posterior)* is triangular and is found at the junction of the sagittal and lambdoid sutures. It ossifies at the beginning of the first year of life.

The paired **sphenoidal**, or **anterolateral fontanelle** *(fonticulus sphenoidalis)* is situated on the anterolateral surface of the skull and is bounded anteriorly and superiorly by the frontal and parietal bones and inferiorly by the greater wing of the sphenoid bone and the squamous part of the temporal bone. It closes soon after birth, sometimes by the end of the intrauterine period.

The other paired fontanelle, the **mastoid**, or **posterolateral fontanelle** *(fonticulus mastoideus)*, is to the back of the sphenoidal one at the articulation of the occipital squama with the mastoid process of the temporal bone. It ossifies in the same period as the sphenoidal fontanelle.

The remnants of the membranous skull permit considerable displacement of the cranial bones during delivery of the infant, as a result of which passage of the head in the narrow parts of the birth canal is easier.

THE BASE OF THE SKULL

The **base of the skull** *(basis cranii)* (Figs 95, 96, 99, 101, 102) is the part of the skull located below the horizontal line which passes in front at the level of the **supraorbital margin** *(margo supraorbitalis)* and at the back in the middle between the **lambda** and the **external occipital protuberance** *(protuberantia occipitalis externa)*.

The external and the internal base (surface) of the skull are distinguished.

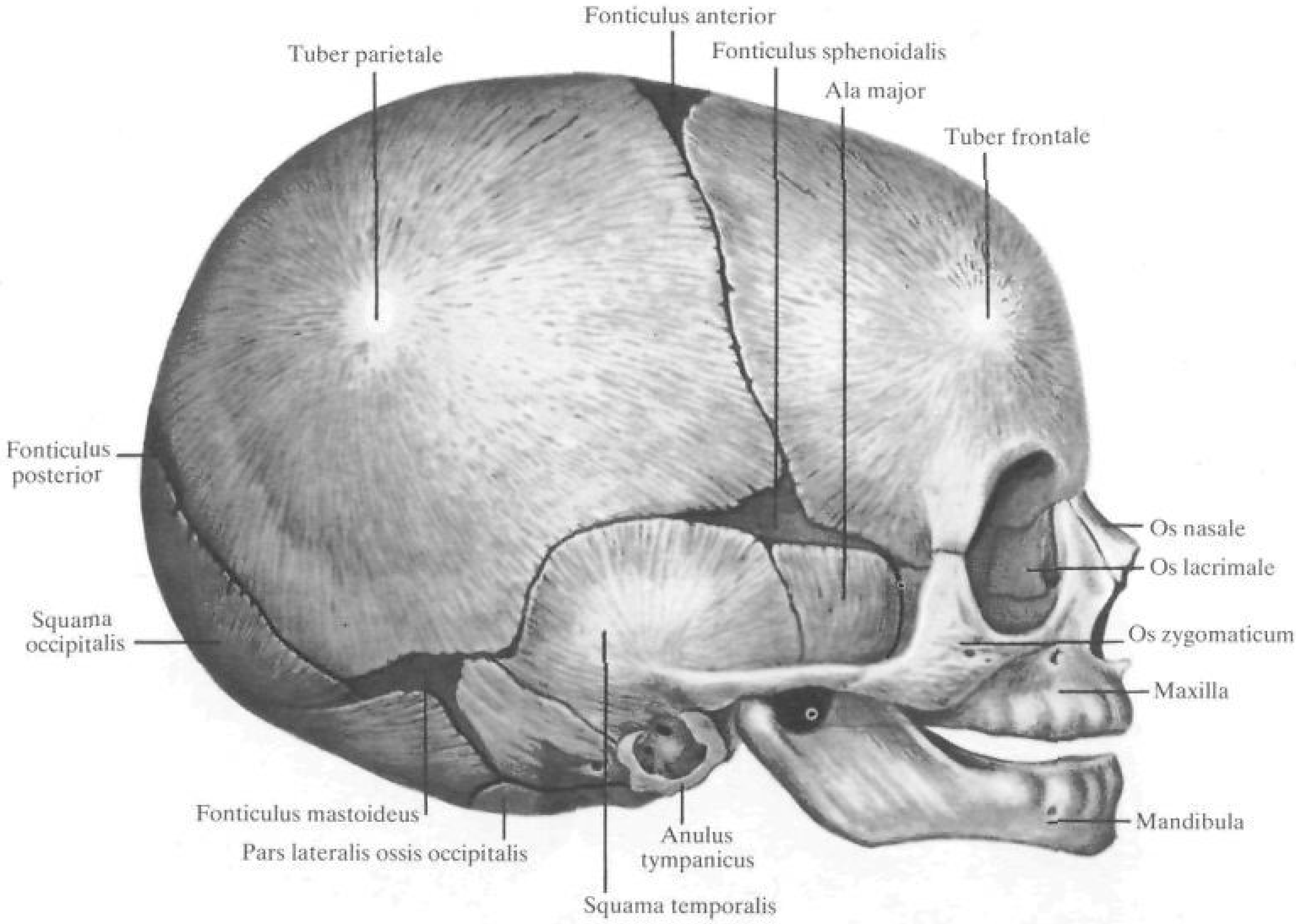
The **external**, or **lower surface of the base of the skull** *(basis cranii externa)* (Figs 95, 96) together with the bony palate is covered by the facial bones. Here, to the back of the bony palate, project the **pterygoid processes** *(processus pterigoidei)* whose medial plates together with the perpendicular plates of the palatine bones form the outer borders of the choanae which are divided by the vomer.

Between the pterygoid processes, lateral and to the back of them, the external surface of the base is formed by the body and greater wings of the sphenoid bone, the inferior surface of the petrous and tympanic parts and an area of the squamous part of the temporal bone, and by the basilar part of the occipital bone and anterior segment of its squama.

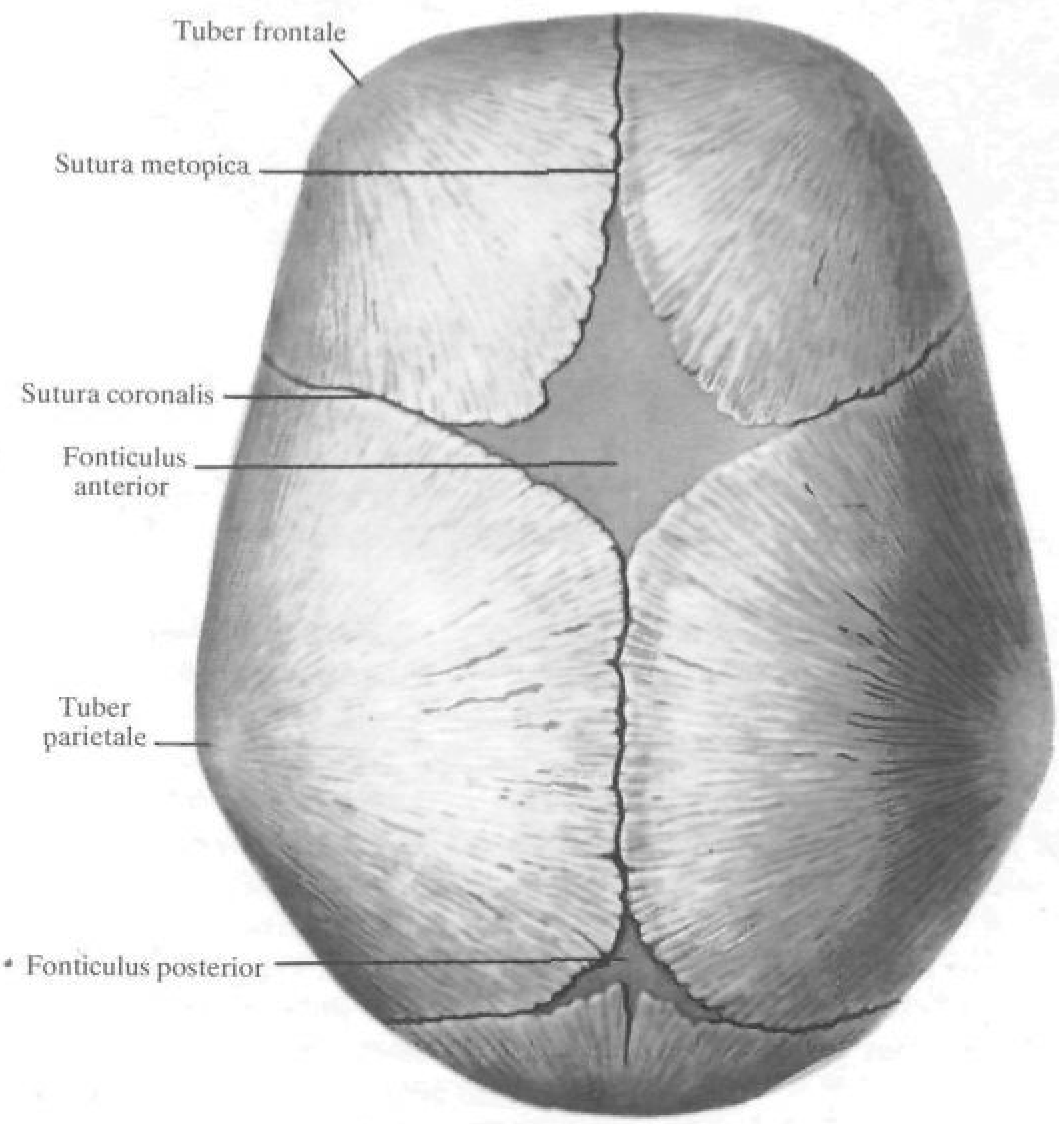
The **scaphoid fossa** *(fossa scaphoidea)* is at the base of the medial plate of the pterygoid process, to the back of which is the **foramen lacerum** which has irregular edges and is filled by cartilaginous tissue on a non-macerated skull. The **foramen ovale** and the **foramen spinosum** open in the region of the greater wing of the sphenoid bone. Lateral of them is the **articular fossa** *(fossa mandibularis)* with an **articular surface** *(facies articularis)*, bounded anteriorly by the **eminentia articularis** *(tuberculum articulare)*. The **carotid canal** *(canalis caroticus)* opens on the inferior surface of the petrous part of the temporal bone. Lateral and to the back of the canal is the **jugular fossa** *(fossa jugularis)* leading into the **jugular foramen** *(foramen jugularis)* which is formed from union of the jugular notches of the petrous part of the temporal bone and the condylar part of the occipital bone. Lateral of the jugular foramen is the **styloid process** *(processus styloideus)* and still further laterally the **mastoid process** *(processus mastoideus)*. Between these two processes is the **stylomastoid foramen** *(foramen stylomastoideum)*.

The body of the sphenoid bone articulates with the basilar part of the occipital bone by means of the **spheno-occipital joint** *(synchondrosis sphenooccipitalis)*. Another two synchondroses are distinguished in the base of the skull. One is the **sphenopetrous joint** *(synchondrosis sphenopetrosa)* and the other the **petro-occipital joint** *(synchondrosis petrooccipitalis)* which on a macerated skull are represented, respectively, by the **sphenopetrosal fissure** *(fissura sphenopetrosa)* and the **petro-occipital fissure** *(fissura petrooccipitalis)* (Fig. 102).

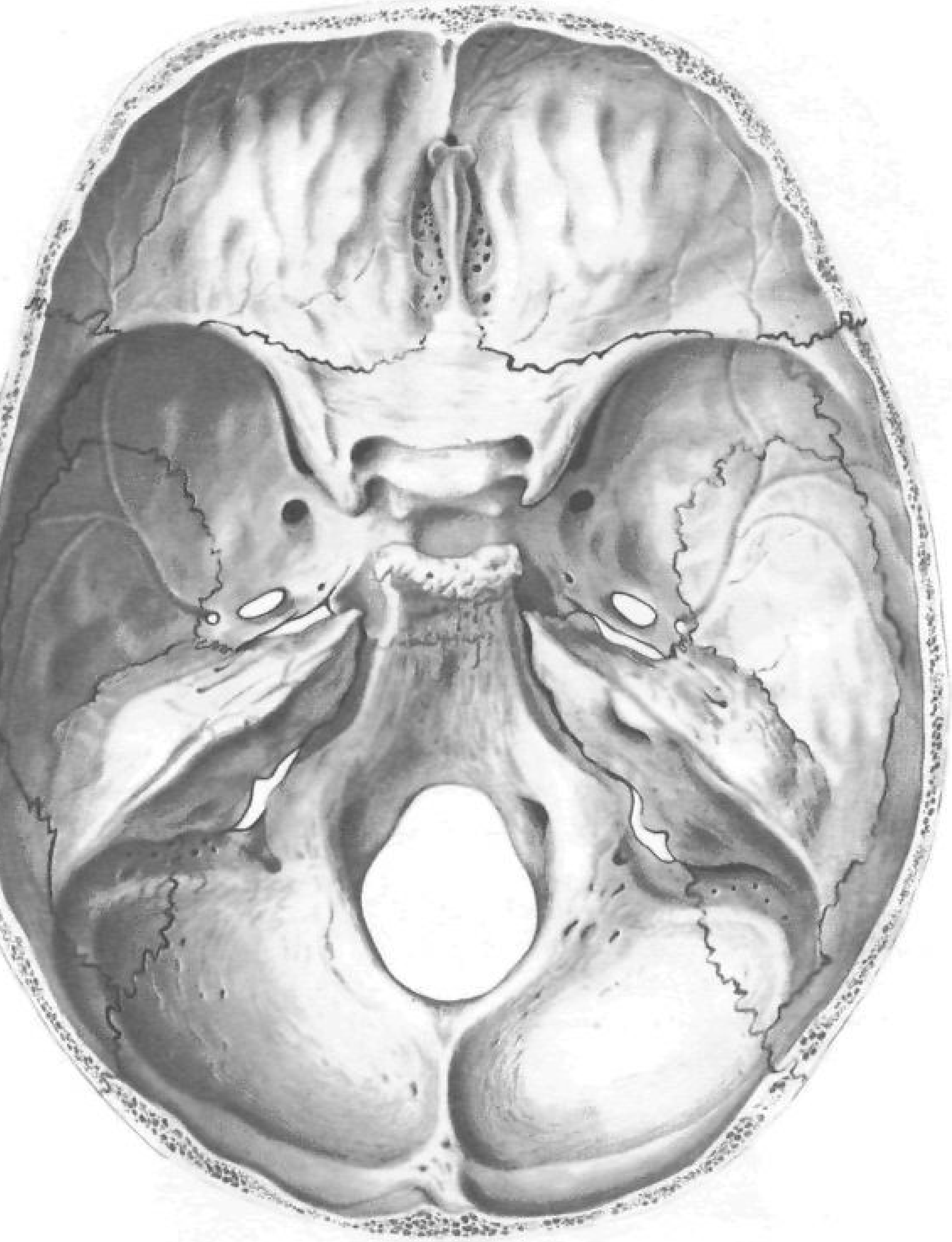
To the back, in the centre of the base of the skull is the **foramen magnum**, to the front of which on the basilar part of the occipital bone is the **pharyngeal tubercle** *(tuberculum pharyngeum)*. The foramen is embraced on both sides by the **occipital condyles** *(condyli occipitales)*. Posteriorly, almost on the midline, stretches the **external occipital crest** *(crista occipitalis externa)* and reaches the **external occipital protuberance** *(protuberantia occipitalis externa)*. The **inferior** and **superior nuchal lines** *(linea nuchae inferior et linea nuchae superior)* arise from the crest.



99. *Skull of a newborn*; from the right side ($^1\!/_1$).



100. *Skull of a newborn*; superior aspect ($^1\!/_1$).

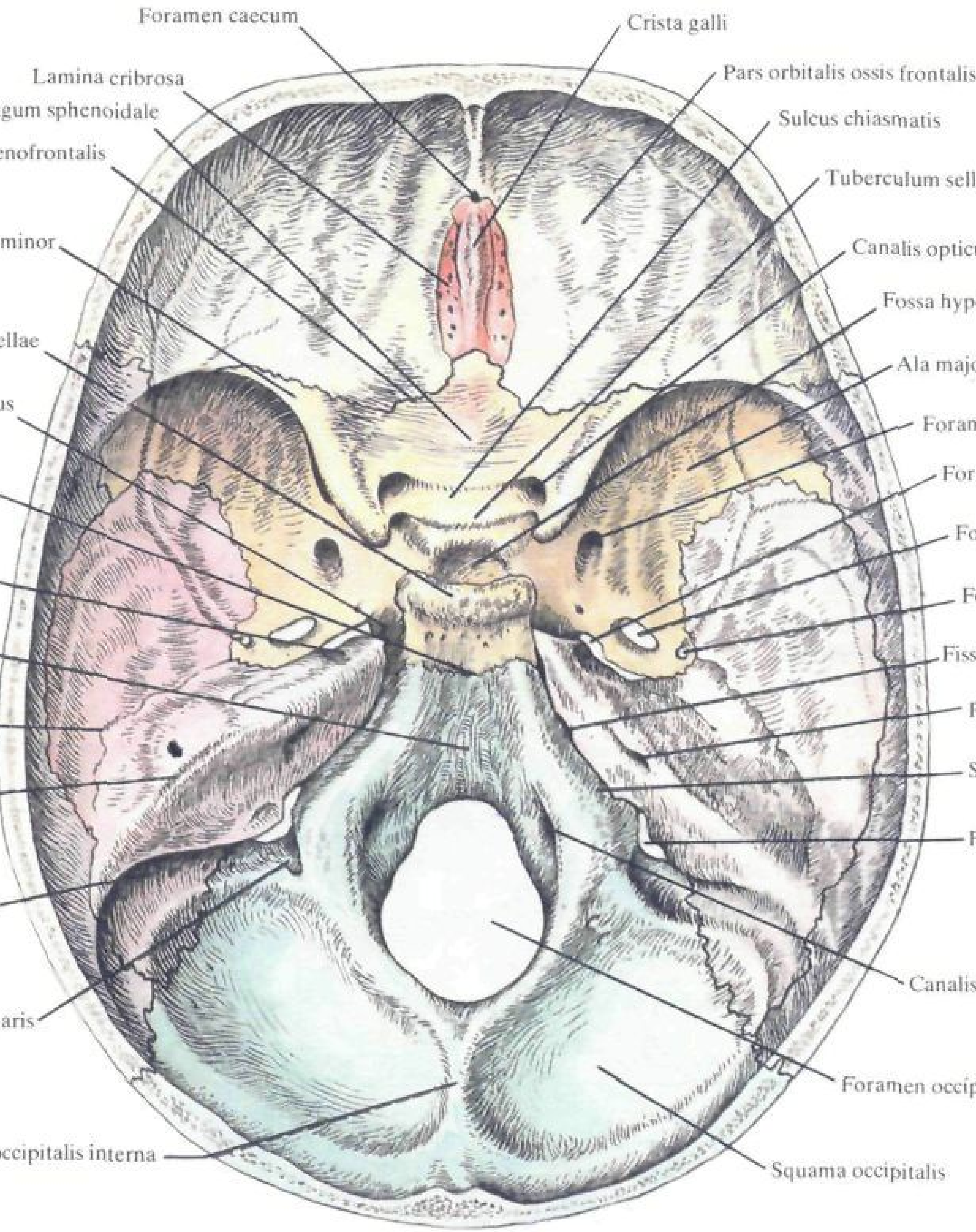


101. *Upper surface of base of skull (basis cranii interna)*; superior aspect (2/3).

The **internal,** or **upper surface of the base of the skull** *(basis cranii interna)* (Figs 101 and 102) is a concave irregular surface reflecting the pattern of the brain lodged on it. It has three depressions, called the anterior, middle, and posterior cranial fossae.

The **anterior cranial fossa** *(fossa cranii anterior)* is the most shallow. Its floor is formed by the **orbital plate** *(pars orbitalis)* of the frontal bone, the **lesser wings** *(alae minores)* of the sphenoid bone, and the **cribriform plate** *(lamina cribrosa)* of the ethmoid bone. Posteriorly it is bounded by the edge of the lesser wings and the tuberculum sellae. The region of the cribriform plate is the deepest part. The **crista galli** projects here. In front of the crista galli is the **foramen caecum** *(foramen cecum).*

The **middle cranial fossa** *(fossa cranii media)* is the deepest in the lateral parts; in its central part projects the **sella turcica** which bears the **hypophyseal fossa** *(fossa hypophysialis)* in the centre. The edge of the lesser wings of the sphenoid bone limits the middle cranial fossa anteriorly, while the **dorsum sellae** and the **superior border of the petrous part** *(margo superior partis petrosae)* limit it posteriorly. The floor of the middle fossa is formed by the **body** *(corpus)* and the **greater wings** *(alae majores)* of the sphenoid bone, the **anterior surfaces of the petrous part** *(facies anteriores partis petrosae)* and the **cerebral surface** *(facies cerebralis)* of the **squamous part** of the temporal bone. The **carotid grooves** *(sulci carotici)* are located on the floor of the fossae to both sides of the base of the sella turcica; each groove runs backwards, downwards, and laterally to the apex of the petrous part and leads into the **carotid canal** *(canalis caroticus).* The following structures open into the lateral parts of the middle cranial fossa: **optic foramen** *(canalis opticus),* **superior orbi-**



102. *Upper surface of base of skull (basis cranii interna);* superior aspect (semischematical representation).

tal fissure *(fissura orbitalis superior)*, **foramen lacerum, foramen rotundum, foramen ovale,** and **foramen spinosum.** The anterior surface of the petrous part bears the **trigeminal impression** *(impressio trigemina)*, **tegmen tympani, arcuate eminence** *(eminentia arcuata)*, and the grooves for the greater and lesser petrosal nerves.

The **posterior cranial fossa** *(fossa cranii posterior)* is limited anteriorly by the **dorsum sellae** and superior border of the petrous part; the posterior border of the fossa passes along the **groove for the transverse sinus** *(sulcus sinus transversus)* and the **internal occipital protuberance** *(protuberantia occipitalis interna)*. The posterior cranial fossa is the deepest and its floor is formed by almost the whole of the occipital bone (except for the upper part of the squama), by part of the body of the sphenoid bone (a small area to the back of the dorsum sellae), posterior surface of the petrous part, and the occipital angle of the parietal bone. In the centre of the fossa is the **foramen magnum** in front of which is the **clivus** formed by the body of the sphenoid bone and the basilar part of the occipital bone. The **anterior condylar canal** *(canalis hypoglossi)* opens at the lateral semicircumference of the foramen magnum. The **posterior condylar canal** *(canalis condylaris)* lying lateral of the anterior condylar canal and to the back of the **jugular foramen** *(foramen jugularis)* is found occasionally. The **internal occipital crest** *(crista occipitalis interna)* ascends on the midline from the posterior border of the foramen magnum to the internal occipital protuberance. A little above the crest, on both sides of the **eminentia cruciata** *(eminentia cruciformis)* arise **grooves for the transverse sinus** *(sulci sinus transversi)* and are continuous with the **sigmoid groove** *(sulcus sinus sigmoidei)* which terminates at the jugular foramen.

THE CAVITY OF THE NOSE

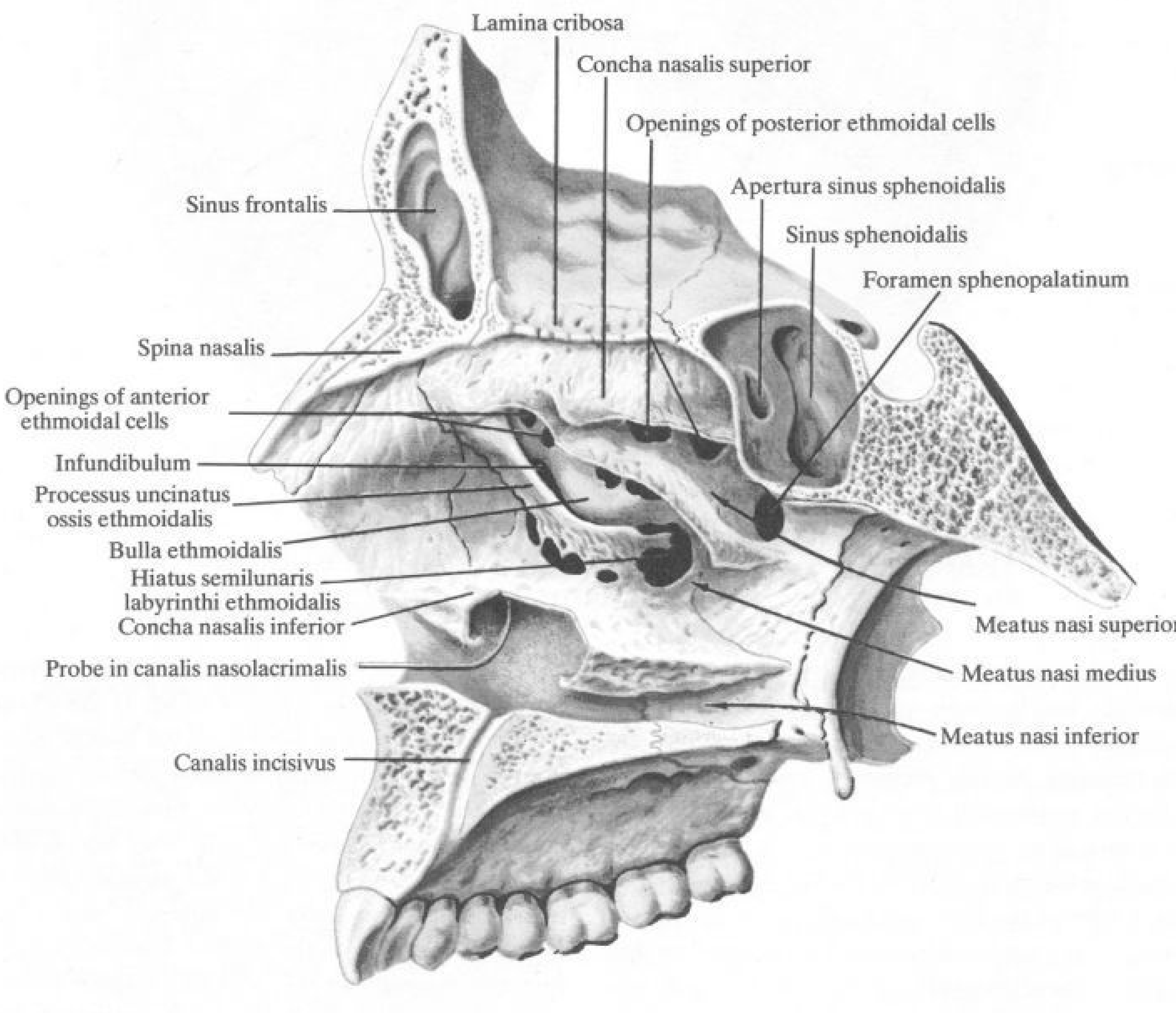
The **cavity of the nose** *(cavum nasi)* (see Figs 93, 94, 103–107) is located in the middle of the superior part of the visceral cranium. Its elements are the nasal cavity proper and the paranasal sinuses situated superiorly, laterally, and to the back of it. The **frontal sinuses** *(sinus frontales)* are above and in front of the cavity, the **ethmoidal cells** *(cellulae ethmoidales)*, or the **ethmoidal labyrinths** *(labyrinthi ethmoidales)* are situated on each side of the cavity, the **maxillary sinuses** *(sinus maxillares)* are slightly below, and the **sphenoidal sinuses** *(sinus sphenoidales)* are situated to the back and above.

The cavity of the nose is divided by the **osseous nasal septum** *(septum nasi osseum)* into the right and left halves. The paranasal sinuses and the cells of the ethmoidal labyrinth open into each half. The cavity of the nose is located in the sagittal plane and its anterior opening is called the **anterior** (or **piriform**) bony **aperture of the nose** *(apertura piriformis)*, the posterior openings are called the **posterior apertures of the nose** *(choanae)*.

The **piriform aperture** *(apertura piriformis)* (see Figs 48 and 49) is bounded above by the free borders of the nasal bones, laterally by the **nasal notches** *(incisurae nasales)* of the maxillae, and inferiorly by the **anterior nasal spine** *(spina nasalis anterior)*.

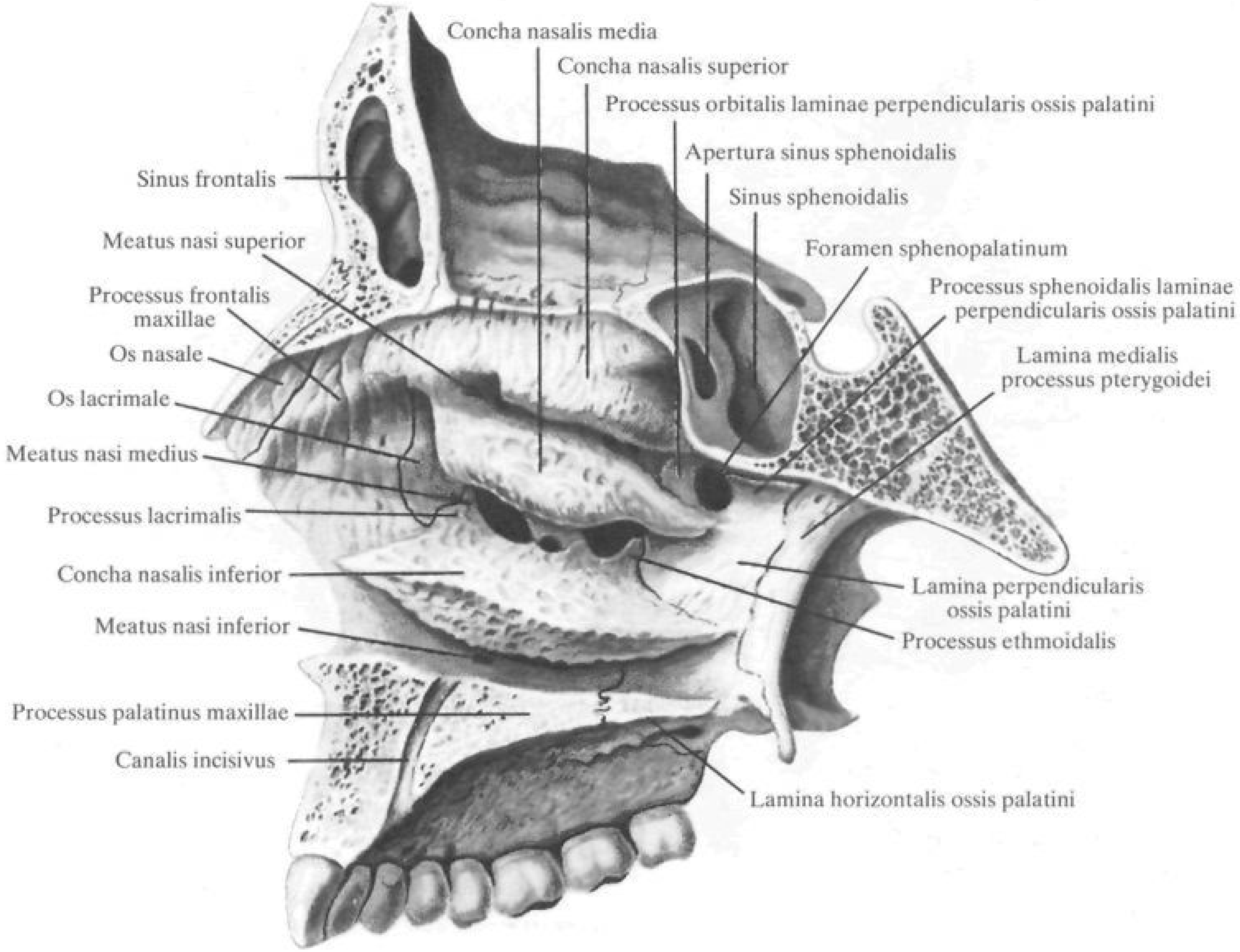
The **choanae** are openings almost oval in shape which are separated by the posterior border of the vomer. They are formed below by the posterior border of the horizontal plates of the palatine bones, on both sides by the medial plates of the pterygoid processes of the sphenoid bone, and above by the body of this bone, the wings of the vomer, and the vaginal processes of the pterygoid processes of the sphenoid bone.

The **osseous nasal septum** *(septum nasi osseum)* (see Figs 93 and 94) is situated in the cavity of the nose and is usually curved to the right or left side. It is formed by the perpendicular plate of the ethmoid bone above and by the vomer below and at the back; the inferior border of the vomer unites with the nasal crests of the maxillae and palatine bones.



103. *Right lateral wall of skeleton of the cavity of the nose (cavum nasi)* (1/1).

(Sagittal section made to the right of osseous nasal septum.)



104. *Right lateral wall of skeleton of the cavity of the nose* ($^1/_1$).

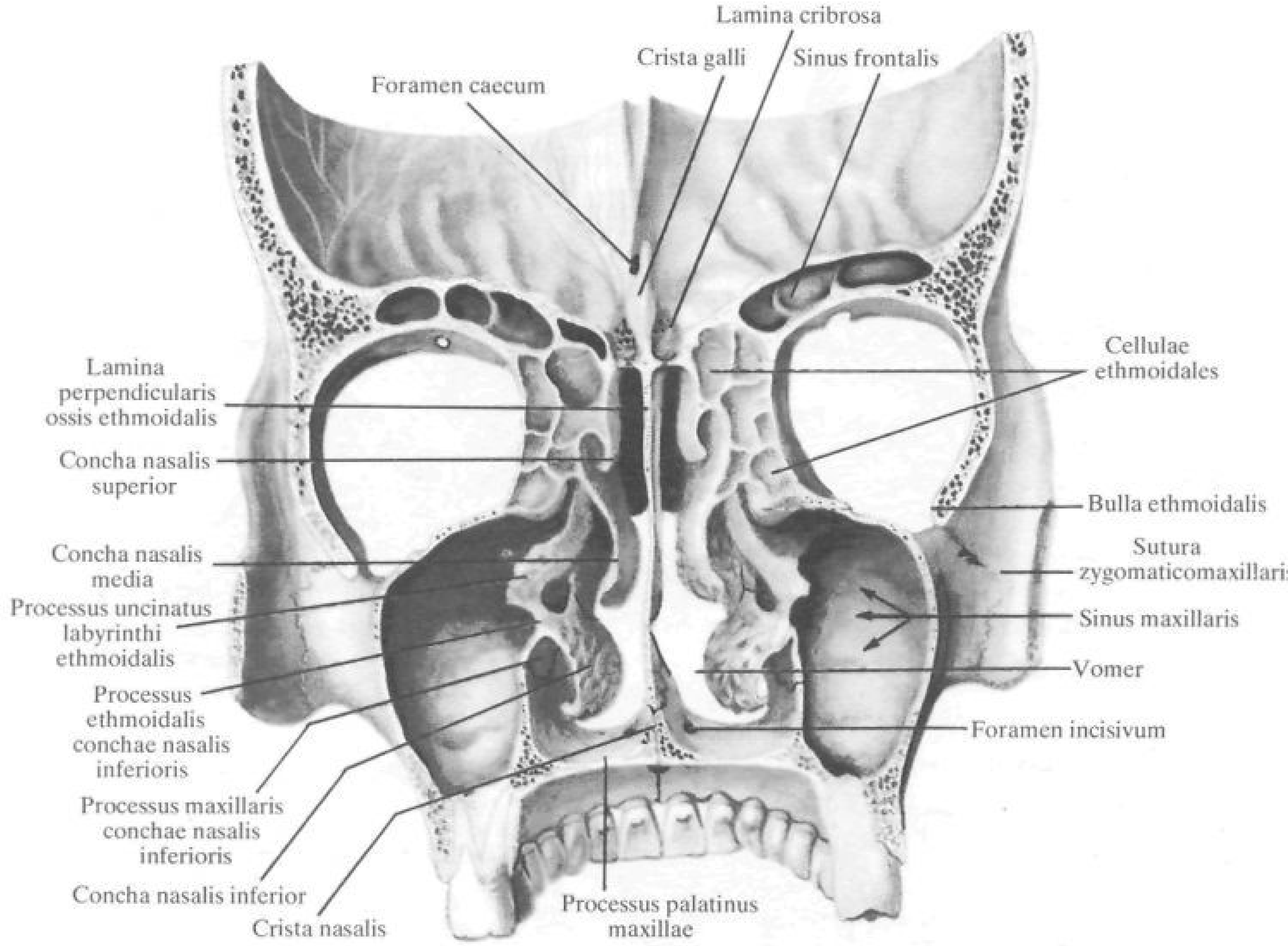
(Sagittal section made to the right of osseous nasal septum. The superior, middle, and inferior nasal conchae are partly removed.)

The inferior wall of the nasal cavity is formed by the **bony palate** *(palatum osseum)* (see Fig. 107).

The superior wall (or roof) of the cavity of the nose is formed by the inner surface of the bones of the nose, the nasal parts of the frontal bones, and the cribriform plate of the ethmoid bone through which the cavity communicates with the **anterior cranial fossa** *(fossa cranii anterior)*. The anterior surface of the body of the sphenoid bone forms the posterior part of the superior wall.

The lateral wall is formed by the surfaces of the frontal process and body of the maxilla facing the cavity of the nose, the lacrimal bone, by the labyrinth of the ethmoid bone with its uncinate process, the perpendicular plate of the palatine bone, and the medial plate of the pterygoid process of the sphenoid bone. Three nasal conchae extend from the lateral wall towards the nasal septum: the **superior nasal concha** *(concha nasalis superior)*, the **middle nasal concha** *(concha nasalis media)* and the **inferior nasal concha** *(concha nasalis inferior)*. Three longitudinal passages form between the conchae and the lateral wall of the nasal cavity (Figs 103 and 104). These are the superior meatus of the nose located under the superior concha, the middle meatus of the nose under the middle concha, and the inferior meatus of the nose under the inferior concha.

The **superior meatus of the nose** *(meatus nasi superior)* is shorter and narrower than the other two and occupies only the posterior parts of the nasal cavity. It is inclined slightly to the back and downwards and its posterior end reaches the **sphenopalatine foramen** *(foramen sphenopalatinum)*. The **posterior ethmoidal cells** *(cellulae ethmoidales posteriores)* open into the anterior part of the superior meatus. Above the superior nasal concha is the **sphenoethmoidal recess** *(recessus sphenoethmoidalis)* in the region of which the **sphenoidal sinus** *(sinus sphenoidalis)* opens.



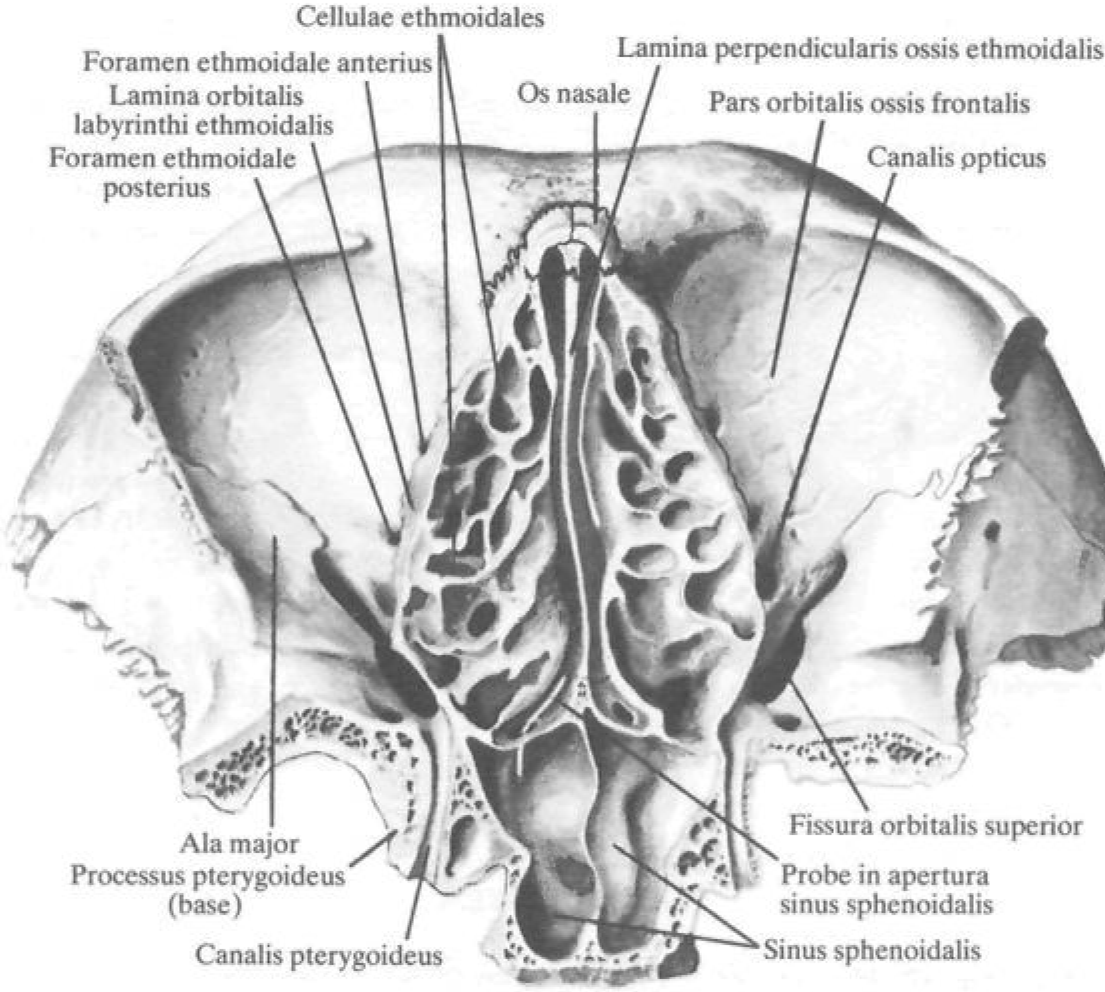
105. *Skeleton of the cavity of the nose and orbits;* posterior aspect ($\frac{2}{3}$).

(Frontal section through base of temporal processes of zygomatic bones.)

The **middle meatus of the nose** *(meatus nasi medius)* runs parallel to the superior meatus on the whole, but is much longer and wider. The **maxillary sinus** *(sinus maxillaris)* opens into it. On an intact skull the opening of the sinus is markedly narrowed by the neighbouring bones, namely, by the perpendicular plate of the palatine bone posteriorly, and by the maxillary and ethmoidal processes of the inferior nasal concha and the uncinate process of the ethmoid bone inferiorly.

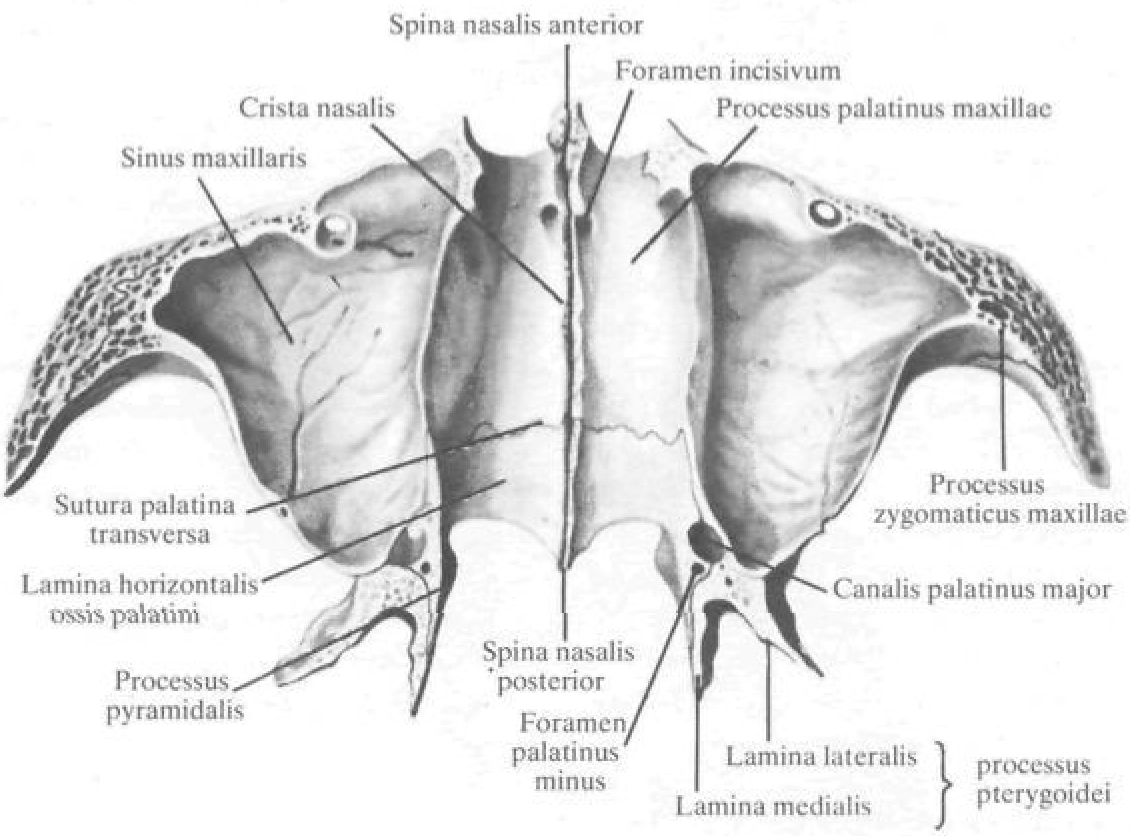
The **uncinate process** *(processus uncinatus)* descending slightly to the back divides the opening of the maxillary sinus into an antero-inferior part and a posterosuperior part. The posterosuperior part is located between the large **ethmoidal bulla** *(bulla ethmoidalis)* and the uncinate process. The opening into the maxillary cavity is seen on a non-macerated skull; it is called the **hiatus semilunaris**. The superior, wider, part of the hiatus is called the **infundibulum of the ethmoid** *(infundibulum ethmoidale)*. The middle nasal meatus communicates with the openings of the anterior ethmoidal cells by means of the hiatus and superiorly through the **aperture of the frontal sinus** *(apertura sinus frontalis)*, with the **frontal sinus** *(sinus frontalis)*.

The **inferior meatus of the nose** *(meatus nasi inferior)* is the longest and widest. Near its anterior end is the inferior opening of the **nasolacrimal canal** *(canalis nasolacrimalis)* (Fig. 104). The inferior nasal concha is the superior wall of the inferior meatus, while the inferior wall is formed by the palatine process of the maxilla and the horizontal plate of the palatine bone. The space on both sides of the nasal septum, between it and the conchae, is a narrow slit called the common meatus of the nose. To the back of the conchae it is continuous with a very short **posterior naris** *(meatus nasopharyngeus)* opening by means of the choanae into the **pharynx**.



106. *Skeleton of the cavity of the nose and orbits*; inferior aspect ($^4/_5$).

(Horizontal section through median parts of orbital openings.)



107. *Skeleton of the cavity of the nose*; superior aspect ($^1/_1$).

(Inferior wall of nasal cavity. Horizontal section through zygomatic processes of maxillae.)

THE BONY PALATE

The **bony palate** *(palatum osseum)* (Fig. 108) is the floor of the **cavity of the nose** *(cavum nasi)* and the roof of the **cavity of the mouth** *(cavum oris).*

The anterior two thirds of the skeleton of the bony palate are formed by the palatine processes of the maxilla, the posterior part by the horizontal plates of the palatine bones and their pyramidal processes.

Anteriorly and laterally the bony palate is bounded by the alveolar processes of the maxilla. The **median palatine suture** *(sutura palatina mediana)* stretches from front to back (sagittally) on the midline of the palate. It forms from the union of both palatine processes of the maxilla and of both horizontal plates of the palatine bone. The posterior parts of this suture are crossed frontally by the **transverse palatine suture** *(sutura palatina transversa)* formed from union of the palatine processes of the maxilla with the horizontal plates of the palatine bones. On the anterior end of the median palatine suture to the back of the incisor alveoli are the **incisive foramina** *(foramina incisiva)* transmitting nerves and vessels and leading into the **incisive canals** *(canales incisivi).* Each incisive canal has two openings on the superior (nasal) surface of the hard palate which are located to both sides of the **nasal crest** *(crista nasalis).* To each side of the incisive foramen the skull of a child, and sometimes that of an adult, carries a poorly defined **incisive suture** *(sutura incisiva)* (Fig. 108) which forms from articulation of the inconstantly found **incisive bone** *(os incisivum)* with the palatine process of the maxilla. In the posterolateral parts of the bony palate, on each side, is a **greater palatine foramen** *(foramen palatinum majus)* to the back of which lies one or two **lesser palatine foramina** *(foramina palatina minora).* Two **palatine grooves** *(sulci palatini)* are located on each side of the bone palate in front of the greater palatine foramen; these are markings of vessels and nerves.

THE ORBIT

The **eye socket**, or **orbit** *(orbita)* (Figs 48, 49, and 109) is a cavity whose four sides form an irregular pyramid. It lodges the eyeball with its muscles, vessels and nerves, as well as the lacrimal gland and fatty tissue. It opens in front by a large **orbital opening** *(aditus orbitae)* which forms the base of the pyramid as it were. The orbital cavity becomes slightly wider immediately at the aditus, but gradually narrows to the back. The longitudinal axes of both orbits, drawn from the middle of the aditus to the middle of the optic canal, meet in the region of the sella turcica. The orbit borders upon the lateral wall of the nasal cavity medially, the corresponding part of the anterior cranial fossa superiorly, the temporal fossa laterally, and the superior wall of the maxillary sinus inferiorly.

The orbital opening has a quadrangular contour with rounded angles. The superior border is bounded by the **supraorbital margin** *(margo supraorbitalis)* and zygomatic process of the frontal bone. On the medial side the aditus is limited by the nasal part of the frontal bone and the frontal process of the maxilla. The inferior border is formed by the **infraorbital margin** *(margo infraorbitalis)* of the maxilla and the adjoining part of the zygomatic bone.

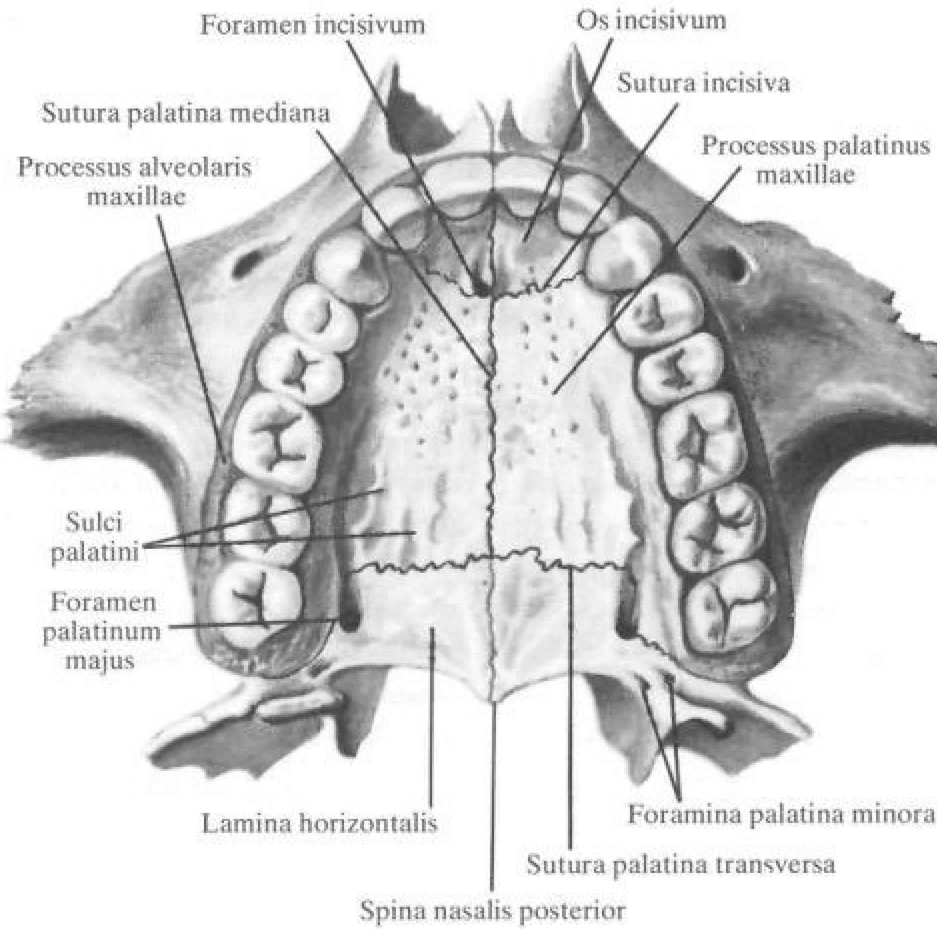
The lateral border of the aditus is formed by the zygomatic bone. All the orbital walls are smooth. The **superior wall**, or **roof** *(paries superior orbitae)* is formed by the orbital part of the frontal bone and, at the back, by the lesser wings of the sphenoid bone. Between these two bones stretches the **sphenofrontal suture** *(sutura sphenofrontalis).* The **optic canal** *(canalis opticus)* transmitting the optic nerve and ophthalmic artery is located at the root of each lesser wing. At the anterior border of the superior wall, closer to the lateral angle, is the **fossa for the lacrimal gland** *(fossa glandulae lacrimalis)* and in front of and medially to the border are the **trochlear fossa** *(fovea trochlearis)* and the **trochlear spine** *(spina trochlearis).*

The **lateral wall of the orbit** *(paries lateralis orbitae)* is formed posteriorly by the orbital surface of the greater wing of the sphenoid bone and anteriorly by the orbital surface of the zygomatic bone. The **sphenozygomatic suture** *(sutura sphenozygomatica)* passes between these bones. The roof is separated from the lateral wall by the **superior orbital fissure** *(fissura orbitalis superior)* which is between the greater and lesser wings of the sphenoid bone. The orbital surface of the zygomatic bone carries the **zygomatico-orbital foramen** *(foramen zygomaticoorbitale).*

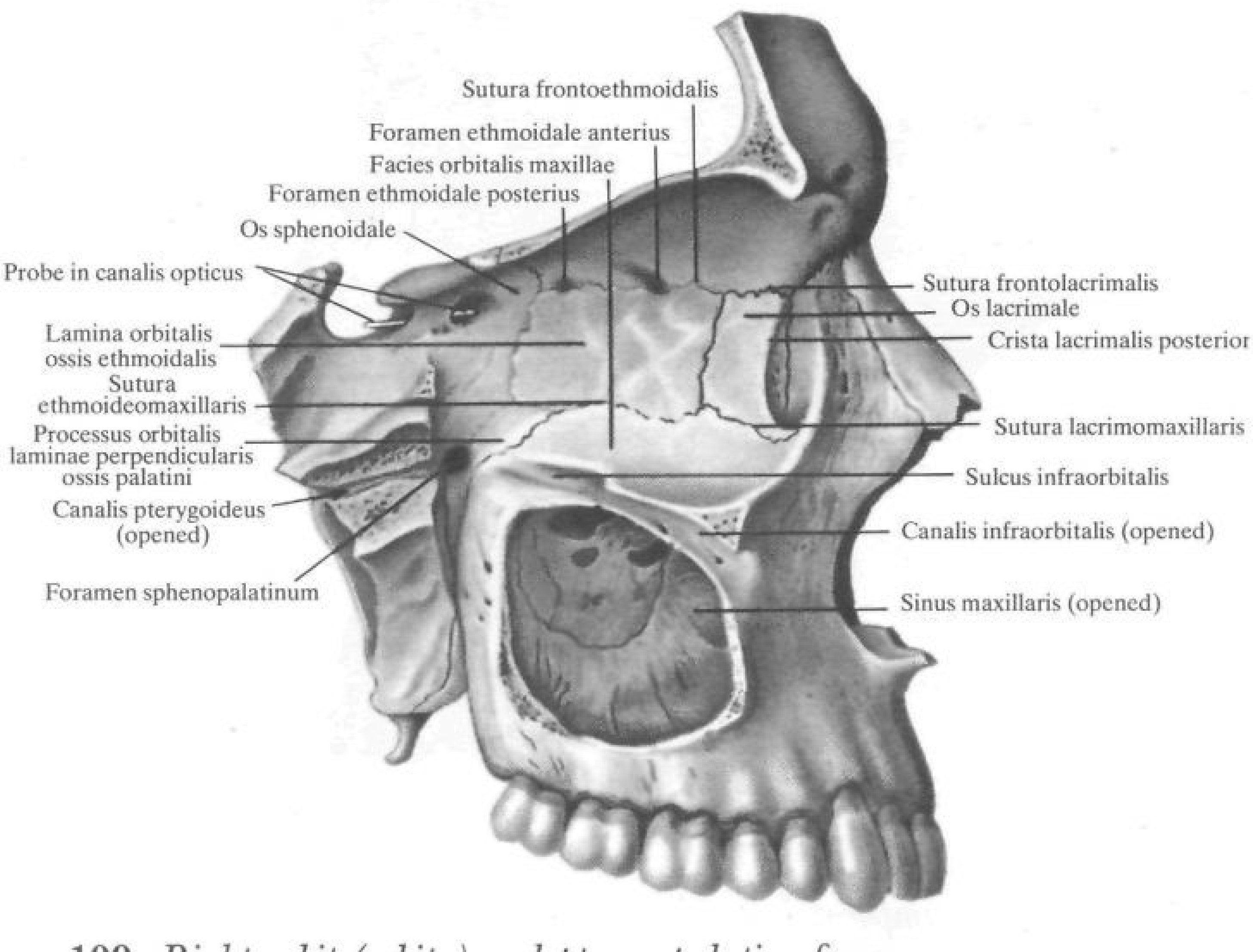
The **inferior wall**, or **floor of the orbit** *(paries inferior orbitae)* is formed for the most part by the orbital surface of the maxilla. The lateral part of the orbital surface of the zygomatic bone and, posteriorly, the orbital process of the palatine bone also contribute to the formation of the floor of the orbit. Between the inferior border of the orbital surface of the greater wing and the posterior border of the orbital surface of the maxilla is the **inferior orbital fissure** *(fissura orbitalis inferior)* whose anterior end reaches the zygomatic bone. Through this fissure the orbital cavity communicates with the pterygopalatine and infratemporal fossae. The **infraorbital groove** *(sulcus infraorbitalis)* arises on the lateral border of the inferior surface of the maxilla and is continuous with the **infraorbital canal** *(canalis infraorbitalis)* passing deep in the anterior parts of the inferior orbital wall.

The **medial wall of the orbit** *(paries medialis orbitae)* (Fig. 109) is formed (from front to back) by the lacrimal bone, the orbital plate of the ethmoid bone, and lateral surface of the body of the sphenoid bone. In the anterior part of the wall is the **lacrimal groove** *(sulcus lacrimalis)* which is continuous with the **fossa of the lacrimal sac** *(fossa sacci lacrimalis)*, which in turn is continuous downwards with the **nasolacrimal canal** *(canalis nasolacrimalis).*

The superior border of the medial wall of the orbit bears two openings: the **anterior ethmoidal foramen** *(foramen ethmoidale ante-*



108. *Bony palate (palatum osseum)*; inferior aspect (5/6).



109. *Right orbit (orbita) and pterygopalatine fossa (fossa pterygopalatina)* (5/6).

(Medial wall of right orbit. The lateral wall of maxillary sinus is removed by vertical section.)

rius) which opens at the anterior end of the frontoethmoidal suture, and the **posterior ethmoidal foramen** *(foramen ethmoidale posterior)* found close to the posterior end of this suture. The **optic canal** *(canalis opticus)* is in the posterior angle of the medial wall; the cavity of the orbit communicates with the cavity of the skull by means of it.

The walls of the orbit are covered by a fine **periosteum** which is called the **periorbit** *(periorbita)*.

THE TEMPORAL FOSSA

The **temporal fossa** *(fossa temporalis)* (see Figs 50, 51, and 110) is situated on each side on the outer lateral surface of the skull. Superiorly and posteriorly it is separated from the other areas of the calvaria by the **superior temporal line** *(linea temporalis superior)* of the parietal and frontal bones, which is in essence a conventional boundary line. The medial wall of the temporal fossa is formed by the inferior part of the external surface of the parietal bone in the region of the sphenoidal angle, the temporal surface of the squamous part of the temporal bone, and the external surface of the greater wing of the sphenoid bone. The anterior wall is formed by the zygomatic bone and part of the frontal bone posterior to the superior temporal line. Laterally the fossa is bounded by the zygomatic arch.

The inferior margin of the temporal fossa is bounded by the **infratemporal crest** *(crista infratemporalis)* of the sphenoid bone.

The **zygomaticotemporal foramen** *(foramen zygomaticotemporale)* opens on the anterior wall of the temporal fossa. The fossa is occupied by the temporal muscle, fascia, fat, vessels, and nerves.

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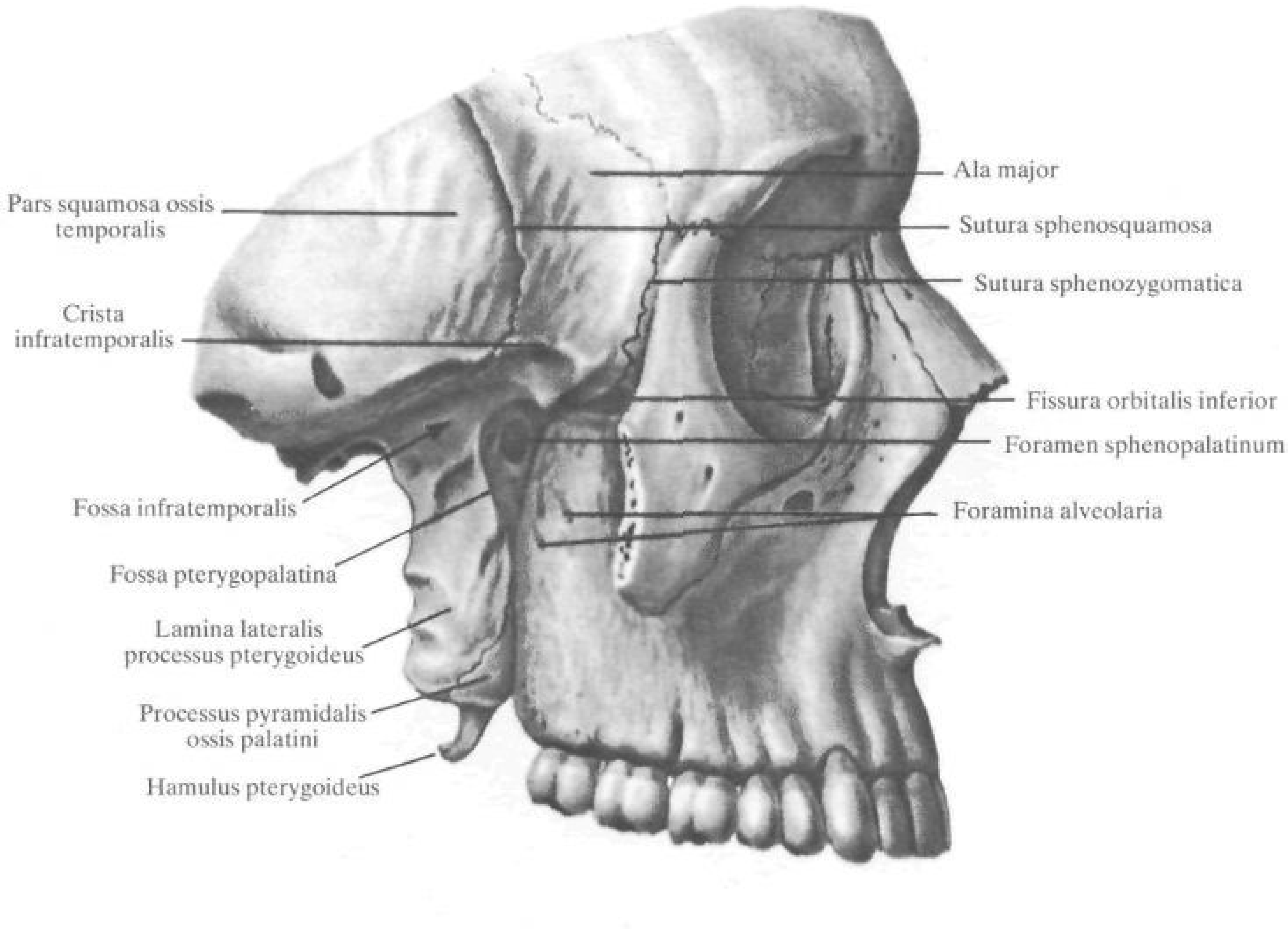


110. *Right temporal fossa (fossa temporalis), infratemporal fossa (fossa infratemporalis), and pterygopalatine fossa (fossa pterygopalatina)* ($^3/_4$).

(The zygomatic arch is removed.)

THE INFRATEMPORAL FOSSA

The **infratemporal fossa** *(fossa infratemporalis)* (Fig. 110) is shorter and narrower than the temporal fossa but its transverse dimension is larger. Its superior wall is formed by part of the greater wing of the sphenoid bone medial to the infratemporal crest.

The anterior wall is formed by the posterior part of the maxillary tuberosity. The lateral plate of the pterygoid process of the sphenoid bone is the medial wall of the infratemporal fossa. Externally and downwards the fossa has no bony wall. Laterally it is limited by the ramus of the mandible. At the junction of the anterior and medial walls the infratemporal fossa becomes deeper and is continuous with a funnel-like slit known as the **pterygopalatine fossa** *(fossa pterygopalatina).*

Anteriorly the infratemporal fossa communicates with the cavity of the orbit through the inferior orbital fissure. The fossa contains the lower portion of the temporal muscle, the lateral pterygoid muscle, some vessels and nerves.

THE PTERYGOPALATINE FOSSA

The **pterygopalatine fossa** *(fossa pterygopalatina)* (see Figs 109 and 110) is formed by parts of the maxilla, the sphenoid and palatine bones. It is connected with the infratemporal fossa through the **pterygomaxillary fissure** *(fissura pterygomaxillaris)* which is wide upwards and narrow downwards. The pterygopalatine fossa is bounded anteriorly by the infratemporal surface of the maxilla (or, to be more precise, the maxillary tuberosity), posteriorly by the pterygoid process of the sphenoid bone, medially by the lateral surface of the perpendicular plate of the palatine bone, and superiorly by the maxillary surface of the greater wing of the sphenoid bone.

In its upper part the pterygopalatine fossa communicates in front with the orbit through the **inferior orbital fissure** *(fissura orbitalis inferior)*, medially with the cavity of the nose through the **sphenopalatine foramen** *(foramen sphenopalatinum)*, to the back with the cranial cavity through the **foramen rotundum** and with the lower surface of the base of the skull through the **pterygoid canal** *(canalis pterygoideus).* The pterygopalatine fossa is continuous laterally with the infratemporal fossa.

On a non-macerated skull the **sphenopalatine foramen** *(foramen sphenopalatinum)* is closed by the mucous membrane of the nasal cavity; it transmits nerves and arteries into the cavity of the nose.

In the lower part, the pterygopalatine fossa is continuous with a narrow canal the superior part of which is formed by the maxilla, the sphenoid and palatine bones, and the inferior part by only the maxilla and the palatine bone. The canal is called the **greater palatine canal** *(canalis palatinus major)* and opens on the hard palate by means of the **greater palatine foramen** and **lesser palatine foramen** *(foramen palatinum majus* et *foramina palatina minora)*; it transmits nerves and vessels.

DEVELOPMENT AND AGE FEATURES OF THE BONES OF THE HEAD

Two parts are distinguished in the skull, the cerebral and the facial, or visceral (extracerebral). The cerebral part consists of the skull cap (calvaria) and base which are formed by several bones. The bones of the calvaria develop in connective tissue and pass through two stages, the membranous and osseous (primary bones), by-passing the cartilaginous stage. The bones of the base also develop in connective tissue but go through three stages, the membranous, cartilaginous (secondary bones), and osseous. The development of the bones of the visceral skull is associated with the development of the branchial arches (first and second) which are the foundation of the facial part of the head. Some of the bones pass through three and the others through two (connective-tissue and osseous) developmental stages (see Figs 3, 99, 100, and 110a).

The occipital bone (except for the upper portion of the squamous part) is a secondary bone and has four enchondral ossification centres (points) which are all concentrated around the foramen magnum (one on each side, one in front and the other at the back). The upper portion of the squamous part is a primary bone and has two ossification points (one on each side of the median plane). Complete fusion of all parts occurs on the 4-6th year of life.

The parietal bone is a primary bone. Its points of ossification appear in the region of the future parietal eminence in the end of the 10th intrauterine week. The bone tissue grows radially in relation to the eminence. The superior and inferior temporal lines start forming by the age of 12-15 years.

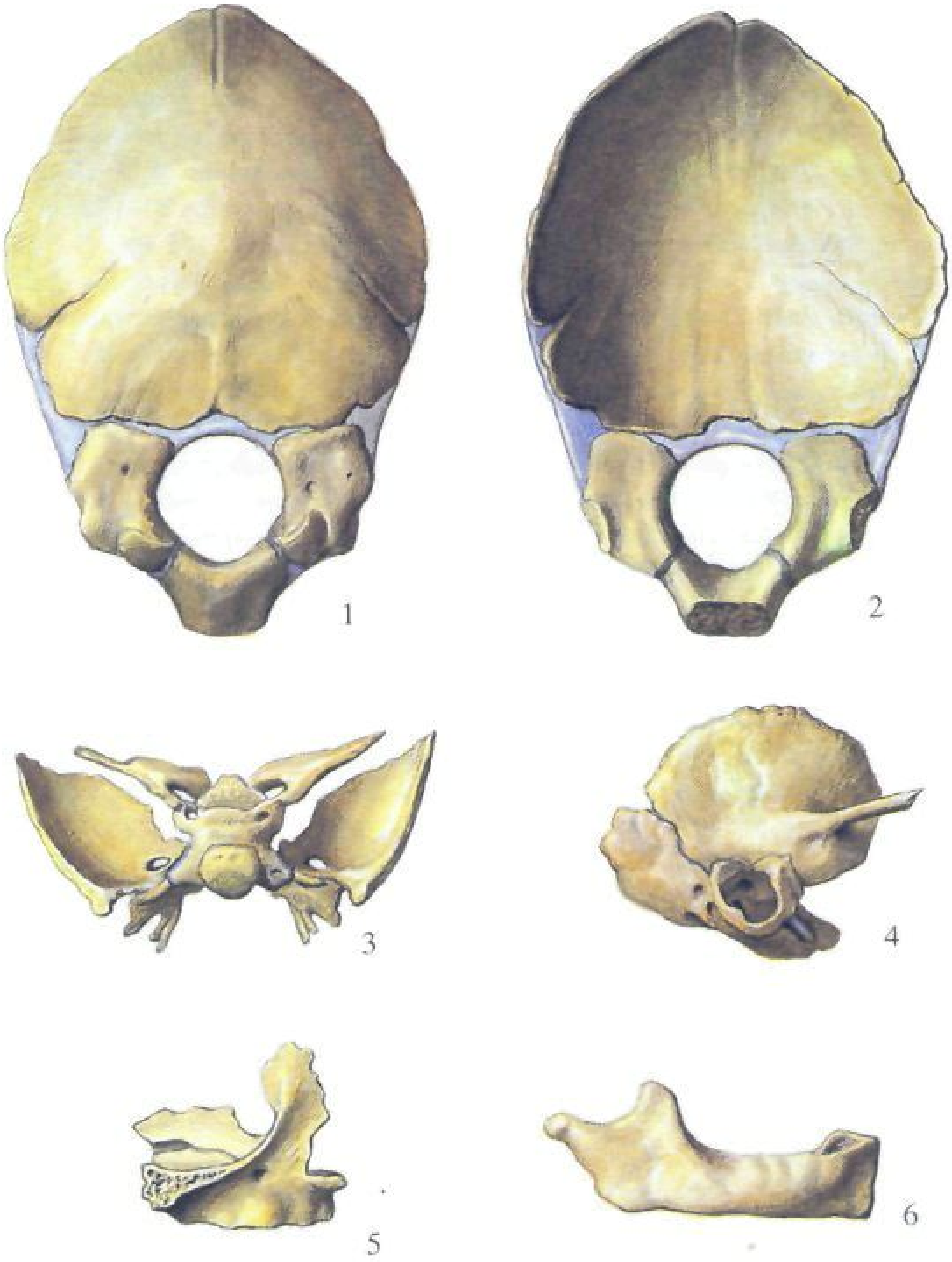
The frontal bone is a primary bone and develops from two points of ossification; each point appears in the region of the future supraorbital margin in the end of the 9th week of the intrauterine period. The frontal bone of the newborn consists of two halves whose fusion on the midplane begins in the 6th month after birth and is completed by the end of the 3rd year to form the frontal (metopic) suture which disappears by the age of 8 years. The frontal sinuses begin appearing in the first year of life.

The sphenoid is a secondary bone (except for the medial plate of the pterygoid process and the superolateral areas of the greater wings). It develops from enchondral nuclei which appear symmetrically in the following order: in the region of the lesser wings, in the region of the greater wings, and in the body of the bone below the hypophyseal fossa in the 3rd month of the intrauterine period; in the region of the carotid groove and the lingula in the beginning of the 4th intrauterine month; in the region of the anterior part of the body in the end of the 4th intrauterine month; two pairs of endesmal nuclei give rise to the bone in the region of the medial plates of the pterygoid processes in the 3rd month and in the region of the superolateral areas of the greater wings in the end of the 3rd intrauterine month. The sphenoid bone ossifies completely in the 10th year of life. The sinuses begin developing at the age of 3 years.

The temporal bone develops from the following points of ossification: endesmal centres of the squama appear in the beginning of the 3rd month, those of the tympanic cavity at the end of the 3rd month of the intrauterine period; enchondral points appear in the 5th month of the intrauterine period for the petrous part and at the end of the first year of life for the styloid process. The tympanic part as such is absent in the newborn and is represented by a ring whose ossification begins in the 3rd month of the intrauterine period (see Fig. 99). As to the mastoid air cells, these are formed completely by the age of 5-6 years. Complete ossification of the temporal bone occurs by the age of 6 years.

The ethmoid is a secondary bone, it develops in cartilage and its ossification begins in several points. The points of ossification appear earliest for the middle nasal concha (4th month of the intrauterine development) and the superior nasal concha (5th intrauterine month). Two nuclei appear in the 9th month for the cribriform plate. The ossification nucleus of the orbital plate forms in the 6th month after birth and the plate ossifies rapidly. At the age of 2 years an ossification nucleus appears on each side for the future crista galli which forms from their fusion later. The perpendicular plate ossifies at the age of 6-8 years, and the ethmoid cells of the labyrinth are completely formed by the age of 12-14 years.

The inferior nasal concha is a secondary bone; it has a single



110a. *Bones of skull (ossa cranii)* of a newborn.

1—occipital bone (os occipitale), external surface
2—occipital bone (os occipitale), internal surface
3—sphenoid bone (os sphenoidale)
4—temporal bone (os temporale)
5—maxilla
6—mandible (mandibula)

ossification nucleus which appears at the beginning of the 3rd month of the intrauterine period.

The lacrimal bone is a primary bone. It develops from a single point of ossification appearing on the 3rd intrauterine month.

The vomer is a primary bone developing from two endosteal centres of ossification appearing in the 2nd month of the intrauterine period. Each centre is situated parallel to the median plane. The right and left plates fuse later, while the cartilage of the nasal septum located between them resorbs after birth.

The maxilla is a primary bone developing from five endesmal centres of ossification, namely superolateral, inferolateral, anteromedian, posteromedian, and middle centre. The superolateral centre forms the medial part of the orbital floor. The inferolateral centre gives rise to the lateral part of the orbital floor, the zygomatic process, anterolateral part of the body, and the posterolateral wall of the alveolar process. The middle nucleus develops into the frontal process and part of the body below it. The posterior two thirds of the palatine process and the internal wall of the alveolar process corresponding to the canine tooth and molars arise from the posteromedian nucleus. The anteromedian ossification point gives origin to the incisal part of the bone, i.e. part of the alveolar process corresponding to the incisors, and the anterior third of the palatine process. In the 5th month the nuclei fuse but the incisive suture uniting the incisive bone with the other part of the maxilla persists in the newborn. The maxillary sinuses appear in the 6th month of the intrauterine period and develop fully by the age of 12-14 years.

The palatine bone is a primary bone. It develops from a single point of ossification which appears in the 2nd month of the intrauterine life at the junction of the perpendicular and horizontal plates.

The zygomatic bone is a primary bone. It forms from a single point of ossification appearing at the end of the 2nd month of the intrauterine period.

The mandible develops as a paired bone and, according to its development, is a mixed bone; its condylar and coronoid processes which pass through the stage of cartilage are secondary bones, whereas the other part undergoes the stage of membranous ossification and is a primary bone. Each half of the mandible grooves the cartilage of the first branchial arch; the cartilage resorbs by the 5th month of the intrauterine period and its distal segment forms the mental ossicle while the proximal end gives rise to the auditory ossicles. The osseous union of both halves begins in the 3rd month after birth and is completed at the age of 2 years.

The hyoid bone is a secondary bone. It develops from five points, one point giving rise to the body, one on each side for the greater horns, and another on either side for the lesser horns. In the body and greater horns the points of ossification appear at the end of the intrauterine period or soon after birth; the lesser horns are ossified by the age of 13-15 years. The greater horns fuse with the body quite late, by 30-40 years of age and sometimes later; the lesser horns fuse in old age.

The age distinctions of the skull as a whole, of its topographic areas and of the separate bones are expressed firstly by the different ratio of the cerebral to the visceral part. These differences, as well as the thickness of the bones, the size of the fossae and cavities of the skull, the presence of the fontanelles, the cranial synostoses, etc. are determined by the growth and development of the skull during five periods. The first period, from birth to the age of 7 years, is characterized by active growth of the skull, particularly in size; the sutures become slightly narrower, the fontanelles gradually reduce in size, the cavities of the nose and orbits grow and acquire the proper shape; the relief of the mandible changes noticeably. In the second period, lasting to the age of 14 years, the size and shape of the skull and its parts change less actively than in the first period, but the fossae, mastoid process and the cavities of the orbits and nose grow noticeably larger. The third period lasts from puberty to the age of 25 years. The frontal parts (forehead) are shaped in this period, the visceral skull becomes longer, the region of the zygomatic arches grows markedly, and the eminences become more prominent. The fourth period, lasting to the age of 45 years, is firstly characterized by the ossification of sutures, which had started at the age of 20-30 years, being completed at its end. It has been noted that premature ossification of the sagittal suture leads to the formation of a short skull, premature ossification of the coronal suture results in the formation of a long skull. The fifth period lasts from the age of 45 to old age and is characterized by atrophy first of the visceral and then of the cerebral skull and gradual loss of teeth, which has an effect on the shape of the jaws. Later, the alveolar processes are smoothed out and the whole skull becomes smaller.

THE BONES OF THE UPPER LIMB

Ossa membri superioris

The **skeleton of the upper limb** *(skeleton membri superioris)* is divided into the **bones of the girdle of the superior extremity,** or **shoulder girdle** *(ossa cinguli membri superioris)* which includes the **collar bone** or **clavicle** *(clavicula)* and the **scapula** or **shoulder blade,** and the **bones forming the skeleton of the free upper extremity** *(skeleton membri superioris liberi)*; these include the **humerus, bones of the forearm** *(ossa antebrachii),* and **bones of the hand** *(ossa manus).*

THE BONES OF THE SHOULDER GIRDLE

THE SCAPULA

The **shoulder blade** *(scapula)* (Figs 111-114 and 119) is a flat bone. It is located between the muscles of the back over the second to seventh ribs. It is triangular, in accordance with which three borders (upper, medial, and lateral) and three angles (superior, inferior, and lateral) are distinguished in it.

The **upper border of the scapula** *(margo superior scapulae)* is thin and bears in its lateral part the **suprascapular notch** *(incisura scapulae)*; on a non-macerated bone the notch is bridged by the **superior transverse ligament of the scapula** or the **suprascapular ligament** *(ligamentum transversum scapulae superius)* as a result of which an opening transmitting the suprascapular nerve is formed.

The lateral parts of the upper border of the scapula are continuous with the **coracoid process** *(processus coracoideus)* which first projects upwards but then curves at an angle and extends forwards and slightly laterally.

The **medial border** *(margo medialis scapulae)* is longer and thinner than the upper border. It faces the vertebral column and is easily palpated through the skin.

The **lateral border** *(margo lateralis scapulae)* is thick and faces the axillary region.

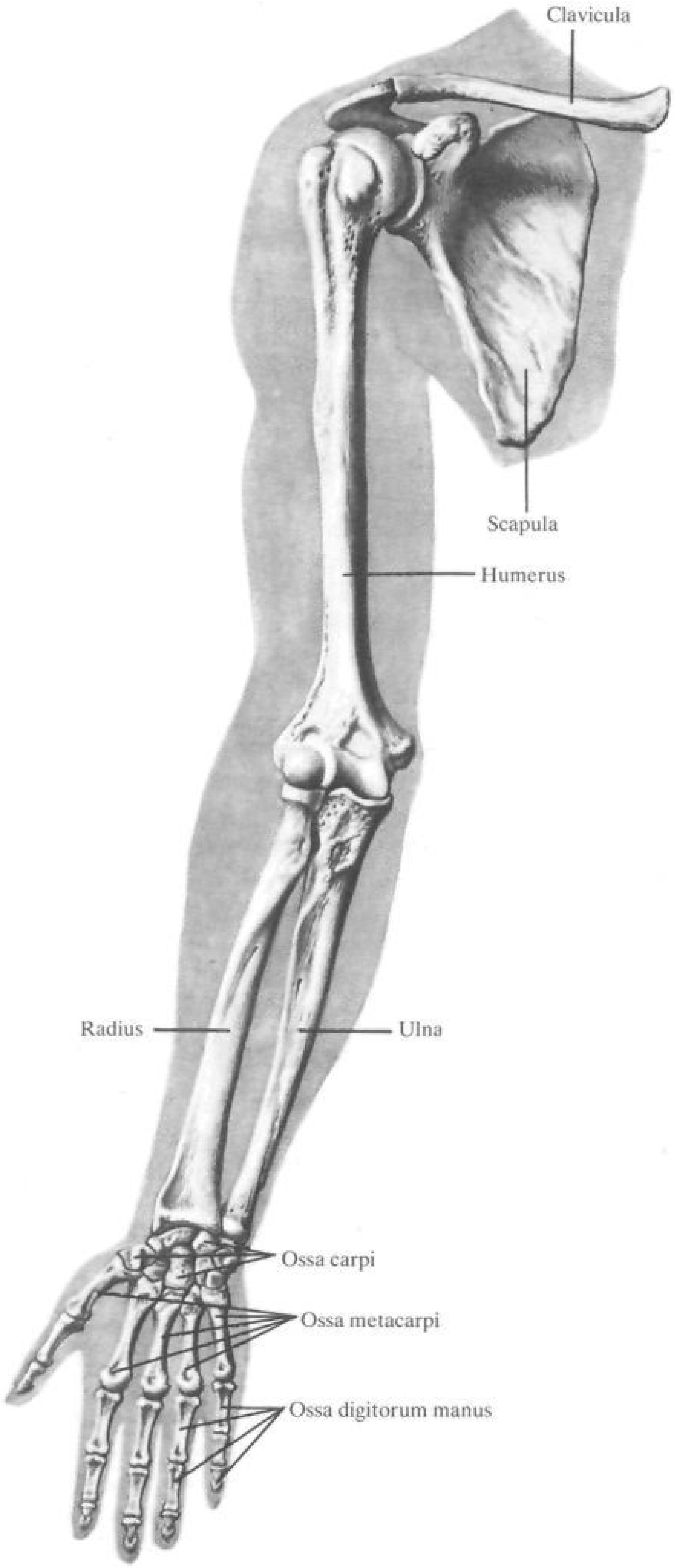
The **superior angle** *(angulus superior)* is rounded and faces upwards and medially.

The **inferior angle** *(angulus inferior)* is rough, thick, and faces downwards.

The **lateral angle** *(angulus lateralis)* is thickened. Its lateral surface bears a thickened shallow articular **glenoid cavity** *(cavitas glenoidalis)* for articulation with the articular surface of the head of the humerus.

The lateral angle is separated from the rest of the scapula by a small narrowed part called the **neck of the scapula** *(collum scapulae).*

In the region of the neck, above the superior margin of the glenoid cavity is the **supraglenoid tubercle** *(tuberculum supraglenoidale),*



111. *Bones of right upper limb (ossa membri superioris)*; anterior aspect ($^1/_4$).

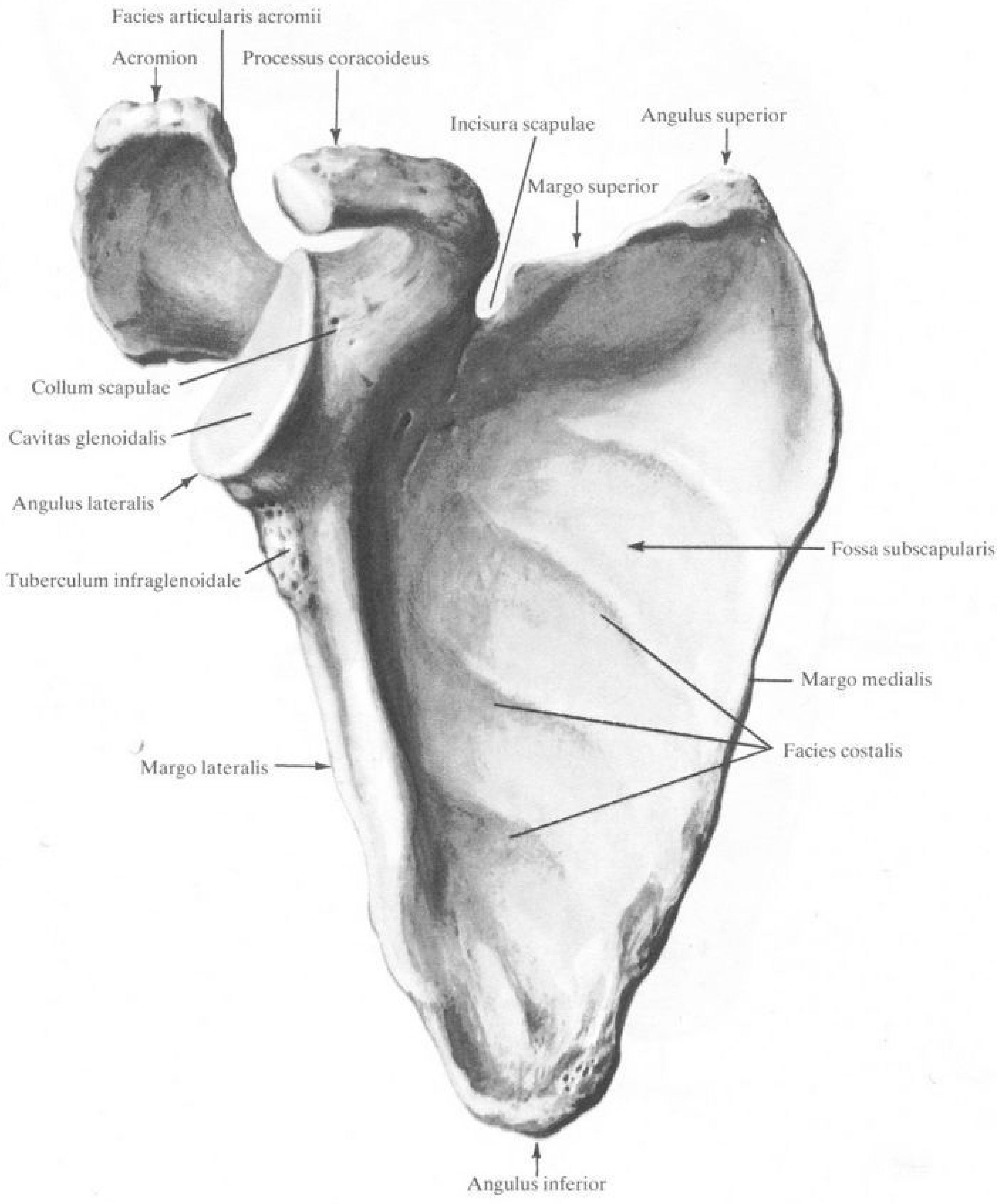
and below the glenoid cavity is the **infraglenoid tubercle** *(tuberculum infraglenoidale)*. These are sites of the origin of muscles.

The anterior, **costal surface** *(facies costalis)* is concave. It is occupied by the subscapular muscle and is called the **subscapular fossa** *(fossa subscapularis)*.

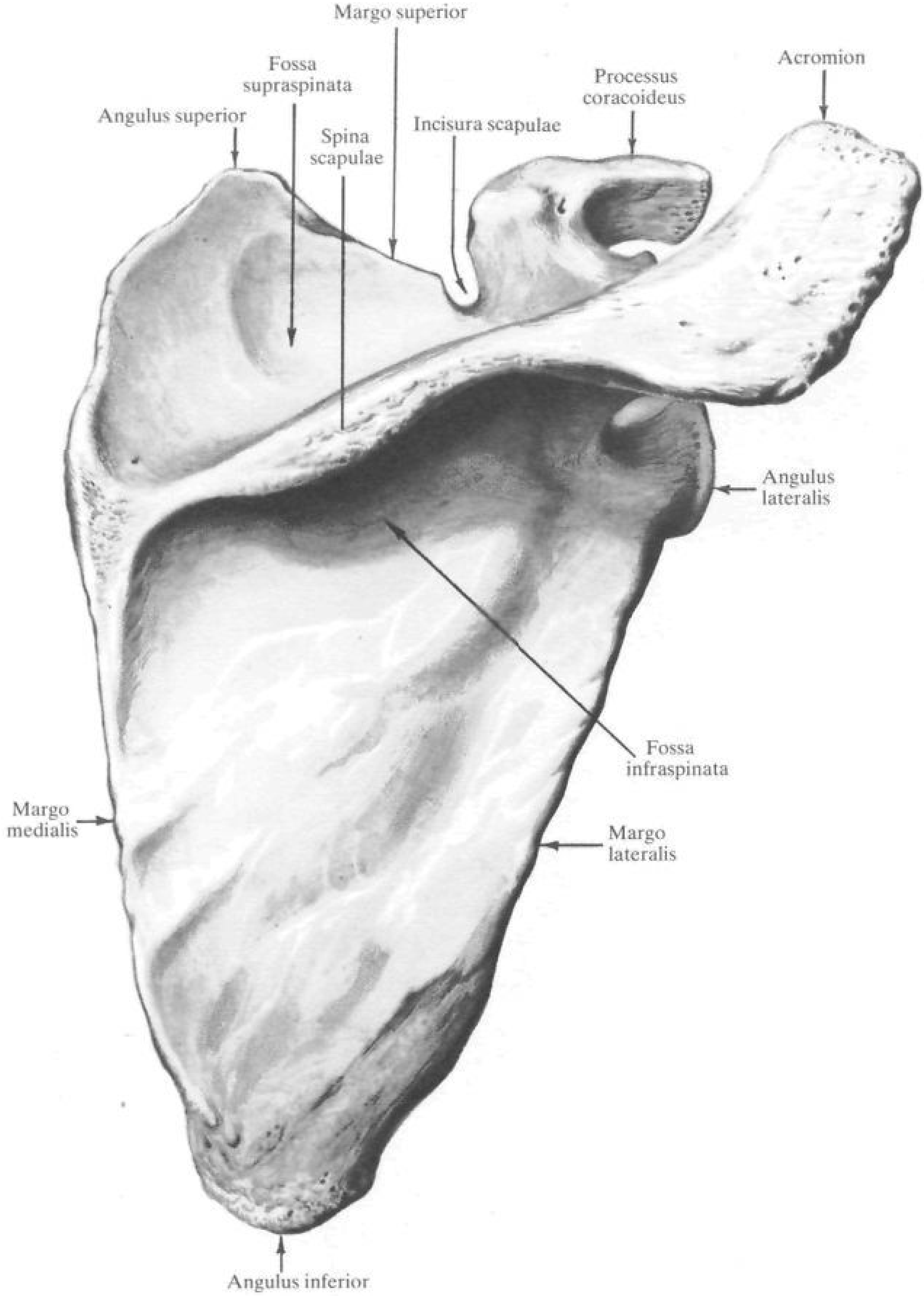
The posterior, **dorsal surface** *(facies dorsalis)* is divided by the **spine of the scapula** *(spina scapulae)* into two parts. The smaller part is situated above the spine and is called the **supraspinous fossa** *(fossa supraspinata)*; the other, larger part occupies the rest of the dorsal surface and is called the **infraspinous fossa** *(fossa infraspinata)*. They are the sites of origin of the supraspinatus and infraspinatus muscles, respectively.

The **spine of the scapula** *(spina scapulae)* is a well developed projection crossing the dorsal surface from the medial border towards the lateral angle.

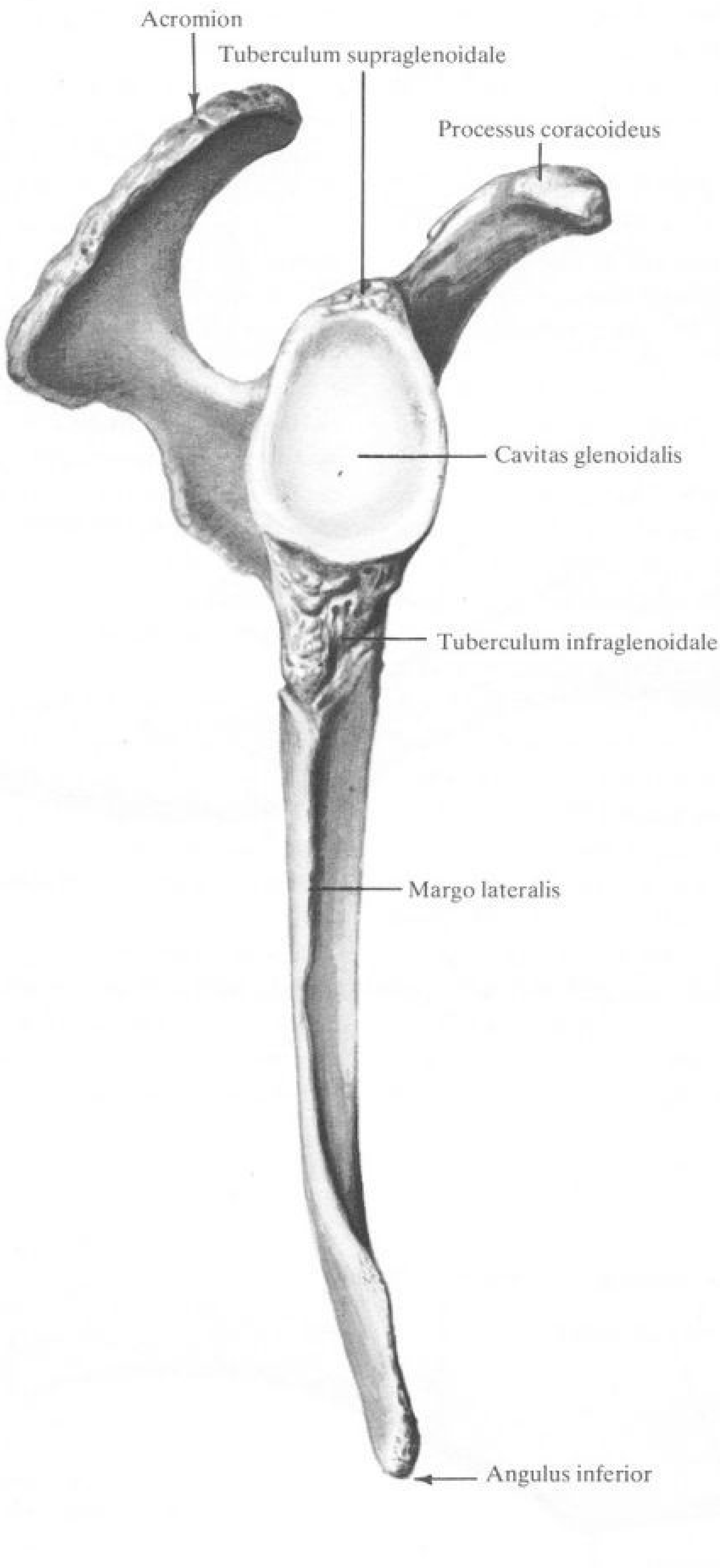
The lateral part of the spine of the scapula is strongly developed and is continuous with the **acromion** stretching laterally and slightly forwards and carrying on its anterior edge the **articular facet of the acromion** *(facies articularis acromii)* for articulation with the clavicle.



112. *Right scapula*; anterior aspect (3/4).



113. *Right scapula*; posterior aspect (4/5).



114. *Right scapula*; lateral aspect ($^3/_4$).

THE CLAVICLE

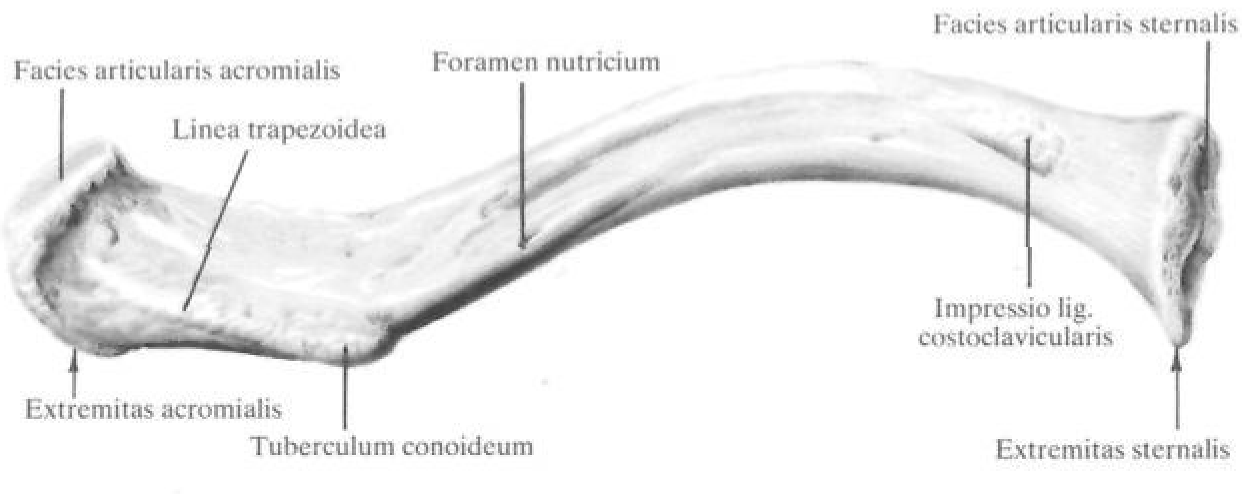
The **clavicle** *(clavicula)* (Figs 111, 115, 116, 119) is a small tubular S-shaped bone. It has a body and two ends, the sternal end facing the manubrium sterni and the acromial end articulating with the acromion of the scapula. The sternal end and the adjoining part of the body of the clavicle are convex forwards, the rest of the clavicle is concave forwards.

The middle part of the clavicle located between its ends is somewhat compressed from top to bottom. On its inferior surface it has a relatively large nutrient foramen. The sternal end bears an **impression for the costoclavicular ligament** *(impressio ligamenti costoclavicularis)*, the acromial end carries the **conoid tubercle** *(tuberculum conoideum)* and the **trapezoid line** *(linea trapezoidea)*; they give attachment to the conoid and trapezoid parts of the coracoclavicular ligament.

The superior surface of the clavicle is smooth. The **sternal end** *(extremitas sternalis)* is thick and carries on its internal surface the **sternal articular facet** *(facies articularis sternalis)* for articulation with the clavicular notch of the manubrium sterni.

The **acromial end** *(extremitas acromialis)* is wider but slightly thinner than the sternal end. On its inferolateral surface is the **acromial articular facet** *(facies articularis acromialis)* for articulation with the acromion of the scapula.

115. *Right clavicle (clavicula)*; superior aspect (2/3).



116. *Right clavicle (clavicula)*; inferior aspect (2/3).

THE SKELETON OF THE FREE UPPER LIMB

THE HUMERUS

The **humerus** (see Figs 111, 117-122) is a long tubular bone. A body, or shaft, and two ends, upper and lower, are distinguished in it.

The **body**, or **shaft** *(corpus humeri)* is rounded superiorly, while the lower part is trihedral. A posterior and an anterior surfaces are distinguished in the lower part of the shaft. The **posterior surface** *(facies posterior)* is bounded by a **lateral** and **medial borders** *(margo lateralis* et *margo medialis)*. The **anterior surface** *(facies anterior)* is separated by a poorly defined border into an **anteromedial surface** *(facies anterior medialis)* and **anterolateral surface** *(facies anterior lateralis)*. Slightly below the middle of its length the anteromedial surface bears a **nutrient foramen** *(foramen nutricium)* leading into a distally running **nutrient canal** *(canalis nutricius)*.

A little above this foramen, the anterolateral surface of the body carries the **deltoid tuberosity** *(tuberositas deltoidea)* for insertion of the deltoid muscle.

A **spiral groove** lodging the radial nerve *(sulcus nervi radialis)* is on the posterior surface of the shaft behind the deltoid tuberosity. It runs downwards and laterally.

The **upper end**, or the **proximal epiphysis** *(extremitas superior* s. *epiphysis proximalis)* is thickened and carries a semispherical **head of the humerus** *(caput humeri)* whose surface faces medially, upwards, and slightly backwards.

The head is separated from the rest of the bone by a shallow annular constriction called the **anatomical neck** *(collum anatomicum)*. On the anterolateral surface of the bone below the anatomical neck are the **greater tuberosity** *(tuberculum majus)* located laterally and the **lesser tuberosity** *(tuberculum minus)* situated medially and a little to the front.

The lower periphery of each tuberosity is continuous with a similarly named crest: the **lateral lip of the bicipital groove** or the **crest of the greater tuberosity** *(crista tuberculi majoris)* and the **medial lip of the bicipital groove** or the **crest of the lesser tuberosity** *(crista tuberculi minoris)*. Descending, both crests reach the upper parts of the shaft and together with the tuberosities form the borders of the well defined **bicipital** or **intertubercular groove** *(sulcus intertubercularis)* lodging the tendon of the long head of the biceps brachii muscle *(tendo capitis longi musculus bicipitis brachii)*.

Below the tubercles at the junction of the upper end and body of the bone is a small constriction called the **surgical neck** *(collum chirurgicum)* corresponding to the zone of the epiphyseal cartilage.

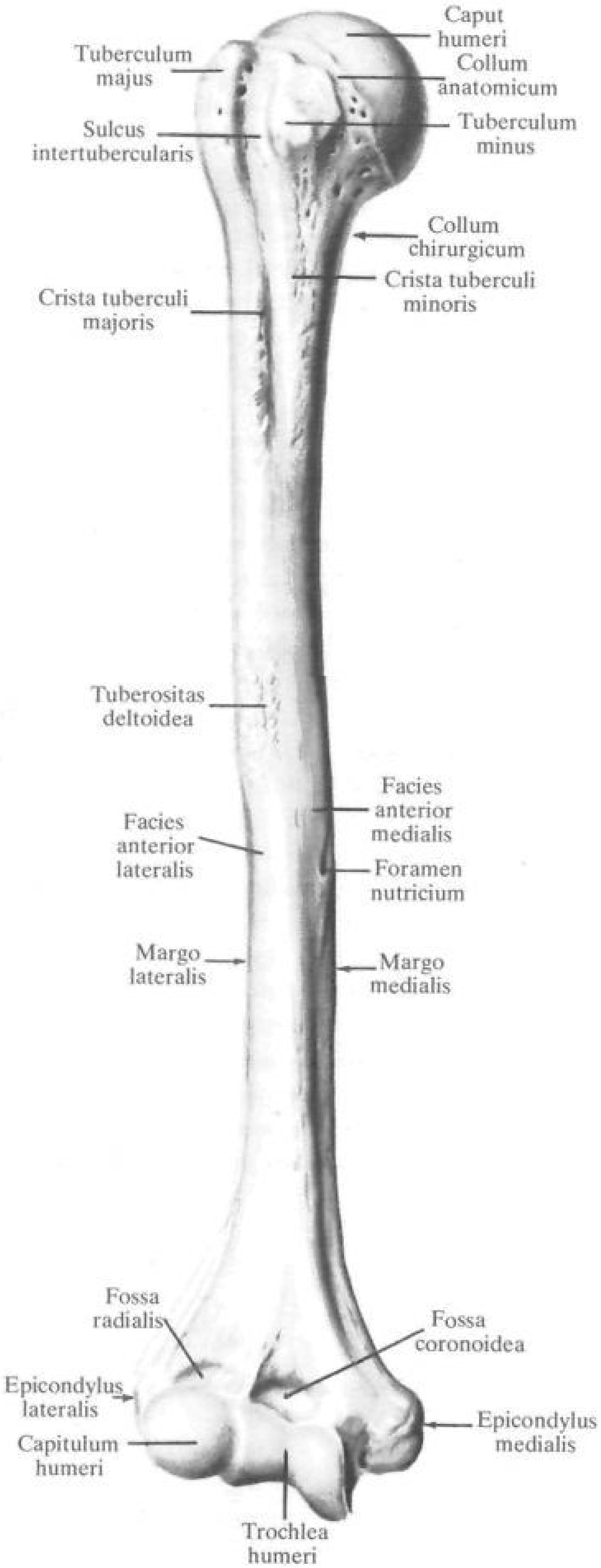
The **lower end**, or the **distal epiphysis** *(extremitas inferior* s. *epiphysis distalis)* is flattened in the anteroposterior direction.

The distal segment of this part of the bone bears in its lateral part a rounded eminence called the **capitulum of the humerus** *(capitulum humeri)* for articulation with the head of the radius. Next to this eminence is the **trochlea of the humerus** *(trochlea humeri)* which articulates with the trochlear notch of the ulna.

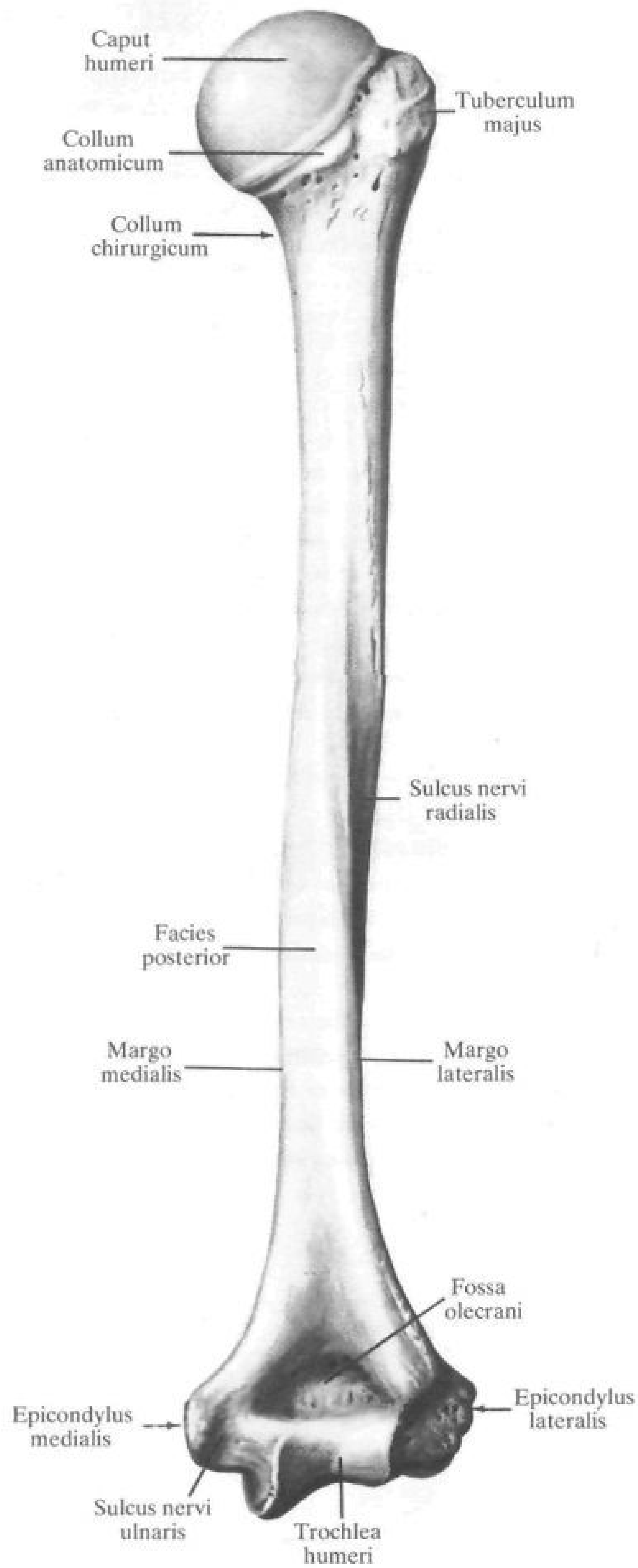
The **coronoid fossa** *(fossa coronoidea)* is on the anterior surface of the inferior end of the humerus above the trochlea, the **radial fossa** *(fossa radialis)* is above the capitulum, and the **olecranon fossa** *(fossa olecrani)* lies on the posterior surface.

The lower end of the humerus terminates distally as the **lateral** and **medial epicondyles** *(epicondylus lateralis* et *epicondylus medialis)*.

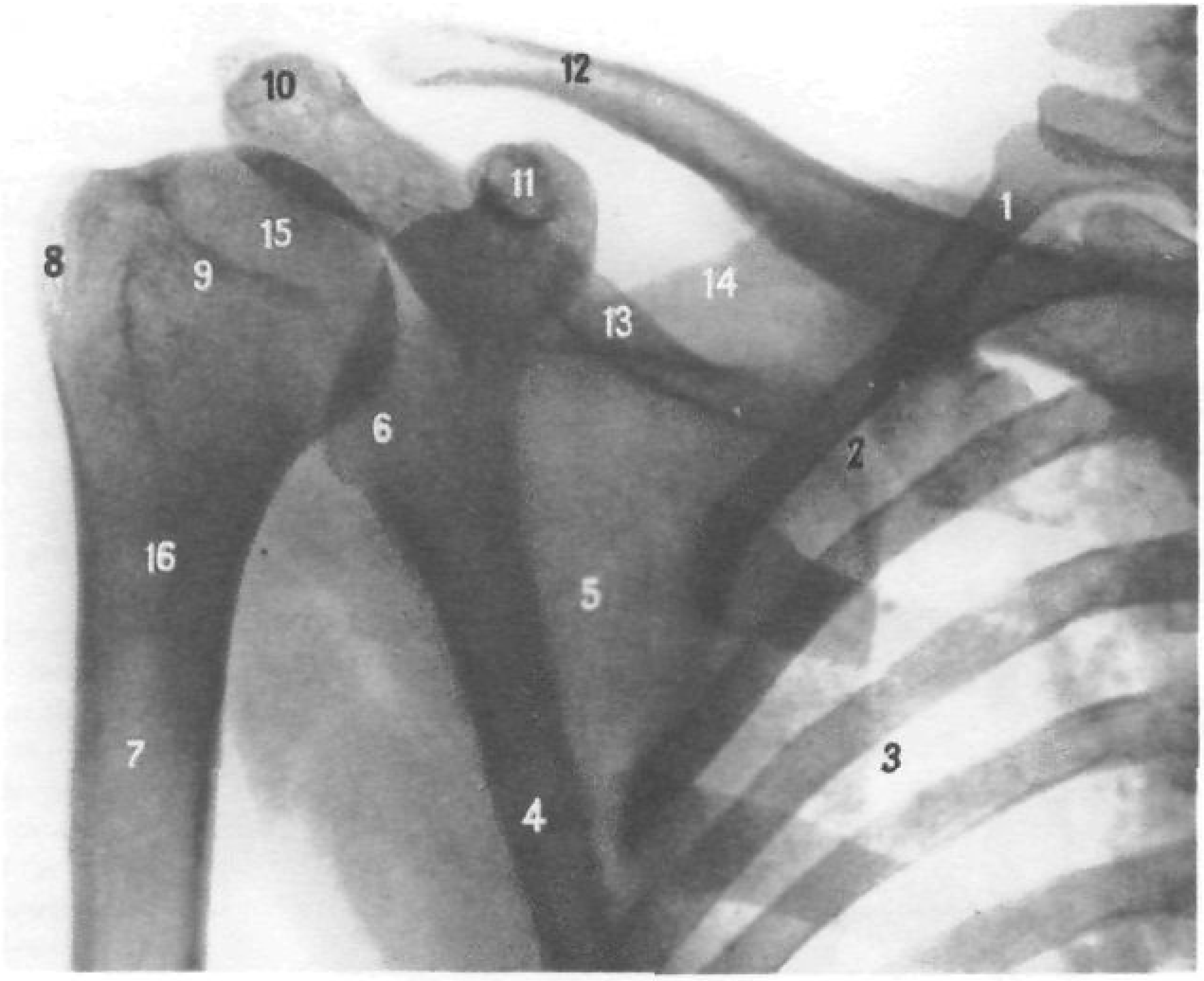
The medial epicondyle is more prominent. Its posterior surface carries the **groove for the ulnar nerve** *(sulcus nervi ulnaris)*. The groove and the epicondyles are easily palpated under the skin.



117. *Right humerus*; anterior aspect (3/5).

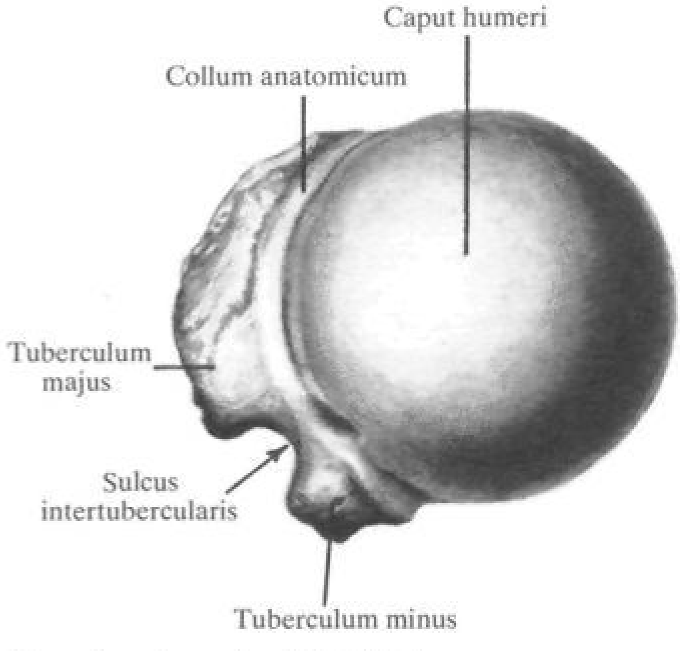


118. *Right humerus*; posterior aspect (3/5).

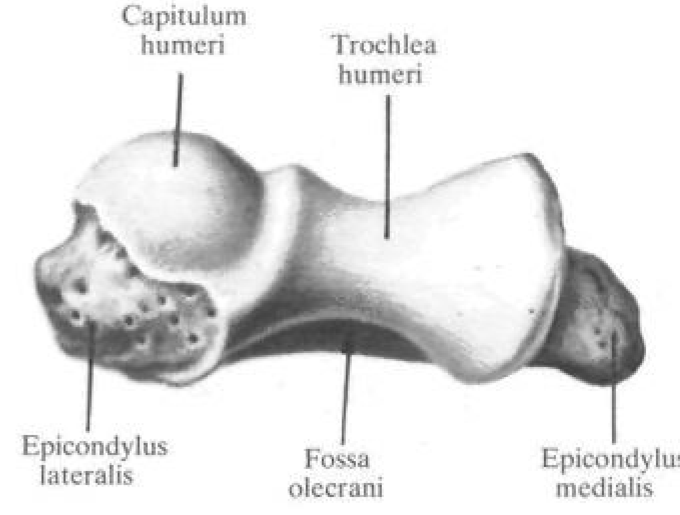


119. *Right shoulder girdle* (radiograph).

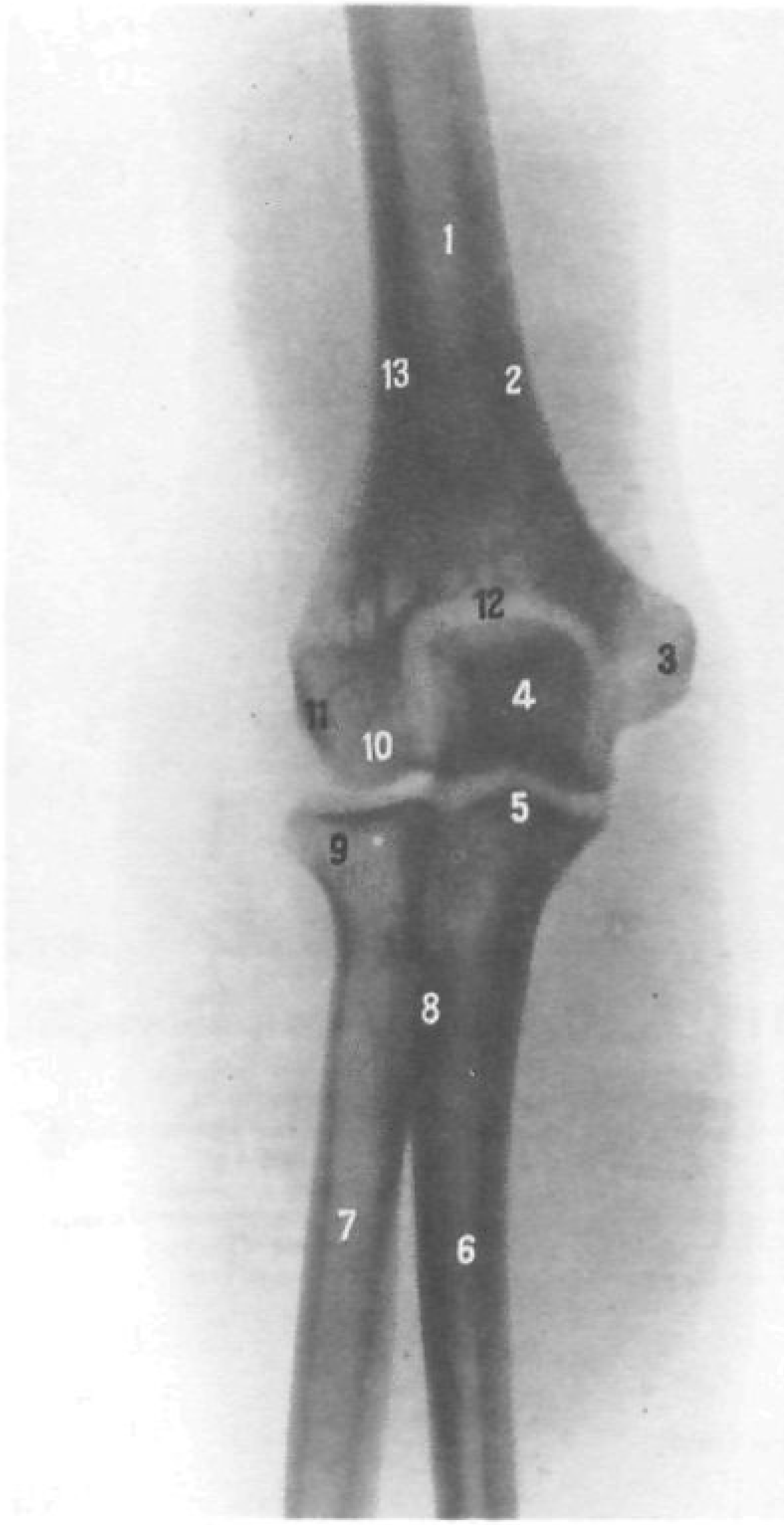
1—first rib
2—medial border of scapula
3—intercostal space
4—lateral border of scapula
5—scapula
6—glenoid cavity of scapula
7—humerus
8—greater tuberosity of humerus
9—anatomical neck
10—acromion
11—coracoid process of scapula
12—clavicle
13—spine of scapula
14—superior border of scapula
15—head of humerus
16—surgical neck



120. *Proximal end of right humerus*; superior aspect ($^3/_4$).



121. *Distal end of humerus*; inferior aspect ($^4/_5$).



122. *Distal segment of right humerus and proximal part of right ulna and radius* (radiograph).

1—humerus
2—medial border of humerus
3—medial epicondyle
4—olecranon
5—coronoid process of ulna
6—ulna
7—radius
8—tuberosity of radius
9—head of radius
10—capitulum of humerus
11—lateral epicondyle
12—olecranon fossa
13—lateral border of humerus

THE BONES OF THE FOREARM

The **bones of the forearm** *(ossa antebrachii)* (Figs 123-131) are the **ulna** and the **radius**. When the limb is hanging freely and in supination (with the forearm and palm turned forward) the ulna is located medially and the radius laterally.

THE ULNA

The **ulna** (see Figs 111, 123-125, 129-131) is a long tubular bone. It has a shaft (body) and two ends, upper and lower.

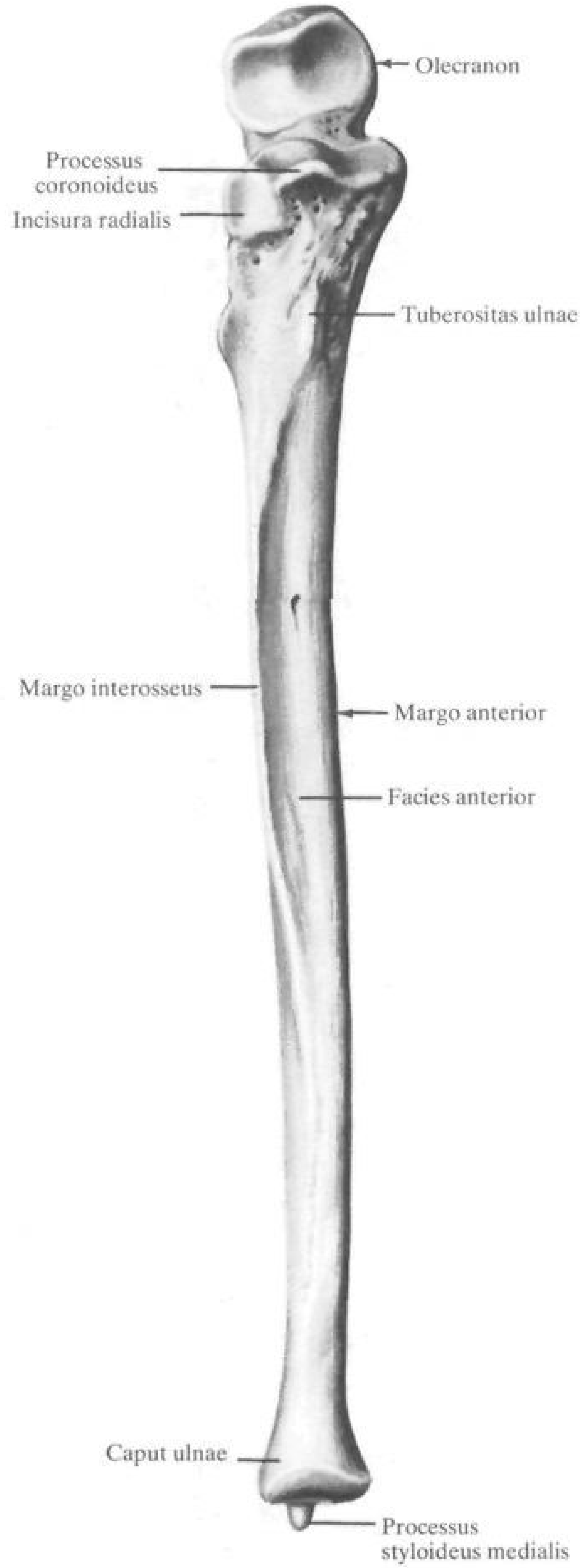
The **shaft of the ulna** *(corpus ulnae)* is trihedral. It has three borders: anterior (palmar), posterior (dorsal), and interosseous (lateral). Its three surfaces are the anterior (palmar), posterior (dorsal) and medial surface.

The **anterior border** *(margo anterior)* is rounded, the **posterior border** *(margo posterior)* faces to the back, and the **interosseous border** *(margo interosseus)* is sharp and faces the radius.

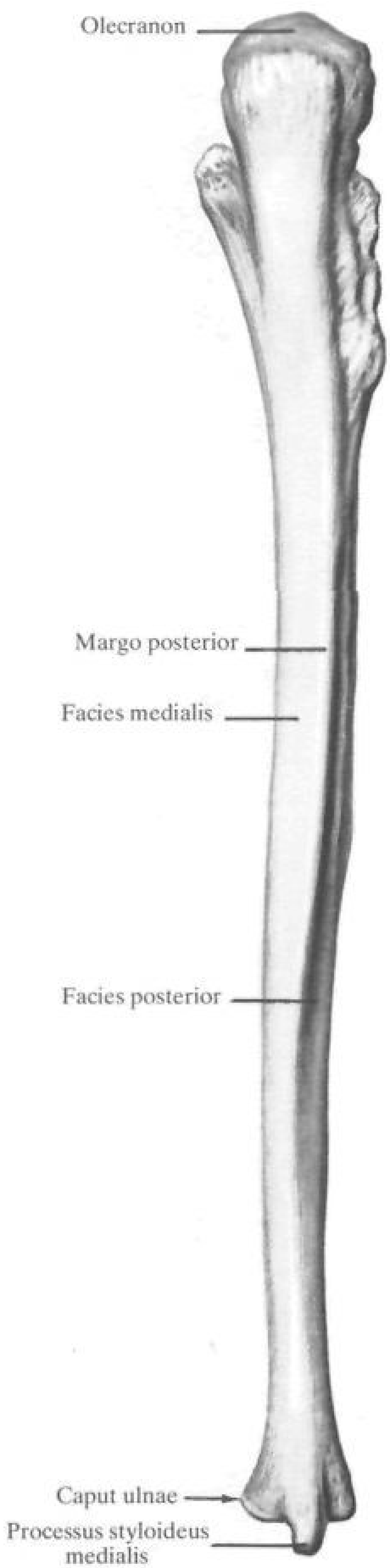
The **anterior surface** *(facies anterior)* is slightly concave. It bears a **nutrient foramen** *(foramen nutricium)* which is continuous proximally with a **nutrient canal** *(canalis nutricius)*. In the upper part of the anterior surface of the junction of the shaft and the upper end of the bone is the **tuberosity of the ulna** *(tuberositas ulnae)*. The **posterior surface** *(facies posterior)* faces to the back, while the **medial surface** *(facies medialis)* faces the medial border of the forearm.

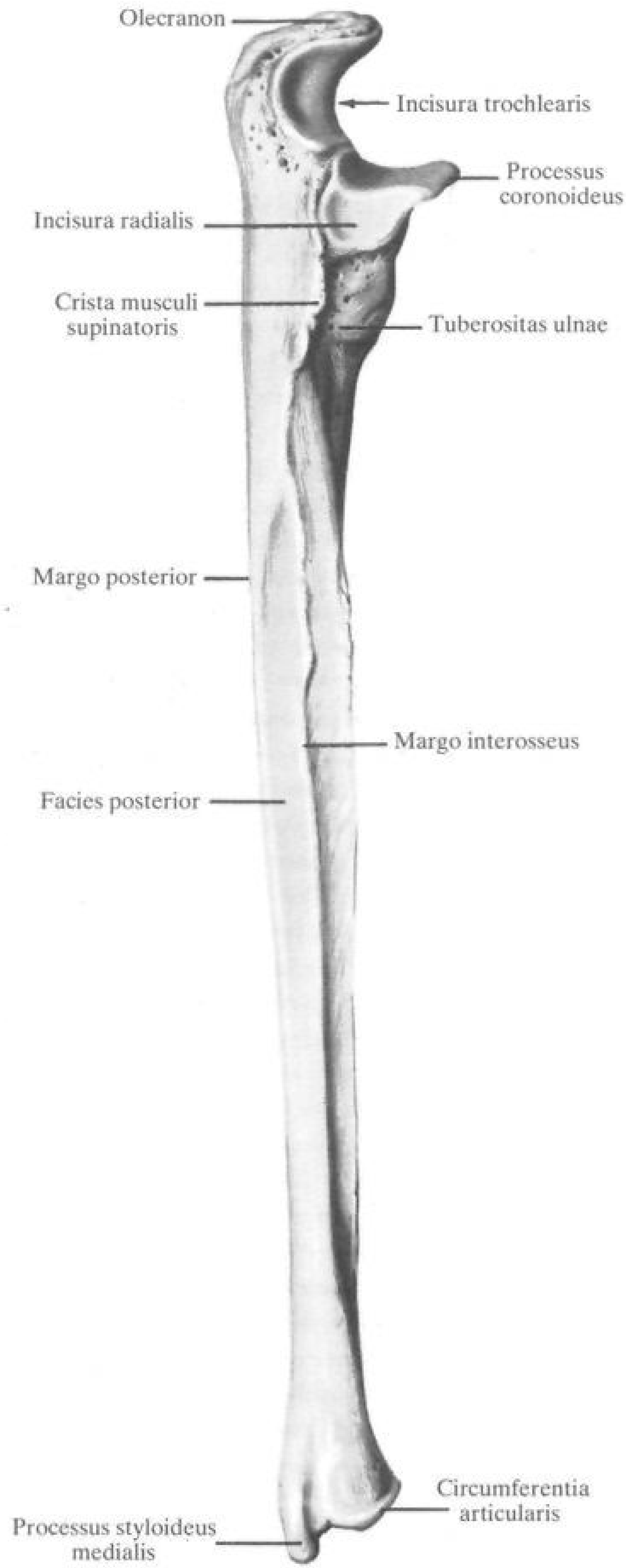
The **upper end**, or **proximal epiphysis** *(extremitas superior* s. *epiphysis proximalis)* is thick and continuous upwards with the **olecranon**. The anterior surface of the olecranon bears the **trochlear notch** *(incisura trochlearis)* which is bounded below by the **coronoid process** *(processus coronoideus)*. The lateral surface of the coronoid process carries the **radial notch** *(incisura radialis)* for articulation of the ulna with the articular circumference of the head of the radius. The **supinator crest** *(crista musculi supinatoris)* arises behind the radial notch and descends to the upper parts of the shaft.

The **lower end**, or **distal epiphysis** *(extremitas inferior* s. *epiphysis distalis)* of the ulna is rounded. The **head** *(caput ulnae)* is distinguished on it. The lower periphery of the head carries an articular surface which faces the wrist and bears a fossa. The lateral periphery of the head carries for a considerable distance the **articular circumference of the ulna** *(circumferentia articularis ulnae)* for articulation with the radius. The posteromedial surface of the head is continuous with the **medial styloid process** *(processus styloideus medialis)* which is easily felt through the skin.



123. *Right ulna*; anterior surface ($\frac{3}{5}$).





124. *Right ulna*;
posterior surface (2/3).

125. *Right ulna*;
surface facing the radius (3/5).

THE RADIUS

The **radius** (see Figs 111, 126–131) is located laterally and a little anteriorly to the ulna. It has a shaft (body) and two ends, upper and lower.

The **shaft of the radius** *(corpus radii)* is triangular. It has three borders (anterior, posterior, and interosseous, or medial) and three surfaces (anterior, or palmar, posterior, or dorsal, and lateral, or outer).

The **anterior border** *(margo anterior)* and the **posterior border** *(margo posterior)* are rounded.

The **medial border** of the bone is sharp, faces the ulna, and is called the **interosseous border** *(margo interosseus)*.

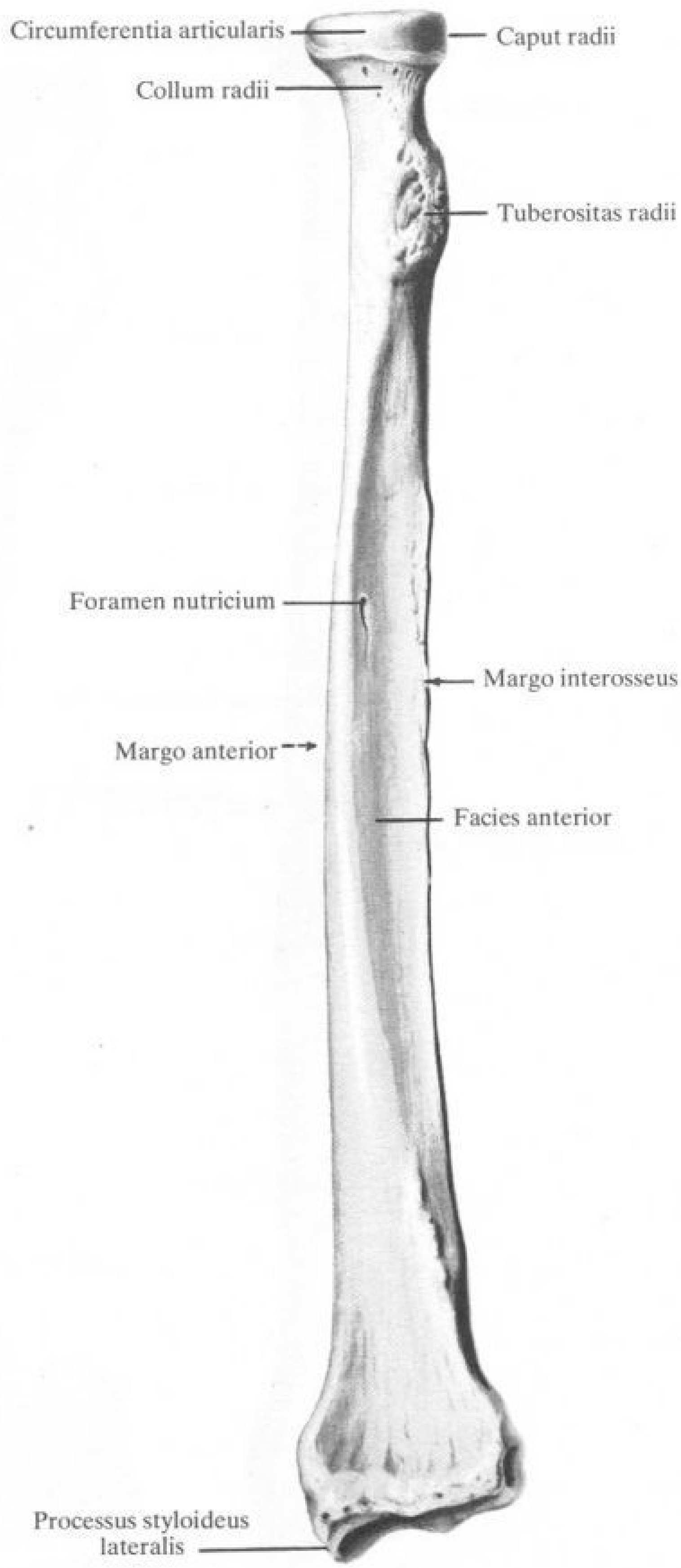
The **anterior surface** *(facies anterior)* is slightly concave. It bears a **nutrient foramen** *(foramen nutricium)* which is continuous proximally with a **nutrient canal** *(canalis nutricius)*.

The **posterior surface** *(facies posterior)* faces to the back, the **lateral surface** *(facies lateralis)* faces the lateral border of the forearm.

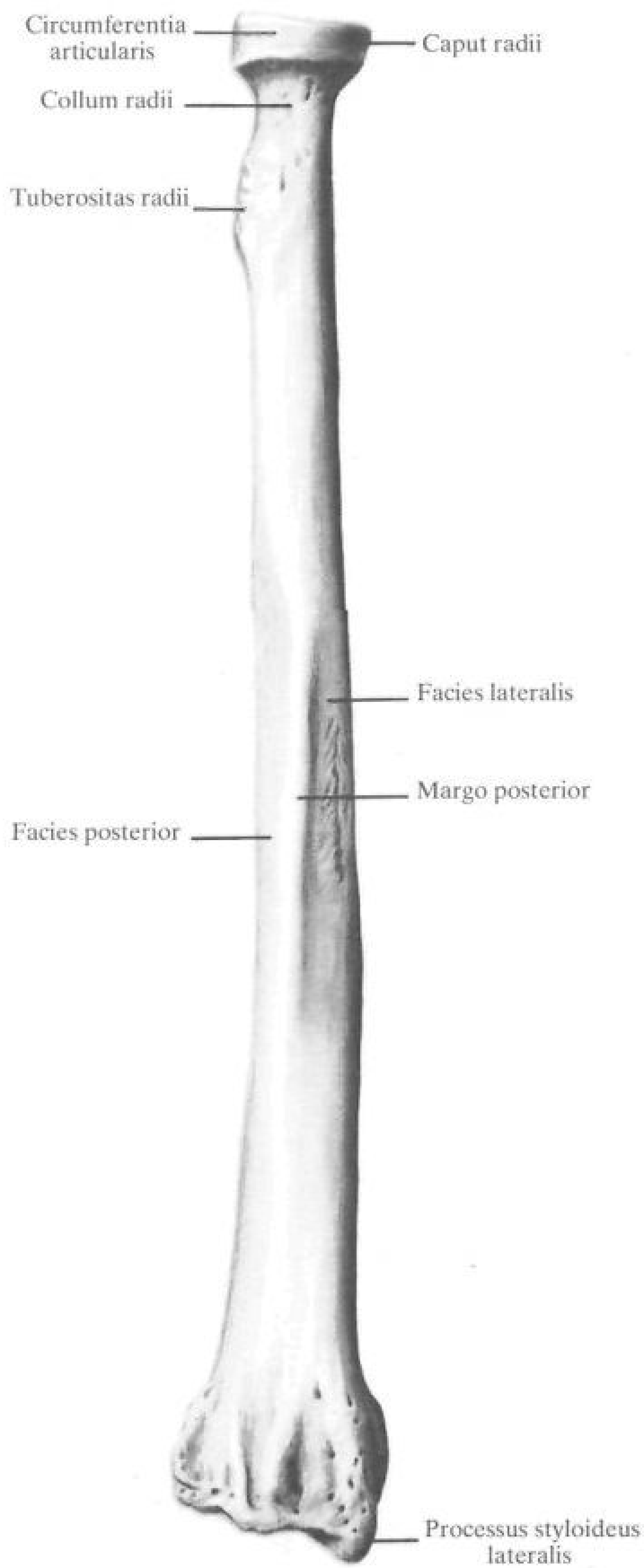
The **upper end,** or **proximal epiphysis** *(extremitas superior* s. *epiphysis proximalis)* carries at its junction with the shaft a well defined **tuberosity of the radius** *(tuberositas radii)* facing medially. Superiorly to the tuberosity is an evenly constricted area of bone called the **neck of the radius** *(collum radii)*. Above the neck is a cylindrical **head of the radius** *(caput radii)*. The superior surface of the head is concave. The lateral part of the head carries a surface for articulating with the radial notch of the ulna; it is called the **articular circumference of the radius** *(circumferentia articularis radii)* and can be partly felt through the skin.

The **lower end,** or **distal epiphysis** *(extremitas inferior* s. *epiphysis distalis)* is thick and wide in the frontal plane. The lateral periphery of the lower end is continuous with the **lateral styloid process** *(processus styloideus lateralis)* which is easily felt through the skin. On the medial surface of the lower end is the **ulnar notch** *(incisura ulnaris)* which bears an articular surface for articulation with the articular circumference of the ulna.

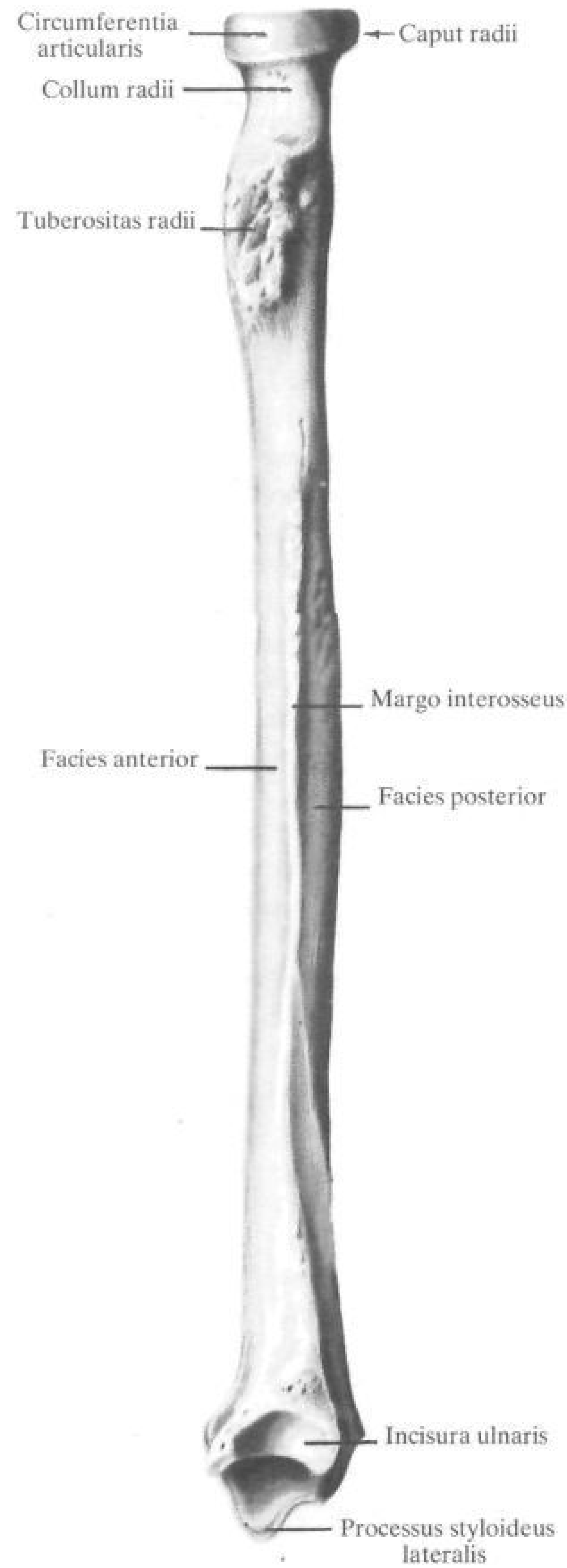
The anterior surface of the lower end of the radius is smooth, the posterior surface carries small ridges separating small grooves which lodge the tendons of muscles. The lower surface is concave from side to side and from front to back. It serves for articulation with the carpal bones and is called the **carpal articular surface** *(facies articularis carpea)*. It carries a small ridge which runs anteroposteriorly and separates it into two parts corresponding to the two carpal bones articulating with the radius.



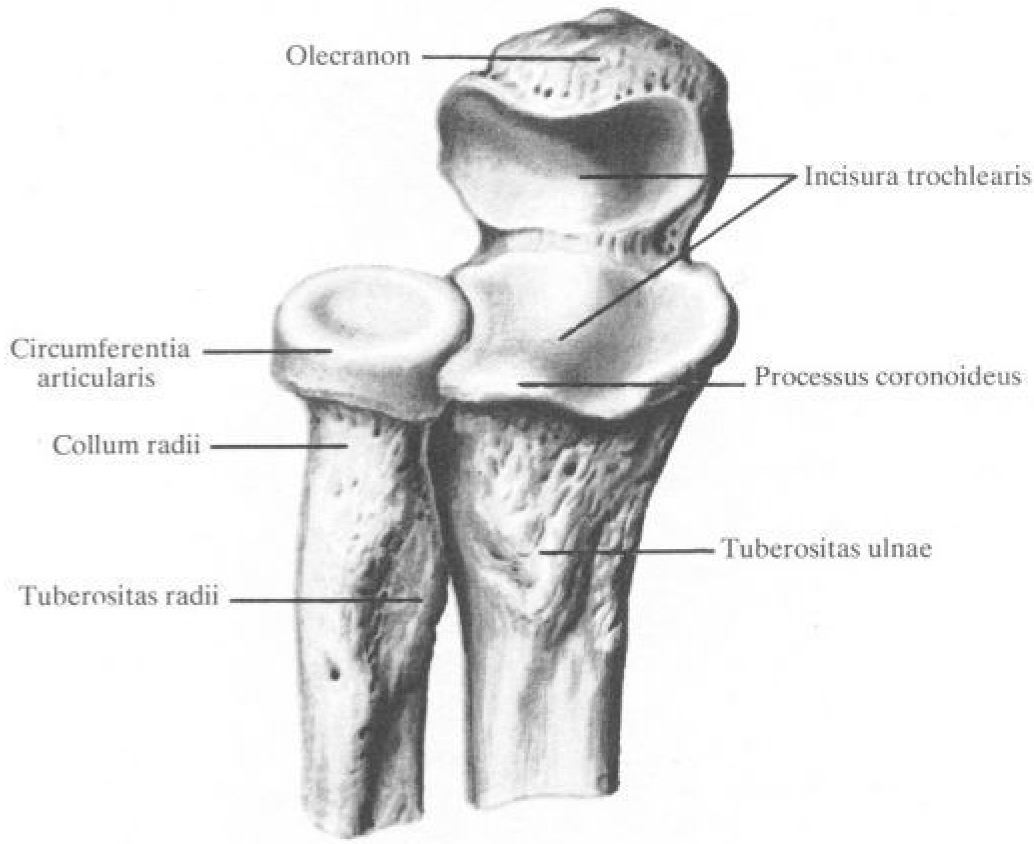
126. *Right radius;* anterior surface ($^3/_5$).



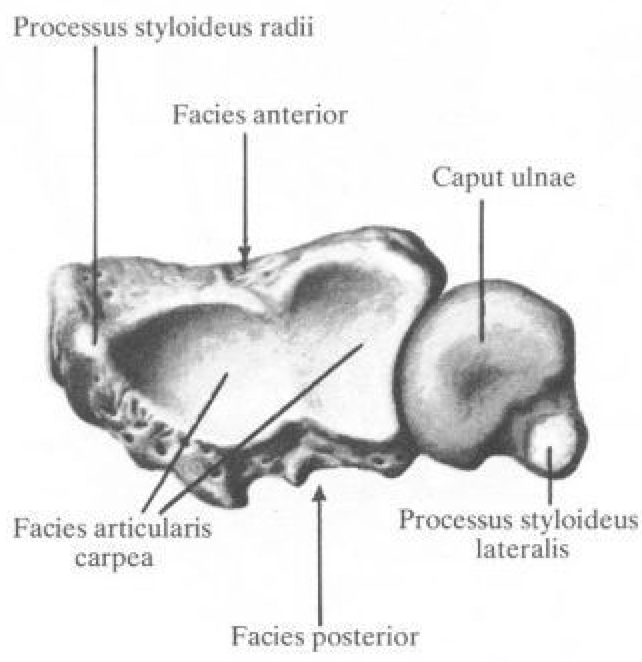
127. *Right radius*;
posterior surface (3/5).



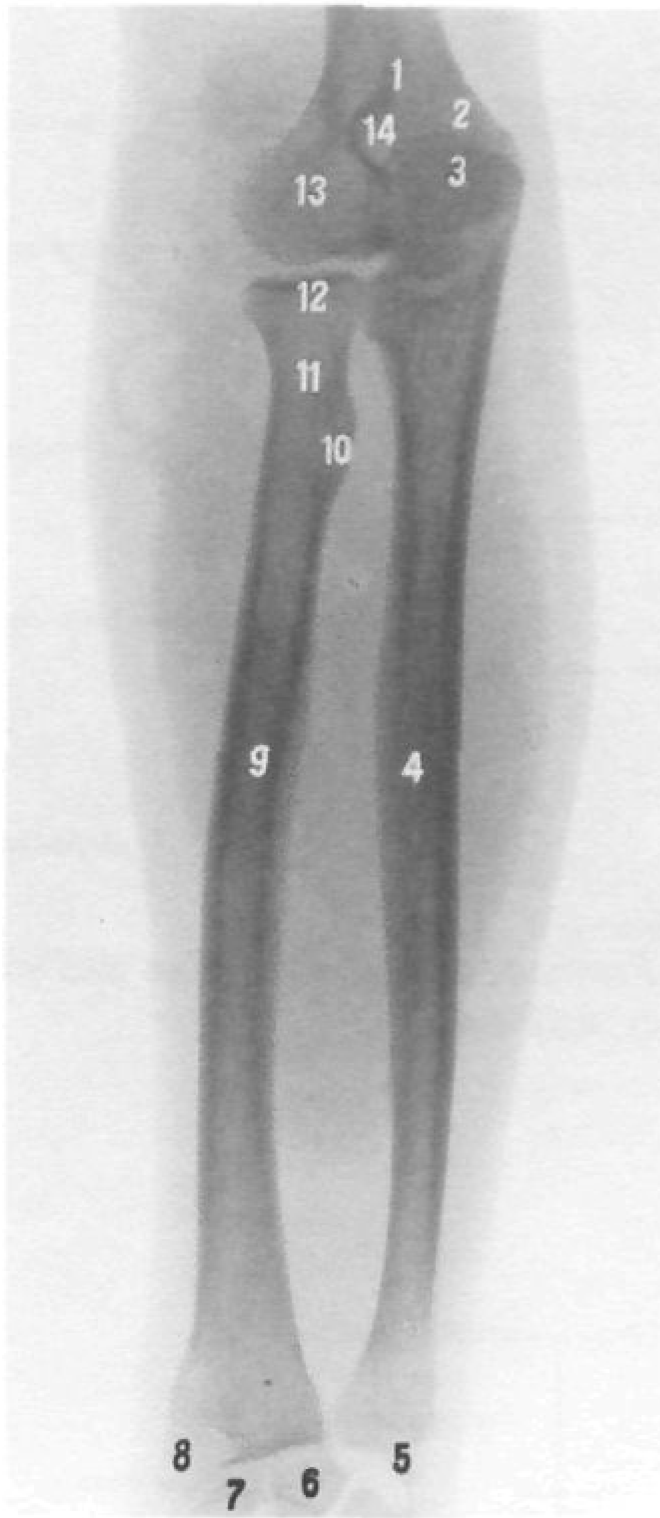
128. *Right radius*;
surface facing the ulna (3/5).



129. *Proximal ends of right ulna and radius;* palmar surface (2/3).



130. *Distal ends of right ulna and radius;* inferior aspect (3/4).

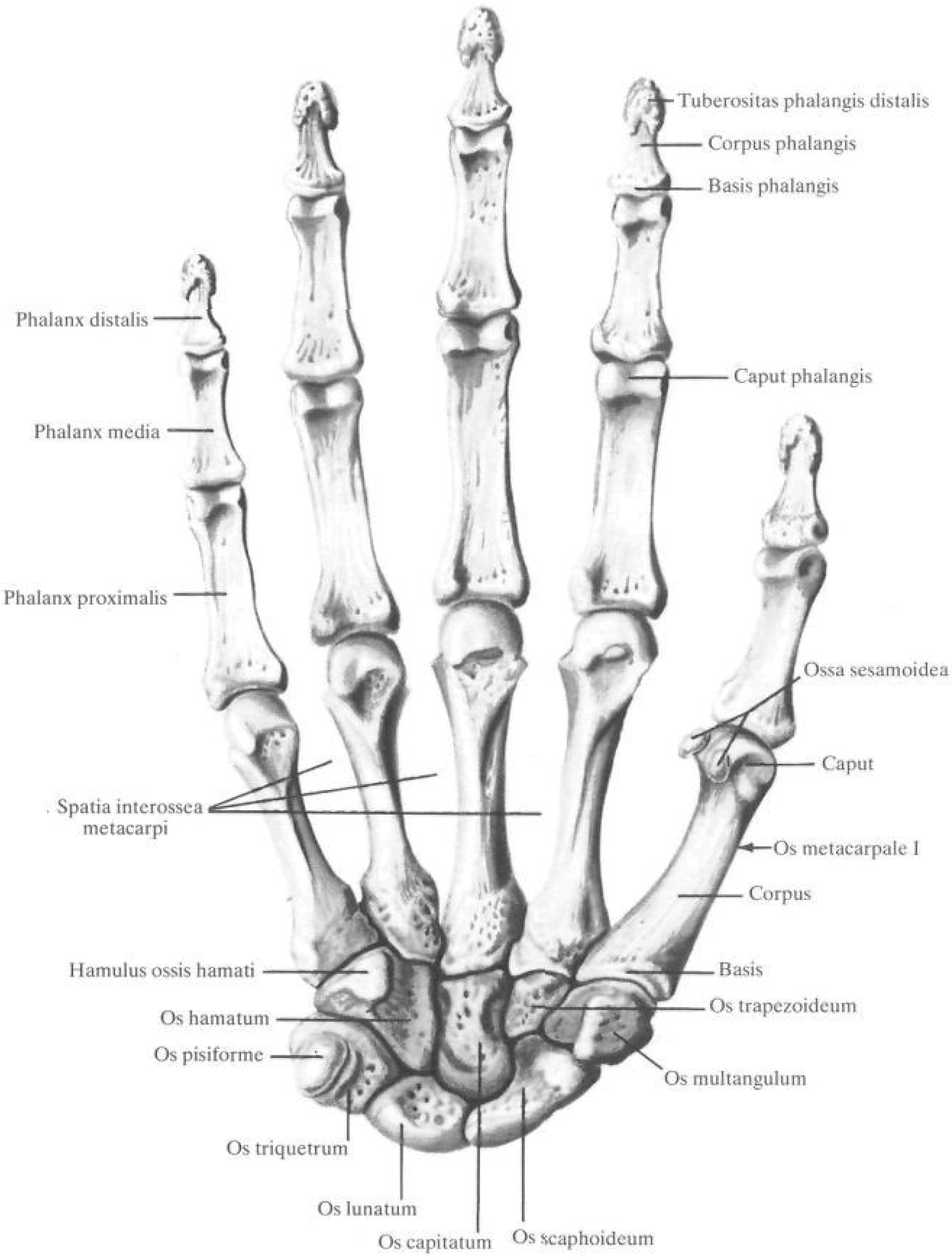


131. *Bones of right forearm* (radiograph).

1—humerus
2—medial epicondyle
3—olecranon
4—ulna
5—medial styloid process
6—lunate bone
7—scaphoid bone
8—lateral styloid process
9—radius
10—tuberosity of radius
11—neck of radius
12—head of radius
13—capitulum of humerus
14—olecranon fossa

THE BONES OF THE HAND

The **bones of the hand** *(ossa manus)* (see Figs 111, and 132–142) are divided into the **carpal bones** *(ossa carpi)*, the **metacarpal bones** *(ossa metacarpalia)*, and the **bones of the fingers** or **phalanges of digits of the hand** *(ossa digitorum manus)*, i.e. the **phalanges of the fingers** *(phalanges digitorum)*.



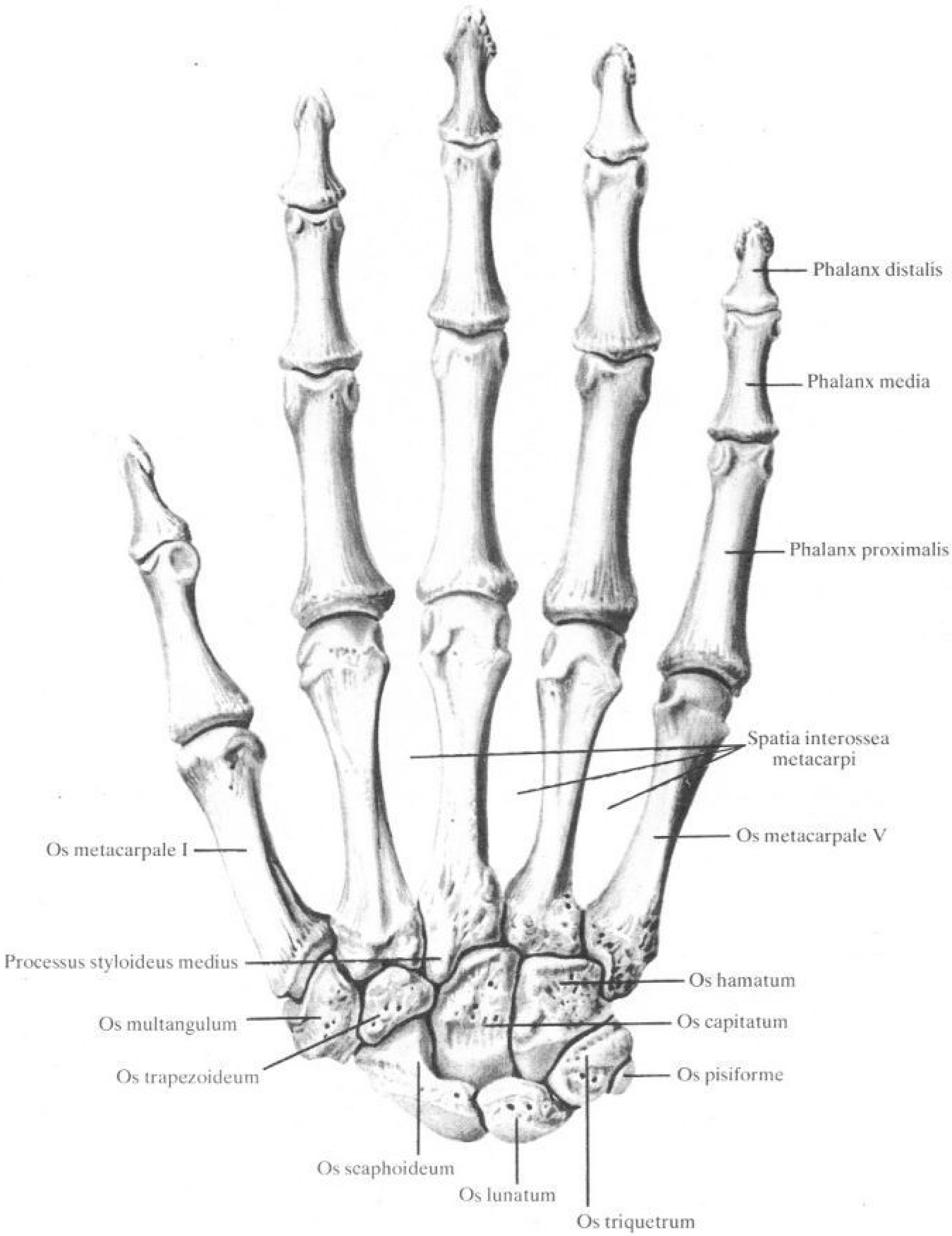
132. *Bones of right hand (ossa manus)*; palmar surface ($\frac{4}{5}$).

THE CARPAL BONES

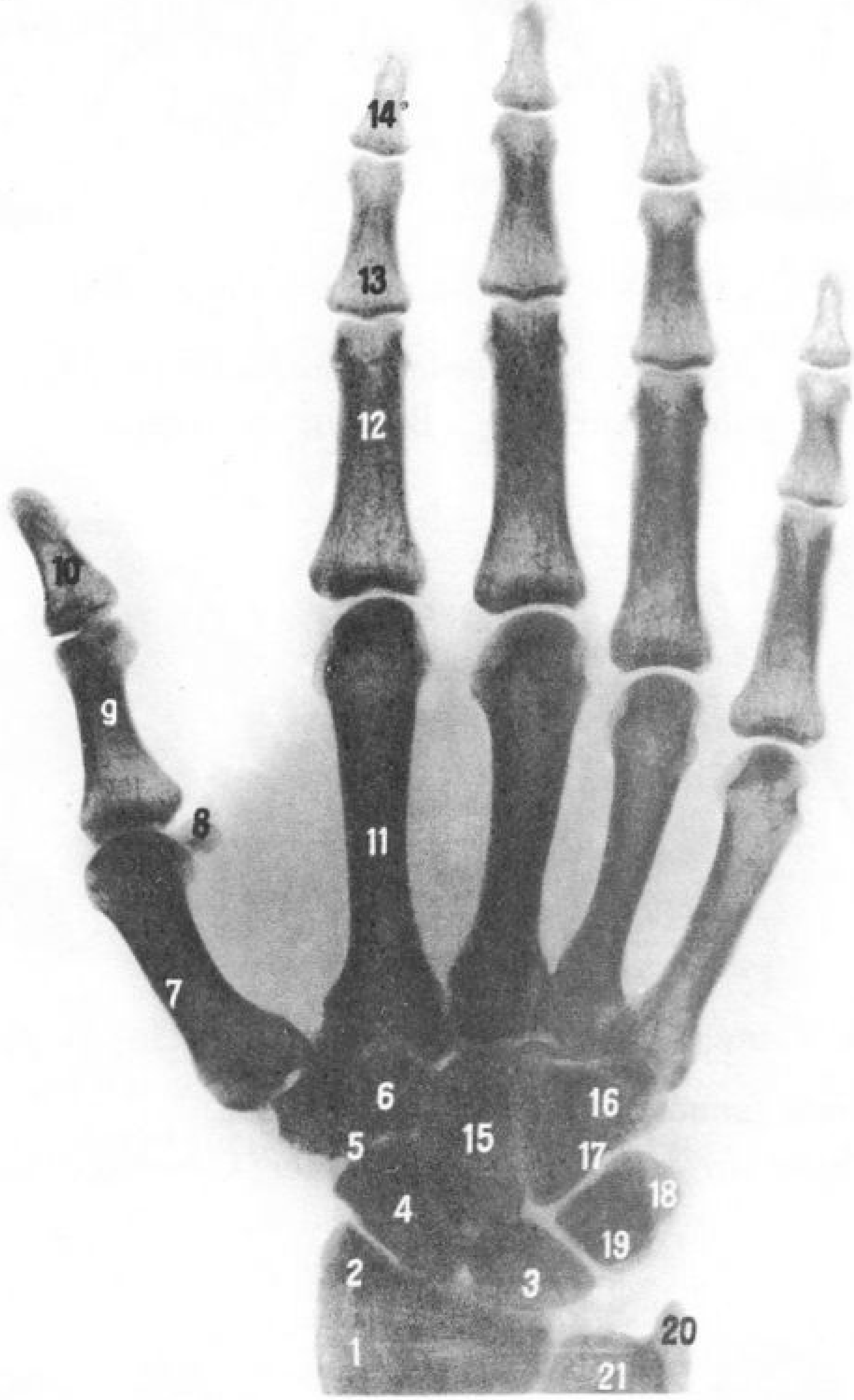
The **carpal bones** *(ossa carpi)* (see Figs 111, 132–142) form two rows, superior and inferior. The superior (or proximal) or first row adjoins the distal part of the forearm bones. The inferior row is known as the distal, or second row. Some of the carpal bones face the metacarpus.

The proximal row is formed by the following bones (named from the radial to the ulnar border of the hand): the **scaphoid bone** *(os scaphoideum)*, the **lunate bone** *(os lunatum)*, the **triquetral bone** *(os triquetrum)*, and the **pisiform bone** *(os pisiforme)*.

The distal row is made up of the **trapezium bone** *(os trapezium* s. *os multangulum majus)*, the **trapezoid bone** *(os trapezoideum)*, the **capitate bone** *(os capitatum)*, and the **hamate bone** *(os hamatum)*.

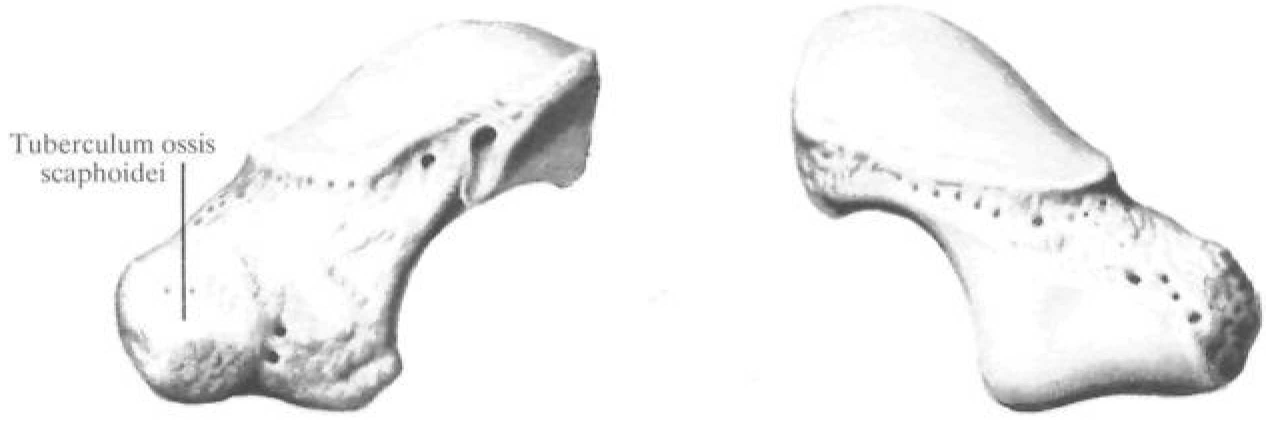


133. *Bones of right hand (ossa manus)*; dorsal surface ($^4/_5$).



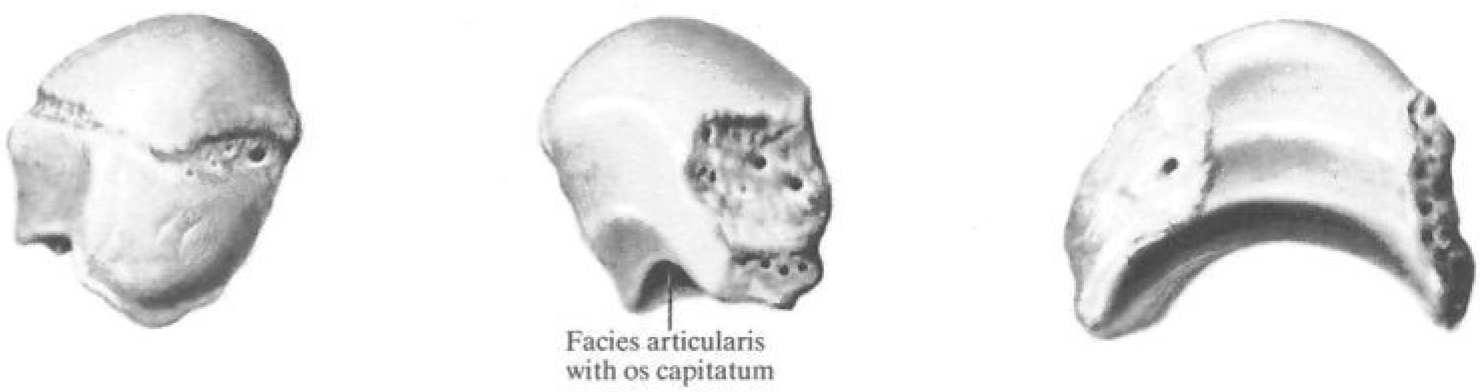
134. *Bones of right hand* (radiograph).

1—radius
2—lateral styloid process
3—lunate bone
4—scaphoid bone
5—multangular (trapezium) bone
6—trapezoid bone
7—first metacarpal bone
8—sesamoid bone
9—proximal phalanx of thumb
10—distal phalanx of thumb
11—second metacarpal bone
12—proximal phalanx of index finger
13—base of middle phalanx of index finger
14—distal phalanx of index finger
15—capitate bone
16—hook of hamate bone
17—hamate bone
18—pisiform bone
19—triquetral bone
20—medial styloid process
21—head of ulna



A B

135. *Right scaphoid bone (os scaphoideum)* ($^2/_1$).
A—palmar surface; B—dorsal surface.

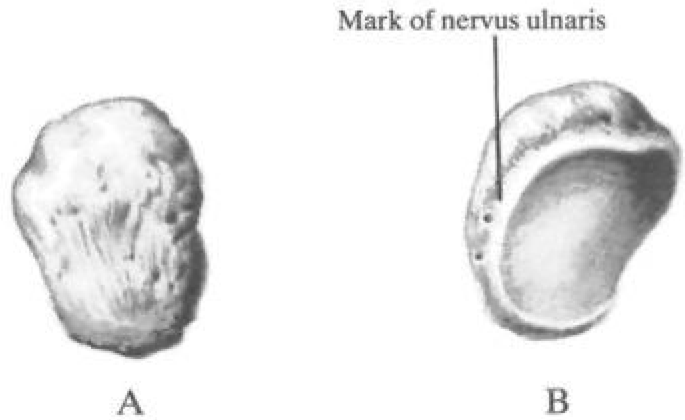


A B C

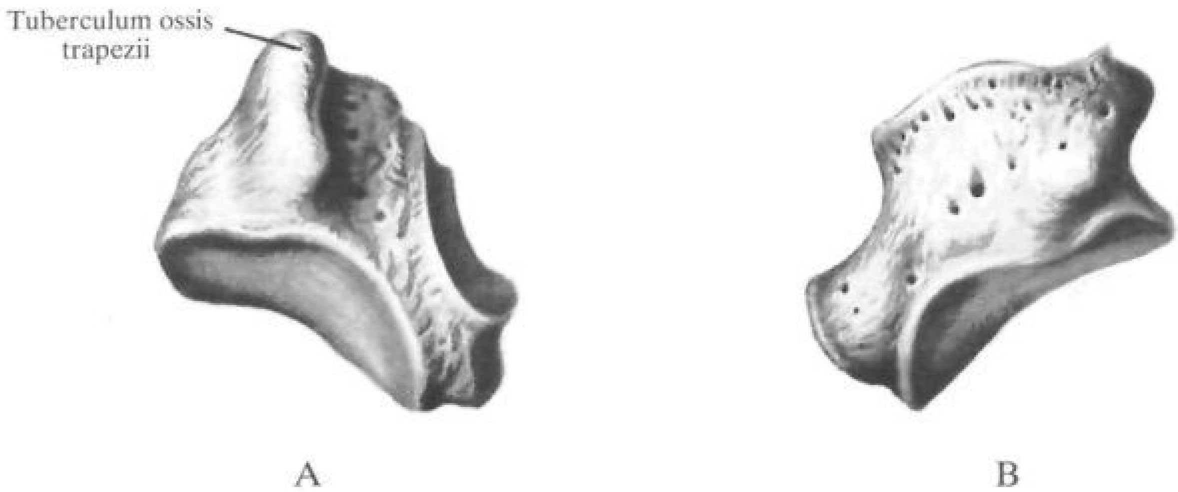
136. *Right lunate bone (os lunatum)* ($^2/_1$).
A—palmar surface; B—dorsal surface; C—distal surface.

A B

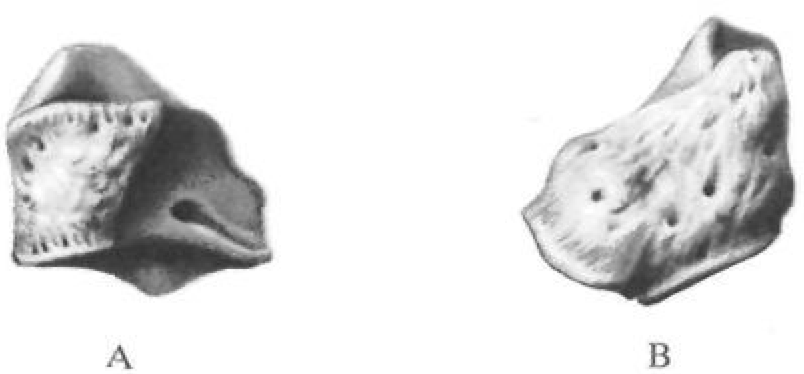
137. *Right triquetral bone (os triquetrum)* ($^3/_2$).
A—palmar surface; B—dorsal surface.



138. *Right pisiform bone (os pisiforme)* $(^2/_1)$.
A—palmar surface; B—dorsal surface.



139. *Right trapezium bone (os multangulum* s. *trapezium)* $(^2/_1)$.
A—palmar surface; B—dorsal surface.



140. *Right trapezoid bone (os trapezoideum)* $(^3/_2)$.
A—palmar surface; B—dorsal surface.

THE SCAPHOID BONE

The **scaphoid bone** *(os scaphoideum)* (Fig. 135) occupies the extreme lateral ('radial') position in the proximal row of carpal bones. Its palmar surface is concave and continuous in the inferolateral part with the **tubercle of the scaphoid** *(tuberculum ossis scaphoidei).*

The dorsal surface occupies a narrow strip which is continuous proximally with a superiorly convex facet articulating with the carpal articular surface of the radius. The inferomedial part of the bone carries a concave articular facet for articulation with the capitate bone. Above it on the medial side of the bone is a facet for articulating with the lunate bone. The inferolateral periphery of the scaphoid bone bears an articular facet for articulation with the trapezium and trapezoid bones.

THE LUNATE BONE

The **lunate bone** *(os lunatum)* (Fig. 136) is medial to the scaphoid bone. Its superior (proximal) surface is convex and articulates with the carpal articular surface of the radius.

The inferior (distal) surface of the lunate bone is concave and bears an articular facet on its lateral part for articulation with the capitate bone and another facet on its medial part for articulation with the hamate bone.

The lateral surface of the bone has an articular facet for articulation with the scaphoid bone. The medial surface of the lunate bone articulates with the triquetral bone.

THE TRIQUETRAL BONE

The **triquetral bone** *(os triquetrum)* (Fig. 137) occupies the extreme medial ('ulnar') position in the proximal row of the carpal bones. Its superior surface is convex and carries an articular facet for articulation with the distal part of the forearm.

The lateral part of the triquetral bone has a flat articular facet for articulation with the lunate bone; the inferior slightly concave surface articulates with the hamate bone, the palmar surface unites with the pisiform bone.

THE PISIFORM BONE

The **pisiform bone** *(os pisiforme)* (Fig. 138) is ovoid. It is related to the **sesamoid bones** *(ossa sesamoidea)* and is situated within the tendon of the flexor carpi ulnaris muscle. On the dorsal surface the pisiform bone carries a small articular facet by means of which it articulates with the triquetral bone.

THE TRAPEZIUM BONE

The **trapezium bone** *(os trapezium* s. *multangulum)* (Fig. 139) is distal to the scaphoid bone and occupies the extreme lateral ('radial') position in the distal row of the carpal bones. Its superior surface bears an articular facet for articulation with the scaphoid bone. The inferior surface of the trapezium bone has a saddle-shaped articular facet which articulates with the base of the first metacarpal bone. The medial part of the trapezium carries two concave articular facets: a superior, larger, and an inferior, smaller. The first is for articulation with the trapezoid bone, and the second for union with the base of the second metacarpal bone.

On the anterior (palmar) surface of the trapezium, in the lateral part, is a small ridge called the **tubercle,** or **crest of the trapezium bone** *(tuberculum ossis trapezii* s. *multanguli).* Medially to it is a groove lodging the tendon of the flexor carpi radialis muscle.

THE TRAPEZOID BONE

The **trapezoid bone** *(os trapezoideum)* (Fig. 140) is located next to the trapezium. Its inferior saddle-shaped articular surface unites with the second metacarpal bone.

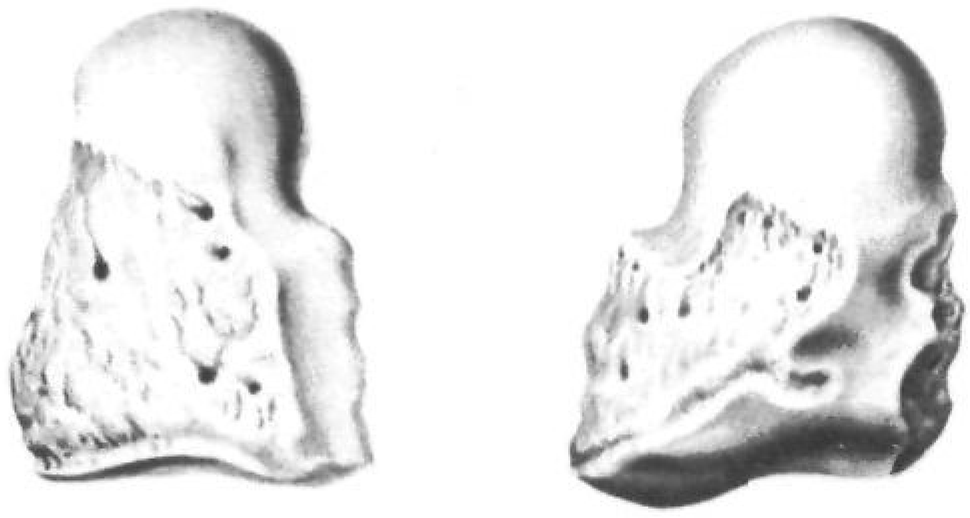
The superior surface of the trapezoid bone is concave and articulates with the scaphoid bone; the lateral, slightly convex surface unites with the trapezium bone, and the medial, concave surface articulates with the capitate bone.

THE CAPITATE BONE

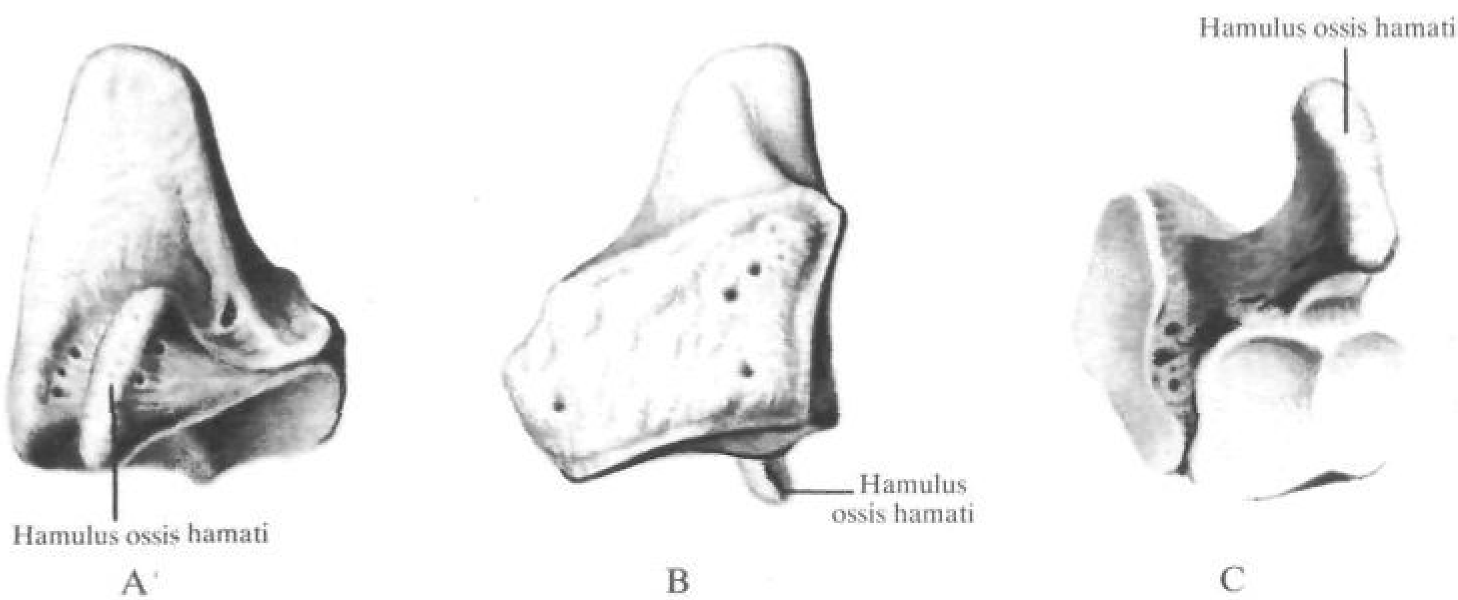
The **capitate bone** *(os capitatum)* (Fig. 141) is the largest of the carpal bones and carries a spherical head in the proximal part. The remaining part of the bone is rather thick. Its medial surface articulates with the hamate bone; the lateral, slightly convex surface articulates with the trapezoid bone. The inferior surface of the capitate bone articulates with the base of the third metacarpal bone by means of a flat articular facet; the lateral surfaces bear small articular facets for articulating with the bases of the second and fourth metacarpal bones.

THE HAMATE BONE

The **hamate bone** *(os hamatum)* (Fig. 142) is located next to the capitate bone and occupies the extreme medial ('ulnar') position in the distal row of the carpal bones. On its anterior (palmar) surface is a well-developed projection which is slightly curved laterally (in the 'ulnar' direction); it is called the **hook of the hamate bone** *(hamulus ossis hamati)*. The proximal surface of the hamate bone articulates with the lunate bone, the lateral surface with the capitate bone, and the medial, slightly convex surface articulates with the triquetral bone. The distal surface of the bone carries two articular facets for articulation with the fourth and fifth metacarpal bones.



141. *Right capitate bone (os capitatum)* ($^3/_2$).
A—palmar surface; B—dorsal surface.



142. *Right hamate bone (os hamatum)* ($^3/_2$).
A—palmar surface; B—dorsal surface;
C—distal surface.

THE CARPUS

The **carpus** is formed by the bones described above and the articulations and ligaments which join them.

The superior, or proximal border of the carpus faces the forearm bones and is more convex transversely.

The superior, or distal border is relatively flat. The posterior, or dorsal surface of the carpus is convex.

The anterior (palmar) surface of the carpus is concave and is called the **carpal sulcus** *(sulcus carpi)*. The sulcus is bounded laterally by the radial carpal eminence formed by the tubercles of the scaphoid and trapezium bones and medially by the ulnar carpal eminence consisting of the pisiform bone and the hook of the hamate bone.

Some of the carpal bones are easily felt through the skin. The scaphoid bone, for instance, is felt a little below and to the back of the lateral styloid process; the lunate bone is felt next to the scaphoid on the dorsal surface of the carpus; the pisiform bone can be palpated when the hand is partly flexed at the wrist joint; the capitate bone is felt on the dorsal surface of the carpus, better in flexion at the wrist.

THE METACARPAL BONES

The **metacarpal bones** *(ossa metacarpalia)* (Figs 111, 132-134) are five small tubular bones. They are numbered in sequence from the lateral (radial) to the medial (ulnar) border of the hand.

A shaft (body) and two ends, upper and lower, are distinguished in each bone.

The **shaft** *(corpus)* has three surfaces: posterior (dorsal), lateral (radial), and medial (ulnar). The lateral and medial surfaces are separated by a small ridge bearing a **nutrient foramen** *(foramen nutricium)* which is continuous with a **nutrient canal** *(canalis nutricius)*. The canal in the second to fifth metacarpal bones runs proximally, while the canal in the first metacarpal extends distally.

The shaft of the metacarpal bones has a palmar concavity.

The upper (proximal) end of a metacarpal bone is called the **base** *(basis)* and is thick. It carries on its sides articular facets by means of which two adjacent bones articulate. The surface facing the carpal bones bears a facet for articulation with the carpal bones forming the distal row. The articular surfaces of the first and fifth metacarpal bones are saddle-shaped.

The base of the third metacarpal bone has in its posterolateral part the **styloid process of the third metacarpal bone** *(processus styloideus medius* s. *processus styloideus ossis metacarpalis tertii)*.

The lower (distal) end of a metacarpal bone is the rounded **head** *(caput)*. Its sides are rough.

The shaft and head of the metacarpal bone are easily felt through the skin on the dorsal surface.

The spaces between the metacarpal bones are called **interosseous spaces of the metacarpus** *(spatia interossea metacarpi)*.

THE BONES OF THE DIGITS OF THE HAND

The **bones (phalanges) of the digits of the hand** *(ossa digitorum manus)* (Figs 132-134) are small and tubular. The thumb has two phalanges, **proximal** *(phalanx proximalis)* and **distal** *(phalanx distalis)*. In addition to the proximal and distal phalanges, all the other fingers have a **middle phalanx** *(phalanx media)*. A shaft and two ends, upper (proximal) and lower (distal), are distinguished in each phalanx.

The **shaft**, or **body** *(corpus)* of a phalanx has a flat palmar surface which is bounded on the sides by small ridges and bears a **nutrient foramen** *(foramen nutricium)* which is continuous distally with a **nutrient canal** *(canalis nutricius)*.

The upper (proximal) end, or the **base of the phalanx** *(basis phalangis)* is thick and carries an articular facet. The facets of the proximal phalanges articulate with the carpal bones, those of the middle and distal phalanges are separated by a small ridge into two parts for articulation of one phalanx with the other.

The lower (distal) end of the proximal and middle phalanges carries a **head** *(caput phalangis)*.

The lower (distal) end of the distal phalanx bears on its dorsal surface a **tuberosity** *(tuberositas phalangis distalis)*.

Sesamoid bones are lodged in the muscle tendons on the palmar surface in the region of the metacarpophalangeal joints of the thumb and index and little fingers and the interphalangeal joint of the thumb.

DEVELOPMENT AND AGE FEATURES OF THE BONES OF THE UPPER LIMB

The bones of the upper limbs, except for the clavicle, develop as secondary bones (see Figs 3 and 142a). The scapula develops from one main or primary ossification nucleus and from 6 or sometimes 8 secondary, or accessory nuclei. The main nucleus appears in the centre of the future scapula at the end of the second month of intrauterine development and gives rise to almost the whole bone. The accessory nuclei appear at different periods between the ages of 11 and 18 years and contribute to the formation of the processes, glenoid cavity, and the inferior angle and medial border of the scapula. All parts of the scapula fuse completely at the age of 20 to 24 years.

The clavicle is the first bone to begin ossification and the last to be completely ossified. It forms from two ossification centres: the main one gives rise to the greater part of the clavicle, the other gives origin to a small segment of the sternal end of the bone. The main ossification centres appear at the end of the first or the beginning of the second month of the intrauterine period, the sternal end of the bone develops later and its ossification begins at the age of 20-21 years. All parts of the clavicle fuse by the age of 23 or 24 years.

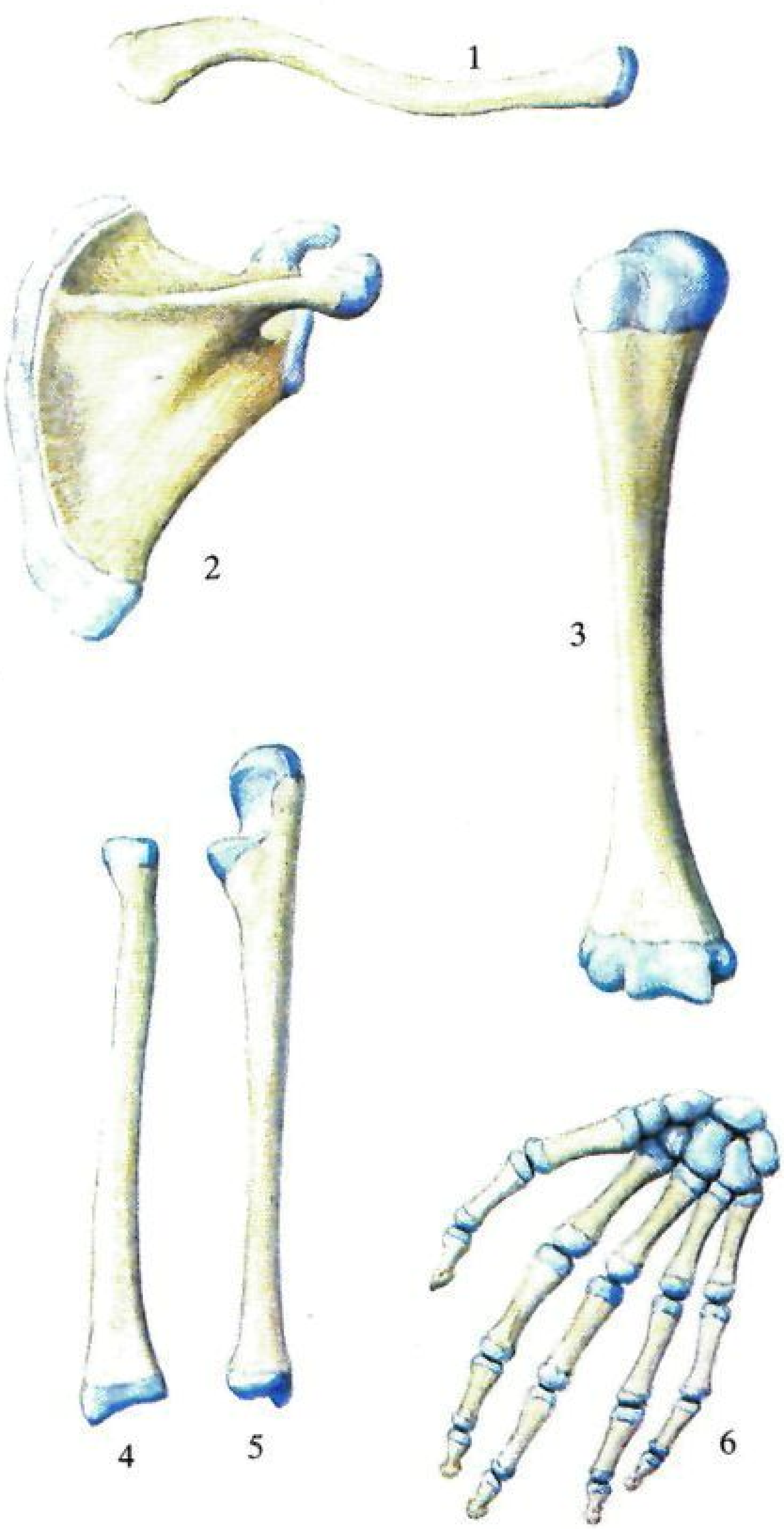
The humerus develops from eight ossification centres, one main, primary, and seven accessory, secondary centres. The primary nucleus appears in the second month of the intrauterine period and gives origin to the whole shaft and the medial epicondyle. All secondary nuclei appear after birth, three of them give rise to the proximal epiphysis, and the other four to the distal epiphysis. These secondary ossification nuclei appear in the first year of life or much later (e.g. the nucleus of the lateral epiphysis appears by the age of 11 years), the proximal a little earlier than the distal nuclei; secondary ossification nuclei appear earlier in girls than in boys. The time of complete ossification also differs. The proximal epiphysis and the shaft fuse at 20-25 years of age, the distal epiphysis fuses with the shaft by the age of 20.

The ulna develops from three centres. One is the primary ossification centre which appears in the second month of the intrauterine period and gives rise to the shaft of the bone. The other two (sometimes three) are secondary centres. One appears at the age of 8 to 12 years and gives origin to the proximal epiphysis and the other appears at 6 to 9 years and gives rise to the distal epiphysis. All parts fuse with the shaft by the age of 18 to 22 years.

The radius develops from four ossification centres, one is a primary centre for the shaft, two are secondary centres for the proximal and distal epiphyses, and the fourth is a secondary centre for the tuberosity of the radius. The fourth centre appears at the age of 14 and fuses with the diaphysis by 18 years. The primary nucleus forms in the second month of intrauterine life, the proximal nucleus at the age of 5 or 6 years, and the distal nucleus appears at the age of 2 or 3. The proximal epiphysis joins the shaft between the ages of 16 and 17, the distal epiphysis fuses with the shaft in the second year of life.

The bones of the hand develop in the following manner. The eight carpal bones remain cartilaginous until birth. Each develops from its own ossification centre. Ossification of the separate bones occurs in the following order: the capitate bone ossifies from an ossification centre in cartilage in the first year of life, the hamate bone at the beginning of the second year, the triquetral bone at the end of the second year, the lunate bone at the end of the fourth year, the trapezium at the age of 5, the scaphoid in the middle of the fifth year, the trapezoid at the age of 6, and the pisiform bone ossifies between the ages of 8 and 10 years. All metacarpal bones develop in cartilage. Each bone has two ossification centres, one is primary, diaphyseal, and the other is secondary, epiphyseal. The primary centres appear during the third month of intrauterine life and give origin to the shaft and base (except for the first metacarpal bone whose shaft and head arise from the primary centre, while the base forms from the secondary centre). The secondary ossification centres appear at the age of 3-4-5 years; the epiphyses join the shaft at 14-16 years of age.

Each phalanx develops in cartilage from two ossification nuclei: primary and secondary (accessory). The primary, diaphyseal nucleus, gives rise to the shaft and head of the phalanx, the epiphyseal nucleus gives origin to the base. The diaphyseal nucleus appears in all phalanges at the end of the second or beginning of the third month of intrauterine life, the epiphyseal nucleus forms at the age of 2 or 3. The ossification nuclei fuse between the ages of 16 and 20.



142a. *Bones of right upper limb (ossa membri superioris) of the newborn.*

1—clavicle
2—scapula
3—humerus
4—radius
5—ulna
6—bones of hand (ossa manus)

THE BONES OF THE LOWER LIMB

Ossa membri inferioris

The **bones of the lower limb** *(ossa membri inferioris)* (Fig. 143) are divided into bones forming the **girdle of the lower limb**, or the **pelvic girdle** *(cingulum membri inferioris)* including the **hip bones** *(ossa coxae)*, the **skeleton of the free lower limb** *(skeleton membri inferioris liberi)* which is represented by the **femur** in the thigh, the **tibia** and **fibula** in the leg, and by the **tarsal bone** *(ossa tarsalia)* and **metatarsal bone** *(ossa metatarsalia)*, and the **phalanges of the digits of the foot** *(ossa digitorum pedis)*.

THE BONES OF THE PELVIC GIRDLE

Both hip bones are joined anteriorly by means of a fibrous cartilage and posteriorly to the sacrum to form a strong ring of bone, the **pelvis**. Hence the name pelvic girdle.

THE HIP BONE

The **hip bone** *(os coxae)* (Figs 143, 144-146) is a composite bone consisting of three separate bones in early childhood; the **ilium** *(os ilium)*, the **ischium** *(os ischii)*, and the **pubis** *(os pubis)*. In the adult these three bones fuse to form the single **hip bone** *(os coxae)*.

The bodies of these bones unite to form the **acetabulum** on the lateral surface of the hip bone.

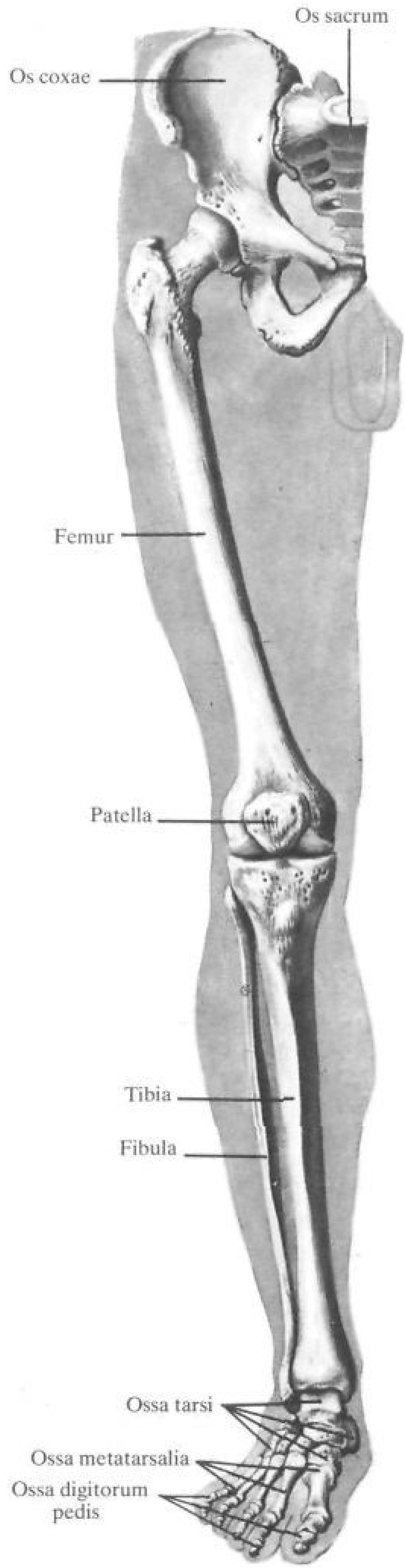
The ilium forms the superior part, the ischium the posteroinferior, and the pubis the anteroinferior part of the acetabulum. In the process of development independent ossification points appear in each of these bones, as a result of which they are joined by means of cartilage to the age of 16-17 years. The cartilage ossifies later and the lines of their junction are not seen.

The **acetabulum** is bounded by a thick edge which is interrupted in the anteroinferior part by the **acetabular notch** *(incisura acetabuli)*.

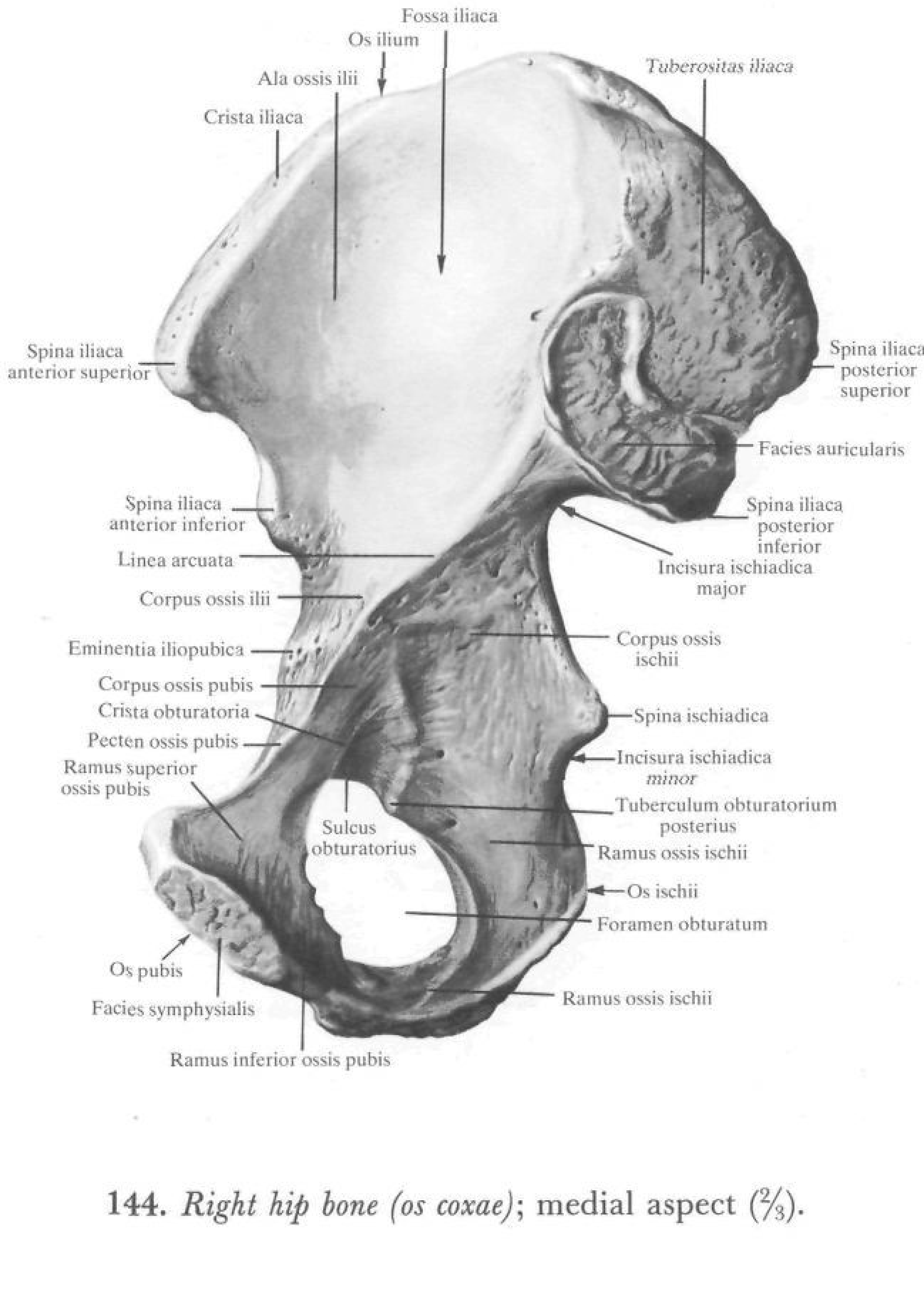
Medially to this edge the internal surface of the acetabulum carries a smooth articular **lunate surface** *(facies lunata)* which bounds the **acetabular fossa** *(fossa acetabuli)* located on the floor of the acetabulum.

THE ILIUM

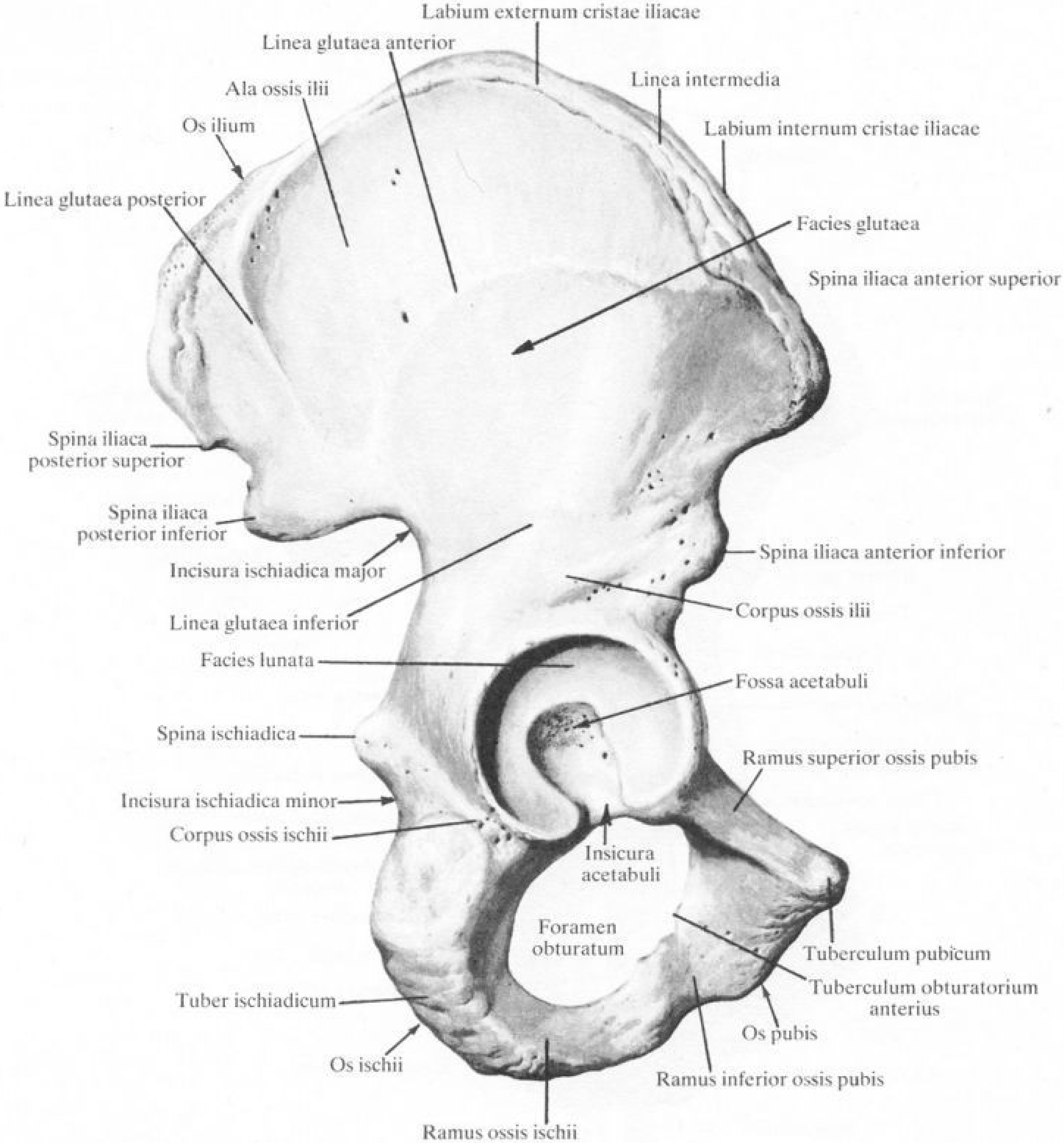
The **ilium** *(os ilium)* (Figs 144-149) is the largest hip bone. Its lower end is thick and is called the **body of the ilium** *(corpus ossis illi)*; it forms the upper part of the acetabulum. The medial surface of the body bears the **arcuate line** *(linea arcuata)* above which is the wide flat part of the bone known as the **ala of the ilium** *(ala ossis ilii)*.



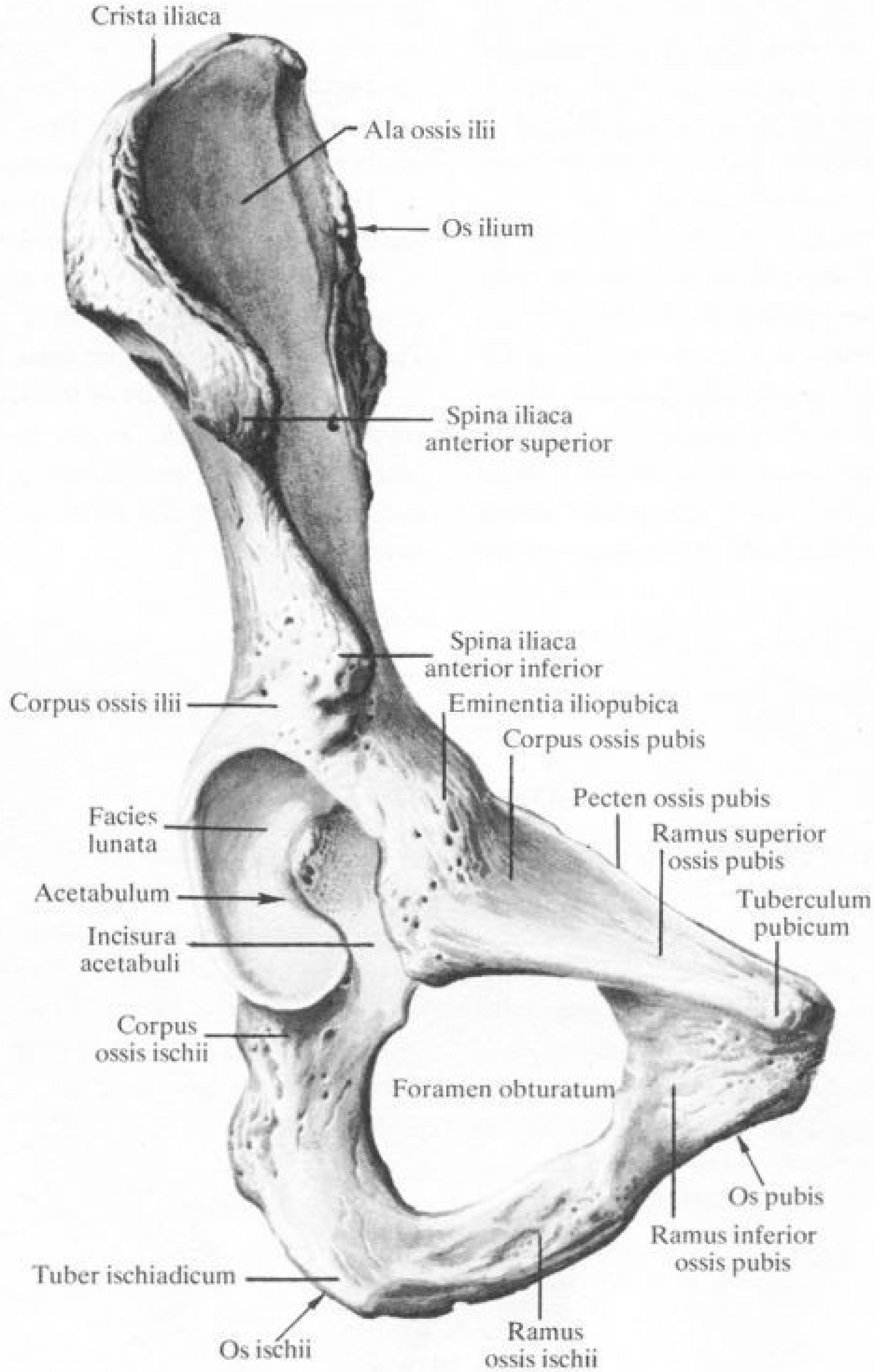
143. *Bones of right lower limb (ossa membri inferioris)*; anterior aspect ($\frac{1}{6}$).



144. *Right hip bone (os coxae)*; medial aspect (⅔).



145. *Right hip bone (os coxae)*; lateral aspect (2/3).



146. *Right hip bone (os coxae)*; anterior aspect (⅔).

The lower part of the ala adjoining the body is narrow, the upper part is wide. The border of the upper part is thick and carries three rough lines, or lips: the **outer lip** *(labium externum)*, the **inner lip** *(labium internum)*, and an **intermediate area** *(linea intermedia)* between them; these lines give attachment to muscles. The upper peripheral border of the ala is called the **iliac crest** *(crista iliaca)*. It is S-shaped and terminates anteriorly as a projection which is easily felt through the skin and is called the **anterior superior iliac spine** *(spina iliaca anterior superior)*. Posteriorly the crest ends as the **posterior superior iliac spine** *(spina iliaca posterior superior)*.

Below the anterior superior spine the anterior end of the ala has an iliac, or lunate notch which is limited below by the **anterior inferior iliac spine** *(spina iliaca anterior inferior)*. Below the spine the border of the bone curves to the front and reaches the **iliopubic eminence** *(eminentia iliopubica)* which marks the junction of the body of the ilium and the pubis. Below the posterior superior iliac spine the posterior border of the ala carries the **posterior inferior iliac spine** *(spina iliaca posterior inferior)* where the **greater sciatic notch** *(incisura ischiadica major)* arises; the body of the ilium contributes to its formation.

The lateral surface of the ala ilii is called the **gluteal surface** *(facies glutea)* and bears marks of the origin of the gluteus muscles, namely the posterior, anterior, and inferior gluteal lines.

The **posterior gluteal line** *(linea glutea posterior)* is in front of the posterior superior iliac spine and runs from the outer lip of the iliac crest to the base of the superior inferior iliac spine.

The **middle gluteal line** *(linea glutea anterior)* arises from the anterior superior iliac spine, stretches backwards and curves downwards to reach the superior margin of the greater sciatic notch.

The **inferior gluteal line** *(linea glutea inferior)* passes above the superior margin of the acetabulum.

The medial surface of the ala ilii is smooth and slightly concave in the anterior part and is called the **iliac fossa** *(fossa iliaca)*. The inferior margin of the fossa is limited by the arcuate line.

In the posterior part of the medial surface of the ala, above the greater sciatic notch, is the **auricular surface** *(facies auricularis)* bounded in front and below by the paraglenoid sulcus. To the back of and above the auricular surface is the **iliac tuberosity** *(tuberositas iliaca)*.

THE ISCHIUM

The **ischium** *(os ischii)* (Figs 144-149) is made up of two parts: a body *(corpus ossis ischii)* and a **ramus** *(ramus ossis ischii)* which is curved at an angle.

The body of the bone forms the posteroinferior part of the acetabulum. On the posterior surface of the body is a bony projection called the **ischial spine** *(spina ischiadica)*. Above and to the back of the spine is the **greater sciatic notch** *(incisura ischiadica major)*. The body of the bone is continuous downwards with the upper part of the ramus of the ischium. The **lesser sciatic notch** *(incisura ischiadica minor)* is on the posterior surface of this part below the ischial spine. The anterior border of this portion of the ramus bears in its superior part the **posterior obturator tubercle** *(tuberculum obturatorium posterius)*. A thickened area with a rough surface is located on the posteroinferior aspect of the curved segment of the ramus; it is called the **ischial tuberosity** *(tuber ischiadicum)*. The inferior part of the ramus fuses anteriorly with the inferior pubic ramus *(ramus inferior ossis pubis)*.

THE PUBIS

The **pubis** *(os pubis)* (Figs 144-149) is made up of three parts: a **body** *(corpus ossis pubis)* and two **rami**: **superior** *(ramus superior ossis pubis)* and **inferior** *(ramus inferior ossis pubis)*.

The body of the pubis forms the anterior part of the acetabulum and is continuous directly with the superior ramus extending forwards, downwards, and medially.

The superior edge of this ramus is sharp and is called the **pectineal line** *(pecten ossis pubis)*. Its anterior end is the **pubic tubercle** *(tuberculum pubicum)*. The inferior edge of the superior ramus is sharp and is called the **obturator crest** *(crista obturatoria)*. In its anterior part it carries the **anterior obturator tubercle** *(tuberculum obturatorium anterius)*. The superior ramus is continuous anteriorly with the inferior ramus at an angle.

On the medial surface of the pubis is a rough **symphyseal surface** *(facies symphysialis)*.

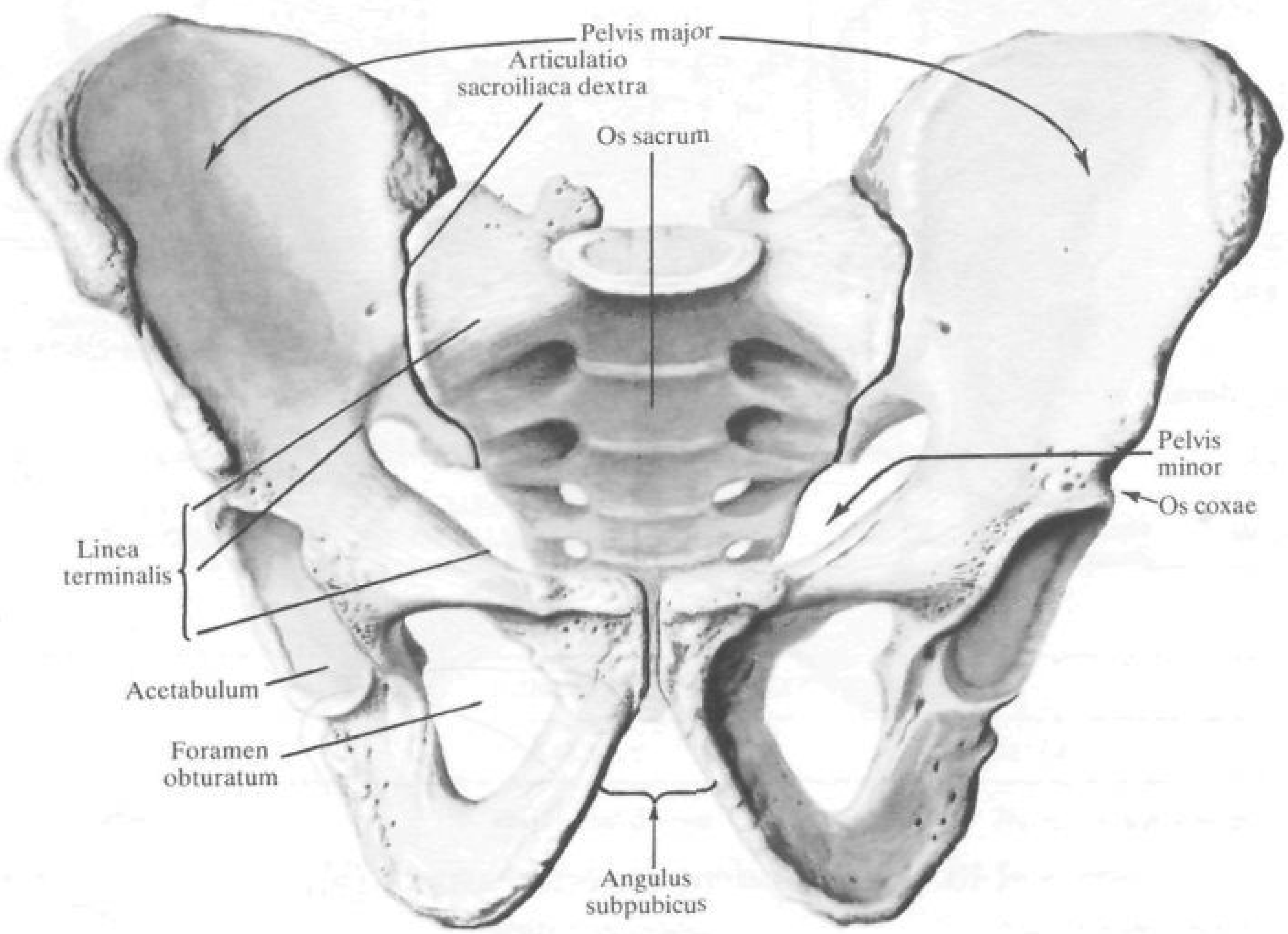
The pubic rami together with the ischium limit the **obturator foramen** *(foramen obturatum)*. The superior edge of this foramen is grooved from back to front and medially by a wide **obturator groove** *(sulcus obturatorius)* lodging the obturator vessels and nerve.

THE PELVIS

The **pelvis** (see Figs 147-149, 150-153) is formed by the two hip bones, the sacrum, the coccyx, and the interpubic cartilage. They are joined by joints, ligaments, and two obturator membranes to form a strong bony ring. A greater (or false) and a lesser (or true) pelvis are distinguished.

The **false (greater) pelvis** *(pelvis major)* is bounded on the sides by the alae of the ilium and posteriorly by the lower lumbar vertebrae and the base of the sacrum. The **arcuate line of the pelvis** *(linea terminalis)* is the inferior boundary of the false pelvis. It runs on the crest of the pubis, then on the arcuate line of the ilium, and passes on the promontorium to the contralateral side where it stretches in a like manner.

The **true (lesser) pelvis** *(pelvis minor)* is below the arcuate line. Its lateral walls are formed by the lower part of the bodies of the



147. *Male pelvis*; anterior aspect (2/5).

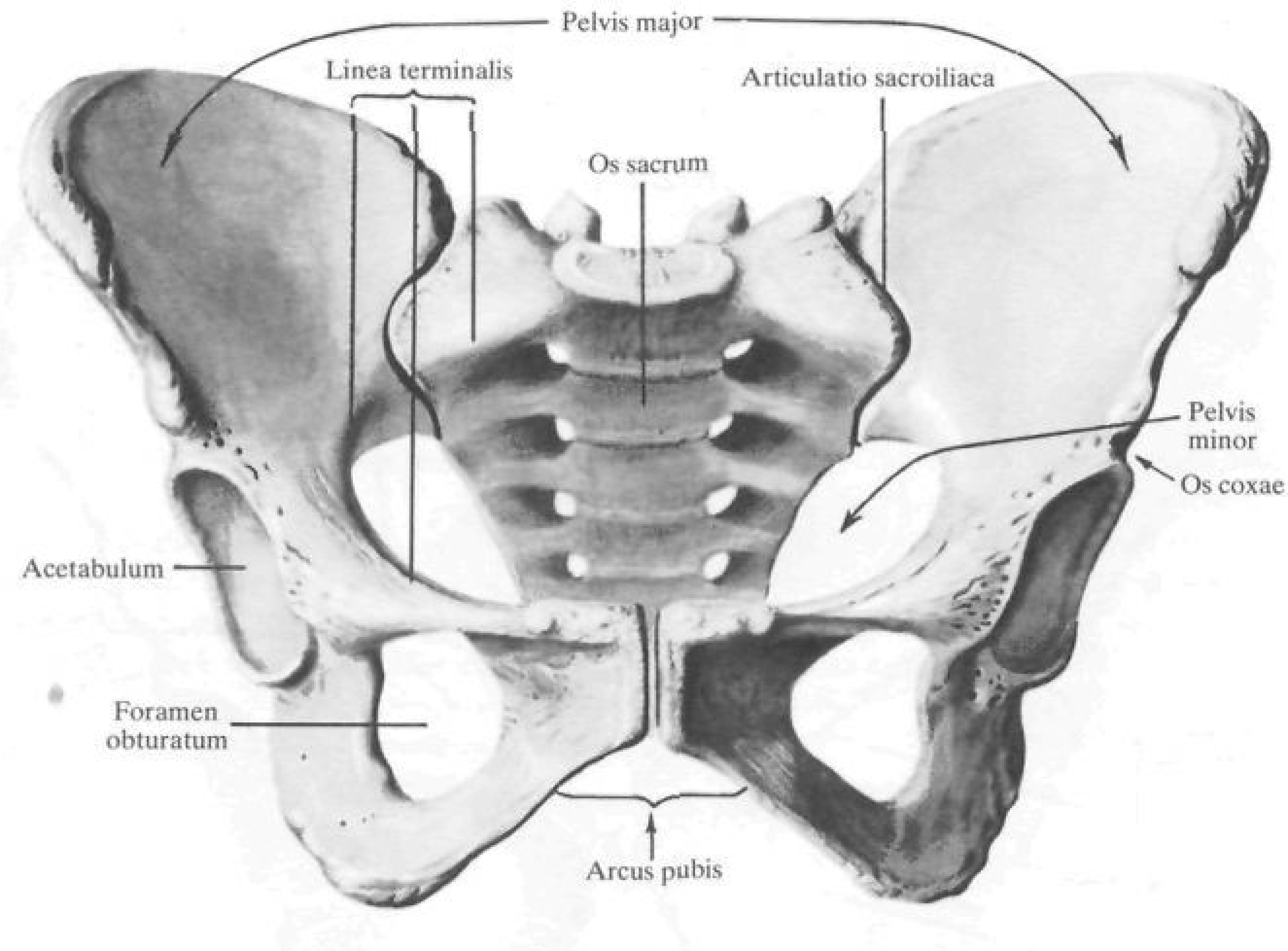
ilia and the ischia, the posterior wall by the sacrum and coccyx, and the anterior wall by the two pubic bones.

The inferior pubic rami meet to form the **subpubic angle** *(angulus subpubicus)* in the male and the **pubic arch** *(arcus pubis)* in the female.

The junction of the false pelvis and the true pelvis, marked by the arcuate line, is the **superior aperture (inlet) of the pelvis** *(apertura pelvis superior)*. The **inferior aperture (outlet) of the pelvis** *(apertura pelvis inferior)* is limited laterally by the ischial tuberosities, posteriorly by the coccyx, and anteriorly by the pubic symphysis and the inferior pubic rami.

The pelvis contains the organs of the alimentary and urogenital systems, large vessels and nerves. Its shape and dimensions are marked by individual features and sexual differences.

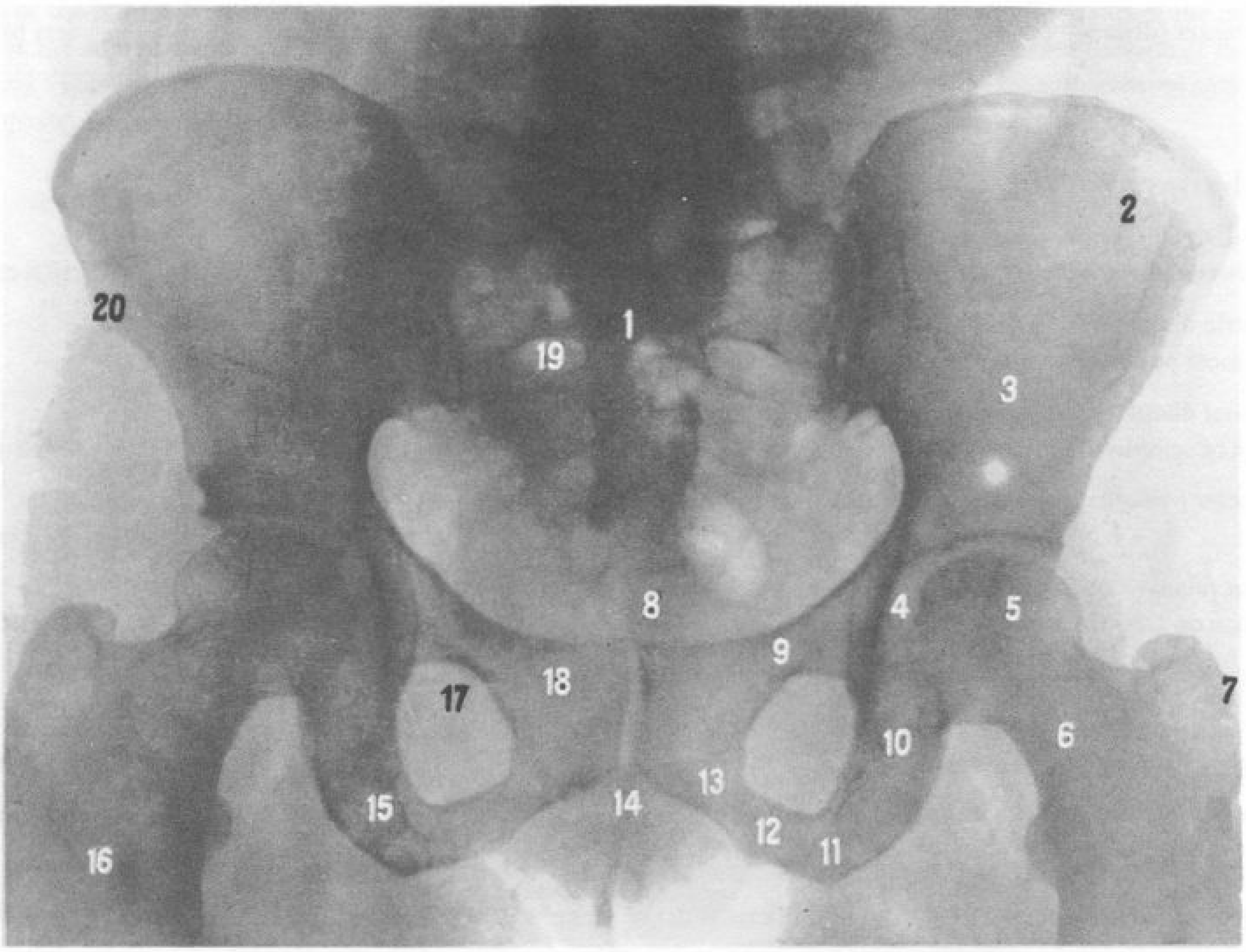
The line connecting the middle points of the straight diameters of the pelvic inlet and outlet is called the **axis of the pelvis** *(axis pelvis)* (Fig. 153). It forms an anterior concavity and runs parallel to the pelvic surface of the sacrum.



148. *Female pelvis*; anterior aspect (2/5).

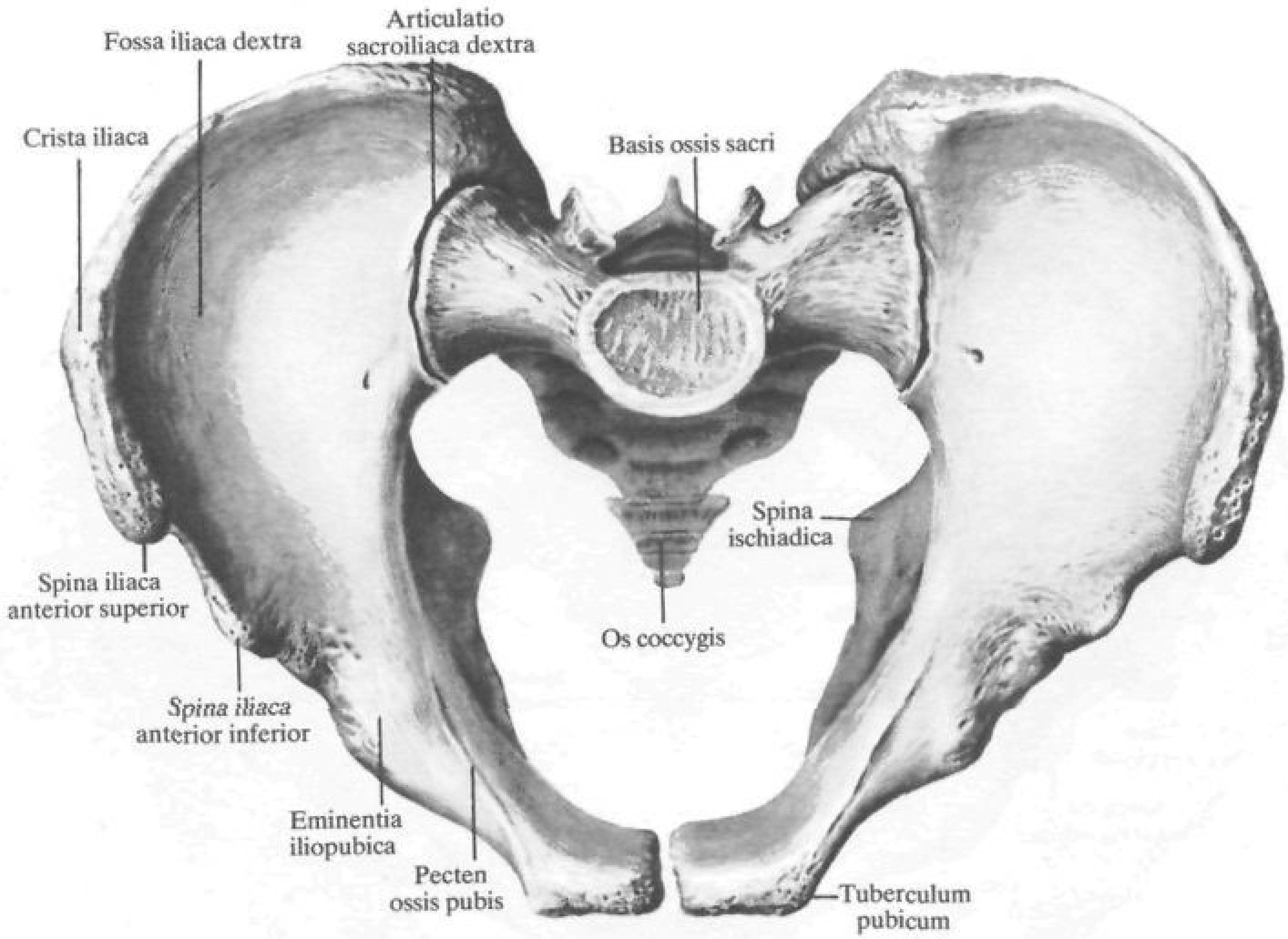
	MEASUREMENTS OF THE PELVIS	
	FEMALE	*MALE*
GREATER (FALSE) PELVIS		
Interspinous diameter (distance between both anterior superior iliac spines)	23–25 cm	less by 2–3 cm
Intercristal diameter (greatest distance between both iliac crests)	25–27 cm	—
LESSER (TRUE) PELVIS		
Inlet *(apertura pelvis superior)*		
Anteroposterior diameter, or anatomic conjugate *(diameter recta seu conjugata anatomica)* (distance between promontorium and superior edge of symphysis)	11.5 cm	10.8 cm
Conjugate obstetric diameter *(conjugata vera s. gynecologica)* (distance between promontorium and most posteriorly prominent point of symphysis)	10.5–11 cm	—
Conjugate diagonal diameter *(conjugata diagonalis)* (distance between promontorium and inferior edge of symphysis)	12.5–13 cm	—
Transverse diameter *(diameter transversa)* (greatest distance between both terminal lines)	13.5 cm	12.8 cm
Oblique diameter *(diameter obliqua)* (distance between sacroiliac joint on one side and iliopubic eminence on the other)	12–12.6 cm	12–12.2 cm
Pelvic cavity *(cavum pelvis)*		
Anteroposterior diameter *(diameter recta)* (distance between articulation of second and third sacral vertebrae and middle of symphysis)	12.2 cm	10.8 cm
Transverse diameter *(diameter transversa)* (distance between centres of acetabula)	11.5 cm	10.8 cm
Outlet *(apertura pelvis inferior)*		
Diameter recta (distance between apex of coccyx and inferior edge of symphysis)	9.5 cm	7.5 cm
Diameter recta (distance between ischial tuberosities)	10.8 cm	8.1 cm
INCLINATION OF PELVIS *(INCLINATIO PELVIS)* IS MEASURED BY THE ANGLE FORMED BY HORIZONTAL PLANE AND PLANE OF PELVIC INLET	55–60°	50–55°

	COMPARATIVE SEX FEATURES OF PELVIS	
	FEMALE	*MALE*
General appearance of pelvis	Wider and shorter	Narrower and higher
Position of alae of ilii	More horizontal	More vertical
Sacrum	Shorter and wider	Narrower and longer
Angle at junction of inferior pubic rami	90–100° (pubic arch)	70–75° (subpubic angle)
Shape of cavity of true pelvis	Cylindrical	Conical
Shape of superior aperture, or inlet of true pelvis *(apertura pelvis superior)*	More rounded	'Card heart' due to marked projection of the promontory forwards

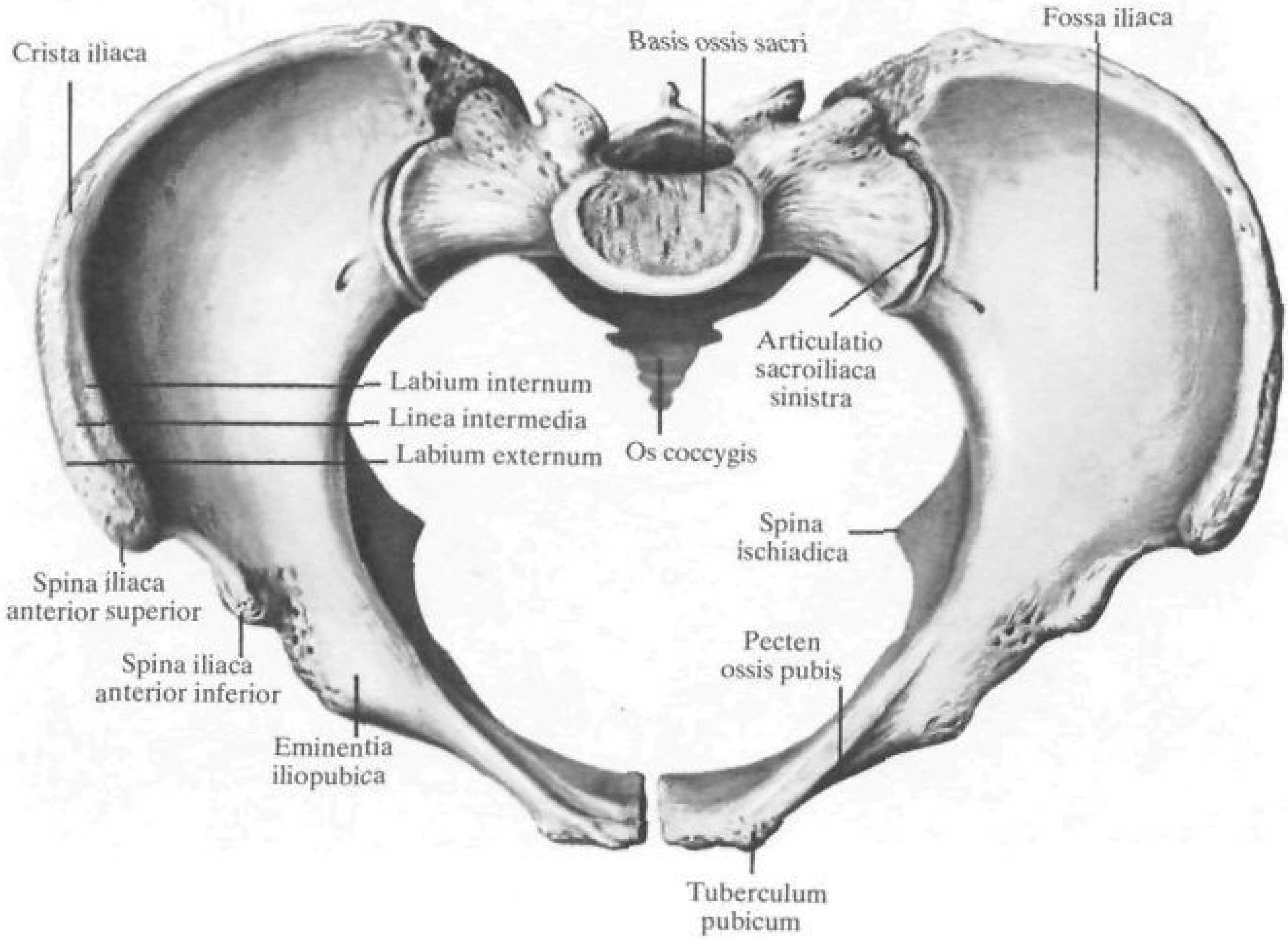


149. *Female pelvis*; anterior aspect (radiograph).

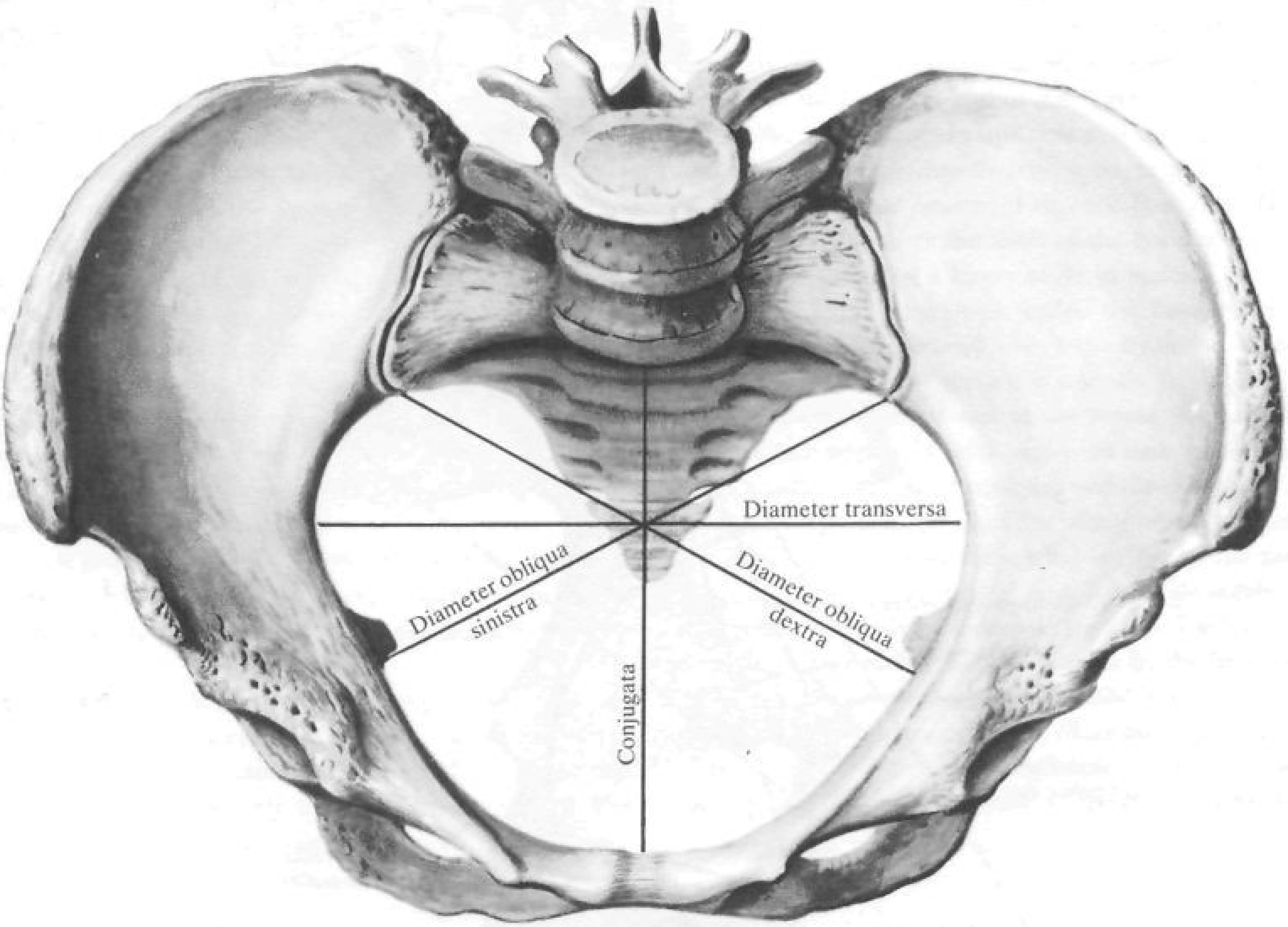
1—sacrum
2—ala of ilium
3—ilium
4—acetabulum
5—head of femur
6—neck of femur
7—greater trochanter
8—coccyx
9—superior ramus of pubis
10—upper part of ischial ramus
11—ischial tuberosity
12—lower part of ischial ramus
13—inferior ramus of pubis
14—pubic arch
15—ischium
16—femur
17—obturator foramen
18—pubis
19—anterior sacral foramen
20—anterior superior iliac spine



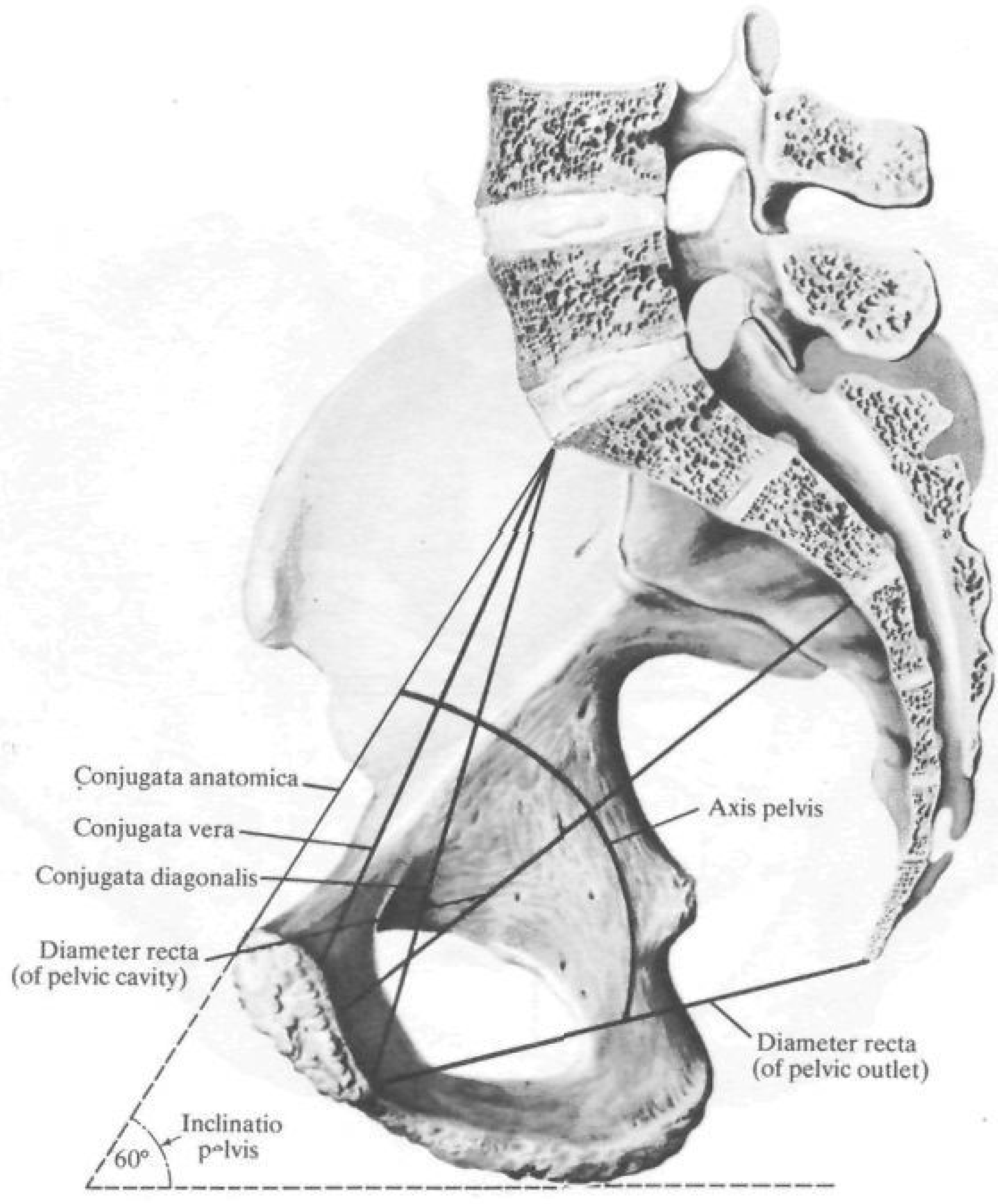
150. *Male pelvis (pelvis masculinum)*; superior aspect (2/5).
(Superior aperture, or inlet of pelvis.)



151. *Female pelvis (pelvis femininum)*; superior aspect (⅖).
(Superior aperture, or inlet of pelvis.)



152. *Diameters of superior aperture (inlet) of pelvis* ($^2/_5$).



153. *Diameters of true (lesser) pelvis* (2/5).

THE SKELETON OF THE FREE LOWER LIMB

THE FEMUR

The **femur** (see Figs 143; 154–157, 159) is the longest and thickest tubular bone in the human skeleton. A body (shaft) and two ends, upper and lower, are distinguished in it.

The **body (shaft) of the femur** *(corpus femoris)* is cylindrical, slightly twisted about the axis and curved forwards. Its anterior surface is smooth, the posterior surface carries a rough **linea aspera** which gives attachment to muscles. The line is divided into two lips, lateral and medial. The **lateral lip** *(labium laterale)* deviates laterally in the lower third of the bone and passes to the lateral condyle; in the upper third it is continuous with the **gluteal tuberosity** *(tuberositas glutea)*. The **medial lip** *(labium mediale)* deviates in the lower third of the femur towards the medial condyle and together with the lateral lip limits a triangular **popliteal surface** *(facies poplitea)*. In the upper part the medial lip is continuous with the **spiral line** *(linea pectinea)*. Approximately in the middle part of the shaft, to the side of the linea aspera is a **nutrient foramen** *(foramen nutricium)* which leads into a proximally running **nutrient canal** *(canalis nutricius)*.

The upper, or **proximal end of the femur** *(extremitas superior*, s. *epiphysis proximalis femoris)* carries two rough prominences at the junction with the shaft. These are the greater and lesser trochanters.

The **greater trochanter** *(trochanter major)* projects upwards and backwards and occupies the lateral part of the proximal end of the bone. Its lateral surface can be easily felt through the skin, the medial surface carries the **trochanteric fossa** *(fossa trochanterica)*. The **trochanteric line** *(linea intertrochanterica)* runs on the anterior surface of the femur from the tip of the greater trochanter downwards and medially and is continuous with the spiral line. The **trochanteric crest** *(crista intertrochanterica)* runs in the same direction but on the posterior surface of the proximal end and terminates at the **lesser trochanter** *(trochanter minor)* situated on the posteromedial surface of the proximal end of the bone. The rest of the proximal end of the femur projects upwards and medially and is called the **neck of the femur** *(collum femoris)*; it terminates as a spherical **head of the femur** *(caput femoris)*. The neck is slightly flattened in the frontal plane. It meets the shaft of the bone at an angle of about 90° in females and at a larger angle in males. The head carries on its surface a small rough pit called the **fossa of the head of the femur** *(fovea capitis femoris)* where the ligament of the head is attached; the rest of the surface is smooth.

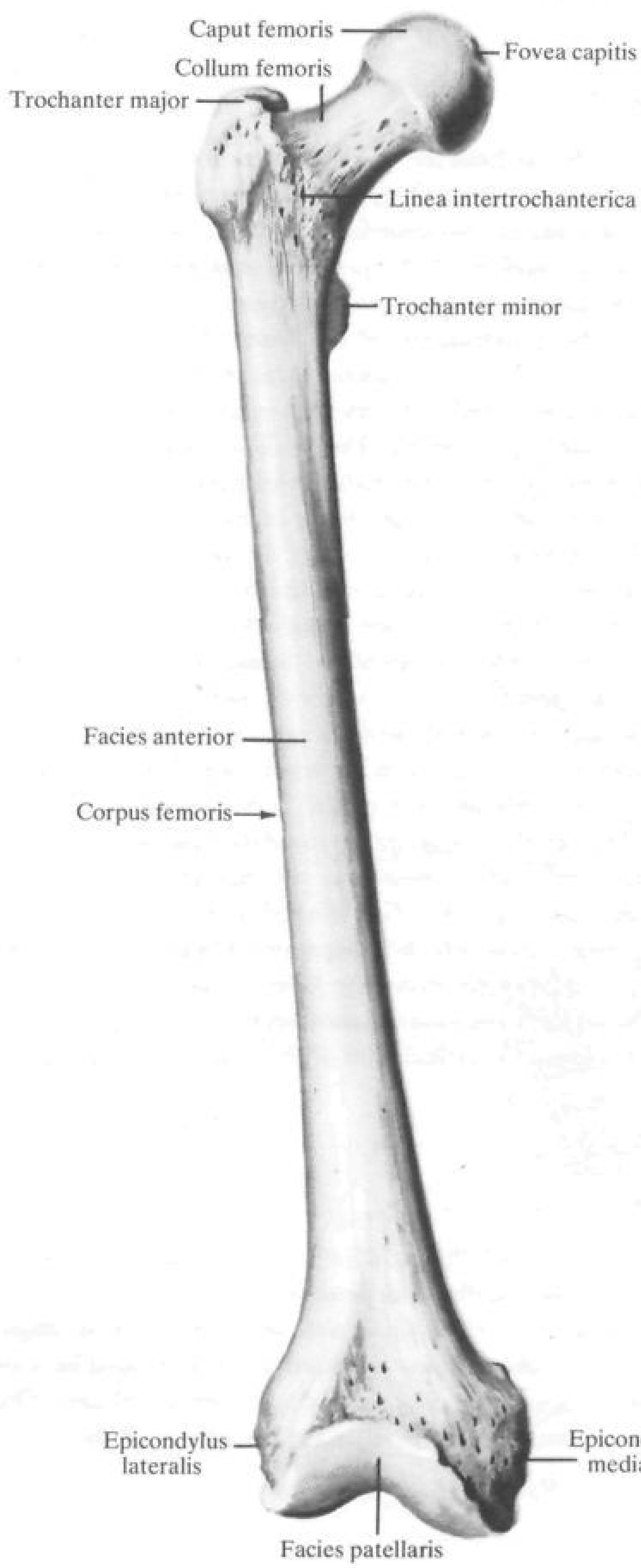
The lower, or **distal end of the femur** *(extremitas inferior* s. *epiphysis distalis femoris)* is thick and wide and terminates as two **condyles, medial** and **lateral** *(condylus medialis* et *condylus lateralis)*. The medial condyle is larger than the lateral one. The lateral surface of the lateral condyle and the medial surface of the medial condyle carry, respectively, the **lateral epicondyle** *(epicondylus lateralis)* and the **medial epicondyle** *(epicondylus medialis)*. The surfaces of the two condyles facing each other are limited by the **intercondylar notch** *(fossa intercondylaris)* which is separated above from the popliteal surface by the **intercondylar line** *(linea intercondylaris)*. The surfaces of both condyles are smooth and fuse to form the **patellar surface** *(facies patellaris)* for articulation of the patella with the femur.

THE PATELLA

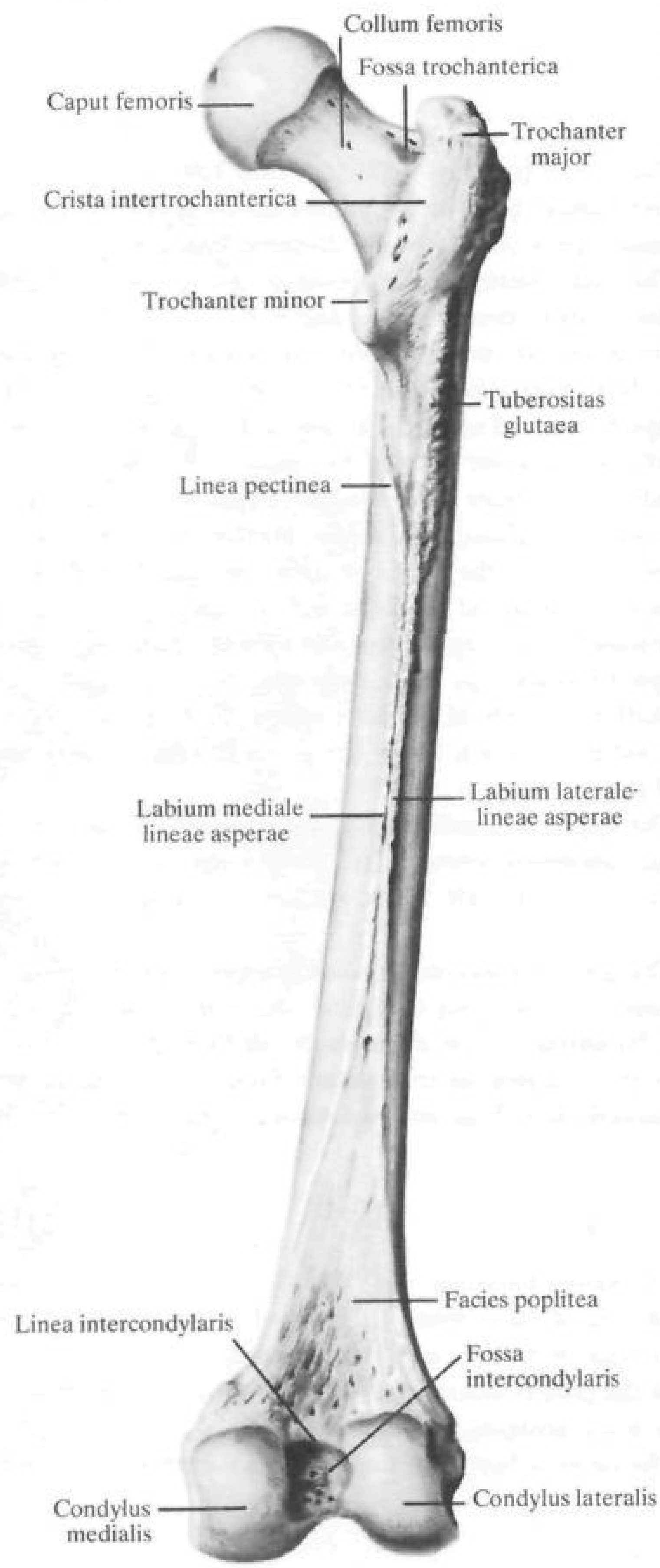
The **patella knee cap** (see Figs 143, 158, 159) is the largest sesamoid bone of the skeleton. It is located in the tendon of the quadriceps femoris muscle and can be easily felt through the skin. When the limb is extended at the knee the patella is easily moved to the sides, upwards, and downwards.

The superior border of the patella is rounded and is called the **base** *(basis patellae)*. The inferior border projects slightly to form the **apex of the patella** *(apex patellae)*.

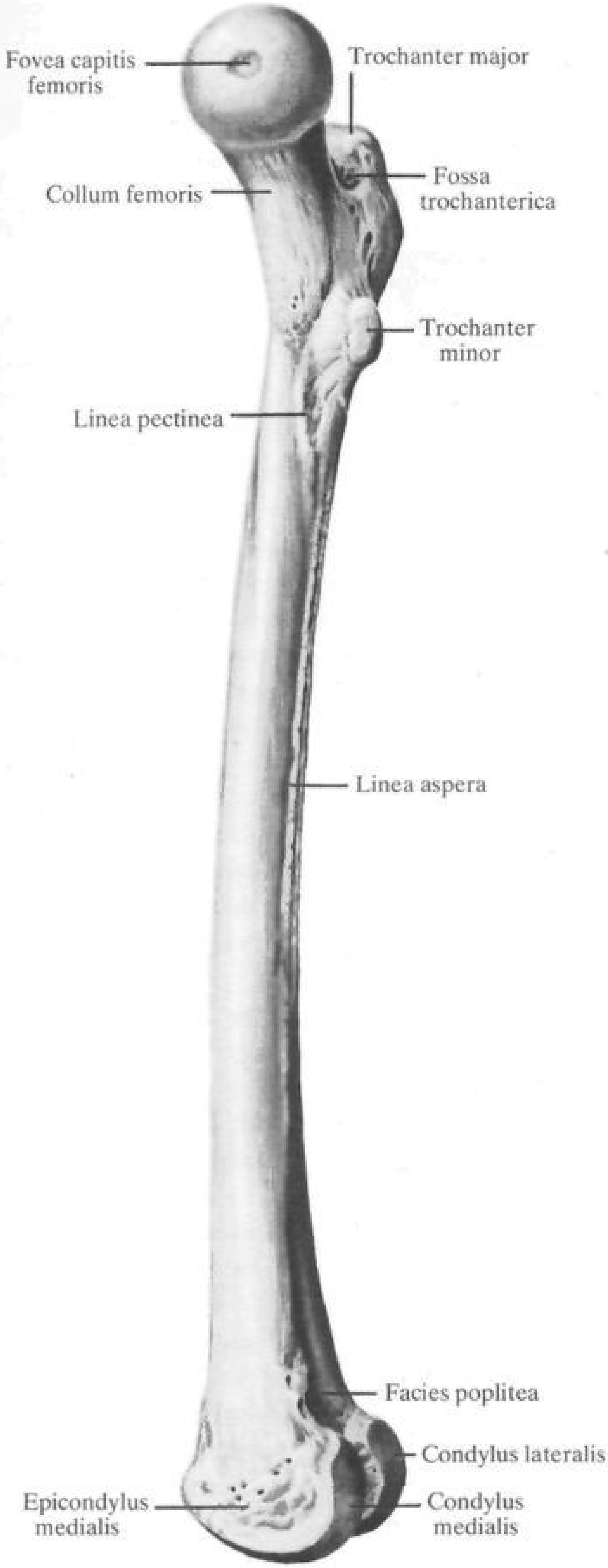
The **anterior surface** *(facies anterior)* of the bone is rough. The posterior, **articular surface** *(facies articularis)* is divided by a vertical ridge into a smaller medial part and a larger lateral part. This surface articulates with the patellar surface of the femur.



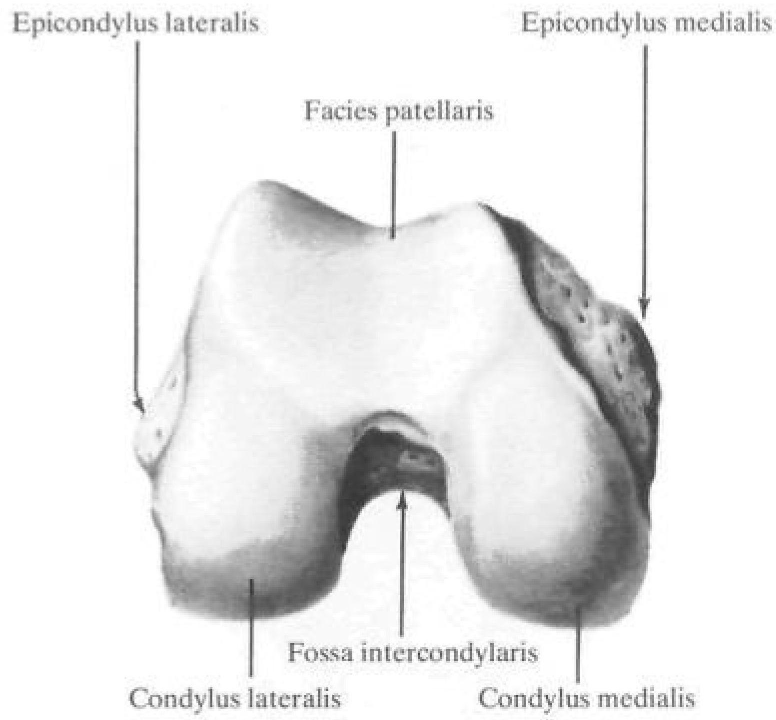
154. *Right femur*; anterior aspect ($\frac{1}{3}$).



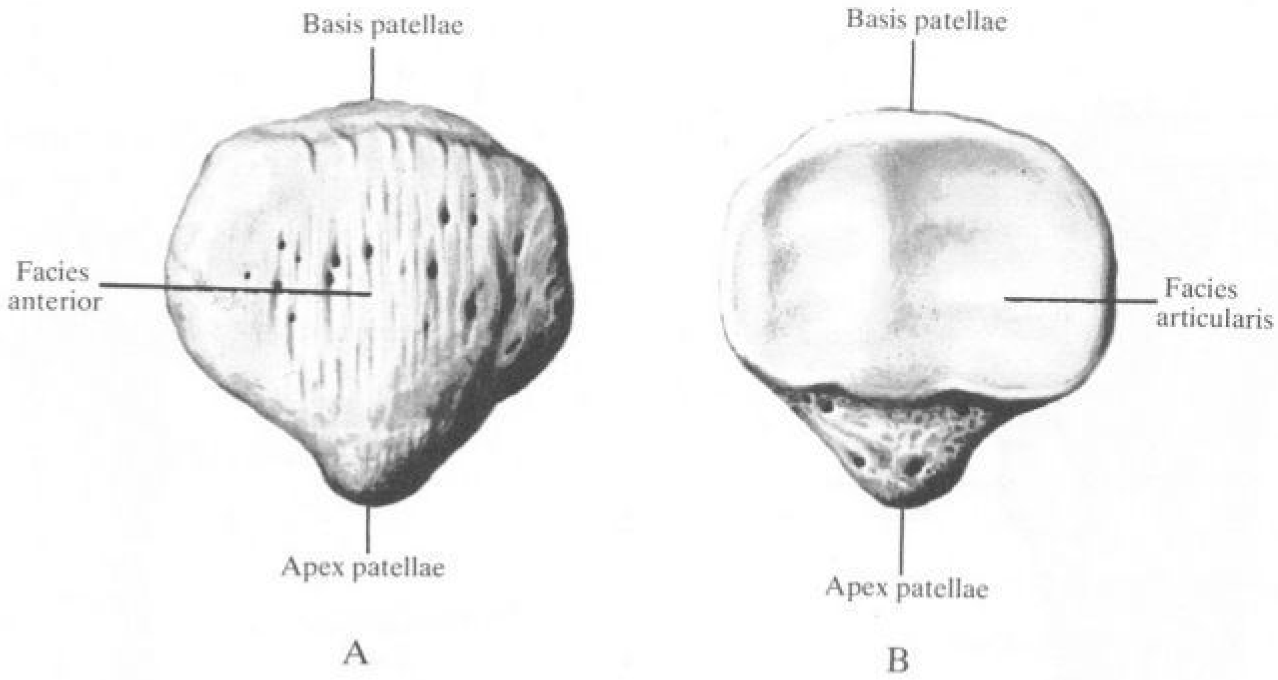
155. *Right femur*; posterior aspect ($\frac{1}{3}$).



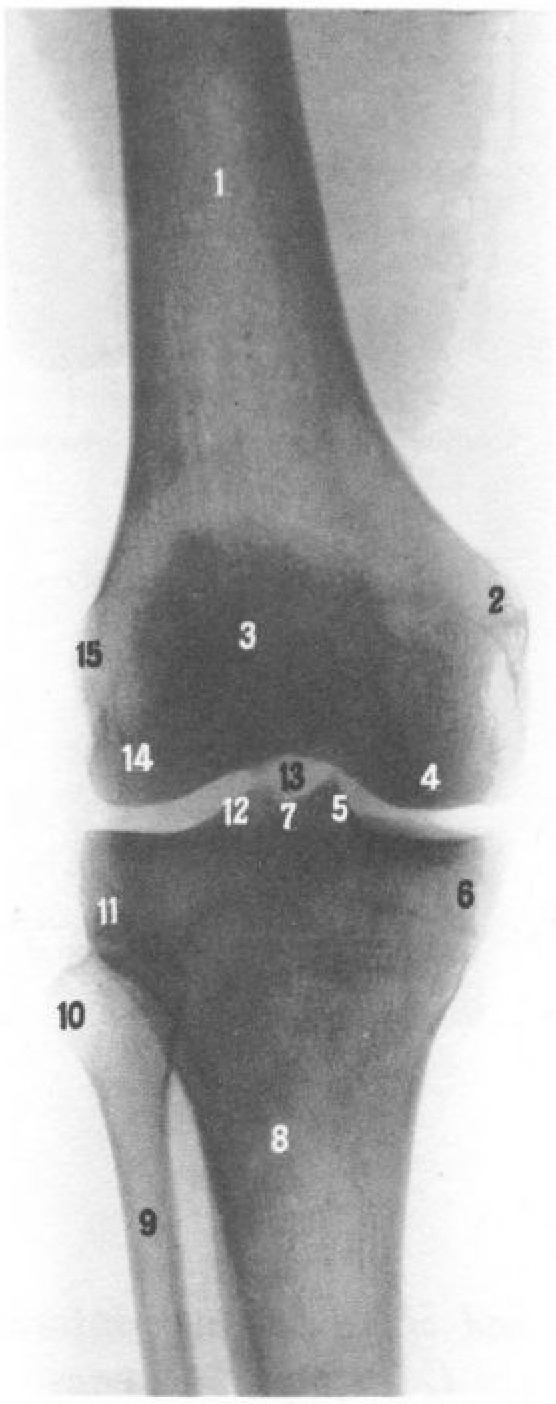
156. *Right femur*; medial aspect (⅓).



157. *Distal end of right femur*; inferior aspect (½).



158. *Right patella* (3/4).
A—anterior aspect; B—posterior aspect.



159. *Distal end of right femur and proximal parts of right tibia and fibula* (radiograph).

1—femur
2—medial epicondyle of femur
3—patella
4—medial condyle of femur
5—medial intercondylar tubercle
6—medial condyle of tibia
7—intercondylar eminence
8—tibia
9—fibula
10—head of fibula
11—lateral condyle of tibia
12—lateral intercondylar tubercle
13—intercondylar notch
14—lateral condyle of femur
15—lateral epicondyle of femur

THE BONES OF THE LEG

The tibia, located medially, and the fibula, located laterally, are the bones of the leg (Fig. 160).

THE TIBIA

The **tibia** (see Figs 143, 159-163, 165) is a long tubular bone. It has a body (shaft) and two ends, upper and lower.

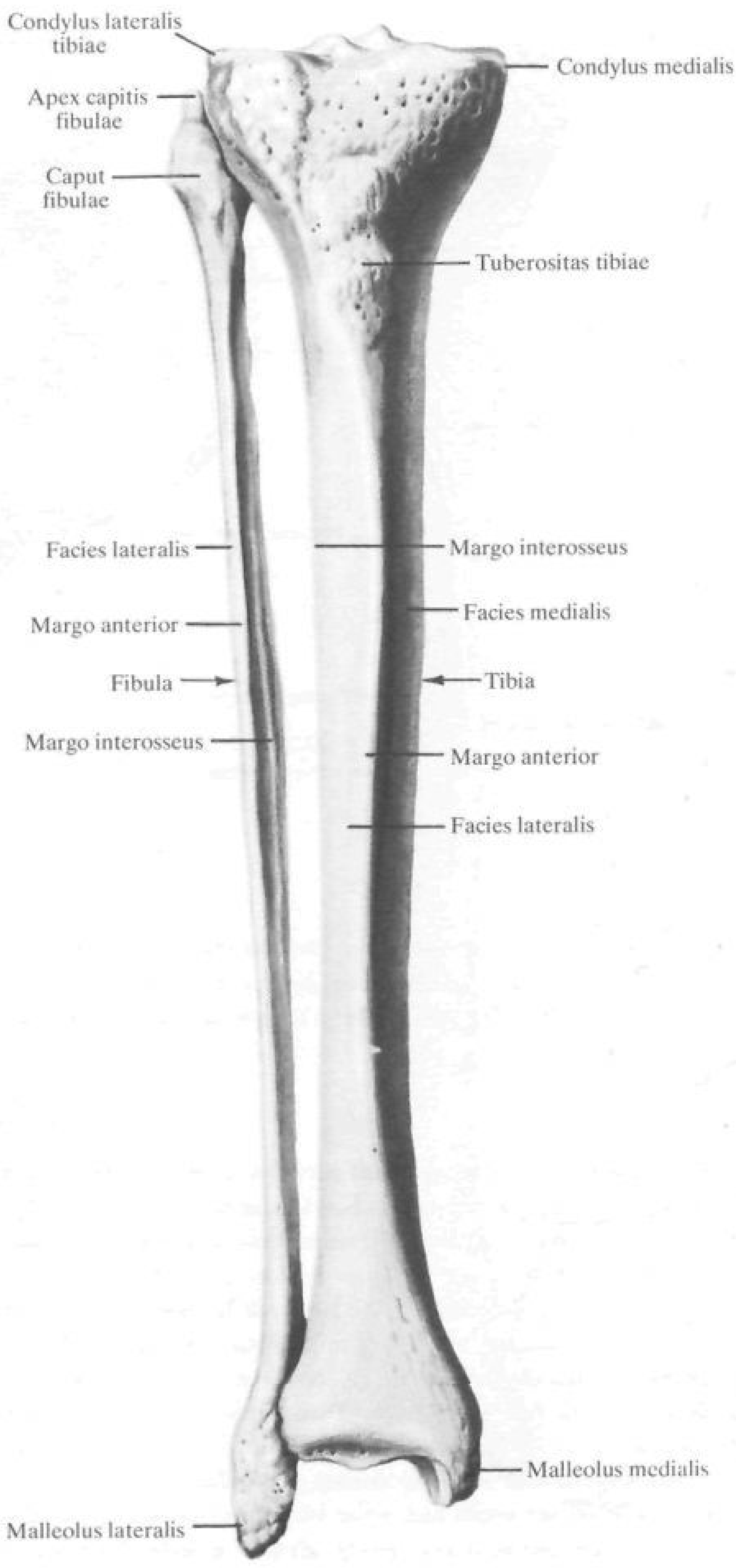
The **body (shaft) of the tibia** *(corpus tibia)* is trihedral. It has three borders: anterior, interosseous (lateral), and medial, and three surfaces: medial, lateral, and posterior.

The **anterior border** *(margo anterior)* is tapered like a ridge and in the upper part of the bone is continuous with the **tubercle of the tibia** *(tuberositas tibiae)*. The **interosseous border** *(margo interosseus)* is sharp and faces the interosseous border of the fibula. The **medial border** *(margo medialis)* is rounded. The **medial**, or **anteromedial surface** of the bone *(facies medialis)* is slightly convex. Like the anterior border limiting it the medial surface can be easily felt through the skin.

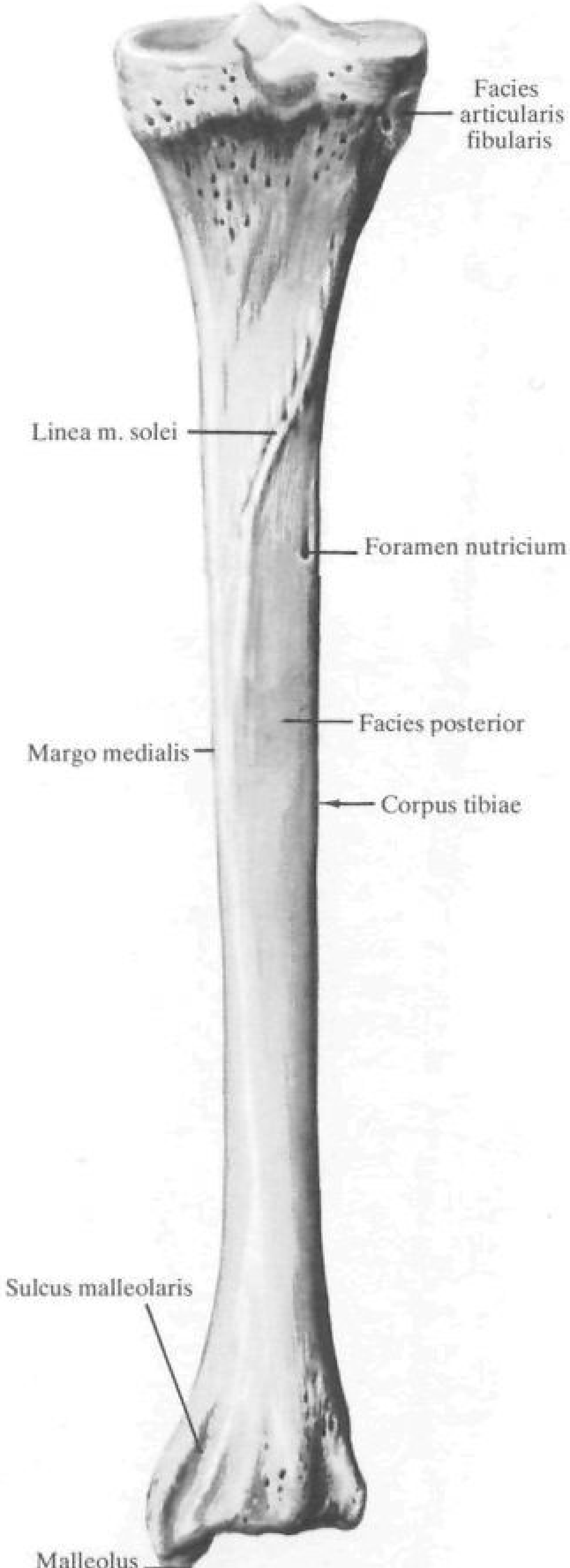
The **lateral**, or **anterolateral surface** of the bone *(facies lateralis)* is slightly concave. The **posterior surface** *(facies posterior)* is flat and bears the **soleal line** *(linea musculi solea)* running from the lateral condyle downwards and medially. Below it is the **nutrient foramen** *(foramen nutricium)* leading into the distally stretching **nutrient canal** *(canalis nutricius)*.

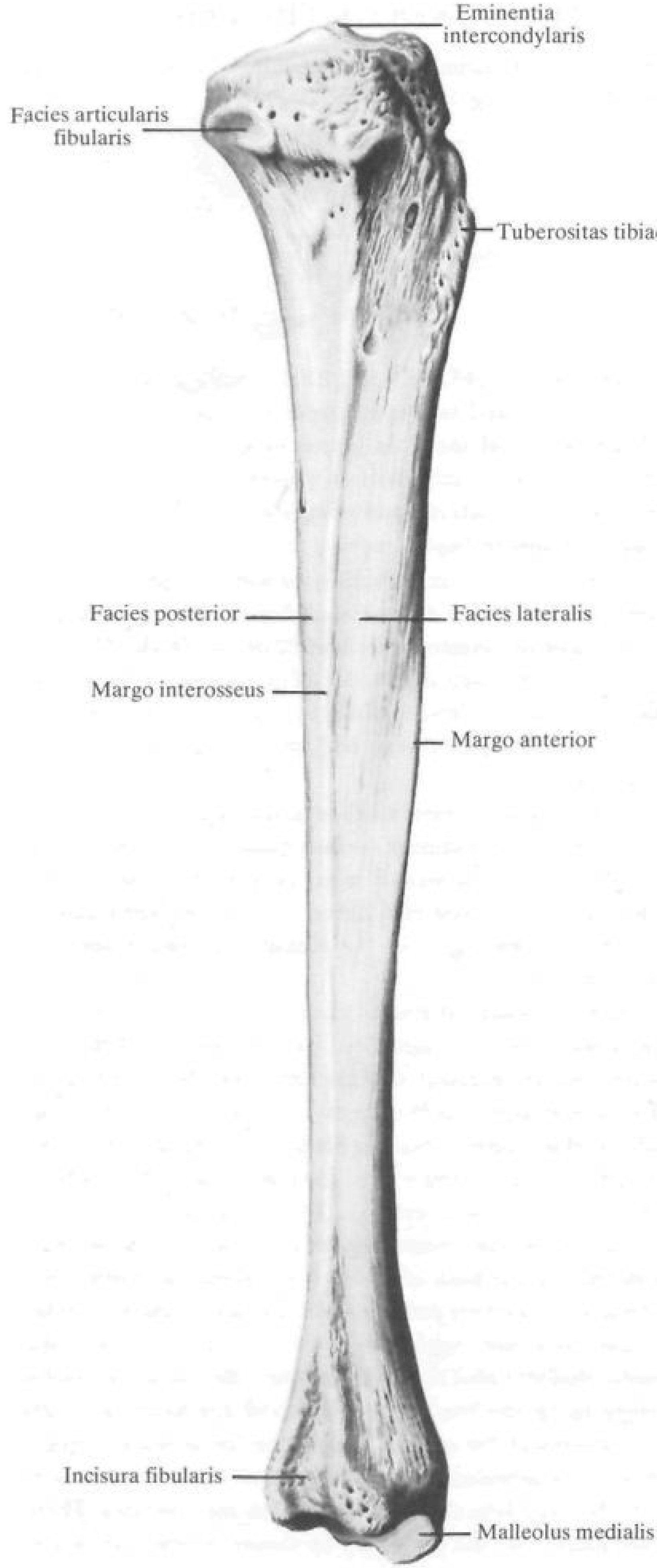
The **upper**, or **proximal end of the tibia** *(extremitas superior* s. *epiphysis proximalis tibiae)* is expanded. Its sides are called the **medial condyle** *(condylus medialis)* and the **lateral condyle** *(condylus lateralis)*. The lateral aspect of the lateral condyle carries a flat **fibular articular surface** *(facies articularis fibularis)*. In the middle of the proximal surface of the upper end of the bone is the **intercondylar eminence** *(eminentia intercondylaris)*. Two tubercles are distinguished in it, the **medial intercondylar tubercle** *(tuberculum intercondylare mediale)* to the back of which is the **posterior intercondylar area** *(area intercondylaris posterior)* and the **lateral intercondylar tubercle** *(tuberculum intercondylaris laterale)* in front of which is the **anterior intercondylar area** *(area intercondylaris anterior)*. Both areas give attachment to the cruciate ligaments of the knee. To both sides of the intercondylar eminence the **superior articular surface** of the bone *(facies articularis superior)* carries two concave articular surfaces, medial and lateral, corresponding to the condyles. These surfaces are limited on the periphery by the infra-articular border of the tibia.

The **lower**, or **distal end of the tibia** *(extremitas inferior* s. *epiphysis distalis tibiae)* is quadrangular. On its lateral surface is the **fibular notch** *(incisura fibularis)* which receives the lower end of the fibula. The **groove for the tibialis posterior muscle** *(sulcus malleolaris)* is situated on the posterior surface of the distal end of the bone. In front of the groove the medial border of the distal end of



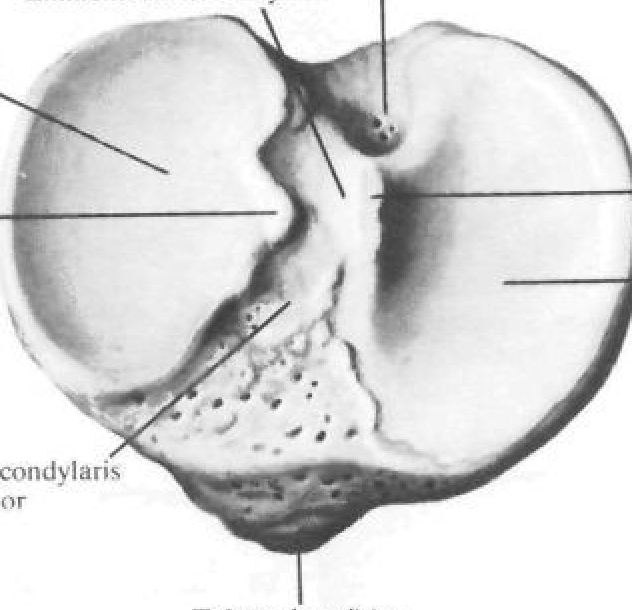
160. *Right tibia and fibula*; anterior aspect ($^2/_5$).





161. *Right tibia*;
posterior aspect (⅖).

162. *Right tibia*;
lateral aspect (⅖).



163. *Proximal end of right tibia*; superior aspect (3/4).

the tibia is continuous downwards with the prominent **medial malleolus** *(malleolus medialis)* which is easily felt through the skin. The lateral surface of the malleolus is occupied by the **articular facet** *(facies articularis malleoli)* which extends to the inferior surface of the bone where it is continuous with the concave **inferior articular surface** *(facies articularis inferior tibiae)* (Fig. 165).

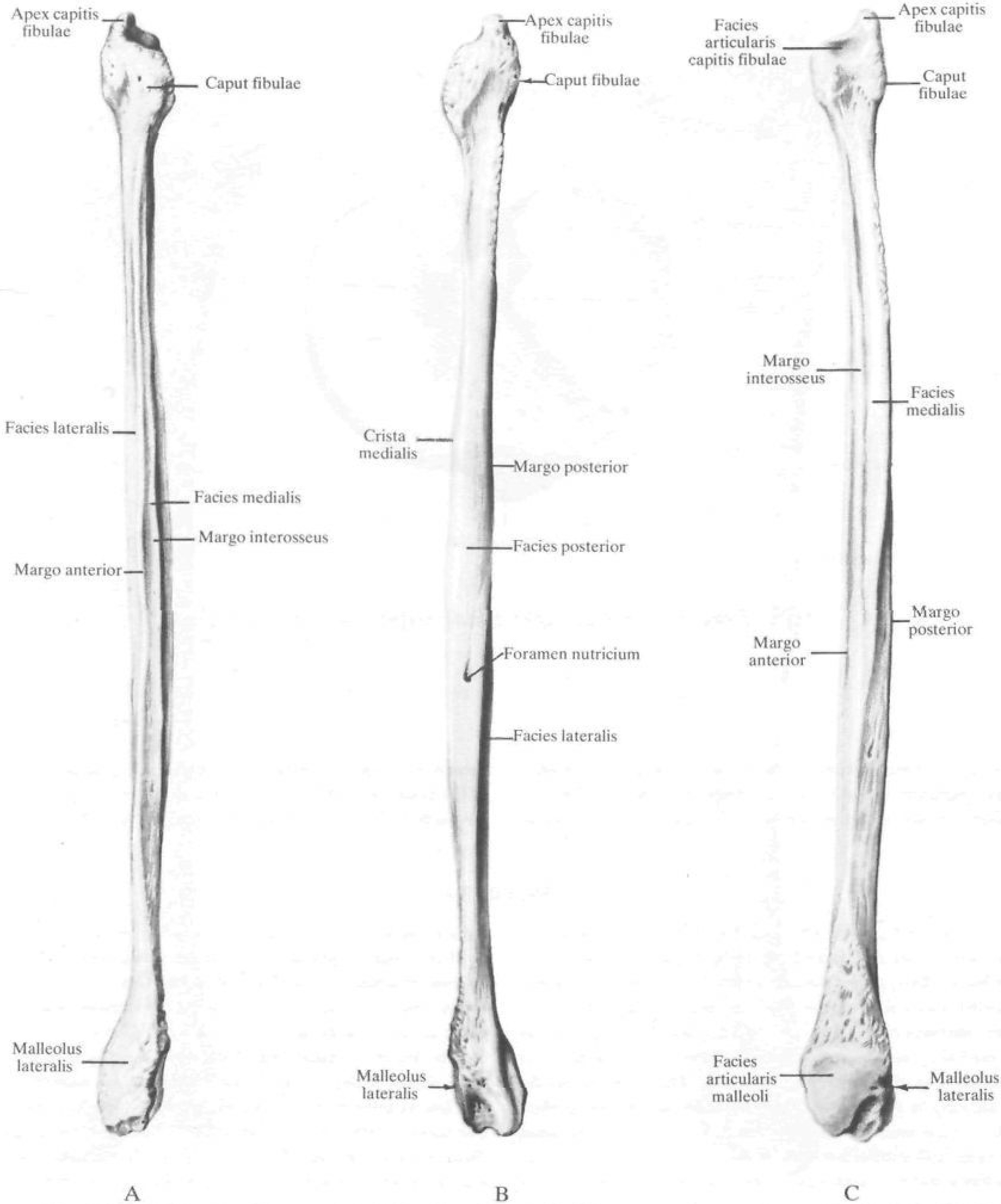
THE FIBULA

The **fibula** (see Figs 143, 159, 160, 164, 165) is a long and thin tubular bone. It has a body and two ends, upper and lower.

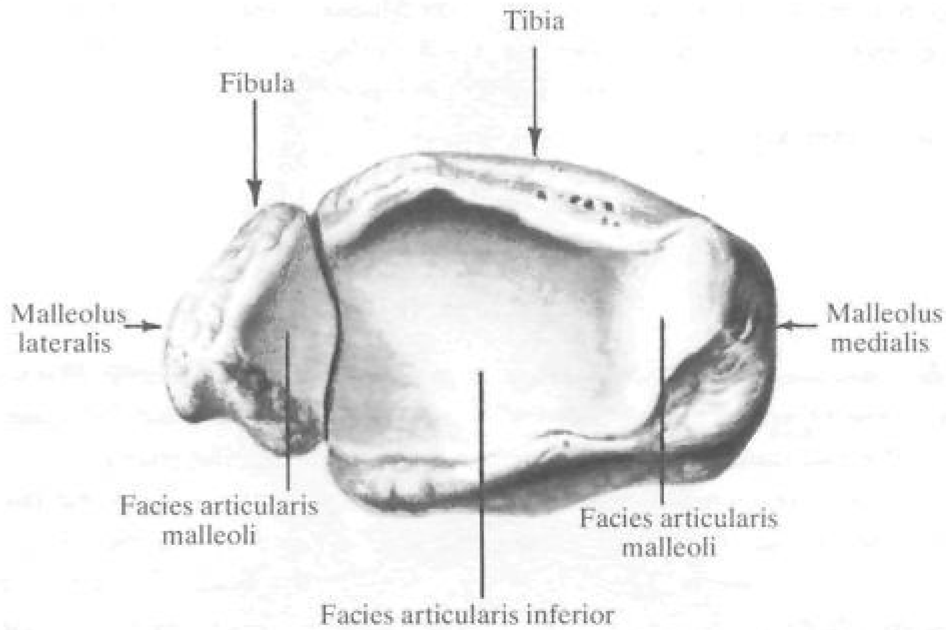
The **body (shaft)** *(corpus fibulae)* is trihedral, prismatic in shape. It is twisted about the longitudinal axis and curved to the back. The three **surfaces** of the bone, the **lateral** *(facies lateralis)*, **anterior** (**facies medialis**), and **posterior** *(facies posterior)*, are separated one from another by three borders, or crests. The **anterior border** *(margo anterior)* is the sharpest and separates the lateral surface from the medial one; the **medial crest** *(crista medialis)* is between the posterior and medial surfaces of the bone. The posterior surface carries a **nutrient foramen** *(foramen nutricium)* leading into a distally running **nutrient canal** *(canalis nutricius)*. The **interosseous border** *(margo interosseus)* is on the anterior surface of the bone.

The **upper**, or **proximal end of the fibula** *(extremitas superior* s. *epiphysis proximalis fibulae)* forms the **head** *(caput fibulae)*. The upper end of the head tapers and is called the **styloid process of the fibula** or the **apex of the head** *(apex capitis fibulae)*.

The **lower**, or **distal end of the fibula** *(extremitas inferior* s. *epiphysis distalis fibulae)* forms the **lateral malleolus** *(malleolus lateralis)*. The lateral surface of the malleolus is easily felt through the skin. The medial surface bears an **articular facet of the lateral malleolus** *(facies articularis malleoli)* by means of which the fibula articulates with the lateral surface of the talus, and above the facet is a rough area for articulation with the fibular notch of the tibia.



164. *Right fibula* (⅖).
A—anterior aspect; B—posterior aspect; C—medial aspect.



165. *Distal ends of right tibia and fibula*; inferior aspect (3/4).

THE BONES OF THE FOOT

The bones forming the **tarsus** of the foot (see Figs 143, 166-179) are as follows: the talus, calcaneum, navicular bone, cuboid, and the three cuneiform bones (medial, intermediate, and lateral). The **metatarsus** is formed of five metatarsal bones. The phalanges of the digits are named like those of the hand.

THE TARSAL BONES

The **tarsal bones** *(ossa tarsi)* (see Figs 143, 166-170) are arranged in two groups: proximal, formed by the talus and calcaneum, and distal, composed of the navicular, cuboid, and three cuneiform bones. The bones of the tarsus articulate with the leg bones, the distal row articulates with the metatarsals.

THE TALUS

The **talus** (Fig. 171) is the only bone of the foot that articulates with the leg bones. Its posterior part, the **body** *(corpus tali)*, is continuous forwards with a constricted part called the **neck** *(collum tali)*. The neck joins the body with the anteriorly directed **head of the talus** *(caput tali)*. The bones of the leg embrace the talus from above and on the sides like a fork. A joint forms between the leg bones and the talus, for which purpose the upper surface of the body of the talus bears an articular pulley-shaped area called the **trochlea** *(trochlea tali)*. On the sides of the body are the lateral and medial malleolar facets—the **malleolar facet of the lateral surface** and the **malleolar facet of the medial surface of the talus** *(facies malleolaris lateralis* et *facies malleolaris medialis)*. The surface of the trochlea is convex sagittally and concave transversely.

The lateral and medial malleolar facets are flat. The lateral malleolar facet continues onto the superior surface of the **lateral tubercle of the talus** *(processus lateralis tali)* located in the lower part of the lateral surface of the bone. On the posterior surface of the talus passes obliquely a **groove for the flexor hallucis longus tendon** *(sulcus tendinis musculi flexoris hallucis longi)*. The groove divides the posterior border of the bone into two tubercles, a larger **medial tubercle** *(tuberculum mediale)* and a smaller **lateral tubercle** *(tuberculum laterale)*. Both tubercles and the groove between them form the **posterior tubercle of the talus** *(processus posterior tali)*. Sometimes the lateral tubercle of the posterior process occurs as a separate **os trigonum**.

In the posterolateral part the lower surface of the body carries a concave **posterior calcanean facet** *(facies articularis calcanea posterior)*. The anteromedial parts of this surface are bounded by the **groove of the talus** *(sulcus tali)* which stretches forwards and laterally. In front and lateral of this groove is the **middle calcanean facet** *(facies articularis calcanea media)*, in front of which is the **anterior calcanean facet** *(facies articularis calcanea anterior)*.

By means of the facets the lower part of the talus articulates with the calcaneum. The **head of the talus** *(caput tali)* is slightly compressed from top to bottom. Its anterior part carries a spherical **navicular facet** *(facies articularis navicularis)* for articulation with the navicular bone.

THE CALCANEUM

The **heel bone,** or **calcaneum** *(calcaneus* s. *os calcis)* (Figs 172-174) is below and to the back of the talus. Its posteroinferior part is called the **posterior surface of the calcaneum** *(tuber calcanei)*. The inferior parts of this surface on the lateral and medial sides are continuous, respectively, with the **lateral tubercle of the calcaneum** *(processus lateralis tuberis calcanei)* and the **medial tubercle of the calcaneum** *(processus medialis tuberis calcanei)*.

The anterior surface of the calcaneum carries a saddle-shaped **facet for the cuboid** *(facies articularis cuboidea)* for articulation with the cuboid bone.

In the anterior part of the medial surface of the calcaneum is a short and thick process called the **sustentaculum tali. A groove for the flexor hallucis longus tendon** *(sulcus tendinis musculi flexoris hallucis longi)* passes on its lower surface.

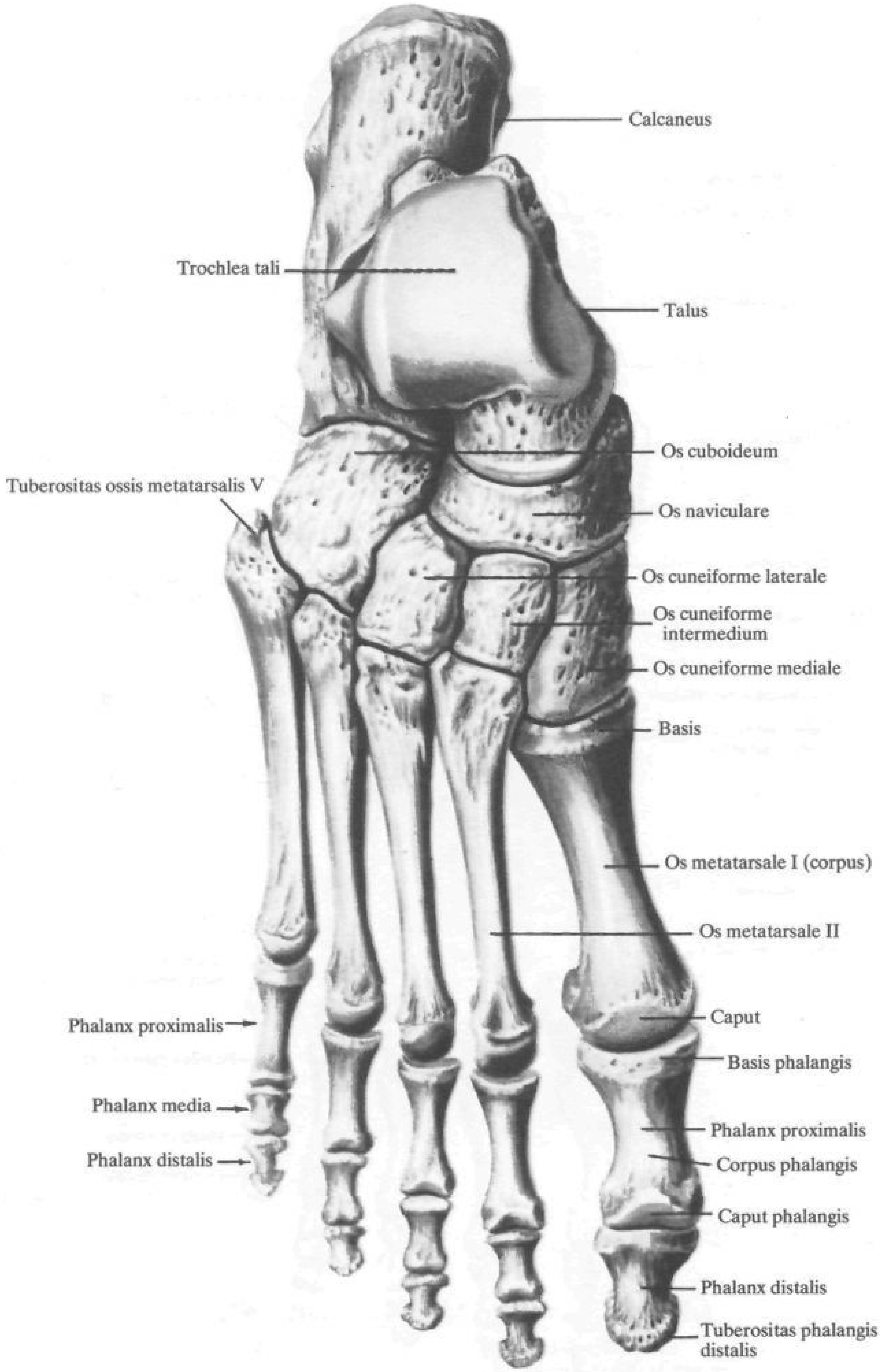
On the lateral surface of the calcaneum, in the anterior part, is a small **peroneal tubercle** *(trochlea fibularis)* to the back of which stretches the **groove for the tendons of the peroneus muscles** *(sulcus tendinus musculi fibularium)*.

A large **posterior facet for the talus** *(facies articularis talaris posterior)* is located in the middle of the upper surface of the calcaneum. To the front of it is a **groove of the calcaneum** *(sulcus calcanei)* running from back to front and laterally. Still more to the front, on the medial border of the bone, are two articular surfaces. One is the **middle facet for the talus** *(facies articularis talaris media)* and the other, anterior to it, is the **anterior facet for the talus** *(facies articularis talaris anterior)*, which fit into the respective facets on the talus. When the talus is fitted to the calcaneum the anterior parts of the groove of the talus and the groove of the calcaneum form a pit called the **sinus tarsi** which is felt through the skin as a small depression.

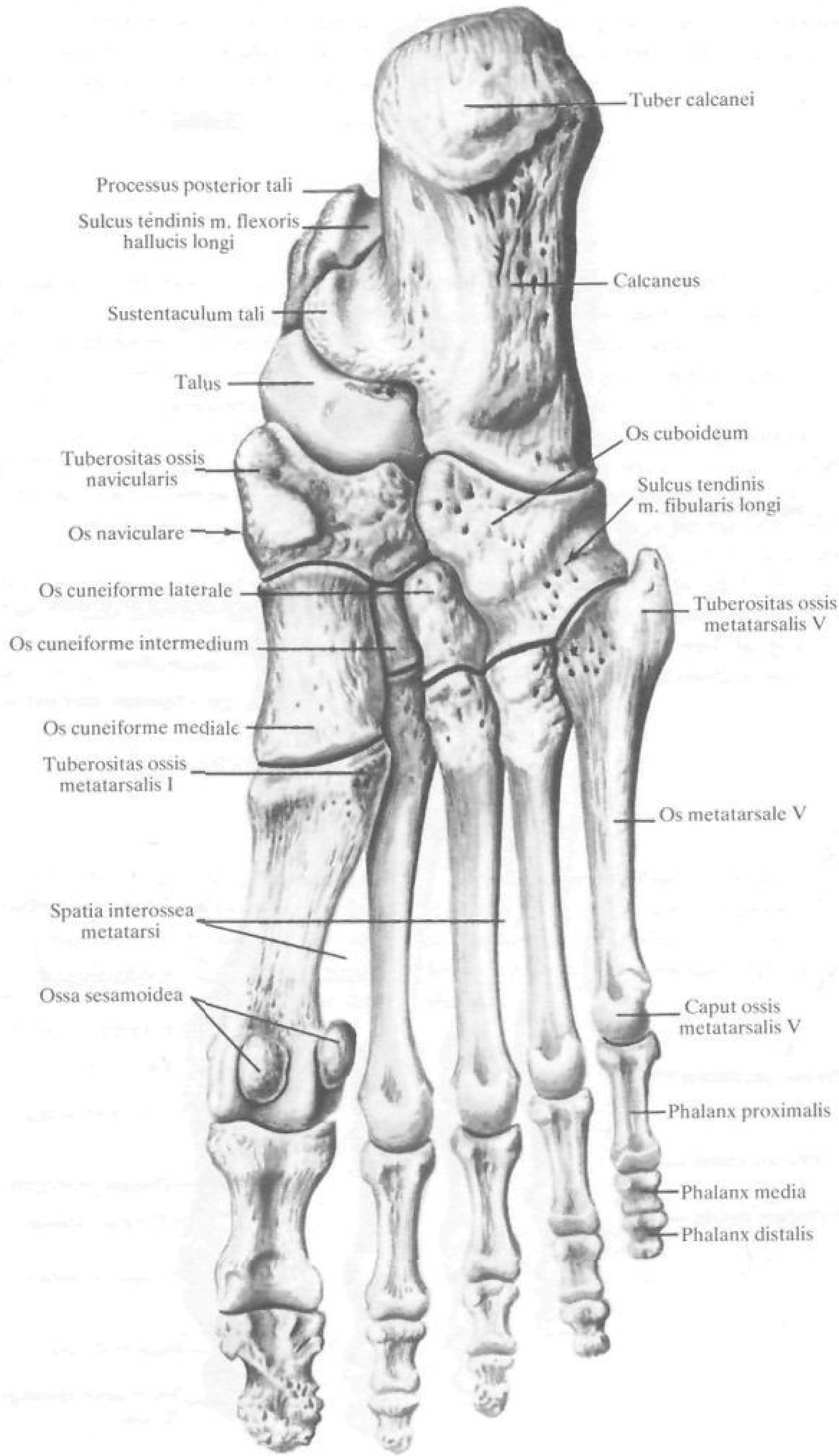
THE NAVICULAR BONE

The **navicular bone** *(os naviculare)* (Fig. 175) is flat anteriorly and posteriorly. On its posterior surface it carries a concave facet for articulation with the navicular facet of the head of the talus. The upper surface of the bone is concave. The anterior surface bears three facets by means of which it articulates with the three cuneiform bones. The facets are separated from one another by small ridges.

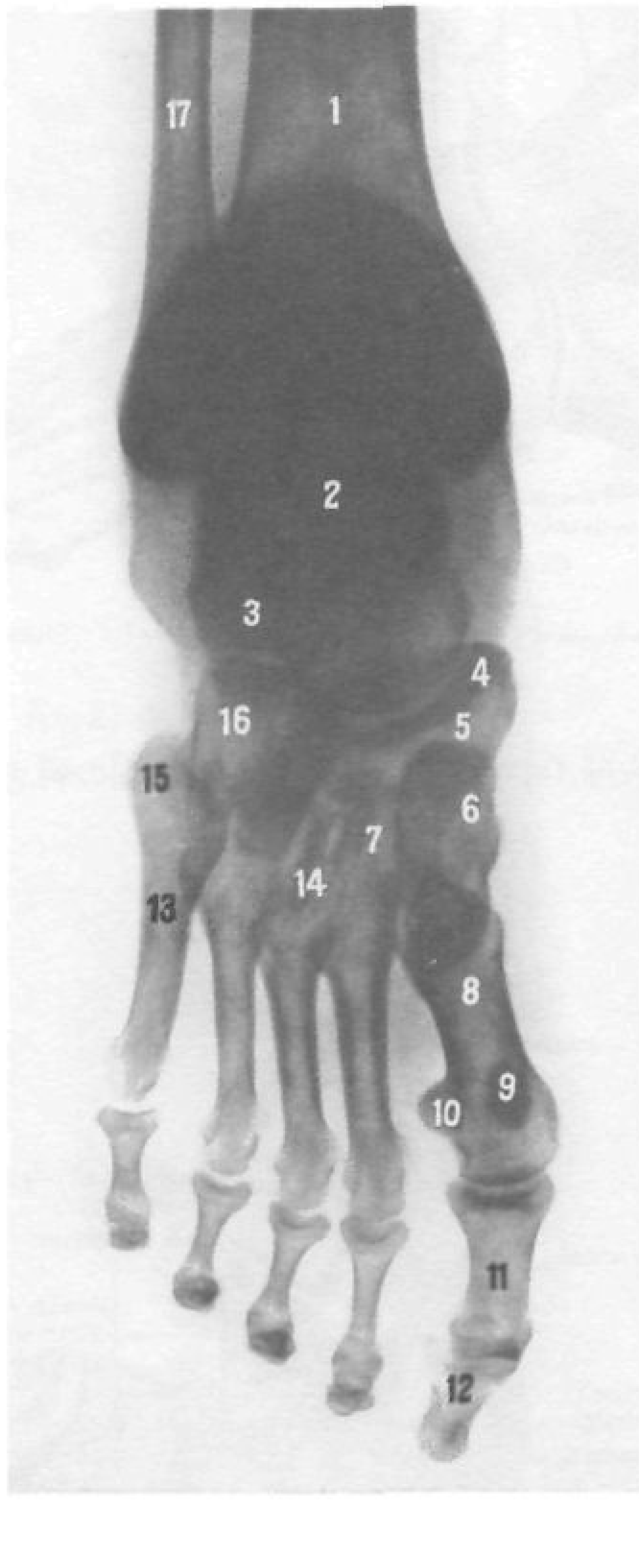
On the lateral surface of the body is a small facet for articulation with the cuboid bone. The lower surface of the navicular bone is concave. In its medial part is the **tuberosity of the navicular bone** *(tuberositas ossis navicularis)* which can be easily felt through the skin.



166. *Bones of right foot (ossa pedis)* (⅔).
(Dorsal surface.)

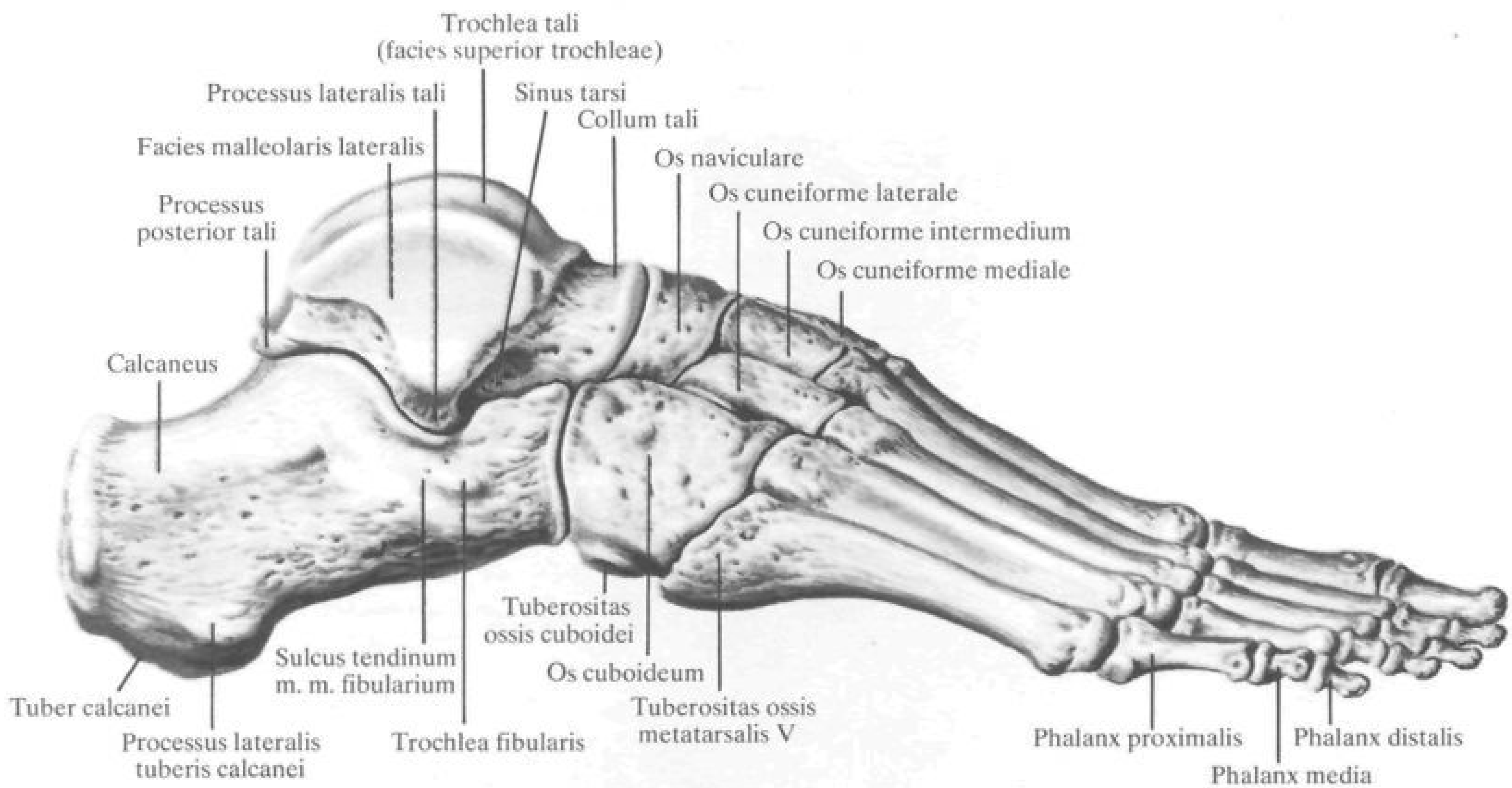


167. *Bones of right foot (ossa pedis)* (2/3).
(Plantar surface.)

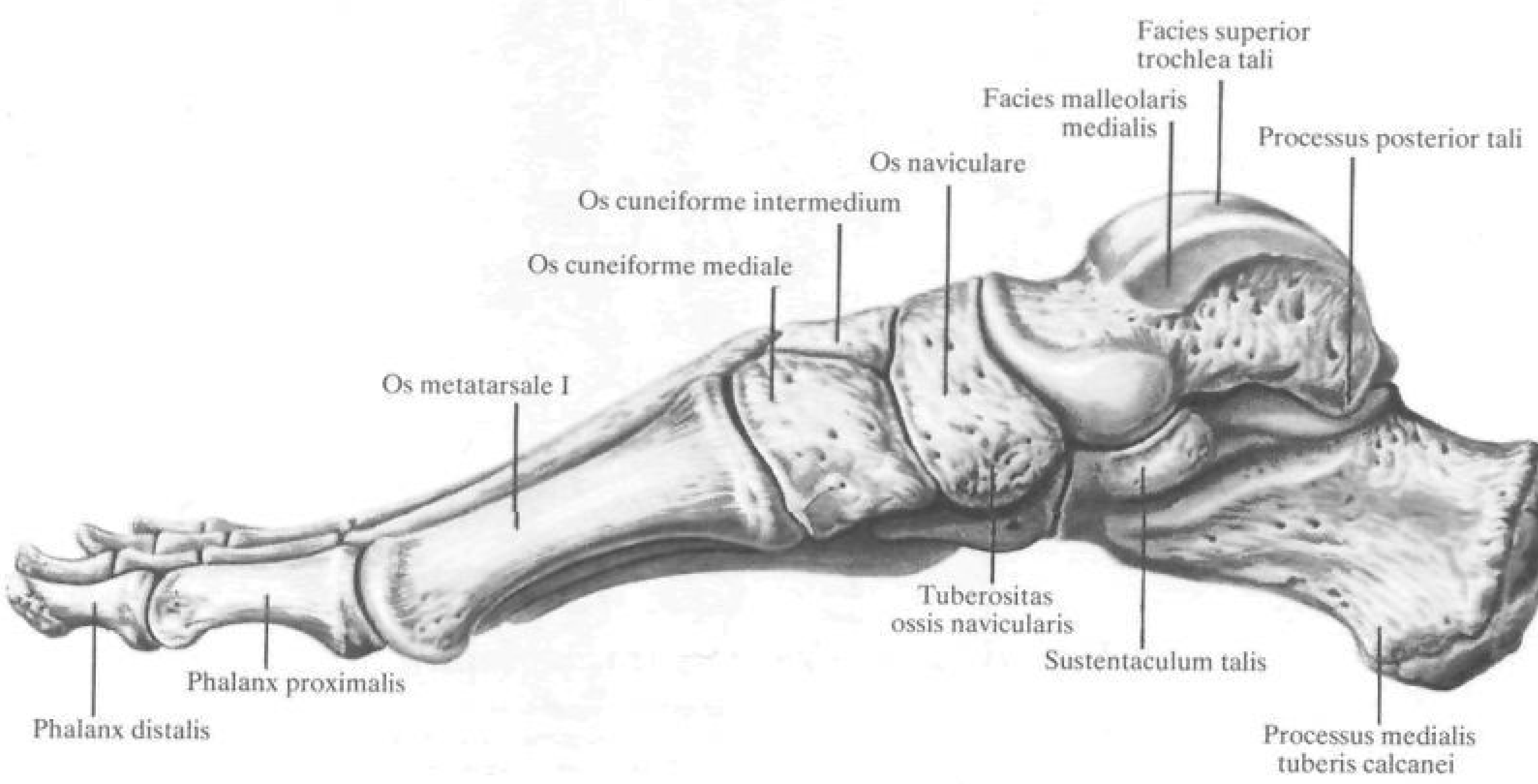


168. *Bones of right foot* (radiograph).

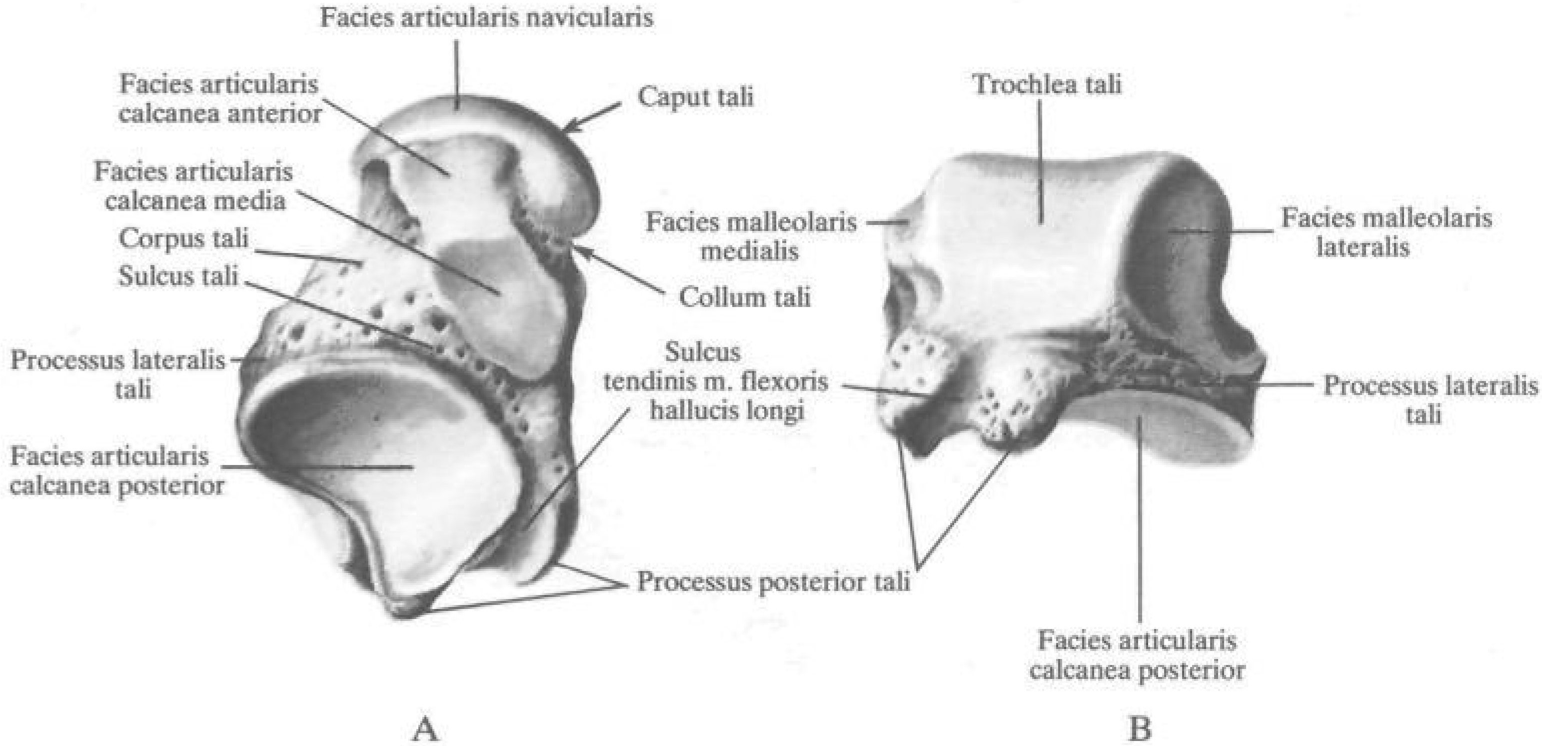
1—tibia
2—talus
3—calcaneum
4—tuberosity of navicular bone
5—navicular bone
6—medial cuneiform bone
7—intermediate cuneiform bone
8—first metatarsal bone
9 and 10—sesamoid bone
11—proximal phalanx of great toe
12—distal phalanx of great toe
13—fifth metatarsal bone
14—lateral cuneiform bone
15—tubercle of fifth metatarsal bone
16—cuboid bone
17—fibula



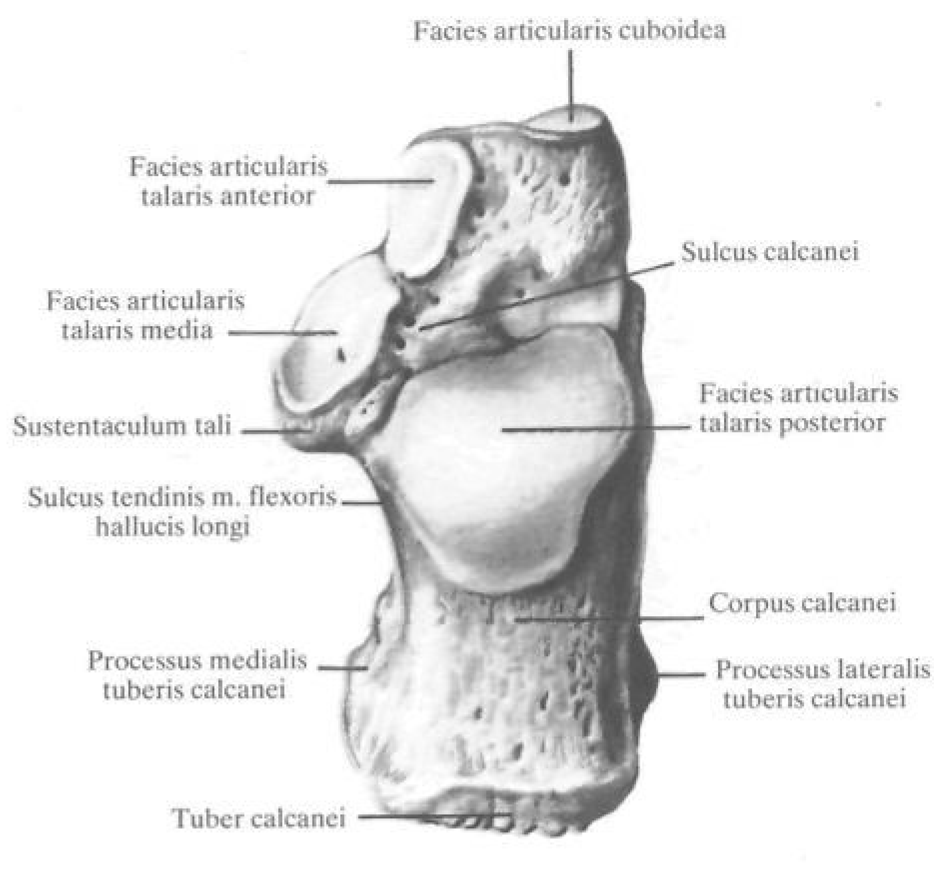
169. *Bones of right foot (ossa pedis)*; lateral aspect (½).



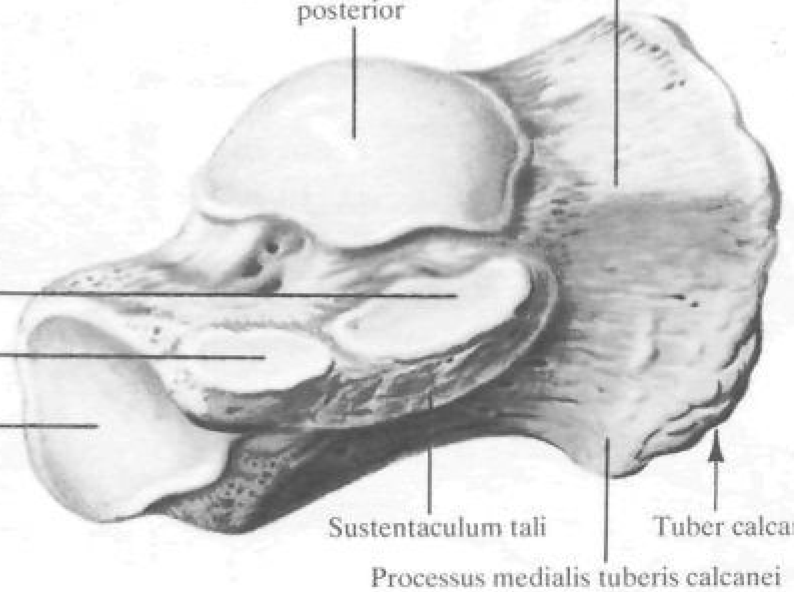
170. *Bones of right foot (ossa pedis)*; medial aspect (½).



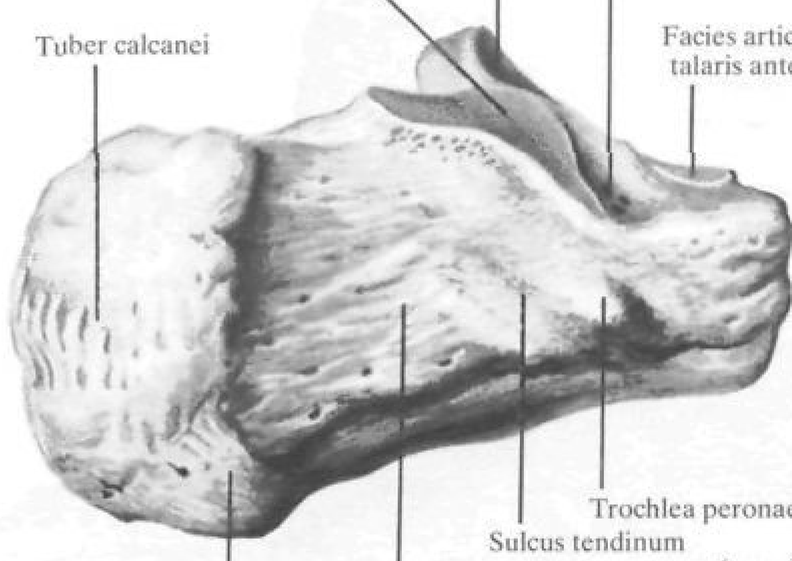
171. *Right talus* (4/5).
A—inferior aspect; B—posterior aspect.



172. *Right calcaneum*; superior aspect (4/5).



173. *Right calcaneum*; anteromedial aspect ($\frac{4}{5}$).



174. *Right calcaneum*; posterolateral aspect ($\frac{4}{5}$).

THE CUNEIFORM BONES

The **cuneiform bones** *(ossa cuneiformia)* (Figs 176-178) are three in number and wedge-shaped. They are located in front of the navicular bone. The intermediate cuneiform bone is shorter than the other bones as a result of which the anterior (distal) surfaces of these bones are at different levels. They have facets for articulation with the respective metatarsal bones.

The base of the wedge (the wider part) of the medial cuneiform bone faces downwards, the bases of the intermediate and lateral bones face upwards.

The posterior surfaces of the bones have facets for articulation with the navicular bone.

The **medial cuneiform bone** *(os cuneiforme mediale)* has two facets on its lateral concave surface for articulation with the intermediate cuneiform bone and the second metatarsal bone.

The **intermediate cuneiform bone** *(os cuneiforme intermedium)* has a facet on the medial surface for articulation with the medial cuneiform bone and a facet on the lateral surface for union with the lateral cuneiform bone.

The **lateral cuneiform bone** *(os cuneiforme laterale)* carries facets on the medial surface for articulation with the intermediate cuneiform bone and base of the second metatarsal bone, and a facet on the lateral side for articulation with the cuboid bone.

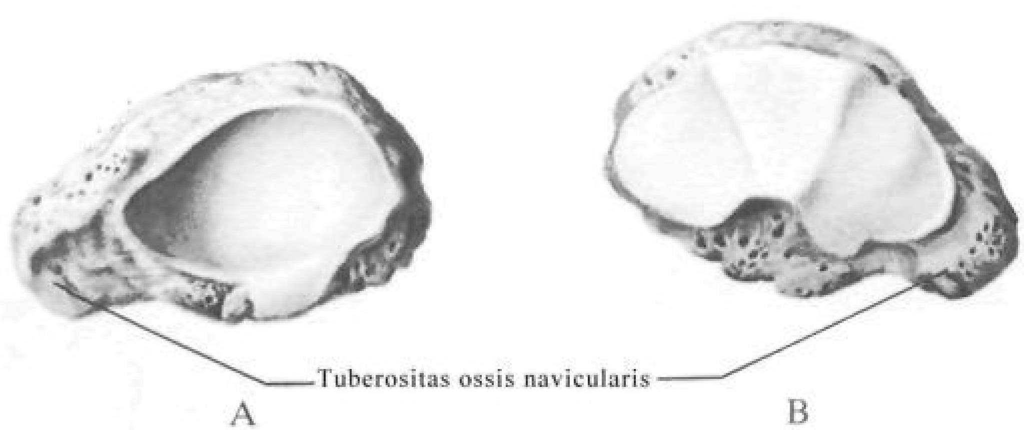
THE CUBOID BONE

The **cuboid bone** *(os cuboideum)* (Fig. 179) is placed outwardly to the lateral cuneiform bone, in front of the calcaneum, and to the back of the bases of the fourth and fifth metatarsal bones.

The upper surface of the bone is rough, the medial surface has facets for articulation with the lateral cuneiform and the navicular bones. The lateral edge of the bone bears the **tuberosity of the cuboid bone** *(tuberositas ossis cuboidei)* (see Fig. 169) which faces downwards. In front of it arises the **groove for the tendon of the peroneus longus muscle** *(sulcus tendinis musculus peronei longi)* (see Fig. 167) which passes over to the lower surface of the bone and crosses it obliquely from the posterolateral to the anteromedial areas, according to the passage of this tendon.

The posterior surface of the bone bears a facet for articulation with a similar facet on the calcaneum.

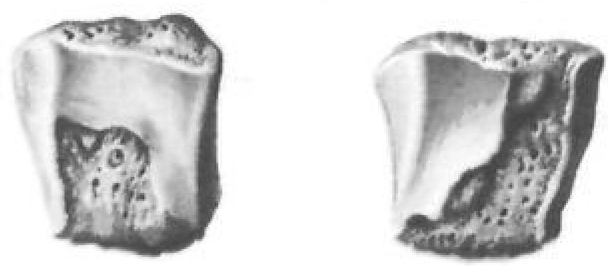
The anterior surface of the cuboid bone has facets which are separated by a ridge. They serve for articulation with the fourth and fifth metatarsal bones.



175. *Right navicular bone (os naviculare)* ($^5/_6$).
A—posterior aspect; B—anterior aspect.

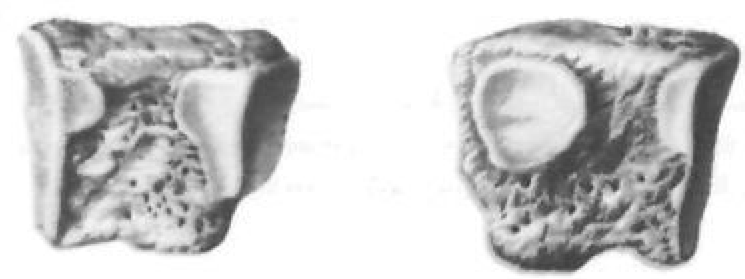
A B

176. *Right medial cuneiform bone (os cuneiforme mediale)* ($^5/_6$).
A—medial aspect; B—lateral aspect.



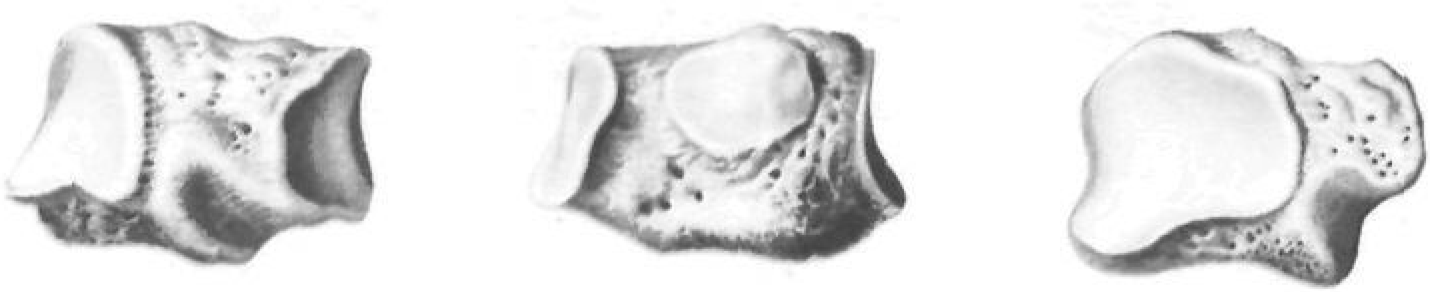
A B

177. *Right intermediate cuneiform bone (os cuneiforme intermedium)* ($^5/_6$).
A—medial aspect; B—lateral aspect.



A B

178. *Right lateral cuneiform bone (os cuneiforme laterale)* ($^5/_6$).
A—medial aspect; B—lateral aspect.



A B C

179. *Right cuboid bone (os cuboideum)* ($^3/_4$).
A—lateral aspect; B—medial aspect; C—posterior aspect.

THE METATARSAL BONES

The **metatarsal bones** *(ossa metatarsalia)* (Figs 143, 166–170) are five thin tubular bones located in front of the tarsus. Each metatarsal bone has a **body** or **shaft** *(corpus)*, the posterior, proximal end called the **base** *(basis)*, and an anterior, distal end called the **head** *(caput)*.

The bones are numbered from the medial side of the foot, from the big toe to the little toe. The first metatarsal bone is shorter but thicker than the others. The second metatarsal is the longest. The bodies of the metatarsals are trihedral. The dorsal surface of the shaft is slightly convex, the two inferior plantar surfaces meet downwards to form a ridge.

The base is the most massive part of a metatarsal. It is wedge-shaped and the expanded part of the first to fourth metatarsals faces upwards, while that of the little toe faces medially. The sides of the bases carry facets for articulation of the metatarsals with one another.

The posterior surfaces of the bases have facets for union with the tarsal bones. On the inferior surface of the base of the first metatarsal bone is a **tubercle of the first metatarsal bone** *(tuberositas ossis metatarsalis I)*. The lateral surface of the base of the fifth metatarsal bone also has a **tubercle** *(tuberositas ossis metatarsalis V)* which can be easily felt through the skin. The anterior ends, or heads, of the metatarsal bones are flattened on the sides. The peripheral parts of the heads bear spherical articular surfaces for articulation with the phalanges of the toes. The inferior surface of the head of the first metatarsal bone carries on each side a small smooth area for the **sesamoid bones** *(ossa sesamoidea)* of the big toe. The head of the first metatarsal is easily felt through the skin.

In addition to the sesamoid bones in the first metatarsophalangeal joint, one sesamoid bone is found in the interphalangeal joint of the big toe, and occasional sesamoid bones are found in the peroneus longus tendon on the plantar surface of the cuboid bone.

THE BONES OF THE DIGITS OF THE FOOT

The **bones (phalanges) of the digits of the foot** *(ossa digitorum pedis)* (see Figs 143, 166–170) are similar to those of the hand in shape, number, and interrelationship. Each phalanx has a **body (shaft)** *(corpus phalangis)*, a posterior (proximal) end, or **base** *(basis phalangis)*, and an **anterior** (distal) end, or **head** *(caput phalangis)*. The heads of the proximal and middle phalanges are pulley-shaped.

The distal end of each distal phalanx carries a **tuberosity** *(tuberositas phalangis distalis)*.

DEVELOPMENT AND AGE FEATURES OF THE BONES OF THE LOWER LIMB

The bones of the lower limbs develop as secondary bones (see Figs 3, 179a). The hip bone develops from three primary centres (or points) of ossification and several (up to eight) secondary (accessory) centres. The primary centres give rise to the ilium (which appears on the third month of the intrauterine period), the ischium (on the fourth month) and the pubis (on the fifth month of intrauterine life); the secondary centres give origin to eminences, depressions, and borders of individual bones. In the region of the acetabulum the three bones are at first joined to one another by layers of cartilage in which secondary ossification centres appear later (by the age of 16-18 years). All centres fuse at 20-25 years of age. The pelvis as a whole undergoes changes in size and shape for the most part. However, sexual features characteristic of male and female adults begin differentiation from the age of 8-10 years. The pelvis is higher in boys but wider in girls.

The femur develops from five ossification centres one of which is primary (diaphyseal) and four are secondary. The primary centre (which appears at the beginning of the second intrauterine month) gives rise to the shaft of the bone. The secondary centres of ossification appear in different periods: the centre for the distal femoral epiphysis appears at the end of the intrauterine period; an ossification centre appears in the cartilaginous femoral head at the end of the first or beginning of the second year; the third centre arises in the cartilage of the greater trochanter at the age of 3, and the fourth appears in the cartilage of the lesser trochanter at the age of 8 years. All these bone structures fuse with the shaft of the bone between the ages of 16 and 20.

The patella forms in cartilage from a single ossification centre in the second year in girls and in the fourth year in boys and ossification is completed by the age of 16-20.

The tibia develops from four ossification centres. One is diaphyseal and appears in the second month of intrauterine life. Three ossification centres are secondary among which the upper epiphyseal point arises in the ninth month of intrauterine life, the lower epiphyseal centre during the first year of life, and the ossification centre for the tuberosity of the tibia appears at the age of 13. All centres fuse with the shaft at different periods ranging from 16-18 to 20-24 years of age.

The fibula develops from three ossification centres. The primary (diaphyseal) centre appears in the middle of the second month of intrauterine life and gives origin to the shaft and areas of the epiphysis. The other two are secondary, epiphyseal, centres; the lower one arises in the first year of life and the upper centre, at the age of 3-5 years. The lower epiphyseal centre of ossification fuses with the shaft at 17-20 and the upper ossification centre at 19-21 years of age.

The bones of the foot develop in the following manner. The talus arises from one ossification centre which appears in the last months of intrauterine life; ossification continues to the age of 8 years.

The calcaneum forms from two ossification centres: the main, primary, centre appears on the sixth month of intrauterine life and the secondary centre by the age of 9 years and gives rise to the tuber calcanei. The centres fuse by 16-18 years of age.

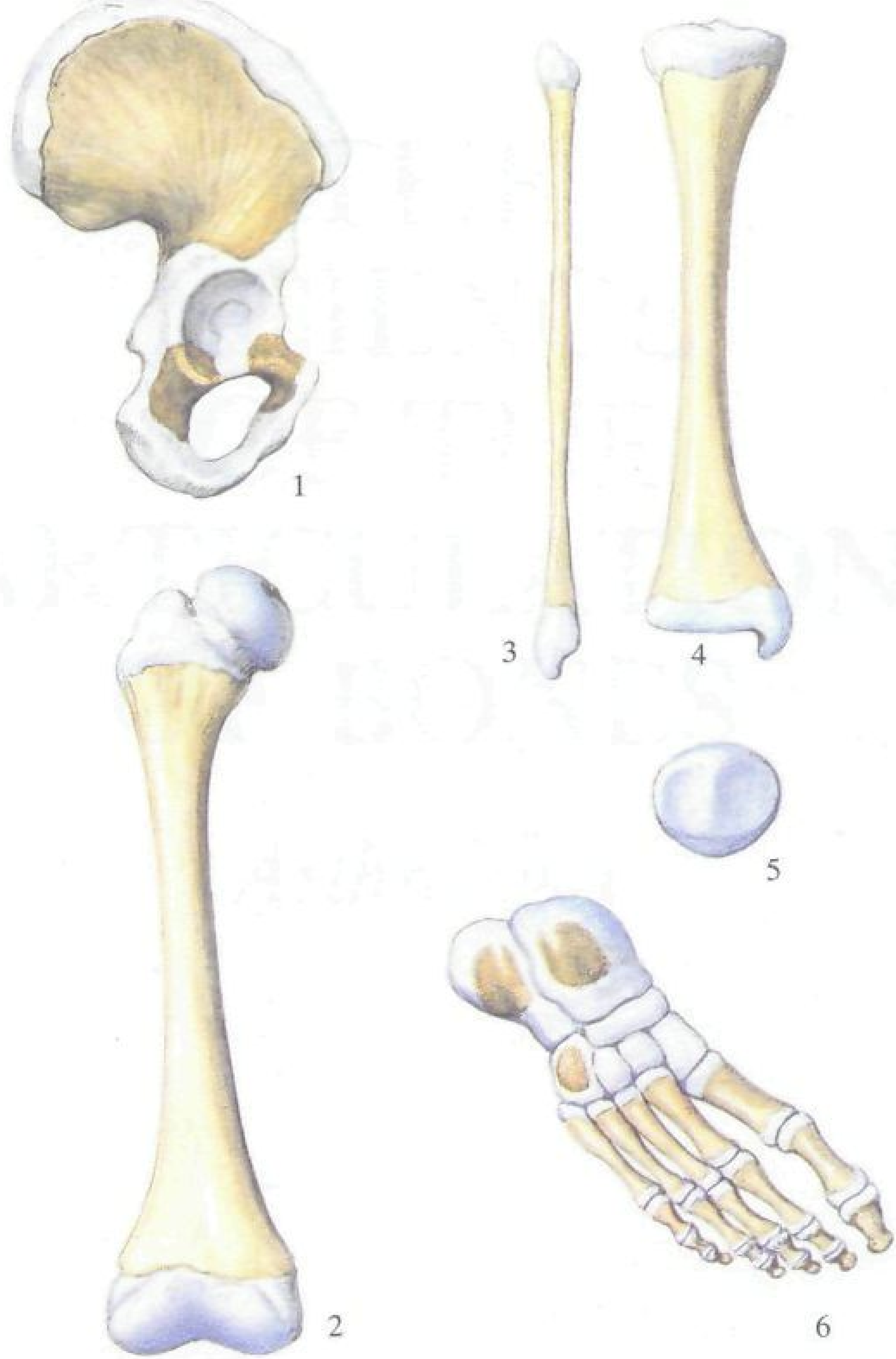
The navicular bone develops from a single ossification centre which appears at the age of 3-5 years.

Each cuneiform bone develops from its own ossification centre. The lateral bone begins ossification by the end of the first year of life, the intermediate bone at the age of 3, and the medial cuneiform bone at the age of 3-4 years.

The cuboid bone develops from one ossification centre which usually appears before birth, less frequently at 3-6 months of age.

Each of the five metatarsal bones develops from two ossification centres: a main, primary, and an accessory (secondary) centre. The main centre appears in the second to fifth metatarsals at the beginning of the third month of intrauterine life and in the first bone at the end of this month; the secondary centres form by the age of 4 years and fuse by the age of 17 in females and by the age of 20 in males.

Each phalanx develops from two ossification centres. The main centre appears between the third and ninth months of intrauterine life, the secondary centre arises by the age of 4. Fusion occurs between the ages of 15 and 20.



179a. *Bones of right lower limb (ossa membri inferioris) of a newborn.*

1—hip bone (os coxae)
2—femur
3—fibula
4—tibia
5—patella
6—bones of foot (ossa pedis)

THE SCIENCE OF THE ARTICULATION OF BONES

Arthrologia

The **articulations**, or **joints**, of bones are separated into two groups: **fibrous joints** *(articulationes s. juncturae fibrosae)* and **synovial joints** *(articulationes synoviales)*. These two types of joints differ in the degree of mobility which they provide for the bones in the skeletal system and in the capacity for bearing mechanical loads.

FIBROUS JOINTS

Fibrous joints *(articulationes s. juncturae fibrosae)* (Fig. 180) provide for contiguous (uninterrupted) union of bones by means of various types of connective tissue—dense connective tissue, cartilaginous tissue or bony tissue.

The group of fibrous joints formed by dense connective tissue includes syndesmoses, sutures, and gomphoses.

Syndesmoses are articulations in which the uniting compact connective tissue forms ligaments. For example, the **pterygospinous ligament** *(ligamentum pterygospinale)* arises from the spine of the sphenoid bone and is attached to the pterygospinous process on the lateral plate of the pterygoid process; the **stylohyoid ligament** *(ligamentum stylohyoideum)*, a thin and long ligament arises from the styloid process, runs downwards and to the front, and is attached to the lesser horn of the hyoid bone, etc. Some ligaments are rich in elastic fibres, e.g. *ligamenta flava* located between the vertebral arches, *ligamentum nuchae*, etc. Syndesmoses are also formed by wide ligaments uniting bones for a considerable distance; these are the **interosseous membranes of the forearm** and **leg** *(membrana interossea antebrachii* et *membrana interossea cruris)*. The **fontanelles of the skull** *(fonticuli cranii)*, formed of primary connective tissue, are also included in the group of syndesmoses.

Sutures *(suturae)* unite the bones of the skull cap and the bones of the face. They are formed by short bands of dense connective tissue running between the borders of neighbouring bones and penetrating them. The sutures ossify with age due to replacement of the compact connective tissue by bony tissue.

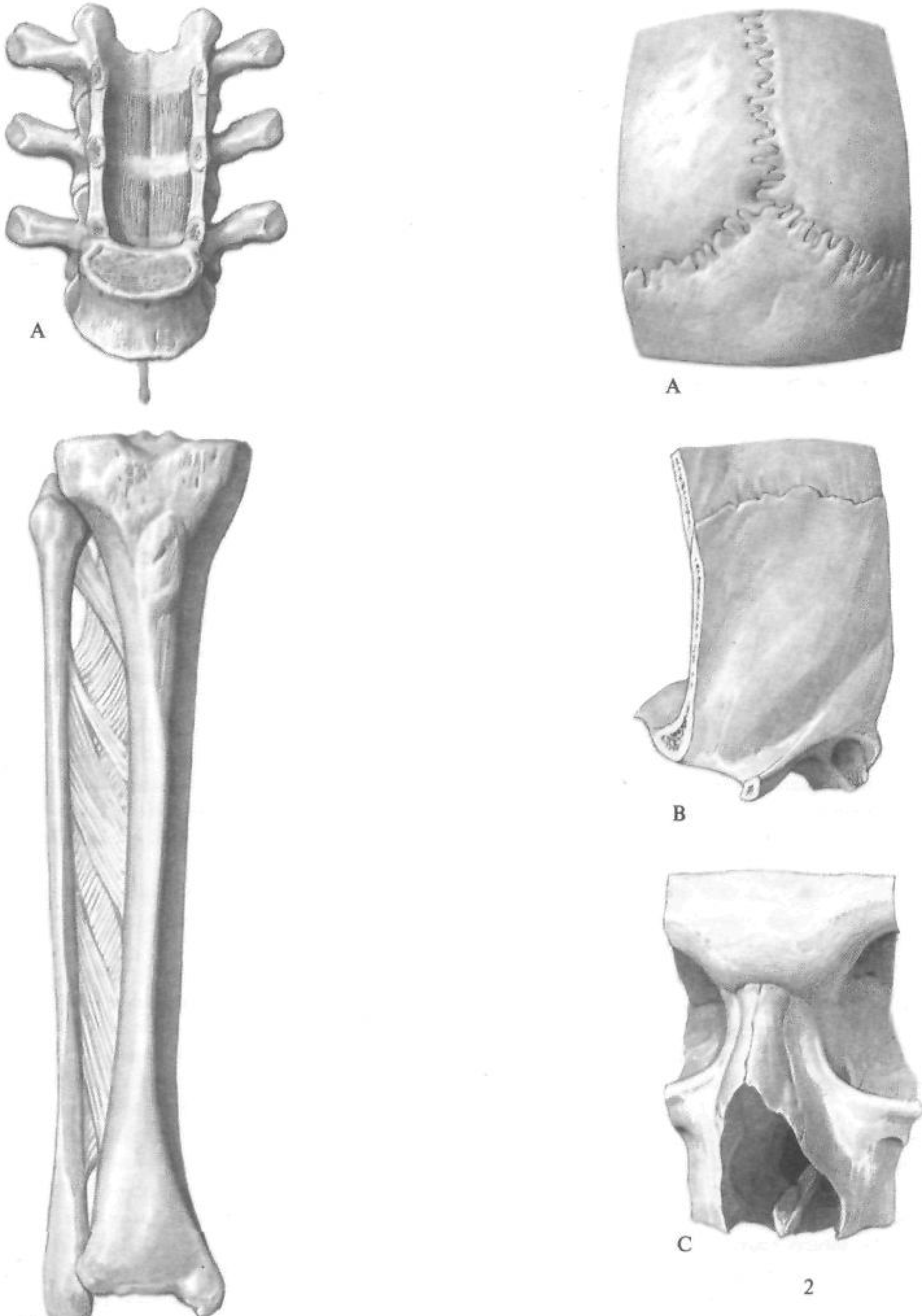
According to the outline of the sutures and the ways in which the opposed surfaces of the bones are fitted to each other, the following types of sutures are distinguished: **serrated suture** *(sutura serrata)*, **squamous suture** *(sutura squamosa)*, and **flat suture** *(sutura plana)*. The bones of the skull cap are joined by squamous and serrated sutures. The facial bones mostly articulate by means of flat sutures which provide accurate and even apposition. Still another type of suture is **schindylesis** (Gk *schindylesis* splintering) in which a plate of one bone fits into a groove in the other bone, as in the articulation between the sphenoid bone and the vomer *(sutura sphenovomeriana)*.

Gomphoses, or **peg-and-socket joints** *(articulationes dentoalveolares)* form when the roots of a tooth, which are surrounded by the periodontium, fit into the alveolar bone. The bands of dense connective tissue hold the teeth in the sockets. With age the hold grows weaker and the teeth get loose (this is discussed in detail in Vol. II. *The Digestive System*).

Cartilaginous joints *(articulationes cartilaginae)* are a variety of fibrous joints formed by cartilaginous tissue. These are synchondroses and symphyses.

Synchondroses are formed by continuous plates of cartilage that join the edges of the bones and restrict movements. There are many of them in the skeletal system of children and adolescents in whom they join some of the bones (e.g. the diaphyses with the epiphyses of the long bones, one sacral vertebra with another, etc.). These are **temporary synchondroses** in which the cartilage is replaced by bone with age. Cranial synchondroses (spheno-occipital, sphenopetrous, petro-occipital, posterior and anterior intraoccipital) and synchondrosis of the sternum (the articulation between the manubrium and xiphoid process) are **permanent synchondroses** maintained in the skeletal system of an adult.

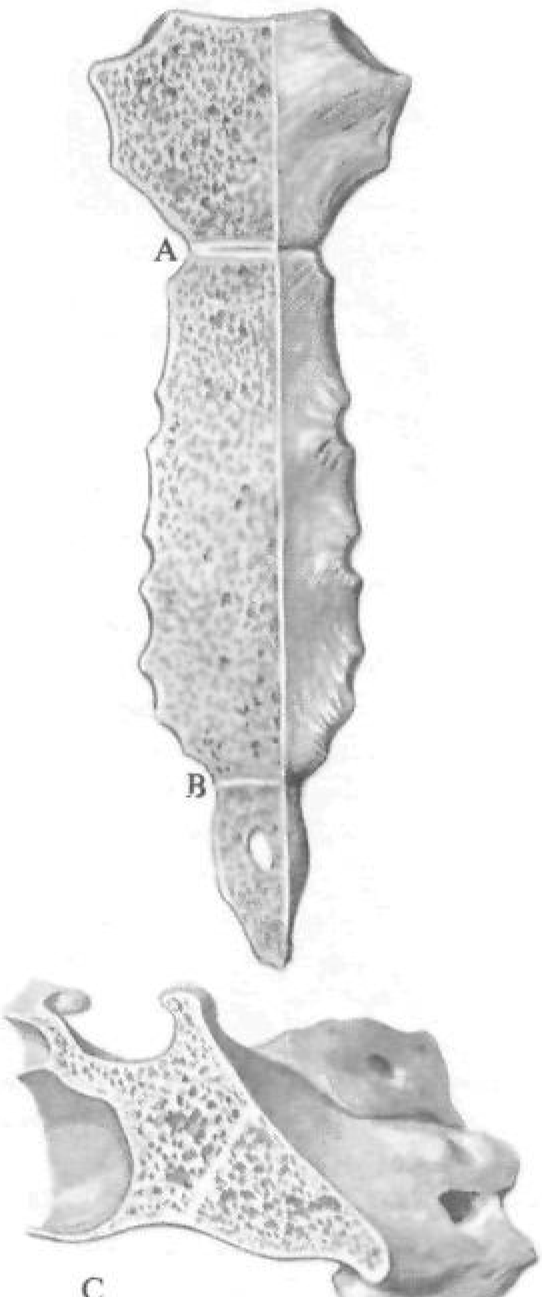
Symphyses are formed by a plate of fibrous cartilage which contains a cavity. Such joints exist between the vertebral bodies, namely the **intervertebral symphysis**, or **intervertebral disc** *(symphysis intervertebralis)* (Fig. 181), the **manubriosternal symphysis** *(symphysis manubriosternalis)* (Figs 180, 195), and the **pubic symphysis** *(symphysis pubica)* (Figs 180, 218).



180. *Fibrous joints (articulationes fibrosae).*

1 — syndesmosis
A — ligamentum flava
B — interosseous membrane of leg (membrana interossea cruris)

2 — suture (sutura)
A — serrate suture (sutura serrata)
B — squamous suture (sutura squamosa)
C — plane suture (sutura plana)



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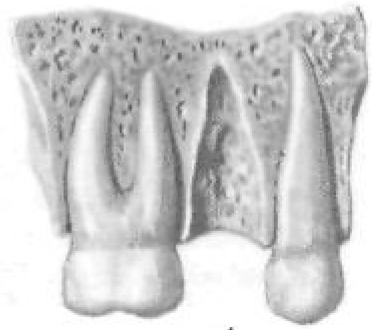

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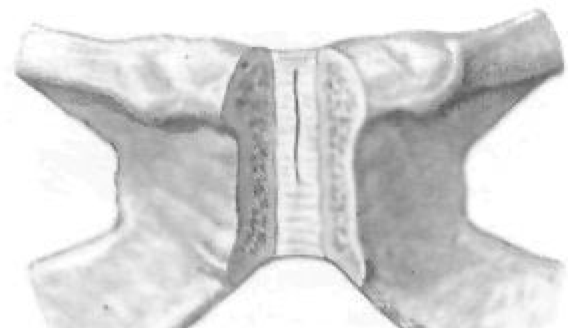
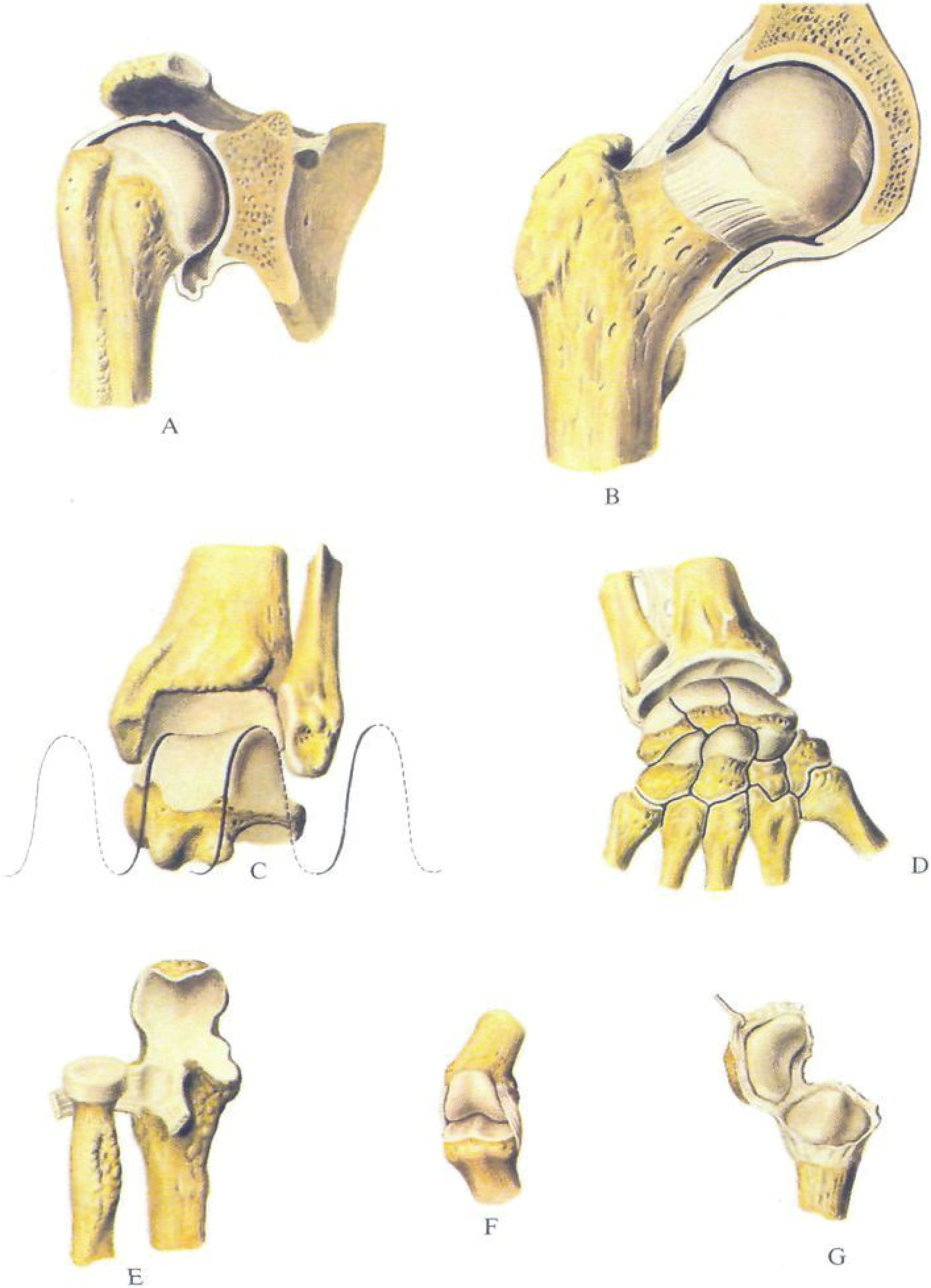


5

3 —synchondrosis
A—of manubrium sterni (synchondrosis manubriosternalis)
B—of xiphoid process (synchondrosis xiphosternalis)
C—spheno-occipital (synchodrosis sphenooccipitalis)

4 —gomphosis
5 —symphysis (symphysis pubica)



180a. *Types of synovial joints* ($\frac{1}{2}$).

A — spheroid or ball-and-socket joint (articulatio spheroidea s. cotylica), shoulder joint (articulatio humeri);
B — variety of ball-and-socket joint, hip joint (articulatio coxae);
C — variety of hinge joint (ginglymus), talocrural joint (articulatio talocruralis);
D — ellipsoidal joint (articulatio ellipsoidea), radiocarpal joint (articulatio radiocarpea);
E — pivot joint (articulatio trochoidea), proximal radioulnar joint (articulatio radioulnaris proximalis);
F — hinge joint (ginglymus), interphalangeal joint (articulatio interphalangea);
G — saddle joint (articulatio sellares), carpometacarpal joint of thumb (articulatio carpometacarpea pollicis).

SYNOVIAL JOINTS

Interrupted articulations of bones, or **synovial joints** *(articulationes synoviales)* (Fig. 180a) are the most commonly encountered type of articulations in the human body. They permit free movements. The joint is called **simple** *(articulatio simplex)*, if it is formed by two bones, and **compound** *(articulatio composita)* if it is formed by three or more bones.

Each synovial joint has compulsory structural elements, in the absence of which union of bones cannot be related to this group of joints, and accessory elements which determine the structural and functional distinctions of a synovial joint.

The compulsory elements of a synovial joint are the **articular cartilages** *(cartilagines articulares)* covering the **articular surfaces** *(facies articulares)*, the **articular capsule** *(capsula articularis)*, and the **joint cavity** *(cavitas articularis)*.

The **articular cartilage** is usually **hyaline** *(cartilago hyalina)* or less frequently **fibrous** *(cartilago fibrosa)*. It covers the articular surfaces on the opposed parts of the articulating bones. Therefore, one surface of the cartilage is fused with the bone surface which it covers, while the other projects freely into the joint.

The **articular capsule** *(capsula articularis)* encloses the articulating ends of the bones without passing over to the articular surfaces and is continuous with the periosteum of these bones. The capsule is made up of fibrous connective tissue and consists of two layers, or membranes. The outer **capsular ligament** *(membrana fibrosa* s. *stratum fibrosum)* is formed of dense fibrous connective tissue and serves as a mechanical factor. It is continuous with an inner **synovial membrane** *(membrana synovialis* s. *stratum synoviale)* which forms **synovial folds** *(plica synovialis)* penetrating between the ends of the articulating bones at places and increasing the congruence of the surfaces forming the joint. This membrane secretes a **synovial fluid** *(synovia)* into the joint which lubricates the articular surfaces of the bones, provides nourishment for the articular cartilage, acts as a shock absorber, and changes mobility at the joint by changing viscosity. The working surface of the membrane increases not only due to the folds but also due to **synovial villi** *(villi synoviales)* projecting into the joint cavity.

The **joint cavity** is a closed narrow space limited by the articulating bone surfaces and the articular capsule and is filled with synovial fluid. The cavity is air-tight.

The various accessory structures of the joints are **ligaments** *(ligamenta)*, **articular discs** *(disci articulares)*, **interarticular fibrocartilages** or **articular menisci** *(menisci articulares)*, and **articular labra** *(labra articularia)*.

The **ligaments** are bands of dense fibrous connective tissue which strengthen the articular capsule and limit or direct movements at the joint. In relation to the articular capsule, the ligaments may be **extracapsular** *(ligamenta extracapsularia)*, **intracapsular** *(ligamenta intracapsularia)*, or **capsular** *(ligamenta capsularia)*, located in the capsule between the fibrous and synovial membranes. Practically all joints possess ligaments. The extracapsular ligaments intertwine with the outer parts of the fibrous layer of the capsule; the capsular ligaments are thickenings of this layer; the intracapsular ligaments are intra-articular in location but are covered by the synovial membrane which separates them from the joint cavity.

The **articular discs** are pads of hyaline or fibrous cartilage wedged between the articular bone surfaces. They are attached to the articular capsule and divide the joint cavity into two compartments. The discs increase the congruency of the articular surfaces and, consequently, the range and variety of movements. Besides, they act as shock absorbers by reducing jolts and shaking during movement. Such discs exist, for instance, in the sternoclavicular and mandibular joints.

The **articular menisci**, or **interarticular fibrocartilages** *(menisci articulares)*, in contrast to the discs, are not complete cartilaginous plates but crescent-shaped structures of fibrous cartilage. Each knee joint has two menisci, right and left, which are attached by their outer edges to the capsule nearer to the tibia, while their sharp inner edge projects freely into the joint cavity. The menisci provide various movements at the joint and are shock absorbers.

An **articular labrum** *(labra articularia)* is formed of dense fibrous connective tissue. It is attached to the edge of the acetabulum or glenoid cavity, making them deeper and increasing the congruency of the surfaces. The lip faces the joint cavity (shoulder and hip joints).

Joints differ in the shape of the articular surfaces and mobility of the articulating bones. According to the shape of the articular surfaces, the following synovial joints are distinguished: **spheroid** or **ball-and-socket** *(articulationes spheroidea* s. *cotylicae)*, **plane** *(articulationes plana)*, **ellipsoidal** or **condyloid** *(articulationes ellipsoideae* s. *condylares)*, **saddle** *(articulationes sellares)*, **ovoid** *(articulationes ovoidales)*, **pivot** *(articulationes trochoideae)*, **hinge** *(articulationes ginglymi)* and **bicondylar** *(articulationes bicondylaris)*.

Movements at a joint are determined by the shape of the articular surfaces. Ball-and-socket and plane joints, in which the generatrix is a segment of a circumference, allow movement about three mutually perpendicular axes: transverse, anteroposterior (sagittal), and vertical. For instance, the following movements are possible at the shoulder joint: **flexion** *(flexio)* and **extension** *(extensio)* about the transverse axis with the movement occurring in the sagittal plane; **abduction** *(abductio)* and **adduction** *(adductio)* about the anteroposterior axis, in which case the movement is made in the frontal plane; and finally, **rotation** *(rotatio)* about the vertical axis including **pronation** *(pronatio)* (medial rotation) and **supination** *(supinatio)* (lateral rotation), with the movement occurring in the horizontal plane. These movements are very limited in plane joints (the flat articular surface in this case is regarded as a small segment of a large-diameter circumference). They occur at a large amplitude in ball-and-socket joints in which circular movement or **circumduction** *(circumductio)* occurs in addition, with the apex of the circumduction centre corresponding to the centre of the spheroidal joint, while the periphery of the limb describes the base of a cone.

Joints allowing movement about only two axes are called **biax-**

ial. Such are the ellipsoid (e.g. the wrist joint) and saddle joints (e.g. the carpometacarpal joint of the thumb).

Uniaxial joints are those with a cylindrical or pulley-shaped articular surface. In a cylindrical (trochoid) joint the generatrix moves parallel to the rotation axis. Such is the median atlantoaxial joint in which the rotation axis passes vertically through the dens of the second cervical vertebra or the superior radioulnar joint. A variety of this type of joint is the hinge joint (ginglimus) in which the generatrix is inclined in relation to the rotation axis (as if bevelled). The humeroulnar and interphalangeal joints serve for illustration.

The **bicondylar joints** are a variety of the ellipsoid joints. These are ellipsoid joints working in combination with one another (e.g. the atlanto-occipital and the knee joints).

The **ovoid joints** are a variety of plane joints with an ovoid articular surface. Basically, flat surfaces are saddle- or ovoid-shaped almost in all cases.

At some joints of the skeletal system movements occur only in conjunction with movements at the neighbouring joints, i.e. anatomically isolated joints are united by a common function. Such functional combination of joints must be borne in mind in studying their structure and analysing the character of movements.

ARTICULATIONS OF THE BONES OF THE TRUNK AND THE HEAD

Juncturae trunci et capitis

ARTICULATIONS OF THE TRUNK BONES

ARTICULATIONS OF THE VERTEBRAL COLUMN

The separate vertebrae are joined to one another by means of various articulations to form the **vertebral column** *(columna vertebralis)*.

These articulations are as follows: (1) intervertebral discs uniting adjacent vertebral bodies; (2) zygapophyseal joints uniting arches and processes of adjacent vertebrae; (3) ligaments of the vertebral column which stretch between the bodies, arches, and processes of the vertebrae.

INTERVERTEBRAL DISCS

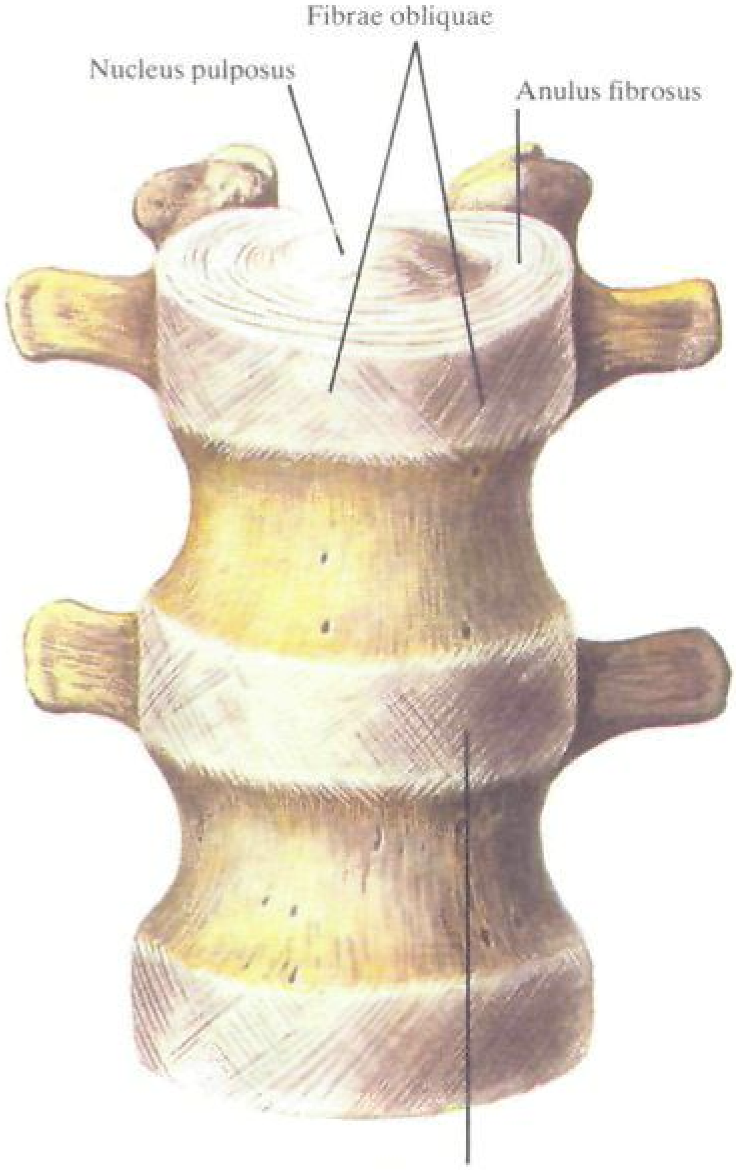
Intervertebral discs (cartilages) are located between the bodies of two adjacent vertebrae in the cervical, thoracic, and lumbar segments of the vertebral column.

An **intervertebral disc** *(discus intervertebralis)* (Figs 181-183) is formed of fibrous cartilage. A peripheral part called the **anulus fibrosus** and a centrally located **nucleus pulposus** are distinguished in it.

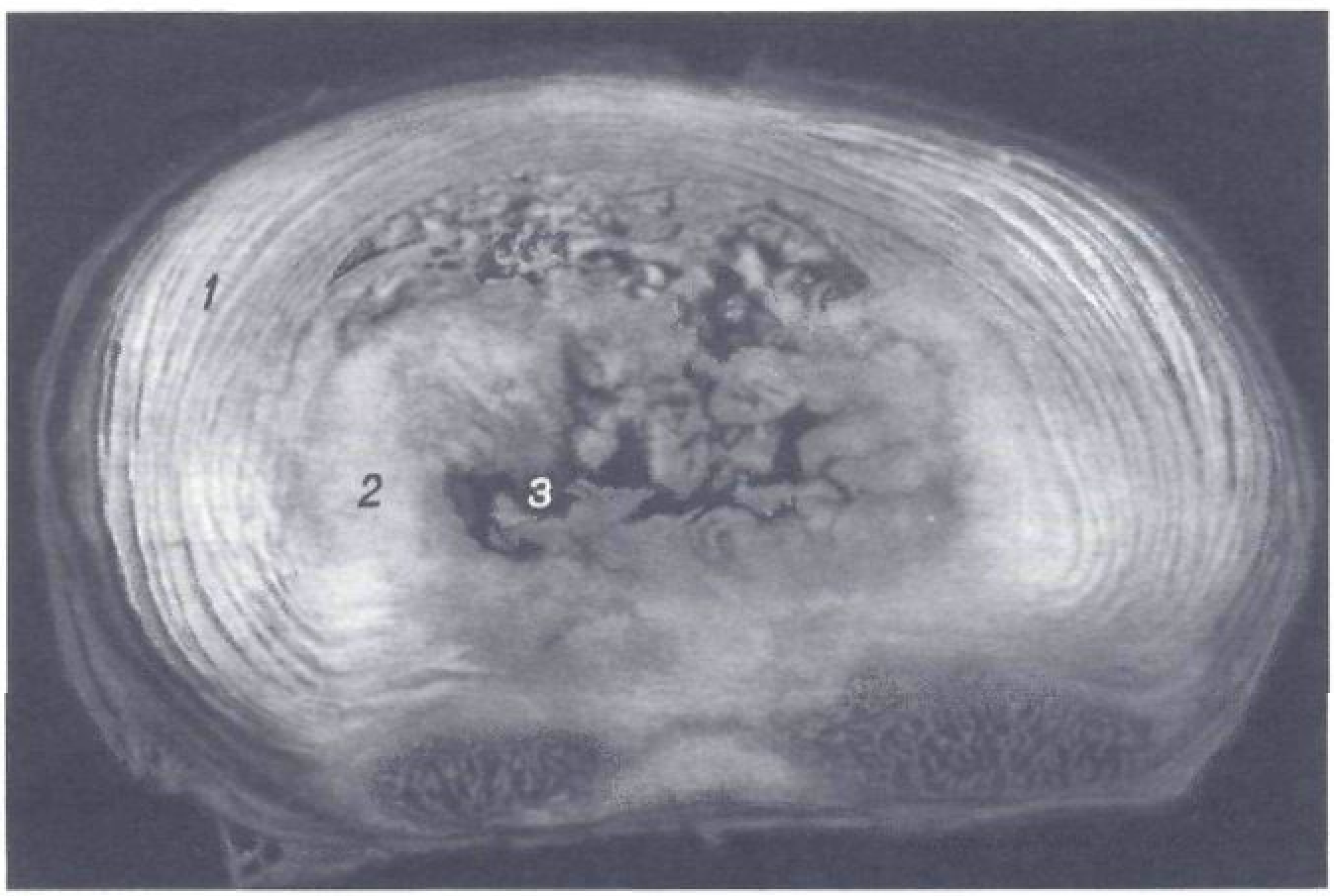
The collagen fibres forming the anulus fibrosus are arranged concentrically, obliquely (one across another), and spirally. Their ends merge with the periosteum of the vertebral bodies. The central part of the disc (nucleus pulposus) is very resilient and is a peculiar elastic layer. In lateral movements of the vertebral column it is displaced to the side of extension. On cross-section of the intervertebral disc the nucleus pulposus, which is normally compressed, protrudes above the level of the anulus fibrosus. The intervertebral disc fuses with the hyaline cartilage covering the adjacent surfaces of the vertebral bodies and is similar in shape to these surfaces. There is no disc between the atlas and axis. The thickness of the discs differs and increases gradually towards the lower segments of the vertebral column; the discs of the cervical and lumbar segments are slightly thicker in front than at the back. The discs are much thinner in the middle part of the thoracic segment than in the proximally and distally located parts. The cartilaginous discs account for a quarter of the length of the vertebral column.

THE ZYGAPOPHYSEAL JOINTS

The **zygapophyseal joints** *(junctura zygapophysealis)* (see Figs 182, 183, 184) form between the **superior articular process** *(processus articularis superior)* of one vertebra and the **inferior articular process** *(processus articularis inferior)* of the next distal vertebra. The **articular capsule** *(capsula articularis)* is attached to the margins of the articular cartilage. The **joint cavity** *(cavum articulare)* is set in



181. *Intervertebral discs (disci intervertebrales)*; anterior aspect (⁴⁄₅).



181a. *Intervertebral discs of the lumbar segment* (photograph).

(Horizontal section through middle of disc.)

1—anulus fibrosus
2—nucleus pulposus
3—cavity of intervertebral disc in the articulation between lumbar and sacral vertebrae

accordance with the position and direction of the articular surfaces and is nearer to the horizontal plane in the cervical segment, to the frontal plane in the thoracic segment, and to the sagittal plane in the lumbar segment.

The zygapophyseal joints are of the plane type in the cervical and thoracic segments and pivot in the lumbar segment.

They are related functionally to joints allowing only a slight range of movements.

The symmetric zygapophyseal joints are combined joints, i.e. those in which movement at one joint inevitably causes movement at the other because both are formed by processes on the same bone.

THE LIGAMENTS OF THE VERTEBRAL COLUMN

The **ligaments of the vertebral column** *(ligamenta columnae vertebralis)* are divided into two groups, the group of long and the group of short ligaments.

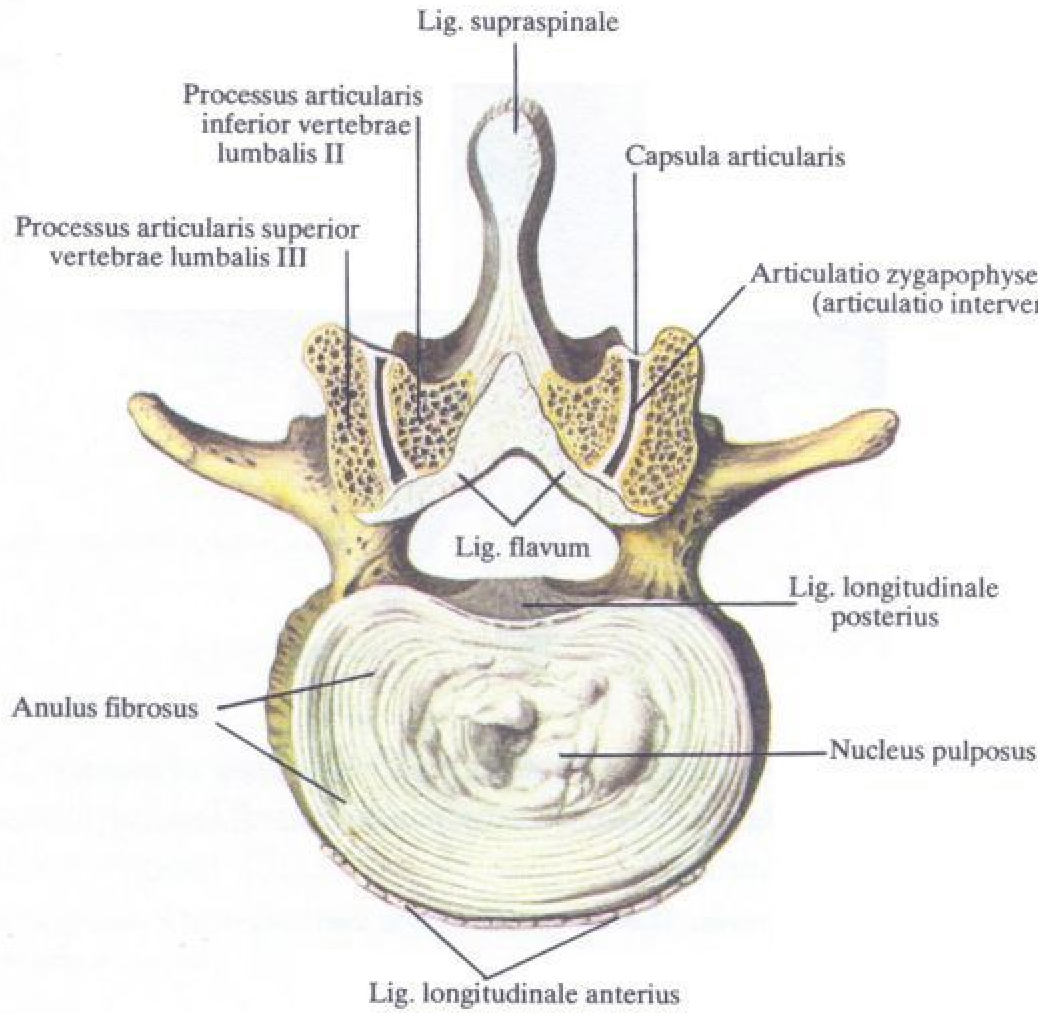
THE LONG LIGAMENTS OF THE VERTEBRAL COLUMN

The long ligaments of the vertebral column are as follows.

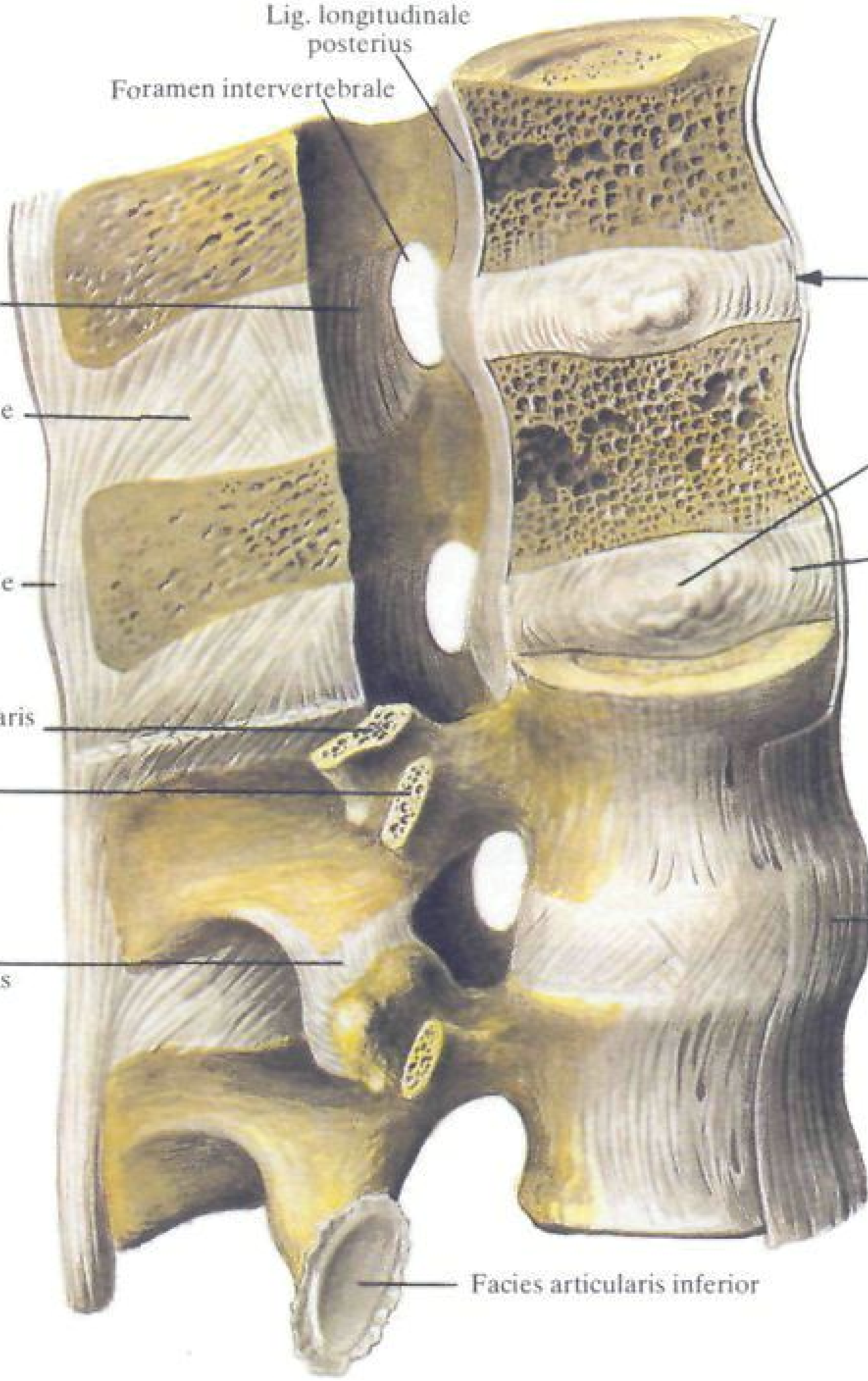
1. The **anterior longitudinal ligament** *(ligamentum longitudinale anterius)* (see Figs 182–187) runs on the anterior and partly on the lateral surfaces of the vertebral bodies from the anterior tubercle of the atlas to the sacrum where it merges with the periosteum of the first and second sacral vertebrae.

In the lower parts of the vertebral column the anterior longitudinal ligament is much wider and stronger; it is joined loosely to the vertebral bodies and firmly with the intervertebral discs because it intertwines with the perichondrium covering them; on the sides of the vertebrae it is continuous with their periosteum. The deep layers of bunches of this ligament are shorter than the superficial layers. As a result they join two adjacent vertebrae, whereas the superficial, longer bunches stretch for the distance of four or five vertebrae. The anterior longitudinal ligament prevents extreme extension of the vertebral column.

2. The **posterior longitudinal ligament** *(ligamentum longitudinale posterius)* (see Figs 182–184, 187, 188) runs on the posterior surface of the vertebral bodies in the **vertebral canal** *(canalis vertebralis)*. It arises on the posterior surface of the axis and is continuous with the **membrana tectoria** at the level of the upper two cervical vertebrae. Inferiorly this ligament stretches to the proximal part of

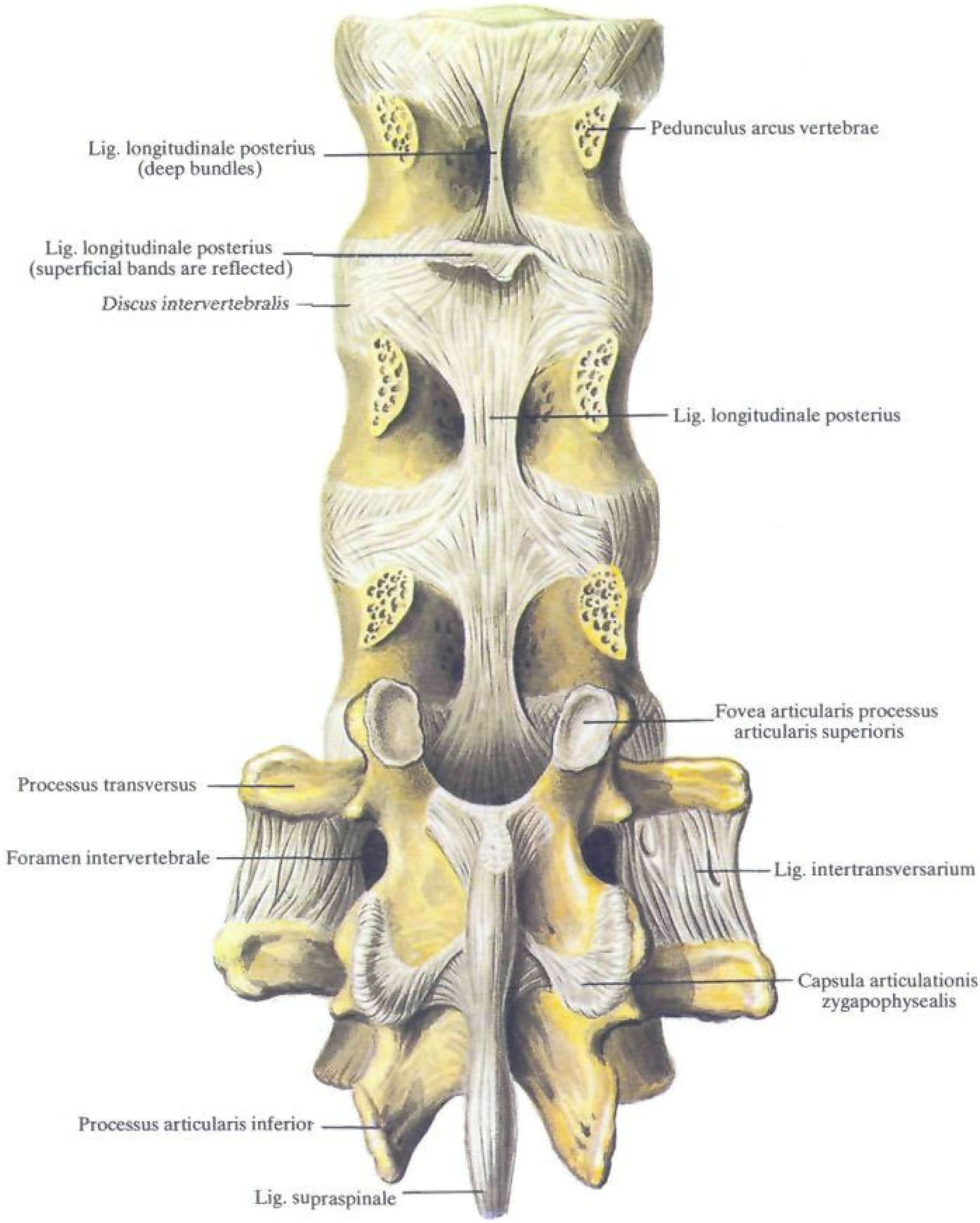


182. *Zygapophyseal joint (junctura zygapophysealis)*; superior aspect (4/5).
(Third lumbar vertebra. Articulation between second and third lumbar vertebrae; section.)



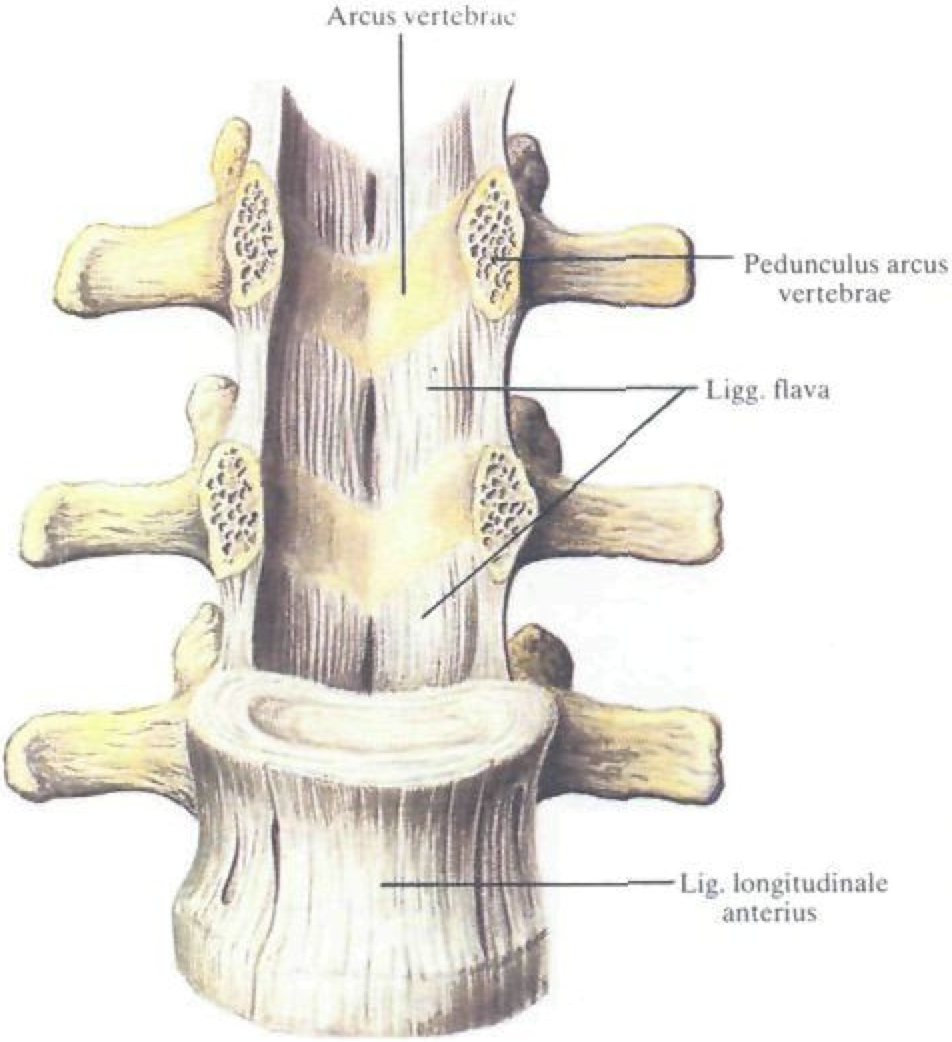
183. *Ligaments and joints of vertebral column (ligamenta et juncturae columnae vertebralis)*; right aspect (4/5).

(Lumbar segment. The vertebral canal is partly opened.)



184. *Ligaments and joints of vertebral column (ligamenta et juncturae columnae vertebralis);* posterior aspect ($^4/_5$).

(Lumbar segment. The arches and processes of twelfth thoracic and first and second lumbar vertebrae are removed.)



185. ***Ligaments of vertebral column (ligamenta columnae vertebralis);*** **anterior aspect ($^3/_5$).**

(Lumbar segment. Bodies of first and second lumbar vertebrae removed by frontal section.)

the sacral canal. In contrast to the anterior longitudinal ligament, the posterior ligament is wider in the upper than in the lower parts of the vertebral column. It is fused firmly with the intervertebral discs and is slightly wider here than at the level of the vertebral bodies. It is joined loosely to the bodies of the vertebrae from which it is separated by a layer of connective tissue lodging a venous plexus. Like in the anterior longitudinal ligament, the superficial bundles are longer than the deep ones.

THE SHORT LIGAMENTS OF THE VERTEBRAL COLUMN

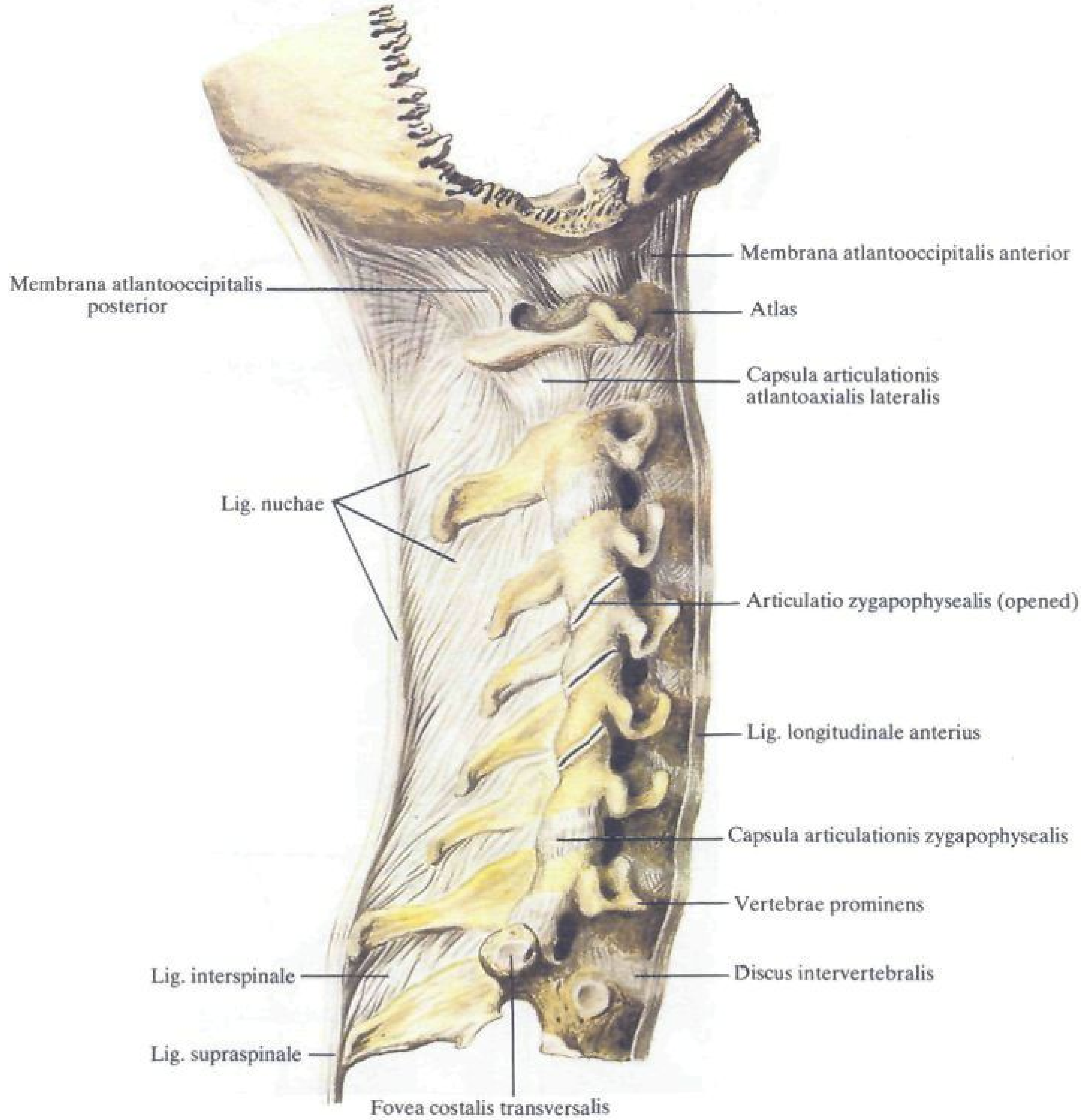
The short ligaments of the vertebral column are as follows.

1. The **yellow ligaments** *(ligamenta flava)* (see Figs 182, 183, 185) fill the spaces between the vertebral arches from the axis to the sacrum. They stretch from the inner surface and lower border of the vertebral arch to the external surface and upper border of the arch of the next lower vertebra, and their anterior edges limit the intervertebral foramen from the back.

The ligamenta flava are made up of vertically running elastic bands lending them a yellow colour. They are strongest in the lumbar segment. The ligamenta flava are very resilient and elastic as a result of which they become shorter in extension of the trunk and act like muscles, holding the trunk in extension and relieving the tension of the muscles. In flexion they stretch and in this way also relieve the tension of the erector muscle of the spine (see *Muscles of the Back*). There are no ligamenta flava between the atlas and the axis; a connective-tissue atlantoaxial membrane is stretched here whose anterior margin limits posteriorly the **intervertebral foramen** *(foramen intervertebrale)* transmitting the second cervical nerve.

2. The **interspinous ligaments** *(ligamenta interspinalia)* (see Figs 183, 186, 187) are thin bands filling the spaces between the spinous processes of two adjacent vertebrae. They are strongest in the lumbar segment of the vertebral column and least developed between the cervical vertebrae. They are joined to the ligamenta flava anteriorly and are continuous posteriorly with the supraspinous ligament at the apex of the spinous process.

3. The **supraspinous ligament** *(ligamentum supraspinale)* (see Fig. 183) is a continuous band running over the tips of the spinous processes in the lumbar and thoracic segments. It is lost downwards on the spinous processes of the sacral vertebrae; above it is continuous with the rudimentary *ligamentum nuchae* at the level of the prominent (seventh cervical) vertebra.



186. *Ligaments and joints of vertebral column (ligamenta, juncturae et articulationes columnae vertebralis)*;
right side, lateral aspect (3/4).

4. The **ligamentum nuchae** (see Fig. 186) is a thin triangular band of elastic and connective-tissue fibres. It ascends from the spinous process of the prominent vertebra along the spinous processes of the cervical vertebrae and, expanding, is attached to the external occipital crest and the external occipital protuberance.

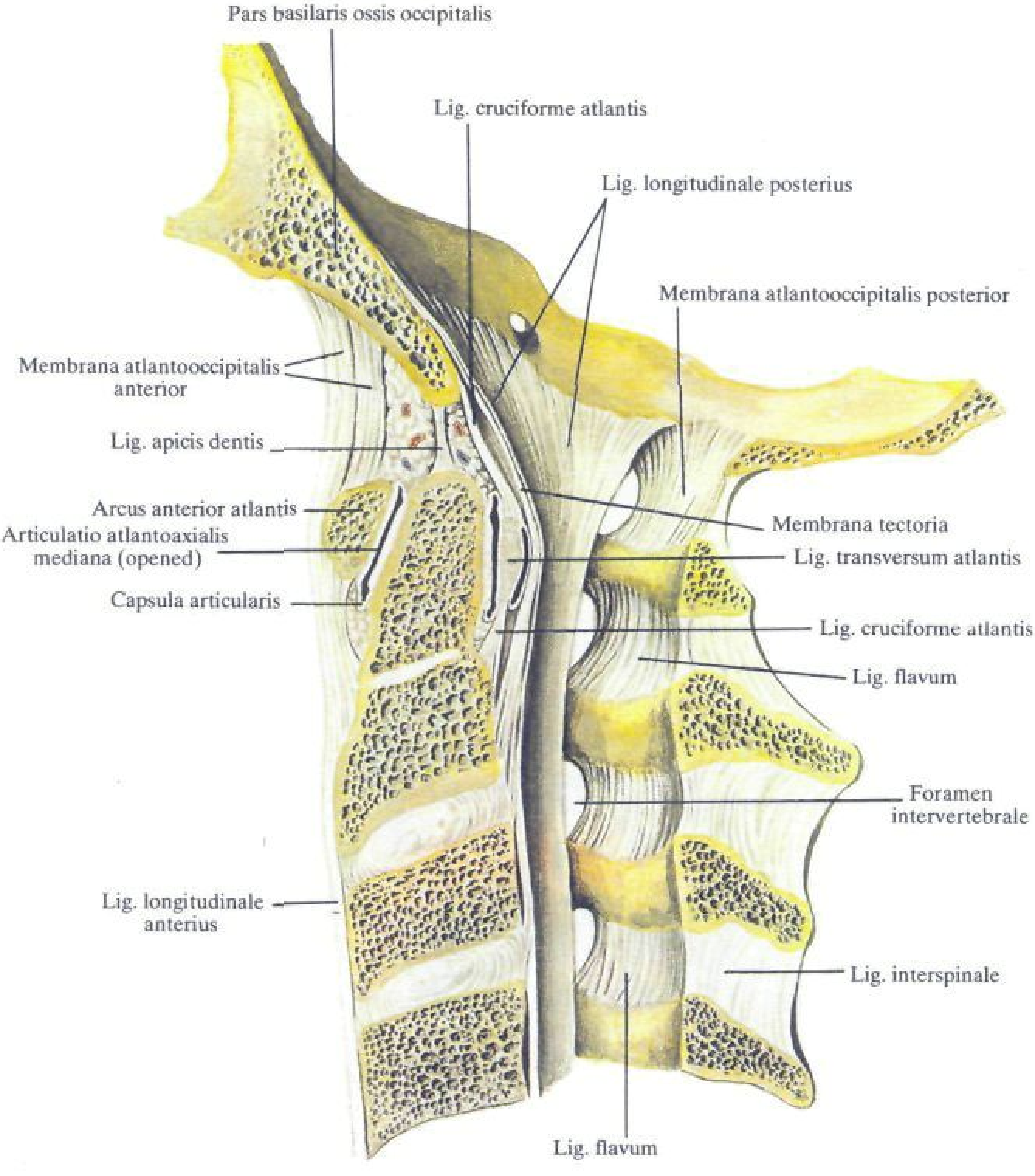
5. The **intertransverse ligaments** *(ligamenta intertransversaria)* (see Fig. 184) are thin bands which are poorly developed in the cervical and partly in the thoracic segments but are stronger in the lumbar part. They are paired ligaments joining the apices of the transverse processes of adjacent vertebrae and limiting flexion of the spine to the contralateral side. In the cervical segment they may be bifid or may be absent completely.

THE SACROCOCCYGEAL JOINT

The **sacrococcygeal joint** *(junctura sacrococcygea)* forms between the bodies of the fifth sacral and first coccygeal vertebrae; the sacrococcygeal synchondrosis contains a small cavity in the intervertebral disc.

This synchondrosis is strengthened by the following ligaments (see Figs 218-219).

1. The **lateral sacrococcygeal ligament** *(ligamentum sacrococcygeum laterale)* stretches between the transverse processes of the last



187. ***Ligaments and joints of cervical vertebrae and occipital bone***; **inner aspect ($^1/_1$).**

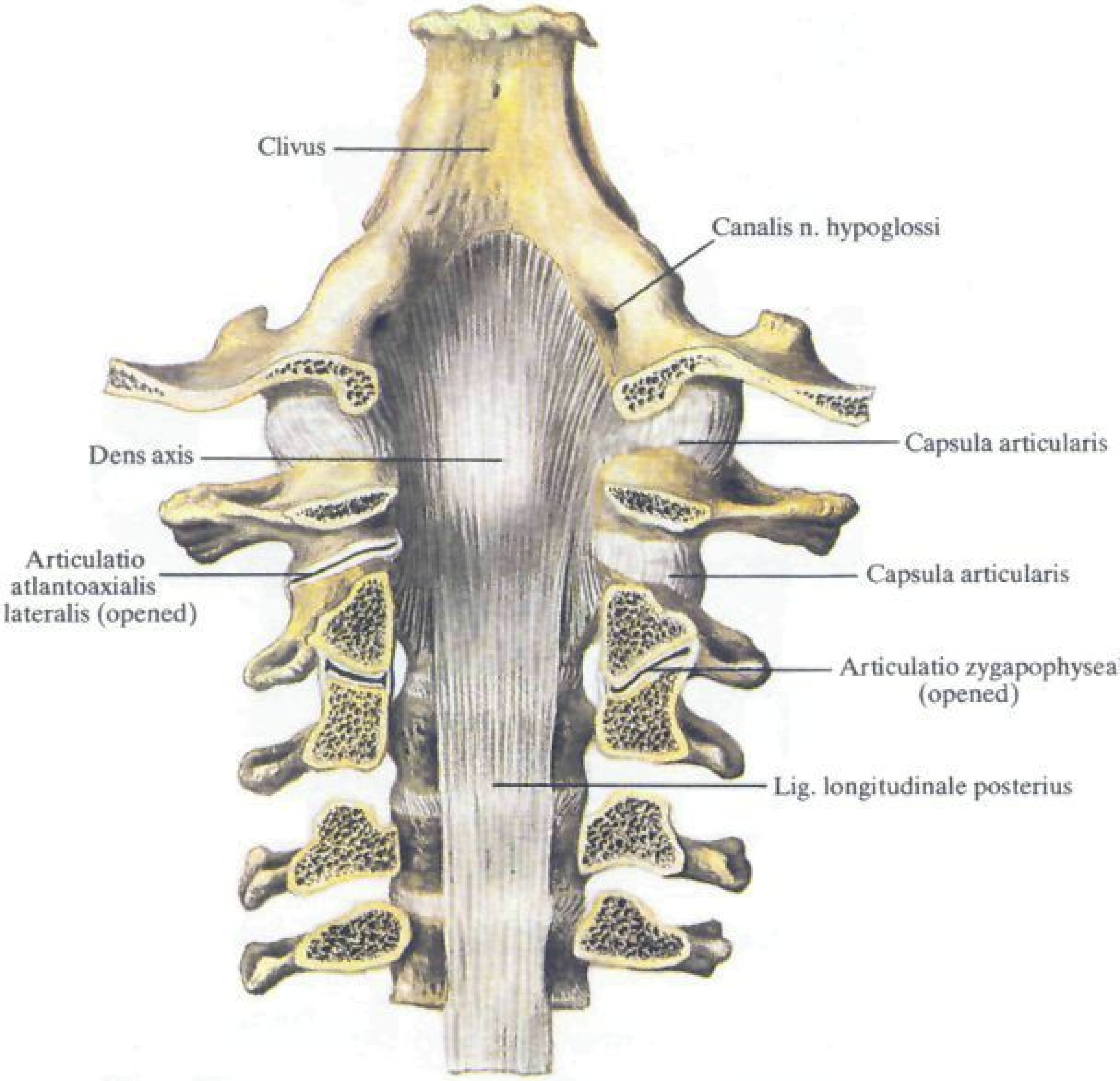
(Sagittal median section through occipital bone and first to fourth cervical vertebrae.)

sacral and first coccygeal vertebrae and is a continuation of the intertransverse ligament.

2. The **anterior sacrococcygeal ligament** *(ligamentum sacrococcygeum ventrale)* is a continuation of the anterior longitudinal ligament and consists of two bands located on the anterior surface of the sacrococcygeal joint. The fibres of these bands intersect.

3. The **superficial posterior sacrococcygeal ligament** *(ligamentum sacrococcygeum dorsale superficiale)* is stretched between the posterior surface of the coccyx and the lateral walls of the opening into the sacral canal and closes its fissure. It corresponds to the ligamenta flava and the supraspinous ligaments of the vertebral column.

4. The **deep posterior sacrococcygeal ligament** *(ligamentum sacrococcygeae dorsale profundum)* is a continuation of the posterior longitudinal ligament.



188. *Ligaments and joints of cervical vertebrae and occipital bone*; inner aspect ($\frac{4}{5}$).

(Posterior parts of occipital bone and arches of first to fifth cervical vertebrae removed by frontal section.)

ARTICULATIONS AND LIGAMENTS BETWEEN THE OCCIPITAL BONE AND THE ATLAS AND AXIS

The **atlanto-occipital joint** *(articulatio atlantooccipitalis)* (see Figs 187, 188; 189–192) is paired. It is formed by the articular surfaces of the **occipital condyles** *(condyli occipitalis)* and the **superior articular facet** *(fovea articularis superior)* of the atlas. The longitudinal axes of the articular surfaces of the occipital bone and the atlas come a little closer to each other anteriorly. The articular surfaces of the occipital bone are shorter than those of the atlas. The articular capsule is attached to the margins of the articular cartilages. According to the shape of the articulating surfaces, this joint is included in the group of **ellipsoid joints** *(articulatio ellipsoidea)*.

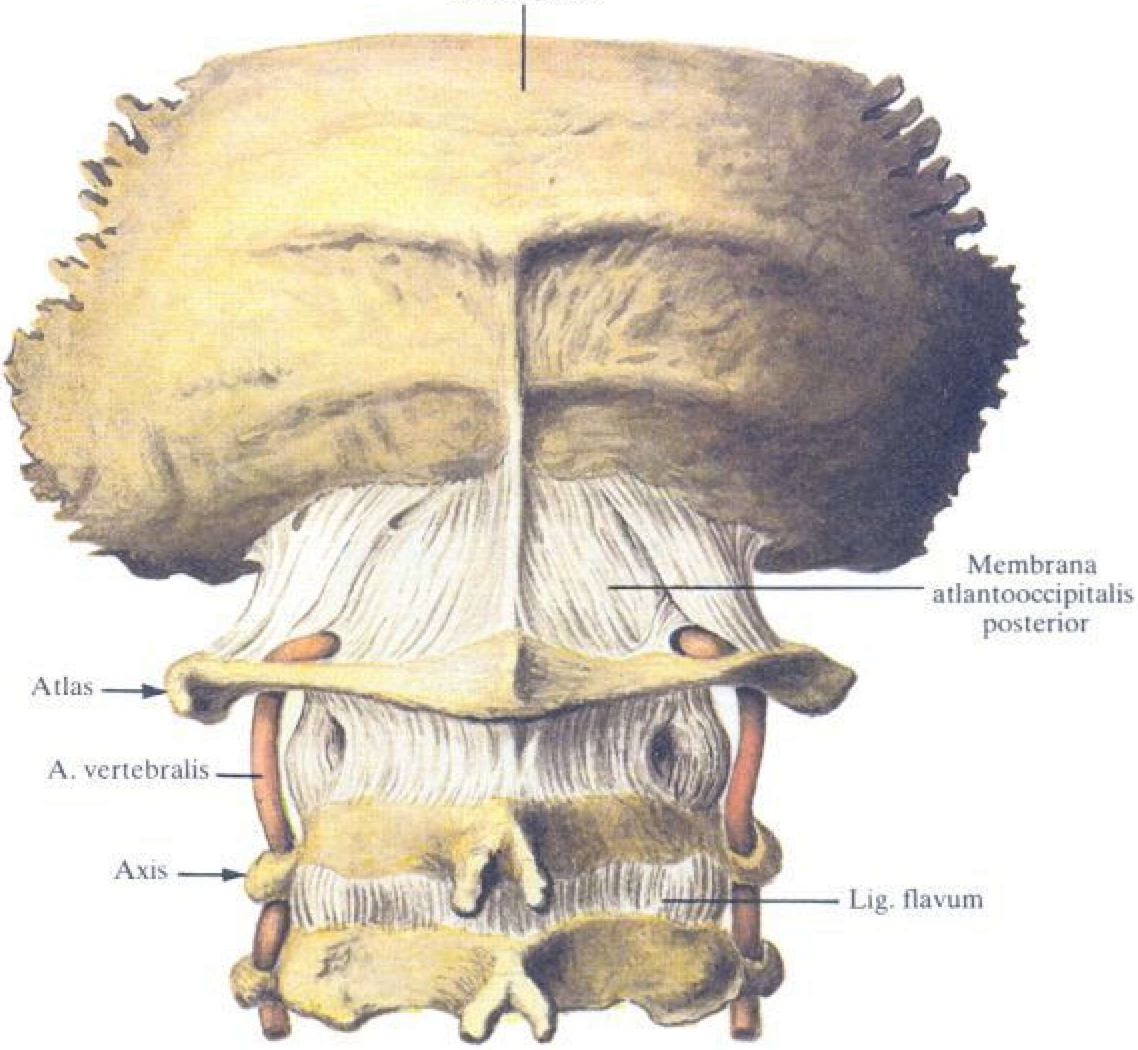
At both joints, the right and the left, possessing separate articular capsules, movements occur simultaneously, i.e. the joints form a single combined joint. Nodding (anterior and posterior flexion) and slight sidewards movements of the head are possible.

1. The **anterior atlanto-occipital membrane** *(membrana atlantooccipitalis anterior)* (see Figs 186, 187) stretches for the whole distance of the gap between the anterior border of the foramen magnum and the superior margin of the anterior arch of the atlas; it merges with the upper end of the anterior longitudinal ligament.

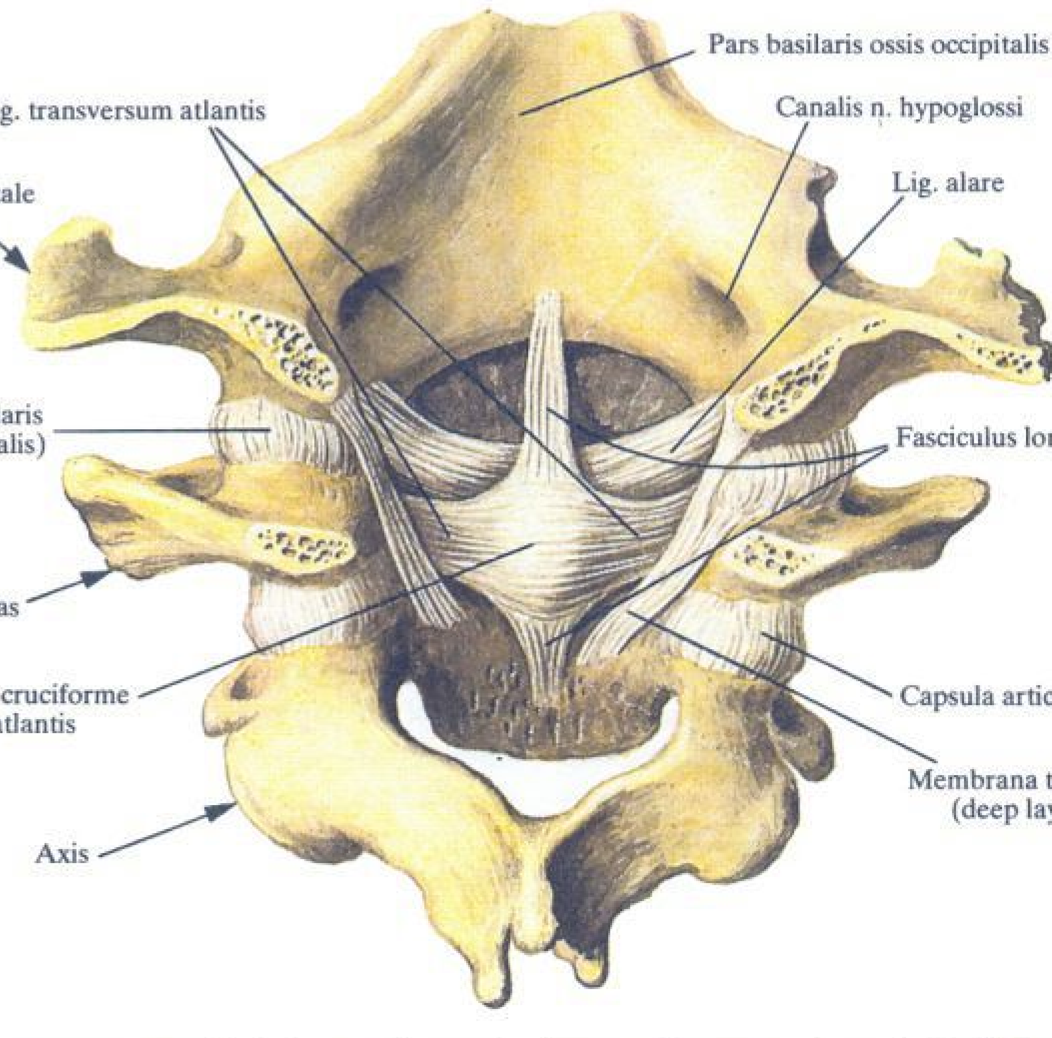
2. The **posterior atlanto-occipital membrane** *(membrana atlantooccipitalis posterior)* (see Figs 186, 187, 189) stretches between the posterior border of the foramen magnum and the superior margin of the posterior arch of the atlas. In its anterior part is an opening transmitting vessels and nerves. It is an altered ligamentum flavum.

The following three joints form in articulation of the atlas and axis; two are paired and one is unpaired.

1. The **lateral atlantoaxial joint** *(articulatio atlantoaxialis latera-*

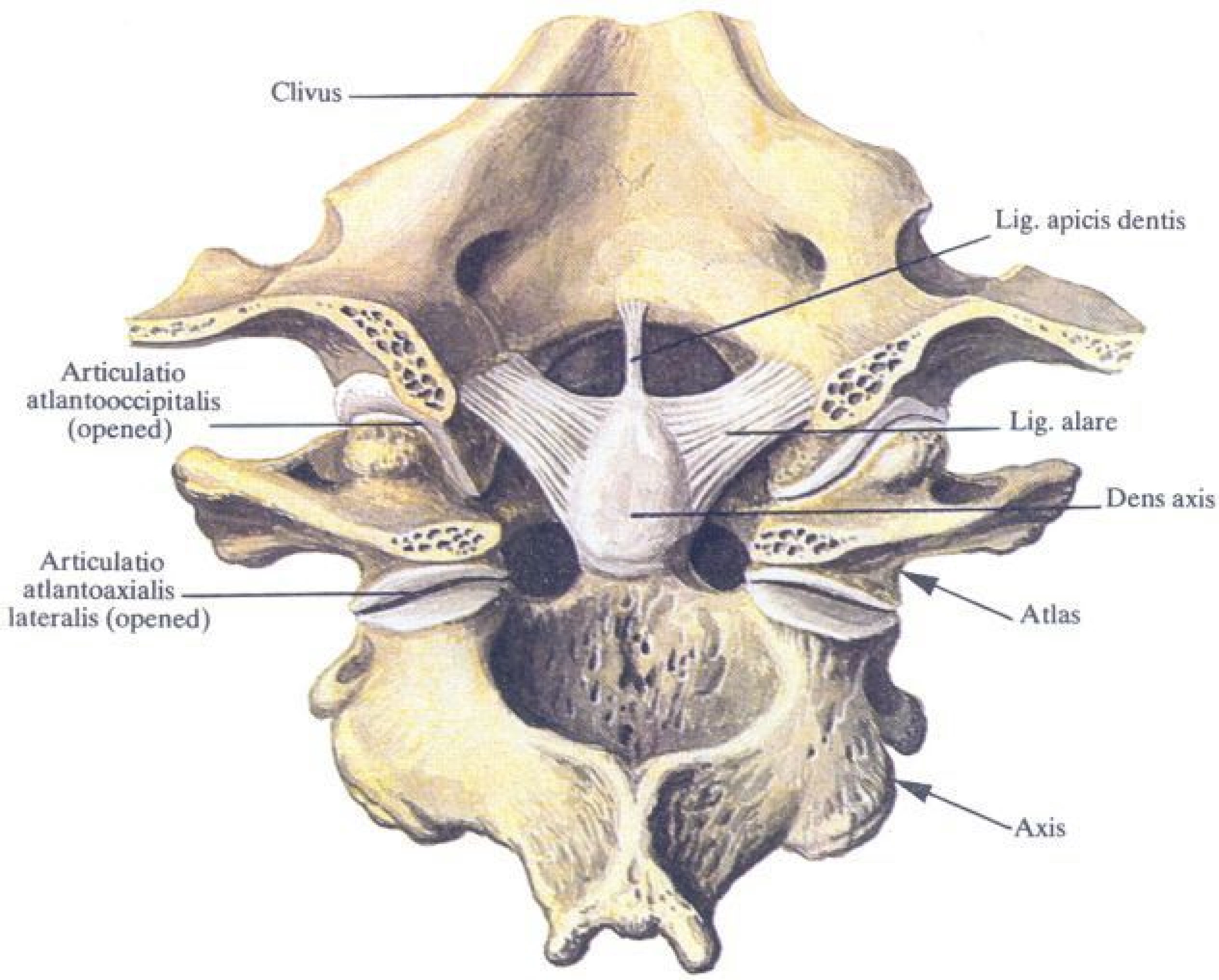


189. *Ligaments of cervical vertebrae and occipital bone*; posterior aspect ($\frac{3}{4}$).

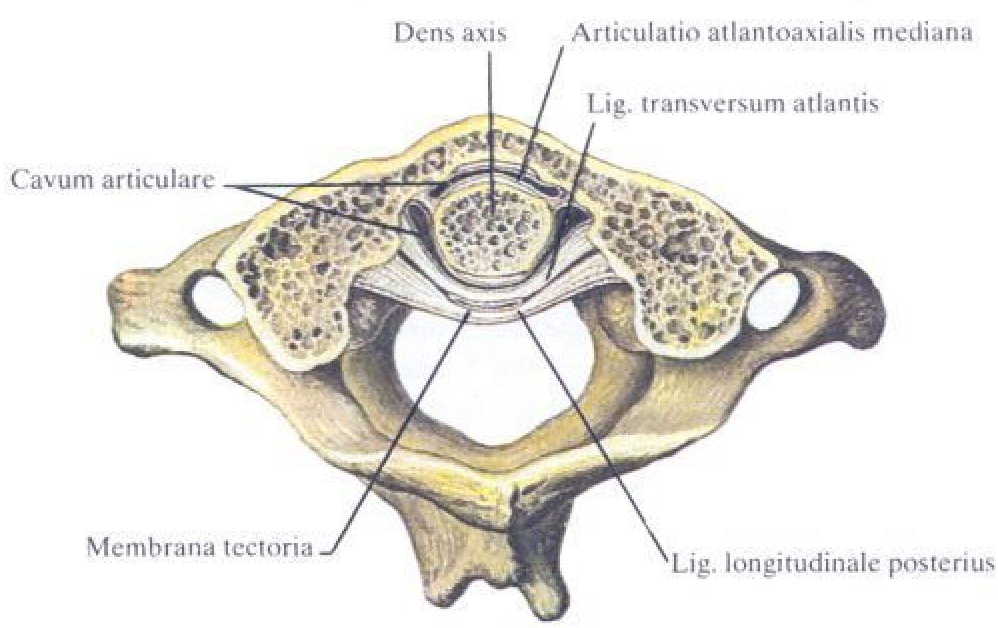


190. *Ligaments and joints of cervical vertebrae and occipital bone*; inner aspect ($\frac{1}{1}$).

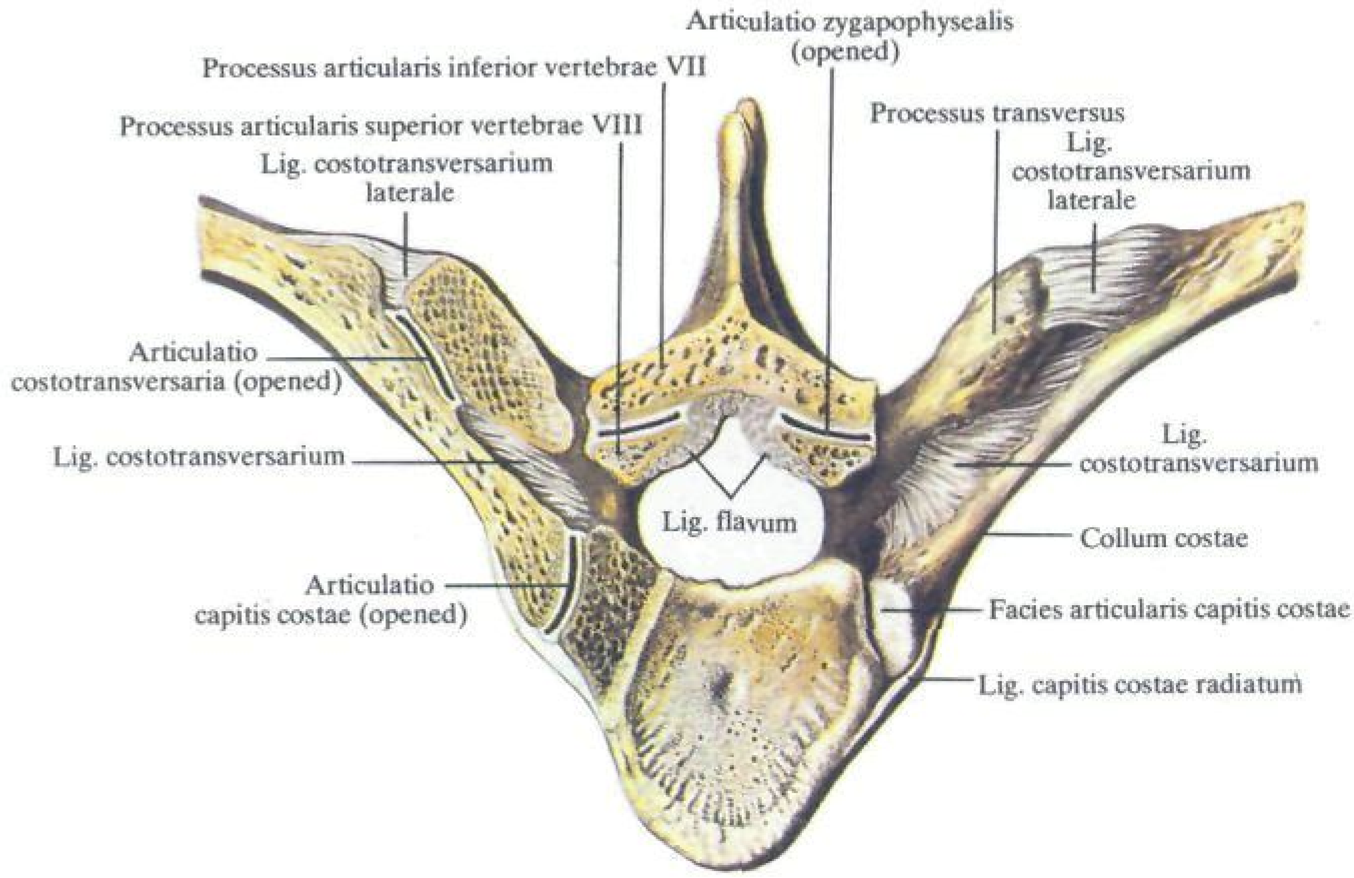
(Posterior parts of occipital bone and posterior arch of atlas are removed.)



191. *Ligaments and joints of cervical vertebrae and occipital bone*; inner aspect (1/1).
(Posterior parts of occipital bone and posterior arch of atlas are removed.)



192. *Ligaments and joints of atlas and axis*; superior aspect (3/4).
(Anterior arch and lateral masses of atlas and dens of axis partly removed by horizontal section.)



193. *Ligaments and joints of ribs and vertebrae*; superior aspect ($\frac{4}{5}$).

(Part of eighth thoracic vertebra and right seventh rib removed by horizontal section.)

lis) (see Figs 187; 190-192) is a paired combined joint formed by the superior articular facets of the axis and the inferior articular facets of the atlas. It allows a poor range of movements because the articulating surfaces are flat and even. The articular facets of the atlas make gliding movement in all directions in relation to the axis.

2. The **median atlantoaxial joint** *(articulatio atlantoaxialis mediana)* (see Figs 187, 191, 192) forms between the posterior surface of the anterior arch of the atlas (fovea dentis) and the dens of the axis. Besides, the posterior articular facet of the dens forms a joint with the transverse ligament of the atlas.

The joints of the dens are related to the group of trochoid, or pivot joints and allow rotation of the atlas together with the head about the dens of the axis, i.e. turning the head to the right and to the left.

The ligaments of the two joints described are as follows.

1. The **membrana tectoria** (see Figs 190, 192) is a broad, rather dense fibrous sheet stretched from the anterior border of the foramen magnum to the body of the axis. It is called so (L *tectum* roof) because it covers posteriorly (from the aspect of the vertebral canal) the dens, the transverse ligament of the atlas, and other structures of this joint. It is regarded as a part of the posterior longitudinal ligament of the vertebral column.

2. The **cruciate ligament of the atlas** *(ligamentum cruciforme atlantis)* (see Fig. 190) consists of two bands (longitudinal and transverse). The stout connective-tissue transverse band stretches between the inner parts of the lateral mass of the atlas. It adjoins the posterior articular surface of the dens of the axis and reinforces it. This band is called the **transverse ligament of the atlas** *(ligamentum transversum atlantis)* (see Figs 190, 192). The **longitudinal band** *(fasciculus longitudinalis)* is made up of two, upper and lower, bands. The upper band runs from the middle of the transverse ligament

of the atlas to the anterior surface of the foramen magnum. The lower band, which also arises from the middle of the transverse ligament, passes downwards to be attached to the posterior surface of the body of the axis.

3. The **apical ligament of the odontoid process** *(ligamentum apicis dentis)* (Figs 187, 191) stretches between the apex of the dens and the middle of the anterior border of the foramen magnum. It is considered a rudiment of the chorda dorsalis.

4. The **alar ligaments of the odontoid process** *(ligamenta alaria)* (see Figs 190, 191) are formed of bands of connective-tissue fibres stretched between the lateral surfaces of the dens and medial surfaces of the occipital condyles.

ARTICULATIONS OF THE RIBS

The joints formed by the ribs allow movements. The posterior ends of the ribs unite with the bodies and transverse processes of the thoracic vertebrae to form the **costovertebral joints** *(articulationes costovertebrales)*, the anterior ends unite with the sternum to form the **sternocostal joints** *(articulationes sternocostales)*.

THE COSTOVERTEBRAL JOINTS

The posterior ends of the ribs articulate with the vertebrae by means of two joints.

1. The **joint of the head of a rib** *(articulatio capitis costae)* (Figs 193-196) is formed by the articular facet of the head of the rib and the costal facets of the vertebral bodies. The heads of the second to tenth ribs are conical and come in contact with the corresponding articular facets of the bodies of two adjacent vertebrae.

The facets of the vertebral bodies are usually formed by a smaller **superior costal facet** *(fovea costalis superior)* located in the lower part of the body of the next vertebra above and a larger **inferior costal facet** *(fovea costalis inferior)* at the upper border of the next vertebra below. The first, eleventh, and twelfth ribs articulate with the facet of only one vertebra. The articular facets of the vertebrae and heads of the ribs are covered by fibrous cartilage.

The **intra-articular ligament of the joint of the head of rib** *(ligamentum capitis costae intraarticulare)* is lodged in the cavity of the joints of the second to tenth ribs. It runs from the crest of the head to the intervertebral disc and divides the joint cavity into two compartments. The articular capsule is thin and strengthened by the **radiant ligament of the joint of the head of the rib** *(ligamentum capitis costae radiatum)* which arises from the anterior surface of the head of the rib and is attached fan-wise to two adjacent vertebrae and the intervertebral disc.

2. The **costotransverse joint** *(articulatio costotransversaria)* (see Figs 193, 194, 196) is formed by the **articular facet of the tubercle of a rib** *(facies articularis tuberculis costae)* and the **costal facet** *(fovea costalis transversalis)* of one of the transverse processes of the thoracic vertebrae. Only the upper ten ribs have such joints. The articular facets are covered by hyaline cartilage. The thin articular capsule is attached to the edges of the facets.

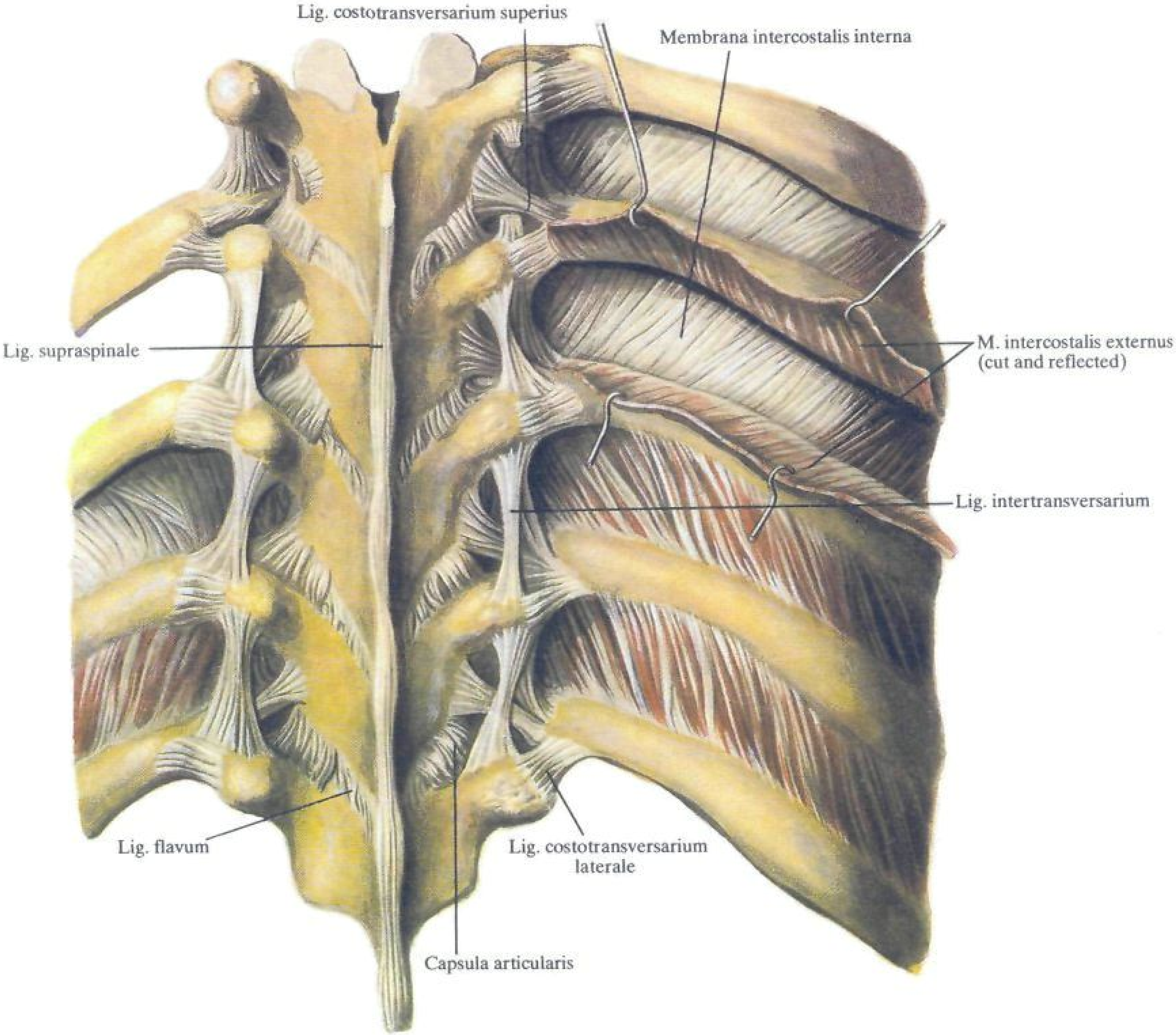
The joint is strengthened by the following ligaments.

A. The **superior costotransverse ligament** *(ligamentum costotransversarium superius)* arises from the inferior surface of a transverse process and is attached to the crest of the neck of the next rib below.

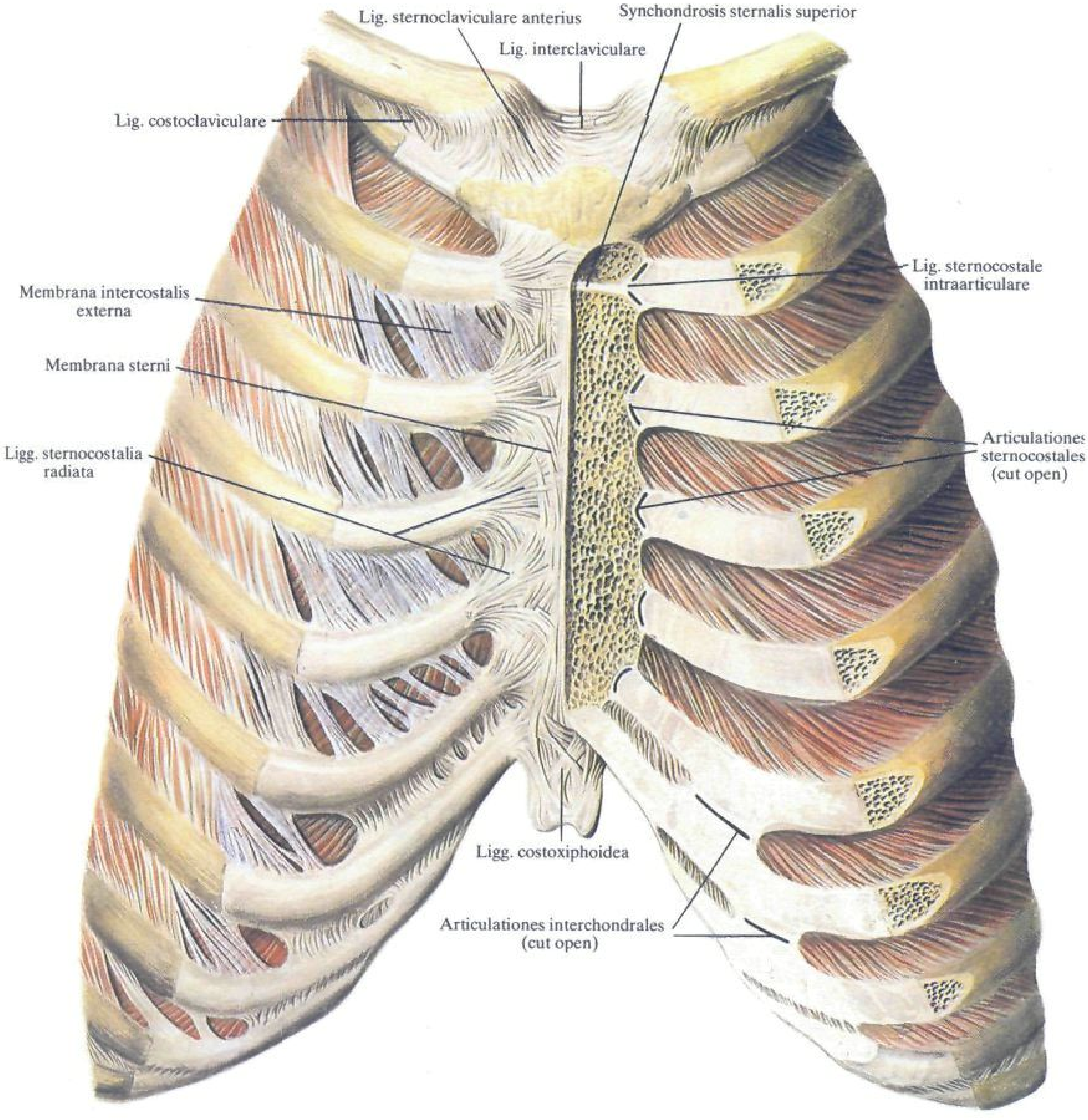
B. The **lateral costotransverse ligament** *(ligamentum costotransversarium laterale)* is stretched between the bases of the transverse and spinous processes and the posterior surface of the neck of the next rib below.

C. The **inferior costotransverse ligament** *(ligamentum costotransversarium)* is lodged between the posterior surface of the neck of a rib and the anterior surface of the transverse process of the corresponding vertebra.

The articulations of the head and tubercle of the rib are combined (cylindrical or pivot) joints because they are connected functionally: movements occur at both joints during respiration.

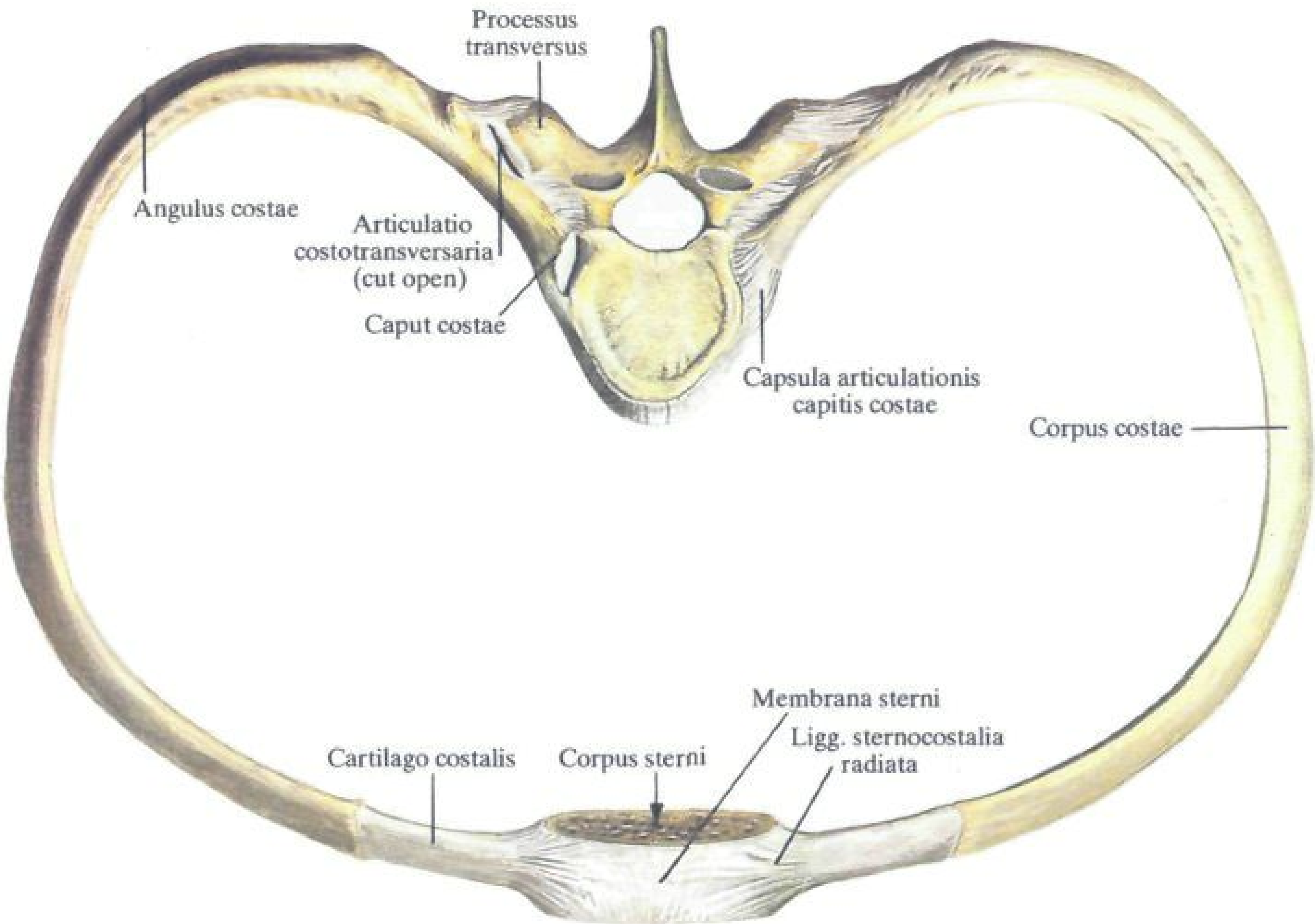


194. *Ligaments and joints of ribs and vertebrae*; posterior aspect ($\frac{3}{5}$).



195. *Ligaments and joints of ribs and sternum*; anterior aspect ($\frac{2}{3}$).

(Anterior parts of ribs and sternum on left side partly removed by frontal section.)



196. *Ligaments and joints of ribs, vertebrae, and sternum*; superior aspect (½).
(Union of fifth pair of ribs with fifth thoracic vertebra and corresponding sternal segment. Joint between head of left rib and vertebra is represented semischematically.)

THE STERNOCOSTAL JOINTS

The anterior ends of the ribs terminate as costal cartilages. The costal cartilage of the first rib is fused with the sternum (synchondrosis). Those of the second to seventh ribs articulate with the costal notches of the sternum to form the **sternocostal joints** *(articulationes sternocostales)* (Figs 195, 196). The cavity of these joints is a narrow vertical slit. The cavity of the second sternocostal joint contains the **intra-articular sternocostal ligament** *(ligamentum sternocostale intraarticulare)*, which passes from the second costal cartilage to the junction of the manubrium and body of the sternum.

In the cavities of the other sternocostal joints this ligament is either poorly pronounced or absent.

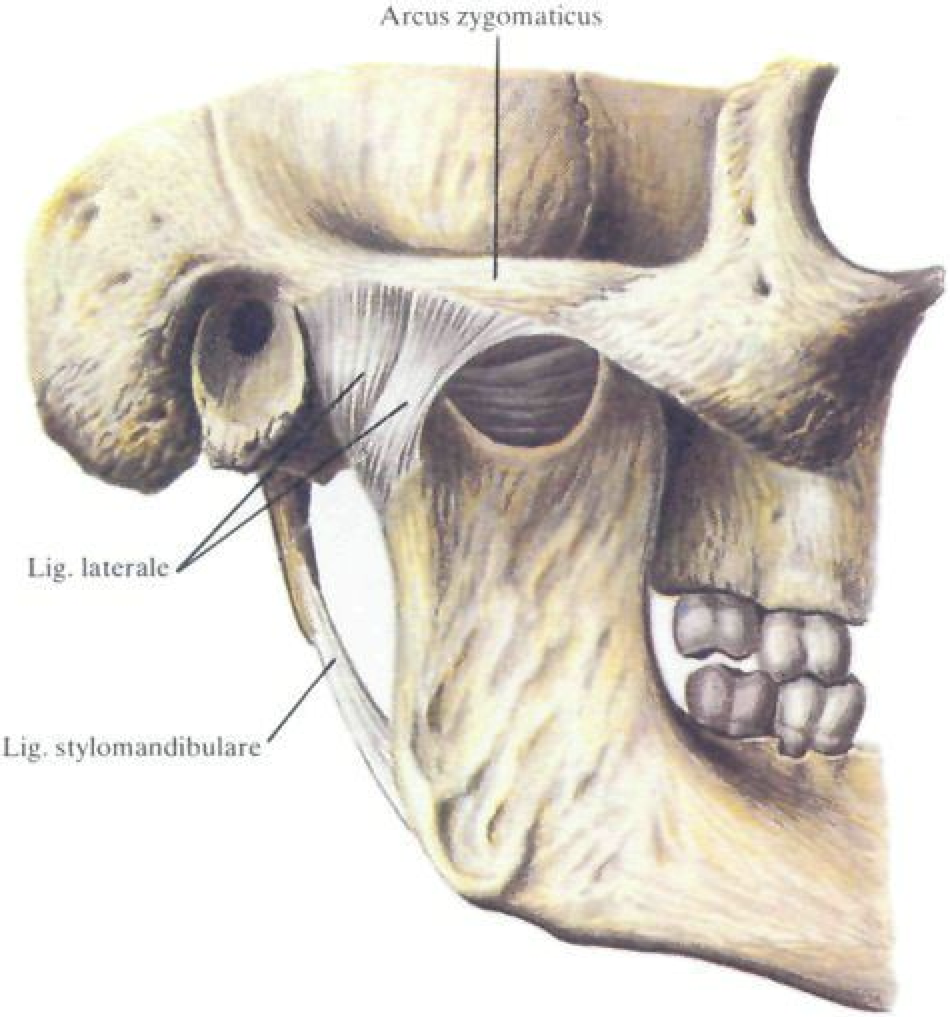
The capsules of these joints are formed by the perichondrium of the costal cartilages and are strengthened by the **sternocostal ligaments** *(ligamenta sternocostalis radiata)* among which the anterior ligaments are stronger than the posterior ones.

These ligaments fan out from the end of the costal cartilage to the anterior and posterior surfaces of the sternum and intersect and interlace with those on the opposite side and with ligaments located above and below them. As a result a strong fibrous layer covering the sternum forms. It is called the **sternal membrane** *(membrana sterni)*.

The bands of fibres descending from the anterior surfaces of the sixth and seventh costal cartilages obliquely and medially to the xiphoid process form the **costoxyphoid ligaments** *(ligamenta costoxiphoidea)*.

The fifth to ninth costal cartilages are joined to one another by means of dense fibrous tissue to form the **interchondral joints** *(articulationes interchondrales)*.

The tenth rib is joined to the cartilage of the ninth rib by fibrous tissue, while the cartilages of the eleventh and twelfth ribs end freely between the abdominal muscles.

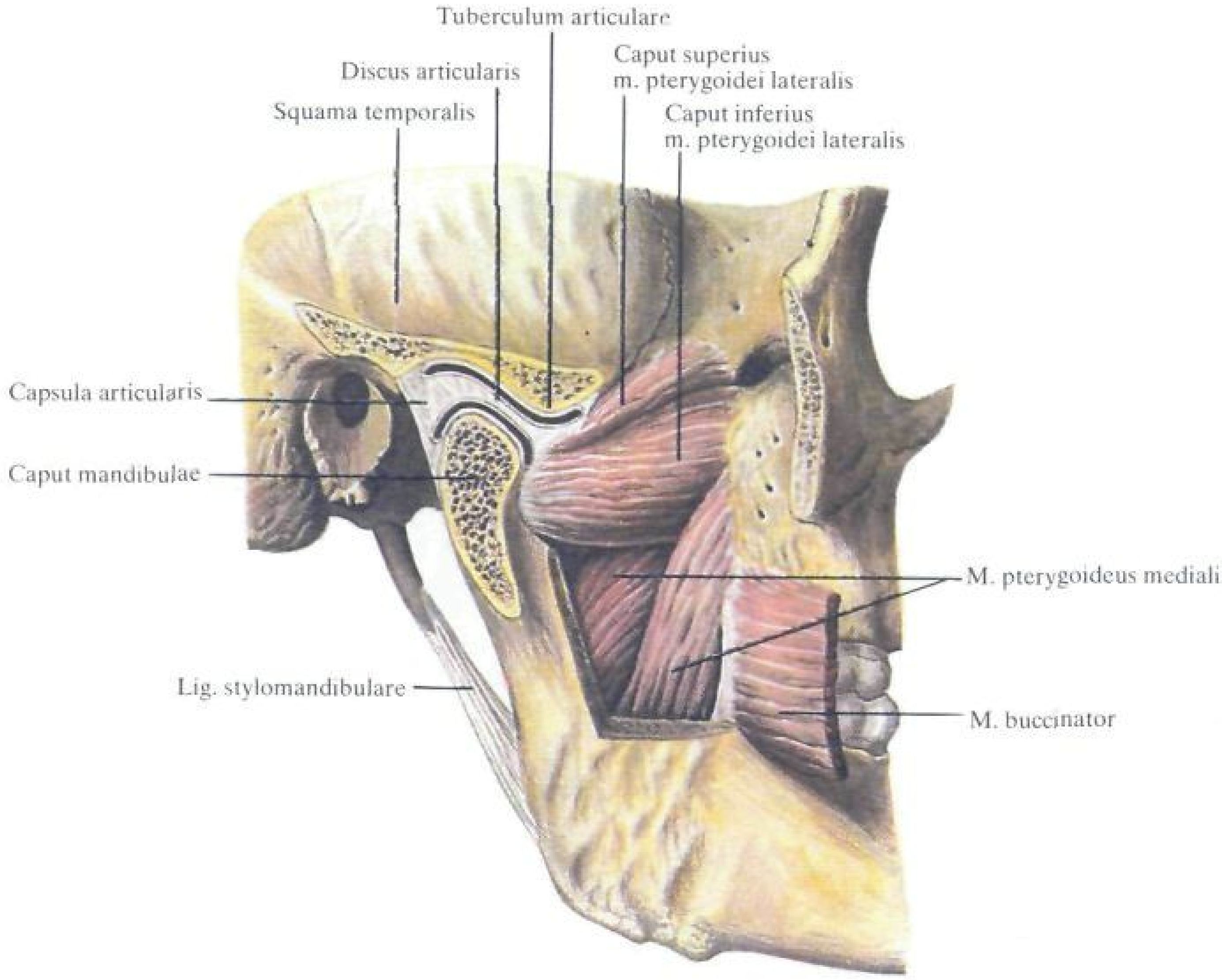


197. *Right mandibular joint (articulatio temporomandibularis)*; lateral aspect (3/4).

ARTICULATIONS OF THE BONES OF THE SKULL

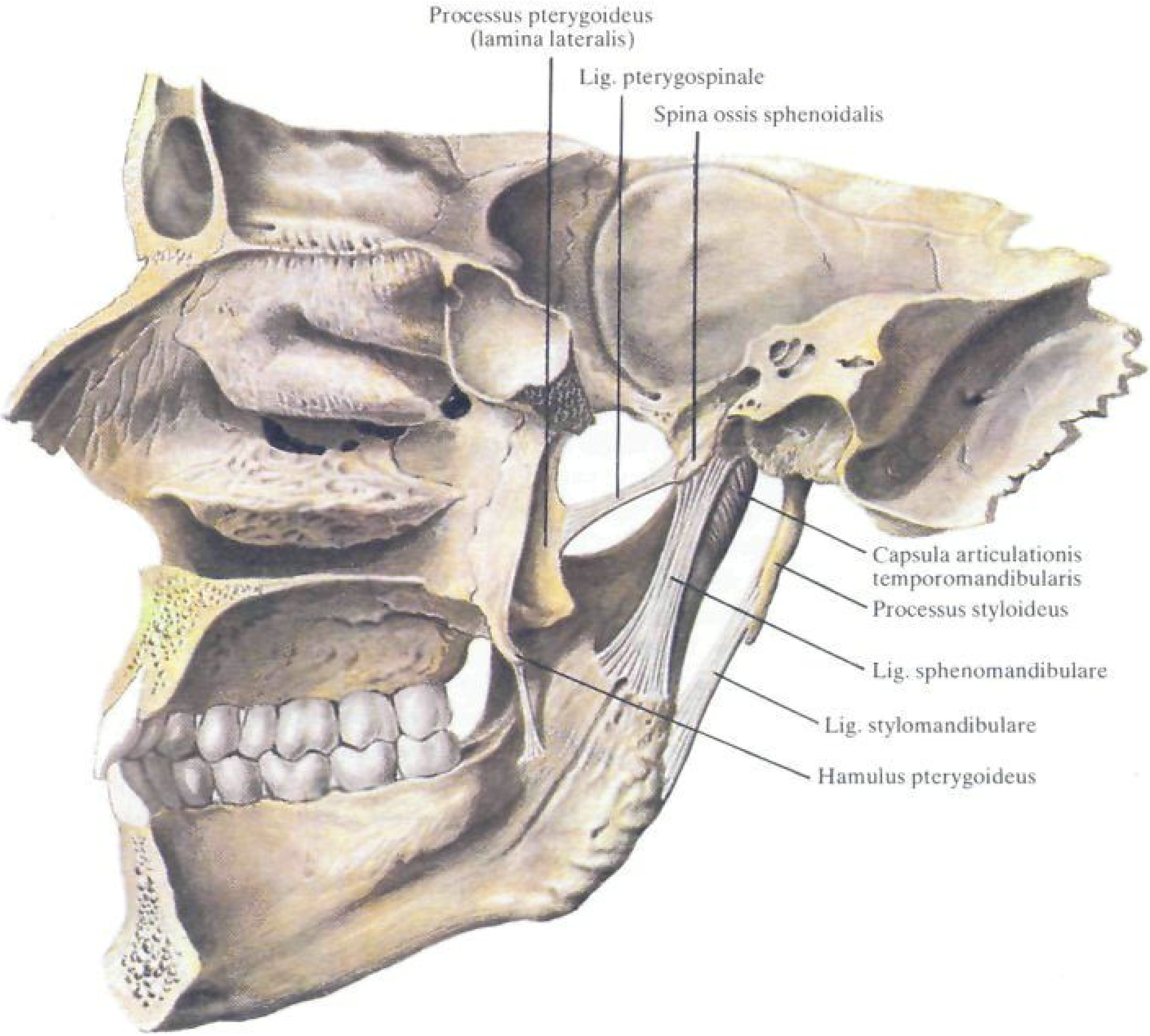
Except for the mandible, the bones of the skull articulate by means of contiguous joints. The bones of the skull cap are joined to one another by fibrous connective tissue to form syndesmoses. The bones of the base of the skull articulate by means of cartilaginous tissue to form synchondroses. Both are replaced with age by bony tissue to form synostoses.

The **fontanelles** *(fonticuli)* (see Figs 99, 100) deserve mention among the syndesmoses. They are described in details in the section *The Skull as a Whole.*



198. *Right mandibular joint (articulatio temporomandibularis)*; lateral aspect ($\frac{3}{4}$).

(Joint opened by sagittal section.)



199. *Right mandibular joint (articulatio temporomandibularis)*; medial aspect ($^4/_5$).

THE MANDIBULAR JOINT

The **mandibular joint** *(articulatio temporomandibularis)* (Figs 197-199) is a paired joint formed by the **head of the mandible** *(caput mandibulae)* and the **articular (mandibular) fossa** *(fossa mandibularis)* and **eminentia articularis** *(tuberculum articulare)* of the squamous part of the emporal bone. The heads of the mandible are ellipsoid-shaped and their long converging axes form an obtuse angle at the anterior border of the foramen magnum.

The articular fossa of the temporal bone is partly included in the cavity of the mandibular joint. Two parts are distinguished in the fossa: **extracapsular,** located behind the squamotympanic fissure and **intracapsular,** which lies to the front of it. The intracapsular part of the articular fossa is enclosed in a capsule which also extends to the anterior margin of the articular tubercle. The articular surfaces are covered by a connective-tissue cartilage. A biconcave oval plate of fibrous cartilage is lodged in the joint cavity. This is the **articular disc** *(discus articularis)* (Fig. 198); it lies horizontally adjoining the articular tubercle above and the head of the mandible below. It is fused on the periphery with the articular capsule and separates the joint cavity into two communicating compartments, superior and inferior. Some tendinous fibres of the lateral pterygoid muscle are attached to the medial edge of the disc.

The **articular capsule** *(capsula articularis)* is attached along the edge of the articular cartilage; on the temporal bone it is fastened anteriorly to the anterior sloping surface of the articular tubercle, posteriorly to the anterior margin of the petrotympanic fissure, and laterally to the base of the zygomatic process. Medially it reaches the spine of the sphenoid bone. The capsule embraces the neck of the mandible and is attached on its posterior aspect somewhat lower than on the anterior aspect.

The ligaments of the mandibular joint can be divided into the following three groups.

I. Intracapsular ligaments *(ligamenta intracapsularia).* These are the meniscotemporal ligaments (anterior and posterior) running from the temporal bone to the posterior parts of the disc, and the meniscomandibular ligaments (medial and lateral) stretching from the neck of the mandible to the inferior circumference of the disc.

II. Extracapsular ligaments *(ligamenta extracapsularia).* This is the **lateral ligament** *(ligamentum laterale)* (Fig. 197). It arises from the base of the zygomatic process of the temporal bone and stretches to the lateral and posterior surfaces of the neck of the mandible. Some of its bands intertwine with the capsule of the joint. Two parts are distinguished in the ligament, anterior (or lateral) and posterior (or medial).

III. Ligaments related to the mandibular joint but not connected with the articular capsule.

1. The **sphenomandibular ligament** *(ligamentum sphenomandibulare)* (Fig. 199) extends from the spine of the sphenoid bone and is attached to the lingula of the mandible.
2. The **stylomandibular ligament** *(ligamentum stylomandibulare)* (Figs 197-199) stretches from the styloid process of the temporal bone to the mandibular angle.

The mandibular joint is a **hinge joint,** or **ginglymus.** The right and left joints form together a single combined articulation. Movements at the joints lower and raise the mandible, displace it forwards, backwards, and to the side (right or left). In movements to the side slight rotation about the vertical axis occurs in one joint, while in the other joint the articular disc is displaced in the direction of the movement of the head of the mandible.

ARTICULATIONS OF THE SHOULDER GIRDLE AND FREE UPPER LIMB

Juncturae cinguli membri superioris et membri superioris liberi

ARTICULATIONS OF THE UPPER LIMB

The **articulations of the upper limb** *(juncturae membri superioris)* are subdivided into the **articulations of the shoulder girdle** *(juncturae cinguli membri superioris)* and the **articulations of the free upper limb** *(juncturae membri superioris liberi).*

ARTICULATIONS OF THE SHOULDER GIRDLE

The bones of the upper limb are joined to the skeleton of the trunk by means of one joint, the sternoclavicular joint.

THE STERNOCLAVICULAR JOINT

The **sternoclavicular joint** *(articulatio sternoclavicularis)* (Fig. 200) is formed by the clavicular notch of the sternum and the sternal end of the clavicle. This is a **simple joint** *(articulatio simplex).*

The articular surfaces are covered by a connective-tissue cartilage, they are incongruent and saddle-shaped in most cases. The incongruency is corrected by the **articular disc** *(discus articularis)* lodged in the joint.

The **articular capsule** *(capsula articularis)* is strong and is attached to the margins of the articular surfaces of the bones. The articular disc divides the joint cavity into two parts, inferomedial and superolateral, which do not communicate. Sometimes the centre of the disc is perforated and both cavities of the joint communicate.

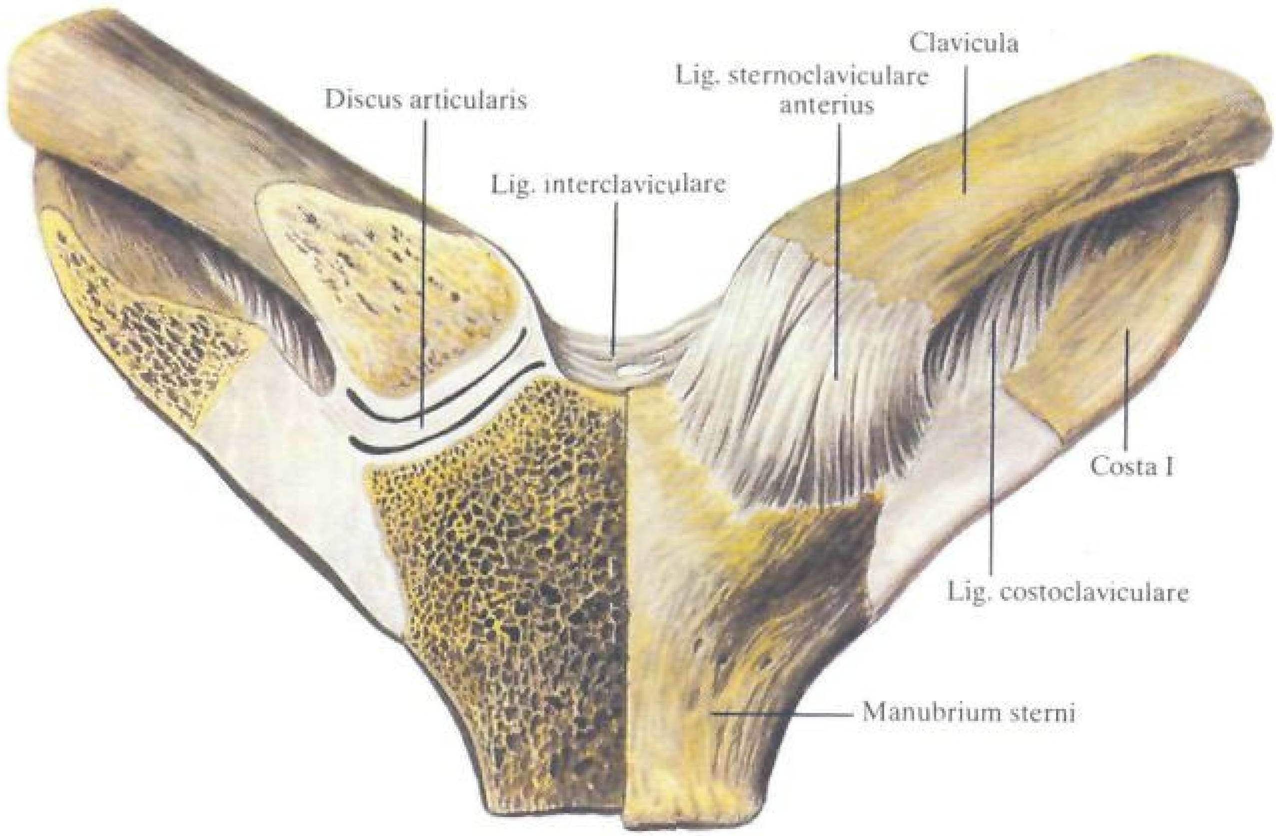
The ligamentous apparatus of the sternoclavicular joint is represented by the following ligaments.

1. The **anterior** and **posterior sternoclavicular ligaments** *(ligamenta sternoclaviculare anterius* et *posterius)* run on the anterior, superior, and posterior surfaces of the articular capsule and strengthen it.

2. The **costoclavicular ligament** *(ligamentum costoclaviculare)* is a strong ligament ascending from the superior border of the first rib to the clavicle and limits its movement upwards.

3. The **interclavicular ligament** *(ligamentum interclaviculare)* stretches between the sternal ends of the clavicles above the suprasternal notch. It limits movement of the clavicle downwards.

According to the range of movements, the sternoclavicular joint is closer to the type of **ball-and-socket (spheroid) joints** *(articulatio spheroidea s. cotylica).*



200. *Sternoclavicular joints (articulationes sternoclaviculares)*; anterior aspect ($^{3}/_{4}$).
(Right sternoclavicular joint opened by frontal section.)

THE ACROMIOCLAVICULAR JOINT

The **acromioclavicular joint** *(articulatio acromioclavicularis)* (see Fig. 204) is formed by the articular facet of the acromial end of the clavicle and the articular facet of the acromion of the scapula. This is a simple joint. The articulating surfaces are flat. An **articular disc** *(discus articularis)* is sometimes present in the joint cavity.

This is a multiaxial joint, but the range of movements is strictly limited in view of which it is related to **plane joints** *(articulatio plana)*.

The **articular capsule** *(capsula articularis)* is attached along the margin of the articular surfaces and is strengthened by the following ligaments.

1. The **acromioclavicular ligament** *(ligamentum acromioclavicularis)* stretches between the acromial end of the clavicle and the acromion of the scapula

2. The **coracoclavicular ligament** *(ligamentum coracoclaviculare)* (see Fig. 204) is stretched between the inferior surface of the acromial end of the clavicle and the coracoid process of the scapula.

Two parts are distinguished in the coracoclavicular ligament: the quadrangular **trapezoid part** *(ligamentum trapezoideum)* which occupies a lateral position and runs from the trapezoid line of the acromial end of the clavicle to the coracoid process of the scapula, and the triangular **conoid part** *(ligamentum conoideum)* stretching medial to the trapezoid part between the conoid tubercle of the acromial end of the clavicle and the coracoid process of the scapula.

Both ligaments meet at the coracoid process at an angle and limit a depression formed above by the clavicle and filled with areolar tissue and sometimes occupied by a synovial bursa.

LIGAMENTS OF THE SCAPULA

The ligaments of the scapula are fibrous bands which join its separate structures.

1. The **coracoacromial ligament** *(ligamentum coracoacromiale)* (Figs 201, 204) is the strongest of the scapular ligaments. It is stretched in the form of a quadrangular plate between the acromion and the coracoid process of the scapula.

2. The **suprascapular ligament**, or **superior transverse ligament of the scapula** *(ligamentum transversum scapulae superius)* (Figs 202, 203) bridges the scapular notch and together with it limits a foramen.

3. The **spinoglenoid ligament**, or **inferior transverse ligament of the scapula** *(ligamentum transversum scapulae inferius)* (see Fig. 202) is the weakest scapular ligament. It stretches on the posterior surface of the scapula from the root of the acromion, over the neck of the scapula, and to the lateral surface of the glenoid cavity; some of its bands intertwine with those of the capsule of the shoulder joint.

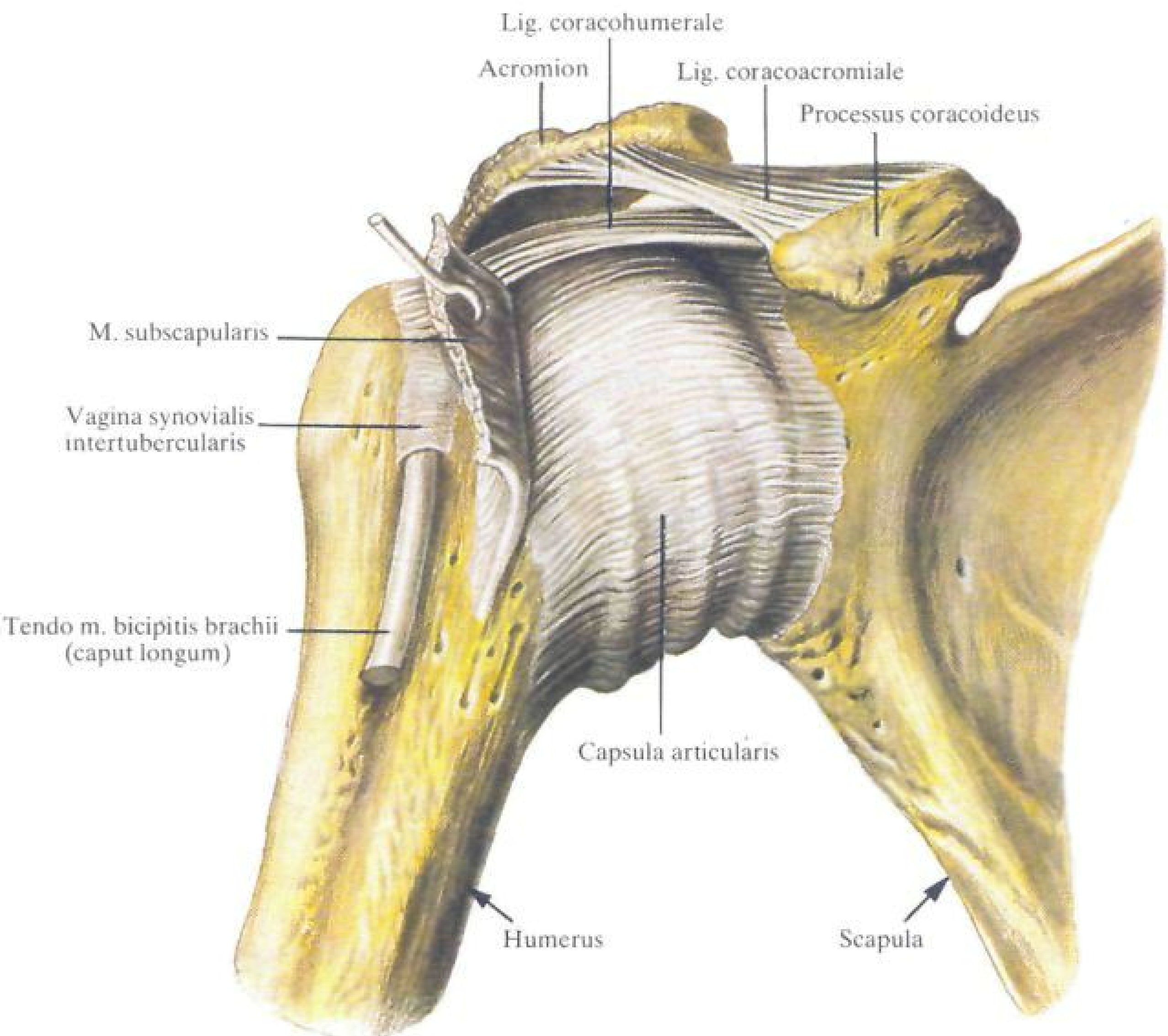
JOINTS OF THE FREE UPPER LIMB

THE SHOULDER JOINT

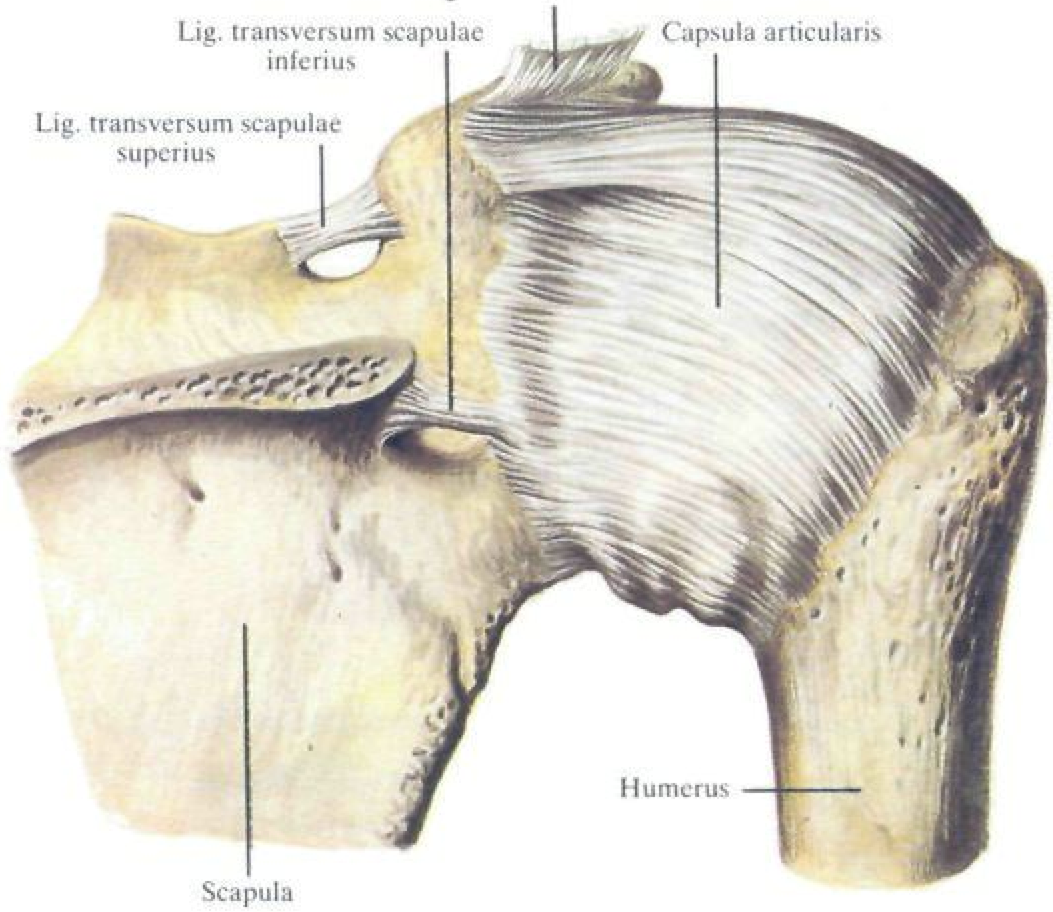
The **shoulder joint** *(articulatio humeri)* (Figs 201-206) is formed by the **glenoid cavity of the scapula** *(cavitas glenoidalis scapulae)* and the head of the humerus *(caput humeri)*. The articular surfaces are covered by hyaline cartilage and do not conform each other in shape. Their congruence is increased by the **labrum glenoidale** (Fig. 204) attached to the edge of the glenoid cavity.

The **articular capsule** *(capsula articularis)* is attached on the scapula to the periphery of the articular cartilage, the glenoid cavity, and external margin of the labrum glenoidale; on the humerus the capsule is attached to the anatomical neck. It is spacious and stretched weakly. Its inferomedial part is thin, but in the other parts the fibrous layer is strengthened by muscle tendons which are interlaced with it: by the supraspinatus, infraspinatus, and teres minor muscles in the lateral parts and by the subscapularis muscle in the medial part. In movement at the shoulder joint these muscles draw out the capsule and prevent its strangulation between the articulating surfaces of the bones.

On the humerus, the articular capsule bridges the biciptal groove and transmits the tendon of the long head of the biceps brachii muscle which arises from the supraglenoid tubercle and the margin of the labrum glenoidale, passes through the cavity of the shoulder joint, and then occupies the bicipital groove. In the



201. *Right shoulder joint (articulatio humeri)*; anterior aspect (3/4).

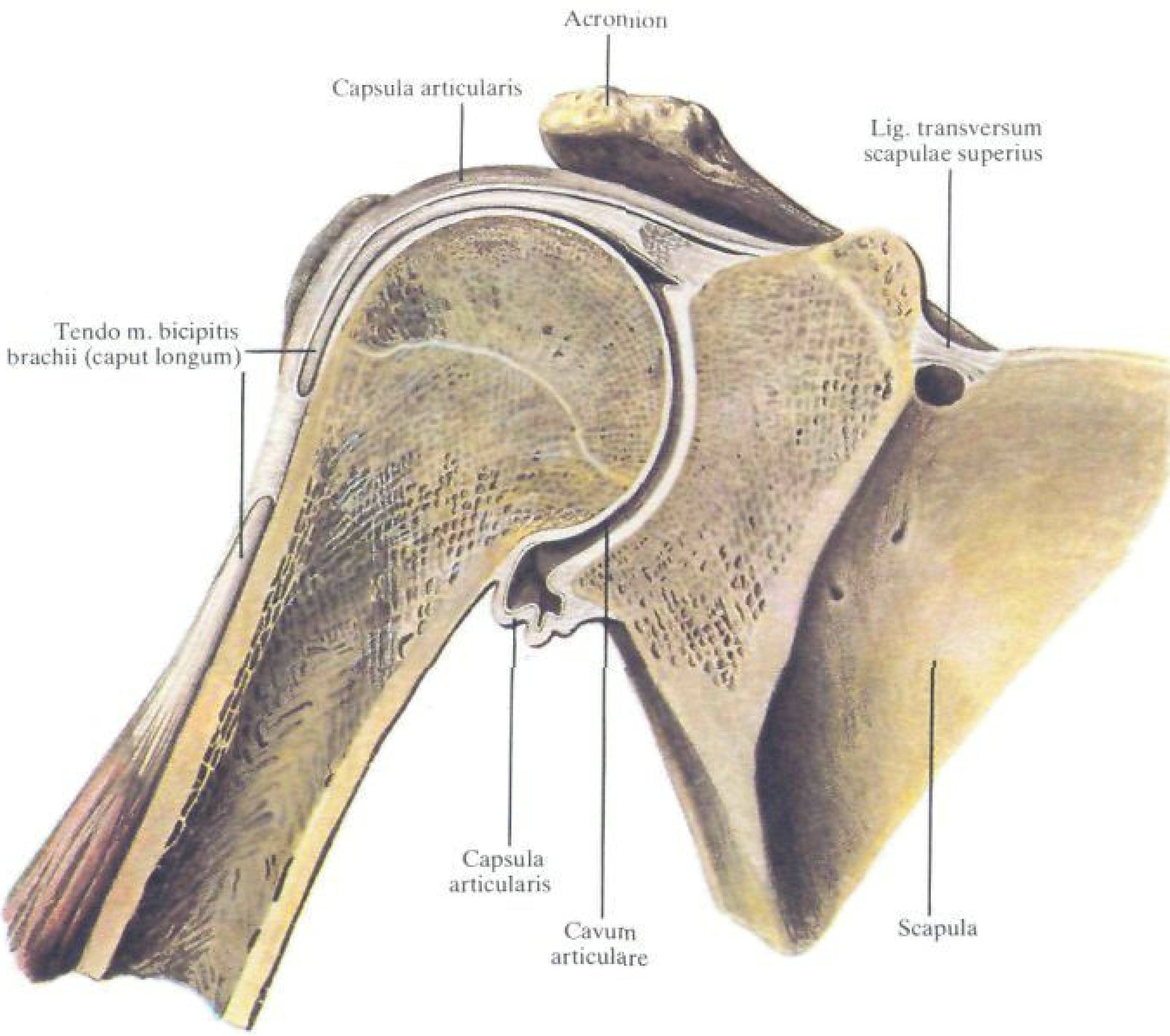


202. *Right shoulder joint (articulatio humeri) and ligaments of right scapula*; posterior aspect ($^3/_4$).
(The spine of the scapula is removed.)

cavity of the joint the tendon is covered by a synovial membrane which is attendant to it to a level 2-5 cm below the anatomical neck. Then the synovial membrane curves upwards and passing on the tendon, is continuous with the synovial layer of the articular capsule.

A double-wall protrusion of the synovial membrane thus forms in the bicipital groove around the biceps brachii tendon. It is called the **intertubercular synovial sheath** *(vagina synovialis intertubercularis)*. The joint cavity often communicates with the **subscapular bursa** *(bursa musculus subscapularis)* located at the root of the cricoid process.

The shoulder joint has only one ligament, the **coracohumeral**

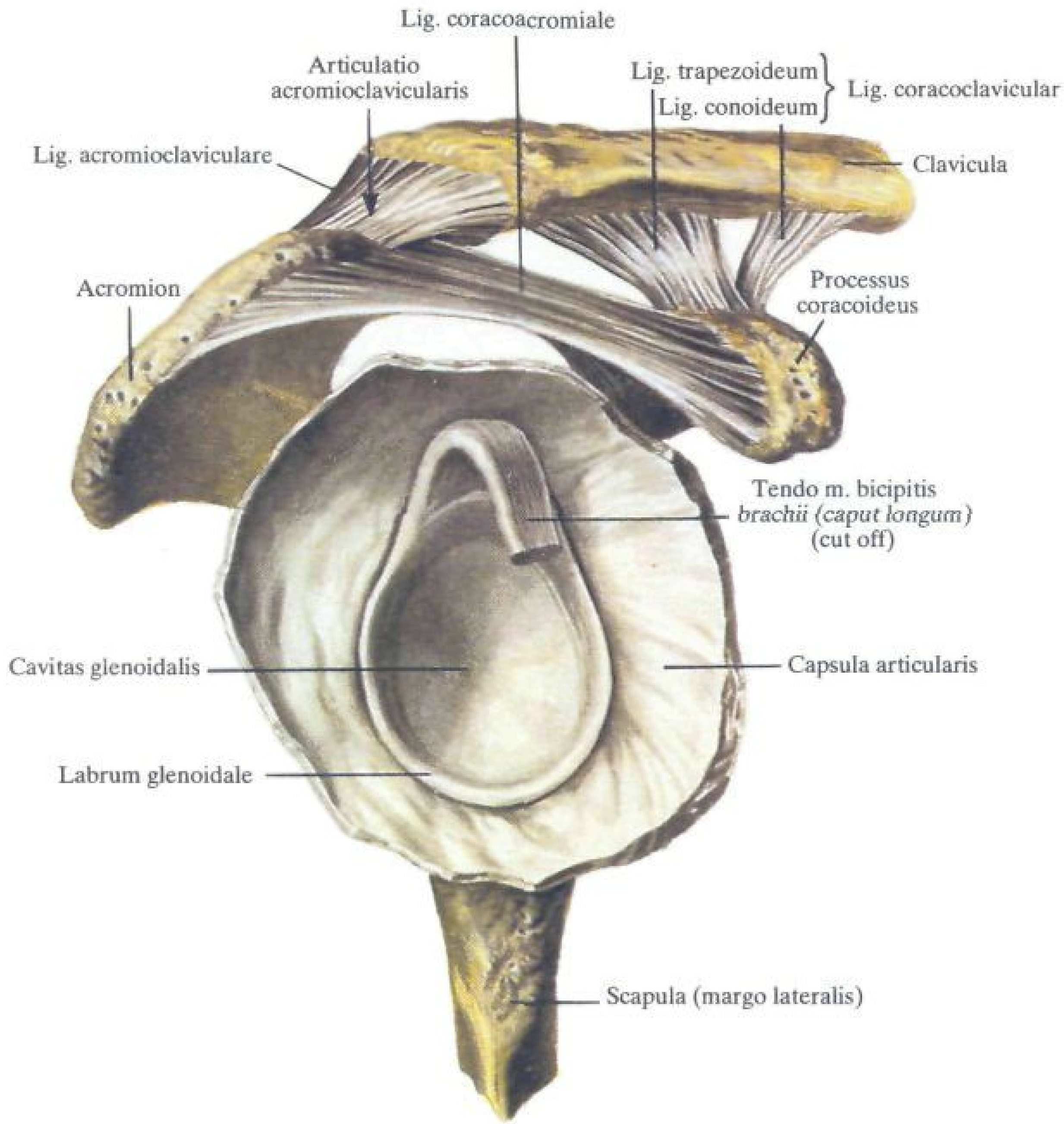


203. *Right shoulder joint (articulatio humeri)* ($^3/_4$).
(Joint opened by frontal section.)

ligament *(ligamentum coracohumerale).* This is a thickened fibrous layer of the capsule, which extends from the lateral edge of the cricoid process to the greater tuberosity of the humerus.

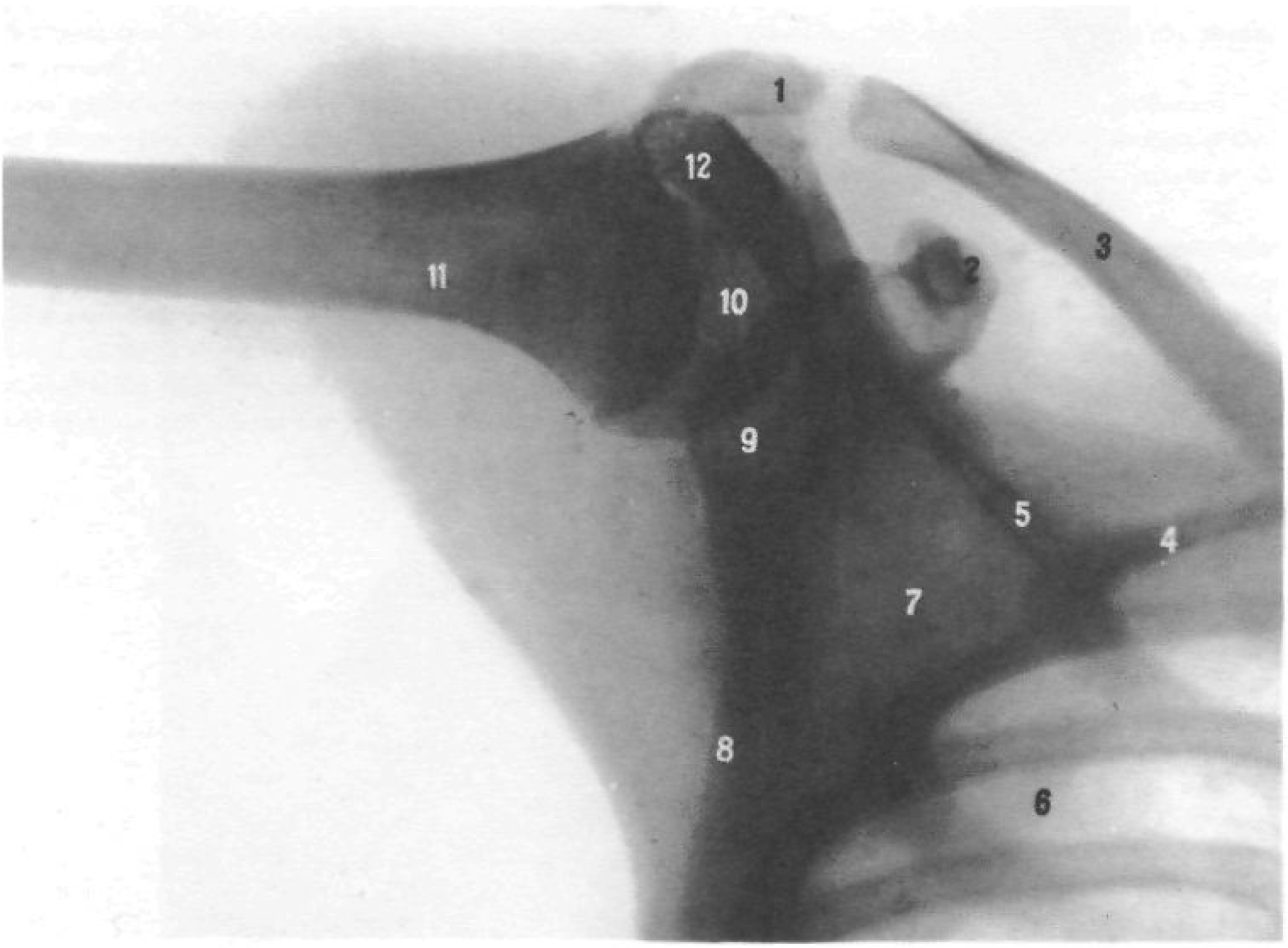
The **coracoacromial ligament** *(ligamentum coracoacromiale)* is located above the shoulder joint and together with the acromion and coracoid process of the scapula forms the vault of the shoulder. The vault protects the shoulder joint from above and together with the tautened articular capsule inhibits abduction and raising of the arm above the shoulder level. Higher raising of the limb is accomplished by concomitant movement of the scapula.

According to shape, the shoulder joint is a **ball-and-socket**, or **spheroid joint** *(articulatio spheroidea)* permitting a wide range of movements.



204. *Right shoulder joint (articulatio humeri) and acromioclavicular joint (articulatio acromioclavicularis)* (3/4).

(Shoulder joint is opened and humerus removed.)



205. *Right shoulder joint* (radiograph).

1—acromion
2—coracoid process
3—clavicle
4—first rib
5—spine of scapula
6—medial border of scapula
7—scapula
8—lateral border of scapula
9—glenoid cavity of scapula
10—head of humerus
11—humerus
12—greater tubercle of humerus

206. *Right shoulder joint.* (Radiograph taken with the arm raised.)

1—acromion
2—clavicle (acromial end)
3—coracoid process
4—first rib
5—superior border of scapula
6—spine of scapula
7—scapula
8—medial border of scapula
9—lateral border of scapula
10—glenoid cavity of scapula
11—head of humerus
12—anatomical neck
13—humerus

THE ELBOW JOINT

The **elbow joint** *(articulatio cubiti)* (Figs 207-212) is formed by the articular surface of the inferior humeral epiphysis (its trochlea and capitulum), the articular surfaces of the ulna (trochlear and radial notches), and the head and articular circumference of the radius. This is a **compound joint** *(articulatio composita)*. The articular surfaces are covered by hyaline cartilage.

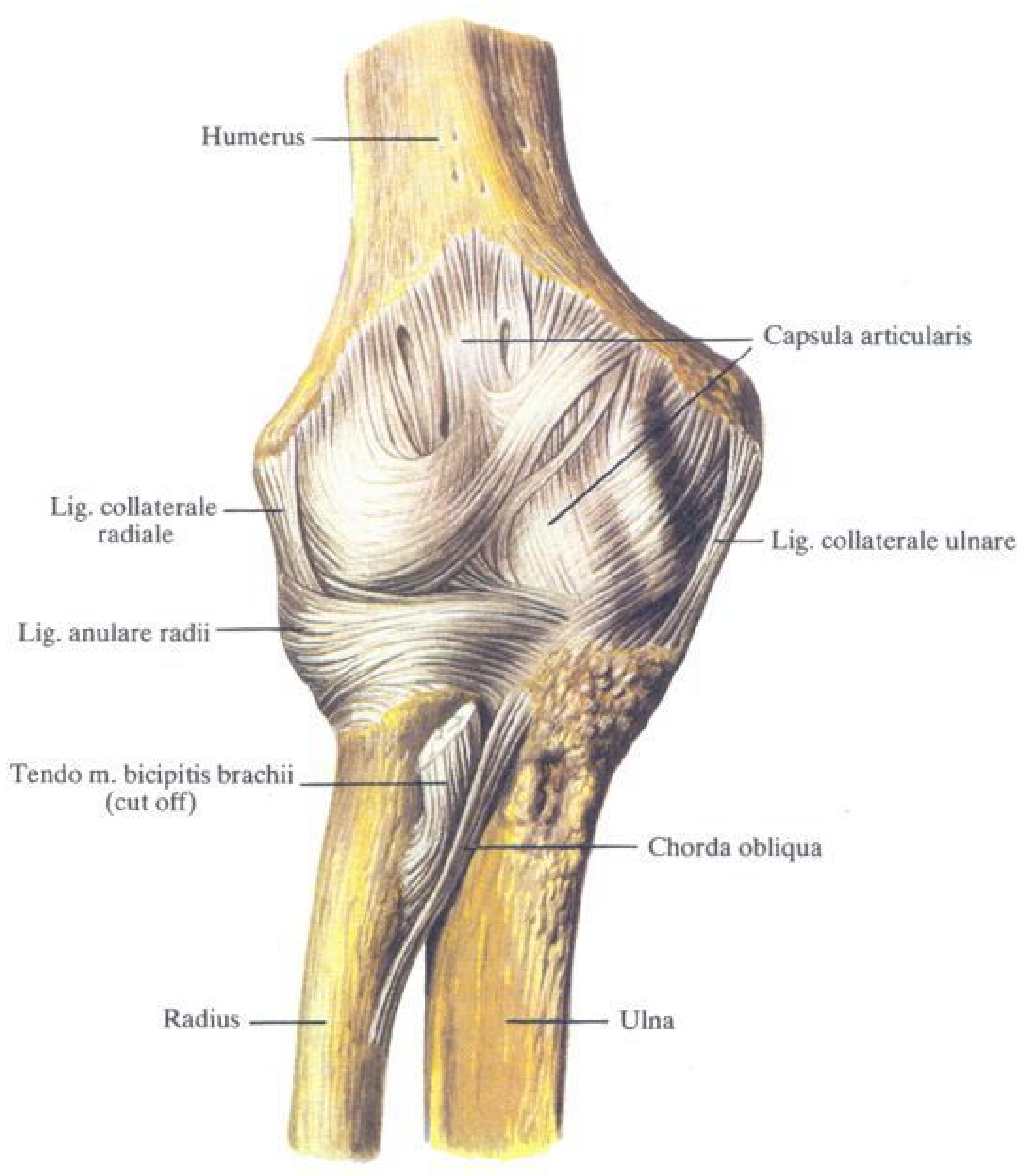
The **articular capsule** *(capsula articularis)* is fastened on the humerus above the margins of the coronoid and radial fossae in front; on the periphery of the bases of the epicondyles (leaving them free) and almost at the margin of the articular surface of the trochlea and head of the humerus on the sides; and a little below the superior margin of the olecranon fossa at the back. On the ulna the articular capsule is attached to the edges of the trochlear and radial notches; on the radius it is fastened to the neck, forming here a sac-like protrusion (Figs 207, 209). The capsule is thin and poorly stretched in front and behind but is strengthened by ligaments at the sides. Its synovial membrane covers also those parts of the bones which are in the joint cavity but are not covered by cartilage (the neck of the radius, etc.).

Three joints are distinguished in the cavity of the elbow joint: the humeroulnar, the humeroradial, and the proximal (superior) radioulnar joints.

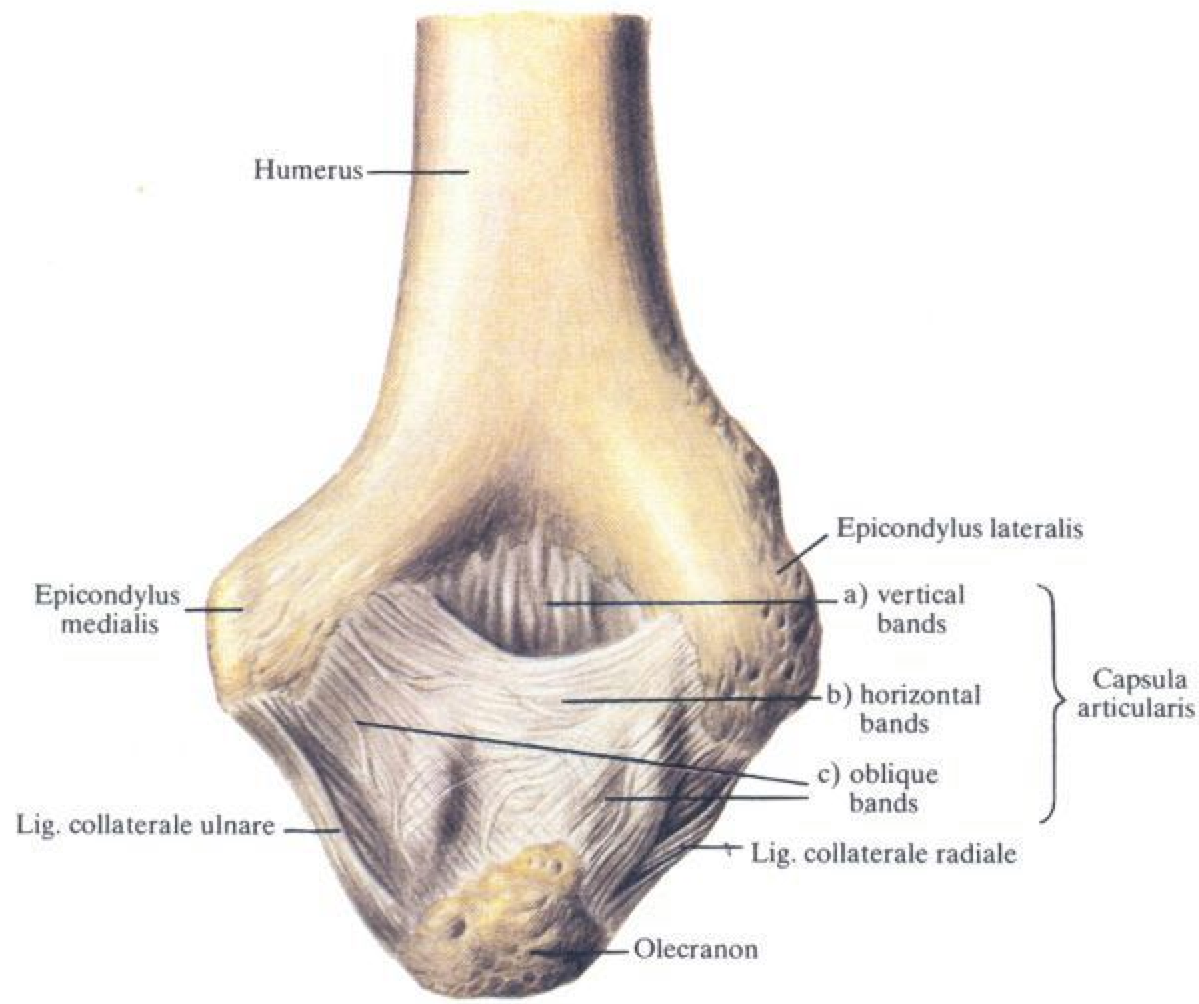
1. The **humeroulnar joint** *(articulatio humeroulnaris)* (Figs 209-212) is formed between the trochlea of the humerus and the trochlear notch of the ulna; it is a variant of the hinge joint and is related to the cochlear joints.

2. The **humeroradial joint** *(articulatio humeroradialis)* (Fig. 209) is formed by the head of the humerus and the facet on the head of the radius. It is related to the ball-and-socket or spheroid joints *(articulatio spheroidea)* (actually movements occur about not three but only two axes, frontal and vertical).

3. The **superior**, or **proximal radioulnar joint** *(articulatio radi-*



207. *Right elbow joint (articulatio cubiti)*; anterior aspect (4/5).



208. *Right elbow joint (articulatio cubiti)*; posterior aspect (4/5).

(Extreme flexion at elbow joint.)

oulnaris proximalis) (Figs 209, 214) is formed by the radial notch of the ulna and the articular circumference of the head of the radius and is a typical trochoid, or pivot joint.

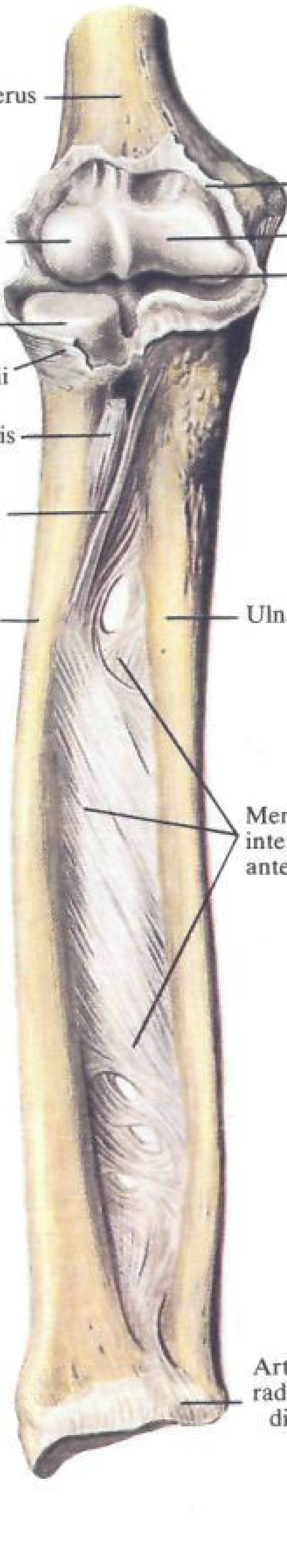
The humeroulnar joint permits **flexion** *(flexio)* and **extension** *(extensio)* which occur with simultaneous movement of the radius at the radiohumeral joint. **Rotation** *(rotatio)* of the radius about the longitudinal axis is also possible in the humeroradial joint; medial rotation is called **pronation** *(pronatio)* and lateral rotation is known as **supination** *(supinatio)*; mild **adduction** *(adductio)* and **abduction** *(abductio)* occur as well. In the superior radioulnar joint rotation of the radius occurs with simultaneous movement at the humeroradial joint.

The following ligaments are related to the elbow joint.

1. The **ulnar collateral (medial) ligament** *(ligamentum collaterale ulnare)* (Figs 207, 208) runs downwards from the lateral humeral epicondyle, then expands fan-wise to be attached at the edge of the trochlear notch of the ulna

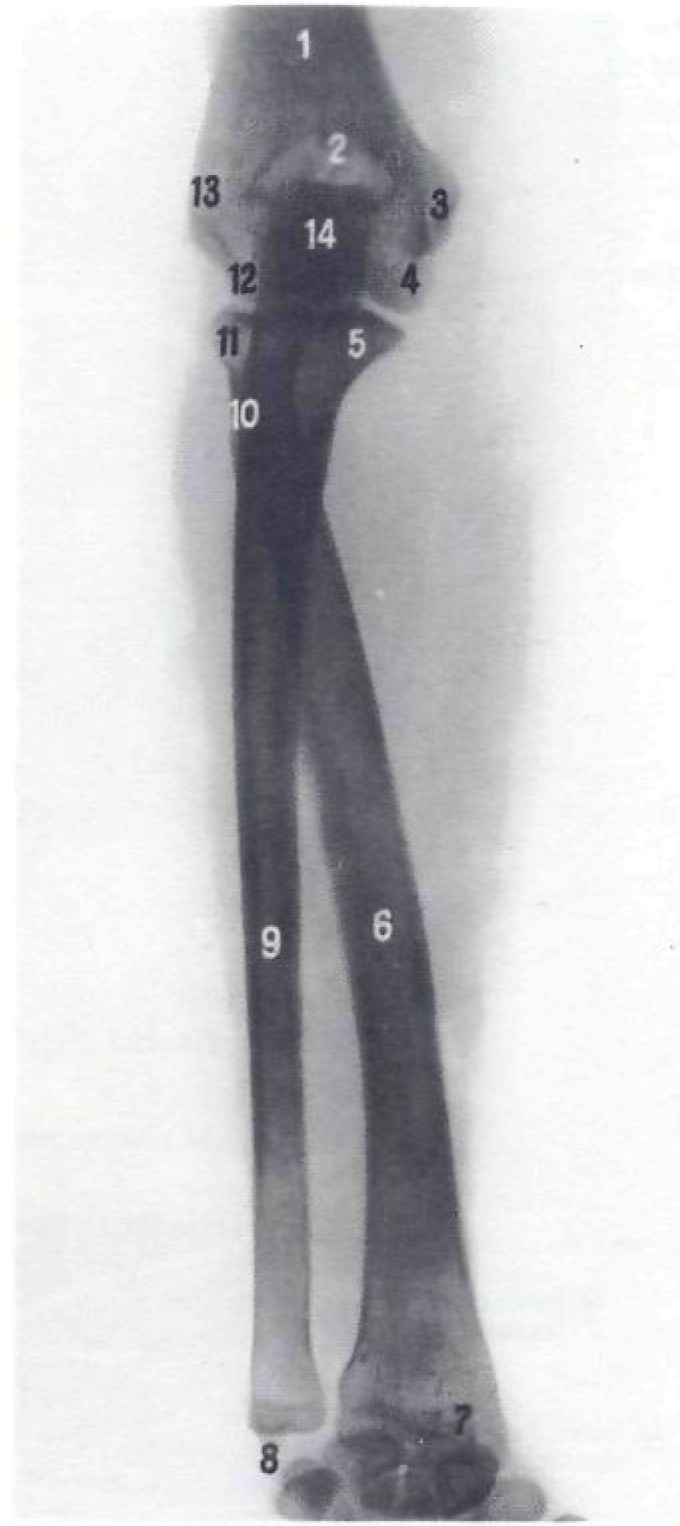
2. The **radial collateral (lateral) ligament** *(ligamentum collaterale radiale)* (Figs 207, 208) arises at the base of the lateral humeral epicondyle, stretches downwards to the lateral surface of the head of the radius, and separates into two bands. These bands run horizontally and then around the head of the radius in front and behind to be attached to the edges of the radial notch of the ulna. The superficial layers of the ligament blend with the flexor tendons, the deep layers are continuous with the annular ligament of the radius.

3. The **annular ligament of the radius** *(ligamentum anulare radii)* (Figs 207, 209) embraces the articular circumference of the radial head from the anterior, posterior, and lateral aspects and, be-



209. *Right elbow joint (articulatio cubiti), interosseous membrane of forearm (membrana interossea antebrachii), and distal radioulnar joint (articulatio radioulnaris);* anterior aspect ($\frac{1}{2}$).

(Cavity of elbow joint is opened.)



210. *Right elbow joint.* (Radiograph taken with the forearm in pronation.)

1—humerus
2—cubital fossa
3—medial epicondyle
4—trochlea of humerus
5—coronoid process of ulna
6—radius
7—lateral styloid process
8—medial styloid process
9—ulna
10—neck of radius
11—head of radius
12—capitulum humeri
13—lateral epicondyle
14—olecranon

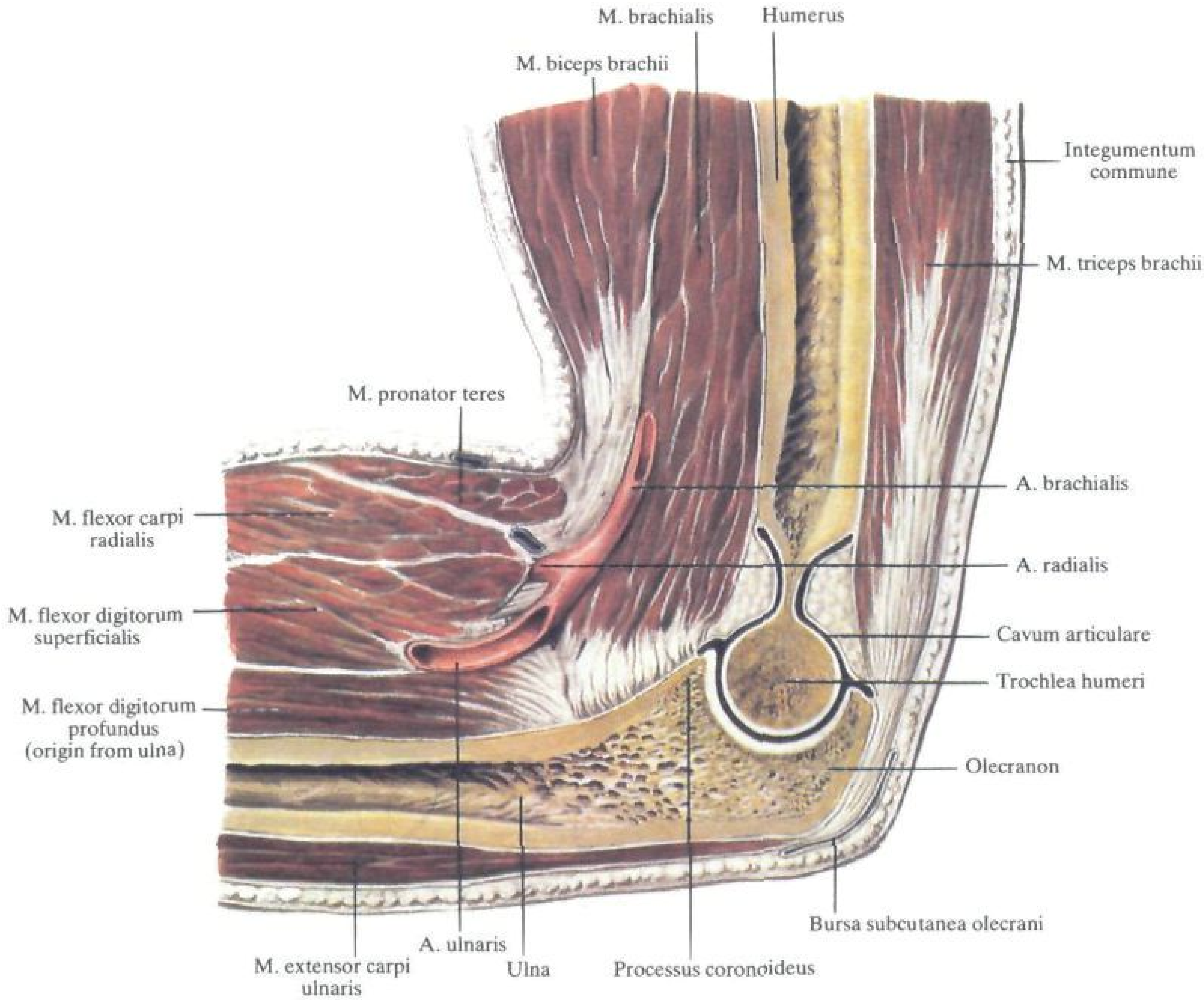
ing attached to the anterior and posterior edges of the radial notch of the ulna, holds fast the radius to the ulna.

The strong collateral ligaments check side movements at the elbow joint. On the whole, the elbow joint is a variety of **hinge joints** *(ginglymus)* and functions as a **cochlear joint**.

In addition to the annular ligament of the radius, the interosseous membrane of the forearm contributes to bracing together the radius and the ulna.

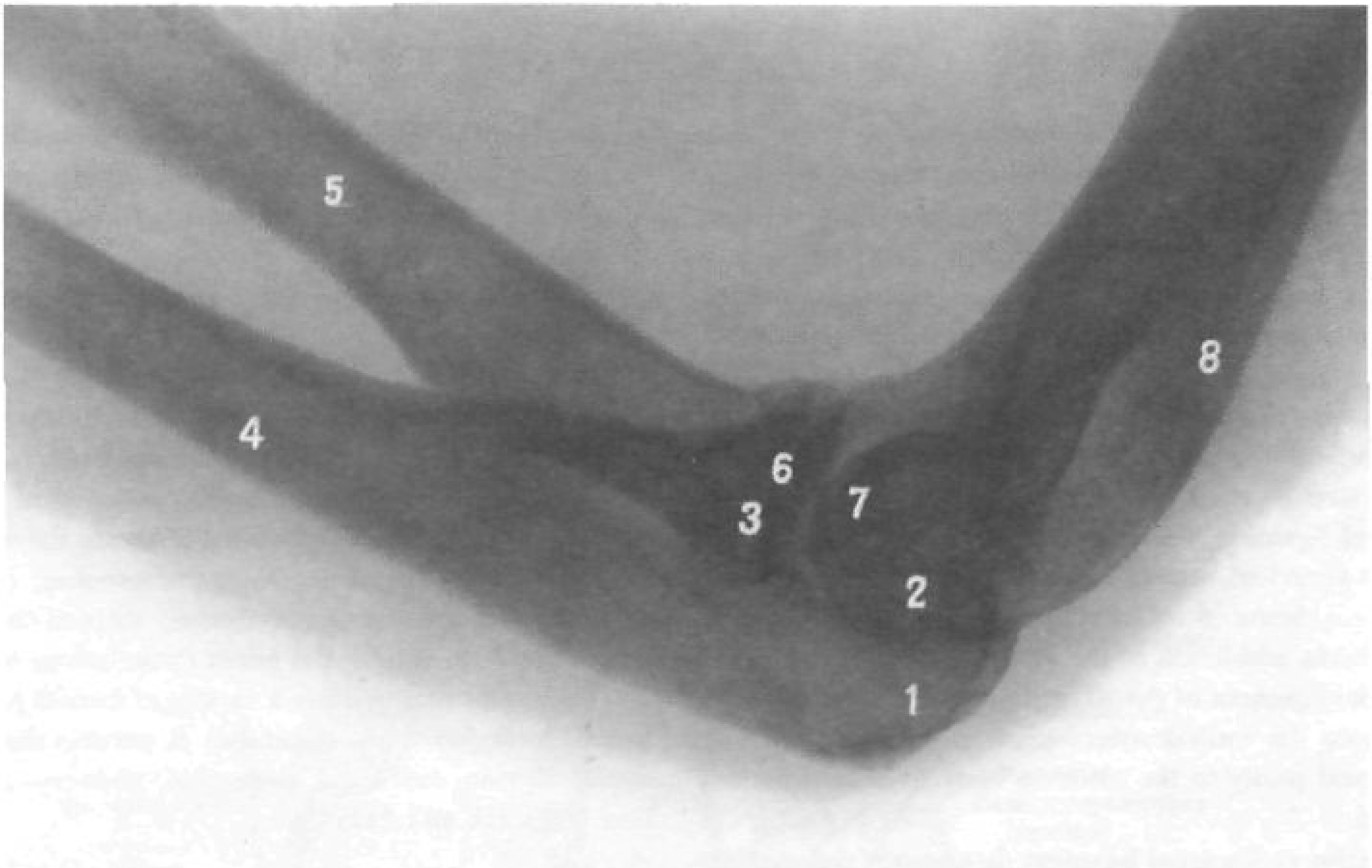
The **interosseous membrane of the forearm** *(membrana interossea antebrachii)* (Fig. 209) fills the space between the radius and the ulna and is attached to their interosseous borders.

It is formed of strong fibrous bands descending obliquely from the radius to the ulna. One of the bands runs in the opposite direction, from the tuberosity of the ulna to the tuberosity of the radius and is called the **oblique cord** *(chorda obliqua)*. The membrane has openings transmitting vessels and a nerve. Some forearm muscles arise on its palmar and dorsal surfaces.



211. *Right elbow joint (articulatio cubiti)* (4/5).

(Cavity of elbow joint opened by sagittal section.)



212. *Right elbow joint.* (Radiograph taken with the elbow flexed.)

1—olecranon
2—trochlea of humerus
3—head of radius
4—ulna
5—radius
6—coronoid process
7—capitulum humeri
8—humerus

THE DISTAL RADIOULNAR JOINT

The **distal,** or **inferior radioulnar joint** *(articulatio radioulnaris distalis)* (Figs 209, 210, 213, 216) is formed by the articular circumference of the head of the ulna and the ulnar notch of the radius. Distal to the head of the ulna is the **articular disc** *(discus articularis)* (Fig. 215). It is a triangular fibrocartilaginous plate attached by its base to the ulnar notch of the radius and by its apex to the medial styloid process of the ulna. The disc separates the cavity of the distal radioulnar joint from the cavity of the radiocarpal joint.

The **articular capsule** *(capsula articularis)* is loose. It is attached along the margin of the articular surfaces of the bones to the disc and forms above between the ulna and radius a pouch called **recessus sacciformis** (Fig. 215).

The distal radioulnar joint is a variant of the **trochoid joint** *(articulatio trochoidea).*

Together with the proximal radioulnar joint it forms a combined joint providing rotation of the radius in relation to the ulna.

JOINTS OF THE HAND

THE RADIOCARPAL JOINT

The **radiocarpal joint** *(articulatio radiocarpea)*, or **wrist joint** (Figs 213, 217), is formed by the carpal articular surface of the radius and the distal surface of the articular disc (see *The Distal Radioulnar Joint)*. They form a slightly concave articular surface which unites with a convex proximal articular surface provided by the proximal row of the carpal bones (scaphoid, lunate, and triquetrum).

A thin **articular capsule** *(capsula articularis)* is attached to the margins of the articular surfaces of the bones forming the joint.

The joint is strengthened by the following ligaments.

1. The **lateral ligament of the wrist** *(ligamentum collaterale carpi radiale)* which is stretched between the lateral styloid process and the scaphoid bone. Some of its bands reach the trapezium bone. The ligament checks adduction of the hand.

2. The **medial ligament of the wrist** *(ligamentum collaterale carpi ulnare)*, arises from the medial styloid process and is attached to the triquetrum and partly to the pisiform bone. It checks abduction of the hand.

3. The **posterior radiocarpal ligament** *(ligamentum radiocarpeum dorsale)*. It turns from the dorsal surface of the distal end of the radius to the carpus where it is attached to the dorsal surfaces of the scaphoid, lunate, and the triquetrum bones. It checks flexion of the hand.

4. The **anterior radiocarpal ligament** *(ligamentum radiocarpeum palmare)*. It arises from the base of the lateral styloid process of the radius and the margin of the carpal articular surface of this bone and runs downwards and medially to be attached to the proximal and distal rows of carpal bones (the scaphoid, lunate, triquetrum, and capitate). The ligament checks extension of the hand.

In addition to these ligaments, there are the **interosseous intercarpal ligaments** *(ligamenta intercarpea interossea)* which connect the proximal carpal bones to one another; some of the carpal bones articulate to form **intercarpal joints** *(articulationes intercarpeae)*.

The radiocarpal joint is a variant of biaxial joints and is an **ellipsoid joint** *(articulatio ellipsoidea)*. It permits the following movements: flexion, extension, adduction, abduction, and circumduction (Figs 216 and 217).

THE PISIFORM JOINT

The **pisiform joint** *(articulatio ossis pisiformis)* joins the pisiform to the triquetrum bone. The sesamoid pisiform bone carries an articular facet only on the side touching the approximate articular surface of the triquetrum bone.

The **articular capsule** *(capsula articularis)* is attached to the margins of the articular surfaces. The joint cavity may communicate with the cavity of the radiocarpal joint. The pisiform joint has the following ligaments.

1. The **pisohamate ligament** *(ligamentum pisohamatum)* stretches between the pisiform bone and the hook of the hamate bone.

2. The **pisometacarpal ligament** *(ligamentum pisometacarpeum)* runs from the pisiform bone to the bases of the third to fifth metacarpal bones.

The ligaments are an extension of the flexor carpi ulnaris tendon within which the large sesamoid pisiform bone is lodged.

Sesamoid bones are small rounded bony or fibrocartilaginous structures embedded in tendons. They are responsible for raising the respective muscle tendon and creating a favourable angle of its action on the bone.

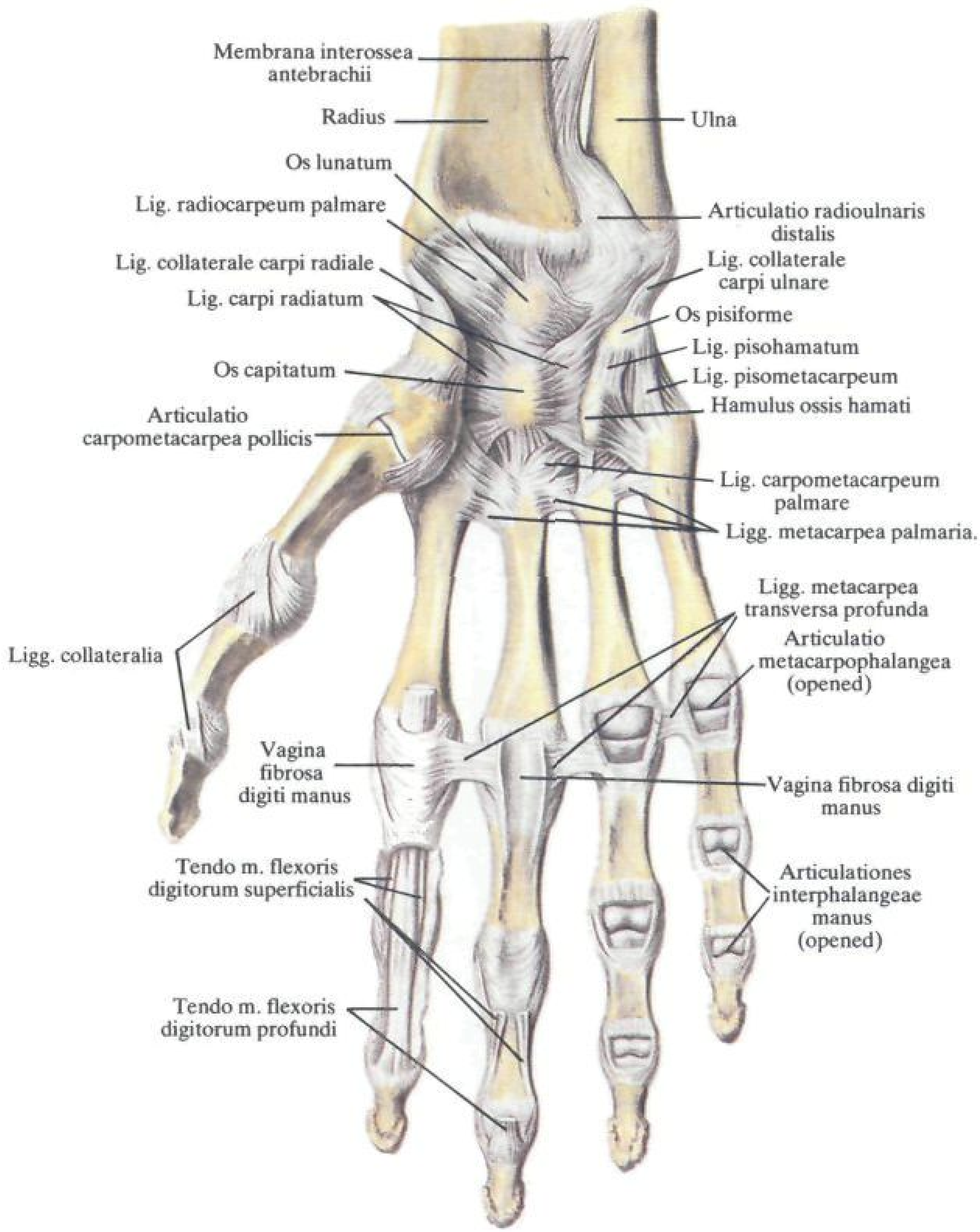
THE INTERCARPAL JOINTS

The carpal bones articulate with one another by means of **intercarpal joints** *(articulationes intercarpea)*, while the proximal and distal rows are joined by the **midcarpal joint** *(articulatio mediocarpea)* (Figs 213-217). The distal surface of the first row of carpal bones forms a large and deep concave articular surface which receives the spherical surface formed by the articular surfaces of the capitate and hamate bones. The lateral part of the first row of carpal bones has a distally facing spherical surface of the scaphoid bone which is received by the corresponding concavity formed by the bones of the second row. The joint cavity is S-shaped. The cavity of the midcarpal joint is continuous with the cavities of the joints formed between some of the carpal bones and communicates with the cavity of the carpometacarpal joint. The articular capsule is attached to the margins of the articular surfaces of the carpal bones.

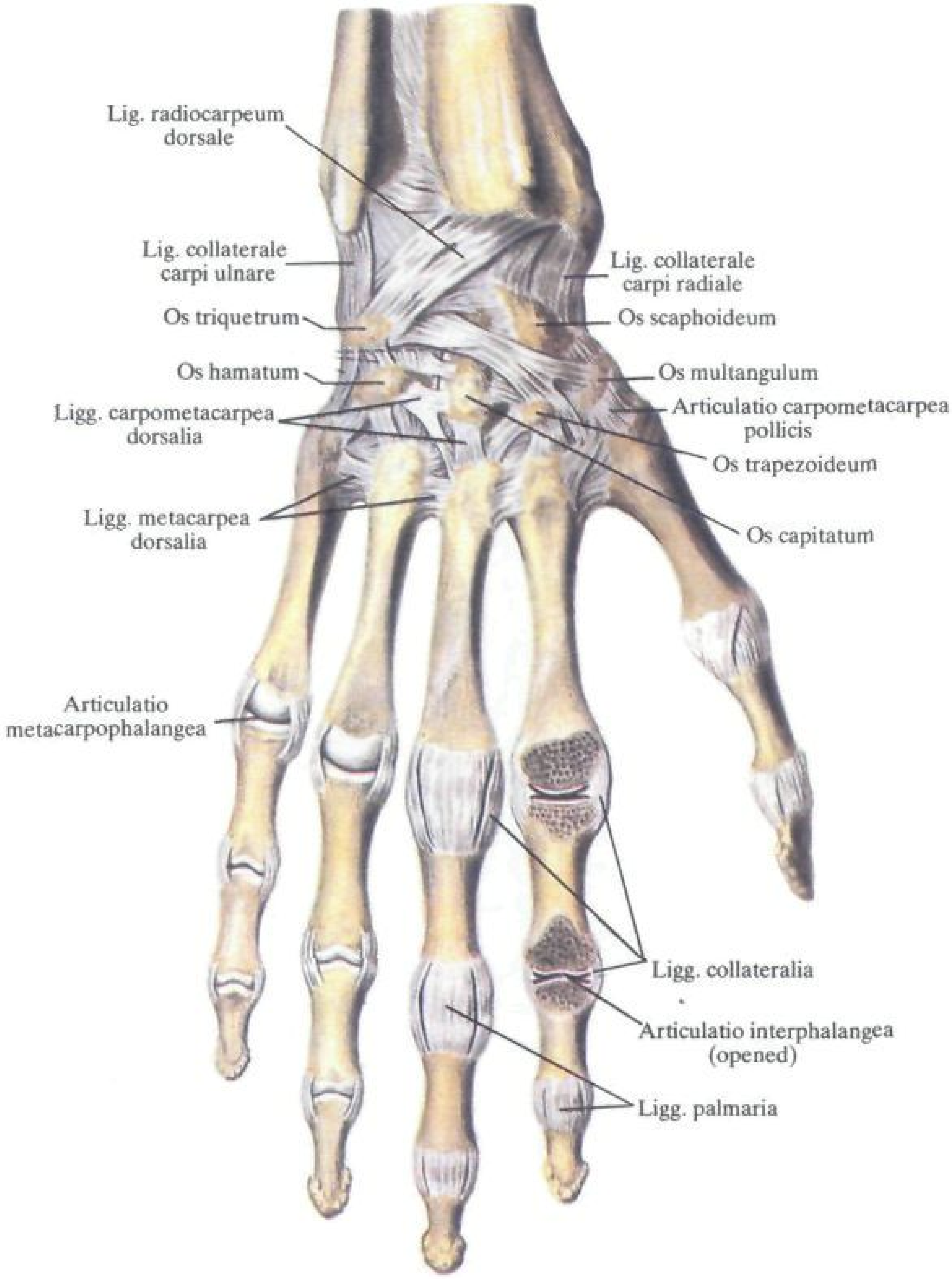
The midcarpal joint is strengthened by the following ligaments.

1. The **dorsal intercarpal ligaments** *(ligamenta intercarpea dorsalia)* stretch between some of the carpal bones on the dorsal surface of the joint.

2. The **palmar intercarpal ligaments** *(ligamenta intercarpea palmaria)* like the dorsal ligaments are stretched between the carpal

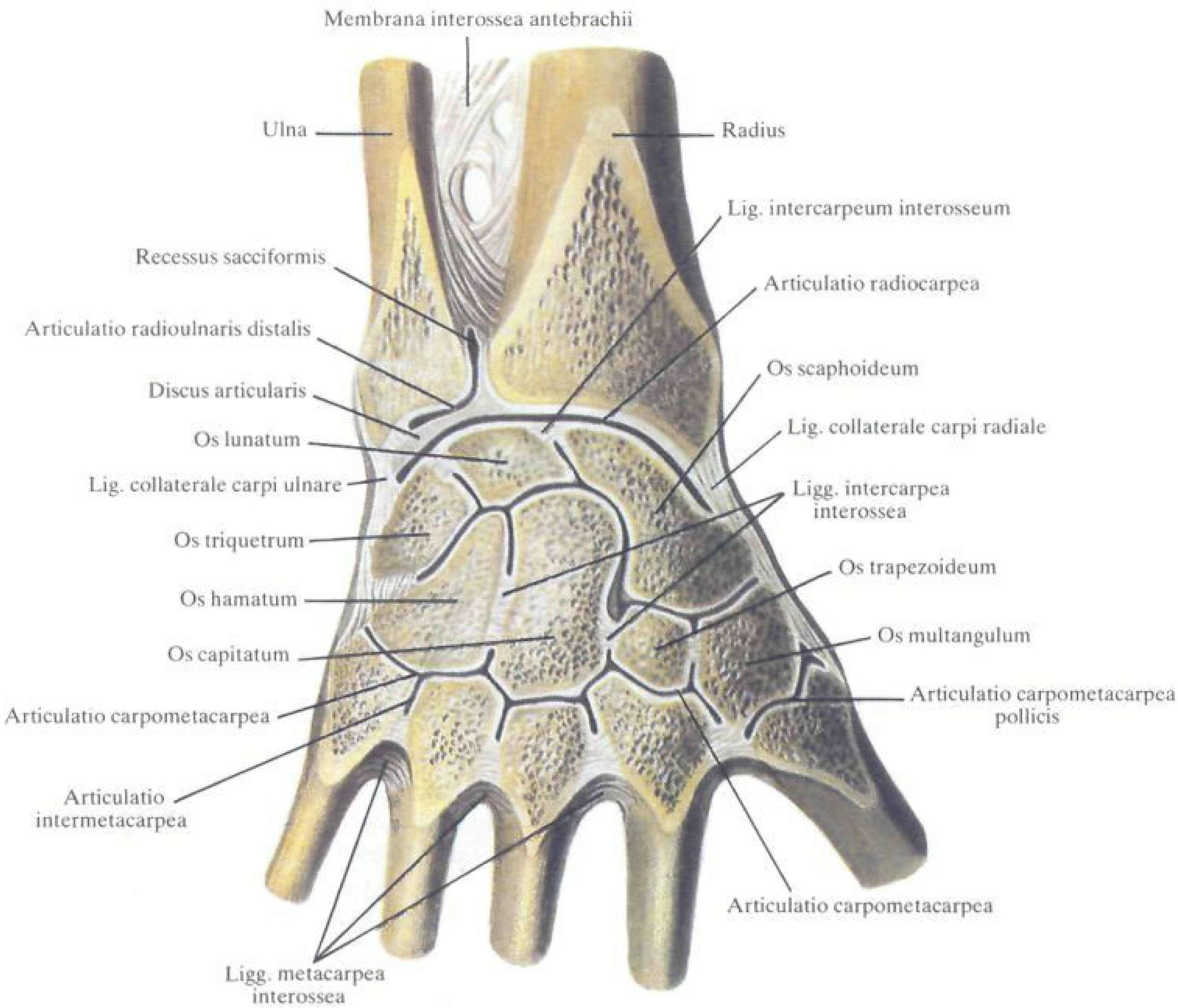


213. *Right radiocarpal joint (articulatio radiocarpea) and ligaments and joints of the hand*; palmar surface (⅔).



214. *Right radiocarpal joint (articulatio radiocarpea) and ligaments and joints of the hand*; dorsal surface ($^2/_3$).

(Cavities of the metacarpophalangeal and interphalangeal joints of index finger opened by section made parallel to dorsal surface of hand.)



215. ***Joints and ligaments of right hand*** **(2/3).**

(Joint cavities opened by section made parallel to dorsal surface of hand.)

bones but on the palmar surface. Some bands arise on the capitate bone and fan out to the bones of the first and second carpal rows to form the **radiate carpal ligament** *(ligamentum carpi radiatum)*.

There are also **interosseous intercarpal ligaments** *(ligamenta intercarpea interossea)* (see Fig. 215) which are located between some of the carpal bones close to the radiocarpal and carpometacarpal joints.

According to the shape of the articulating surfaces, the midcarpal joint is related to the **spheroid joints** *(articulatio spheroidea)* with two spheroid heads. It permits a very small range of movements and is therefore a poorly mobile joint.

THE CARPOMETACARPAL JOINTS

The **carpometacarpal joints** *(articulationes carpometacarpeae)* (Figs 213-217) are formed by the distal surfaces of the carpal bones of the second row and the bases of the metacarpal bones. Two carpometacarpal joints are distinguished: one is formed by the trapezium bone and the first metacarpal bone and is related to the thumb; the other is formed between the trapezium, trapezoid, capitate, and hamate bones and the medial four metacarpals.

The **carpometacarpal joint of the thumb** *(articulatio carpometacarpea pollicis)* is formed by the distal saddle-shaped articular facet of the trapezium bone and the saddle-shaped articular facet of the base of the first metacarpal bone.

The carpometacarpal joint of the thumb is a variety of biaxial joints and is a **saddle joint** *(articulatio sellaris)*.

The second to fifth carpometacarpal joints are formed by the flat articulating facets on the distal surfaces of the trapezium, trapezoid, capitate, and hamate bones and the contiguous proximal articulating surfaces of the bases of the medial four metacarpals. The joint of the fifth metacarpal bone is related in shape to a **saddle joint** *(articulatio sellaris)*. The articular capsule is attached to the margins of the articular surfaces of the bones and is tightly stretched. The cavity of the carpometacarpal joint communicates with the cavities of the intercarpal, midcarpal, and intermetacarpal joints. The **palmar** and **dorsal carpometacarpal ligaments** *(ligamenta carpometacarpea palmaria* et *dorsalia)* stretching between the carpals and metacarpals on the respective surfaces are related to the ligaments of the carpometacarpal joints.

The carpometacarpal joints form a unit which is from the mechanical standpoint the firm framework of the hand.

These joints permit a very small range of movements and are related to **plane joints** *(articulationes planae)*.

THE INTERMETACARPAL JOINTS

The **intermetacarpal joints** *(articulationes intermetacarpeae)* (Figs 213-217) are formed between the flat facets on the contiguous sides of the bases of the medial four metacarpals. The articular capsule is attached to the margins of the articular facets. The cavities of the joints communicate proximally with the carpometacarpal joints.

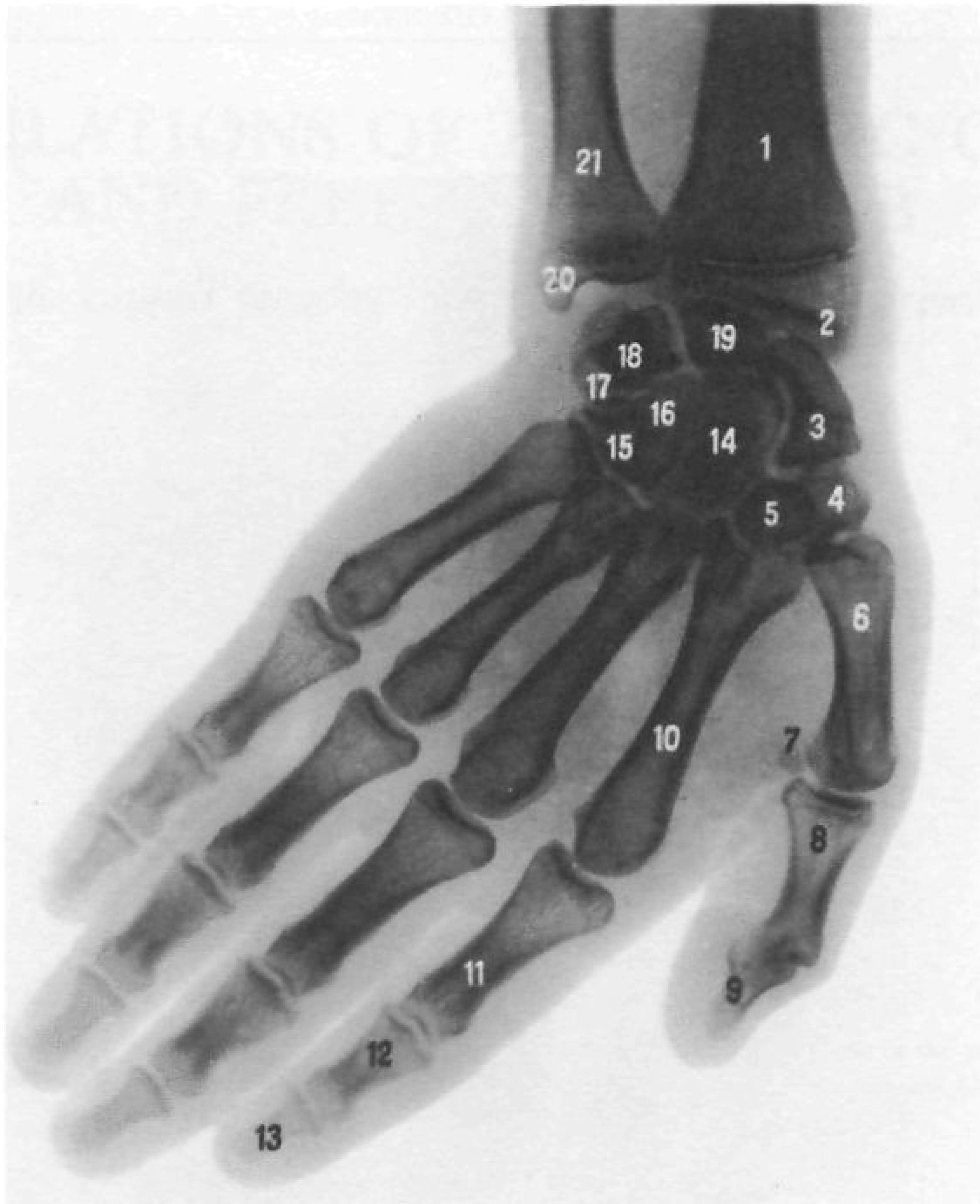
Two groups of ligaments are related to the intermetacarpal joints. Ligaments of one group are located on the dorsal and palmar surfaces of the joints. These are the four **dorsal metacarpal ligaments** *(ligamenta metacarpea dorsalia)* and the three **palmar metacarpal ligaments** *(ligamenta intercarpea palmaria)*. Ligaments of the other group are between the bases of the metacarpal bones. These are called the **interosseous metacarpal ligaments** *(ligamenta metacarpea interossea)*. The intermetacarpal joints are plane joints permitting a very limited range of movements.

THE METACARPOPHALANGEAL JOINTS

The **metacarpophalangeal joints** *(articulationes metacarpophalangeae)* (Figs 213, 214, 216) are formed by the articular surfaces of the heads of the metacarpal bones and the contiguous articular facets on the bases of the proximal phalanges. The head of the first metacarpal bone is compressed from front to back and is trochlear in shape; the heads of the other metacarpals are spherical. The articular capsules are loose. They are attached on the sides by the **collateral ligaments** *(ligamenta collateralia)* which arise from depressions on the ulnar and radial surfaces of the heads of the metacarpals and are attached to the sides and partly to the palmar surface of the base of the proximal phalanx. Some fibres of these ligaments pass from the sides of the metacarpal heads to the palmar surface of the bases of the proximal phalanges to intersect with similar contralateral fibres. These are called **palmar ligaments** *(ligamenta palmaria)*.

The **deep transverse ligaments of the palm** *(ligamenta metacarpea transversa profunda)* are stretched on the palmar surface of the joints between the heads of the medial four metacarpals.

The metacarpophalangeal joint of the thumb is a **hinge joint** *(ginglymus)*, while those of the other fingers are **ball-and-socket** or **spheroid joints** *(articulationes spheroideae)*.



216. *Joints of right hand.* (Radiograph taken with the hand in adduction, ulnar deviation.)

1—radius
2—lateral styloid process
3—scaphoid bone
4—multangular, or trapezium bone
5—trapezoid bone
6—first metacarpal bone
7—sesamoid bone
8—proxymal phalanx of thumb
9—distal phalanx of thumb
10—second metacarpal bone
11—proximal phalanx of index finger
12—middle phalanx of index finger
13—distal phalanx of index finger
14—capitate bone
15—hook of hamate bone
16—hamate bone
17—triquetral bone
18—pisiform bone
19—lunate bone
20—medial styloid process
21—ulna

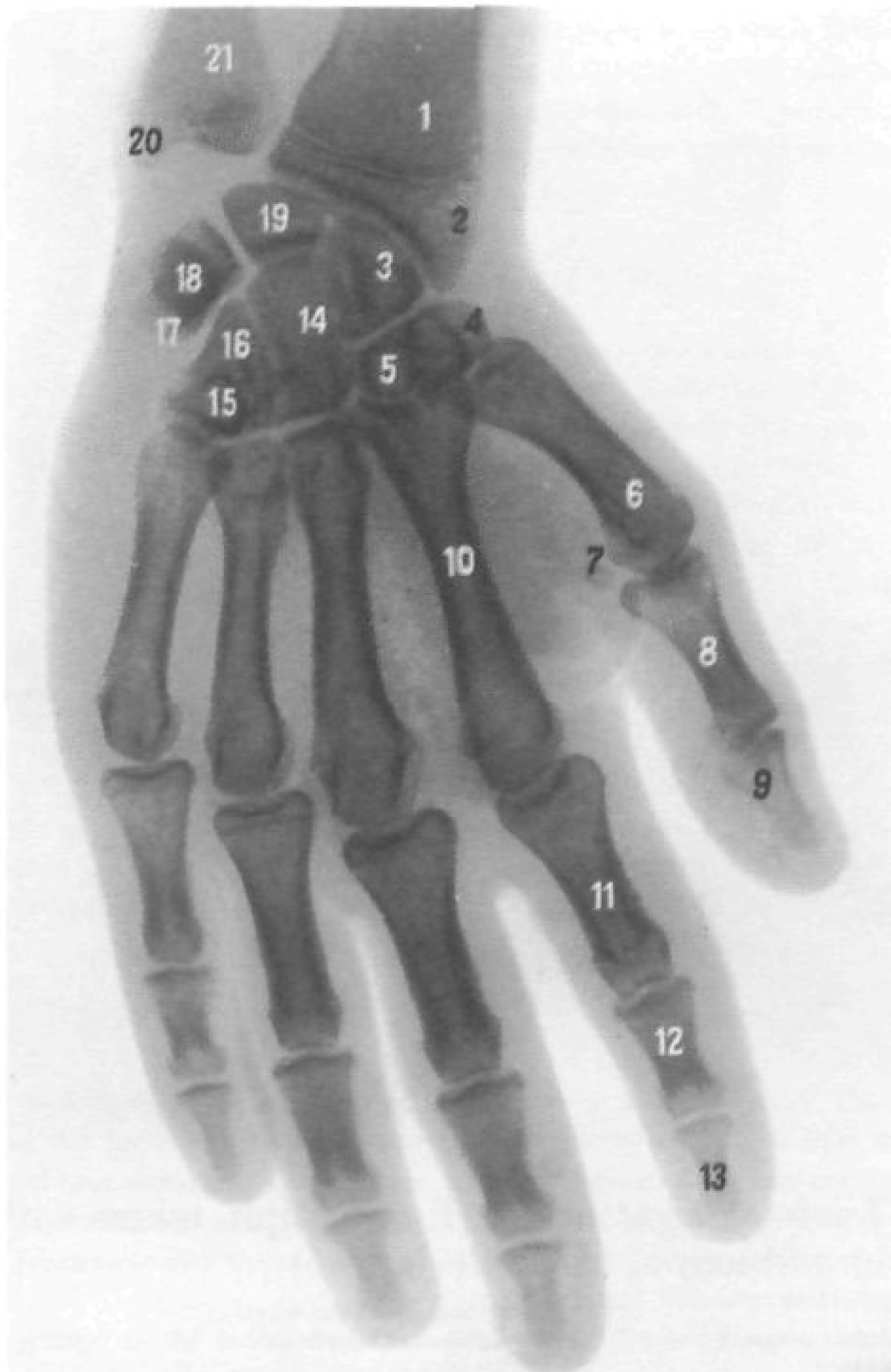
THE INTERPHALANGEAL JOINTS OF THE HAND

The **interphalangeal joints of the hand** *(articulationes interphalangeae manus)* (Figs 213, 214, 216, 217) form between the approximate phalanges of each finger. The articular surface on the head of each phalanx is trochlear in shape and carries a guiding groove, while the base of the phalanx bears a flat facet with a guiding ridge.

The ligaments of the interphalangeal joints are the **palmar ligaments** *(ligamenta palmaria)* which pass from the sides of the trochlea, and are attached one to the side of the base of the phalanges (collateral ligaments), and the others to their palmar surface.

The thumb has only one interphalangeal joint.

The interphalangeal joints between the proximal and middle phalanges of the other fingers are called proximal interphalangeal joints, those between the middle and distal phalanges are the distal interphalangeal joints. Interphalangeal joints are typical **hinge joints** *(ginglymus)*.



217. *Joints of right hand.* (Radiograph taken with the hand in abduction, radial deviation.)

1—radius
2—lateral styloid process
3—scaphoid bone
4—multangular, or trapezium bone
5—trapezoid bone
6—first metacarpal bone
7—sesamoid bone
8—proximal phalanx of thumb
9—distal phalanx of thumb
10—second metacarpal bone
11—proximal phalanx of index finger
12—middle phalanx of index finger
13—distal phalanx of index finger
14—capitate bone
15—hook of hamate bone
16—hamate bone
17—triquetral bone
18—pisiform bone
19—lunate bone
20—medial styloid process
21—ulna

ARTICULATIONS OF THE PELVIC GIRDLE AND FREE LOWER LIMB

Juncturae cinguli membri inferioris et membri inferioris liberi

JOINTS OF THE LOWER LIMB

The **joints of the lower limb** *(juncturae membri inferioris)* are subdivided into **joints of the pelvic girdle** *(juncturae cinguli membri inferioris)* and **joints of the free lower limb** *(juncturae membri inferioris liberi).*

JOINTS OF THE PELVIC GIRDLE

The bones of the pelvic girdle articulate by means of two sacroiliac joints, the pubic symphysis, and some ligaments.

THE SACROILIAC JOINT

The **sacroiliac joint** *(articulatio sacroiliaca)* (Figs 218–220) is a paired joint formed between the iliac bone and sacrum.

The articulating **auricular surfaces** *(facies auriculares)* of the iliac bones and sacrum are flat and covered by fibrous cartilage. The **articular capsule** *(capsula articularis)* is attached to the margins of the articular surfaces and is taut. The ligaments of the joint are strong fibrous bands tightly stretched on its anterior and superior surfaces. The **anterior (ventral) sacroiliac ligaments** *(ligamenta sacroiliaca ventralia)* are short fibrous bands stretching on the anterior surface from the pelvic surface of the sacrum to the iliac bone.

The following ligaments are located on the posterior surface of the joint.

1. The **interosseous sacroiliac ligaments** *(ligamenta sacroiliaca interossea)* lie behind the sacroiliac joint in the space between the bones forming it. They are attached to the iliac and sacral tuberosities.

2. The **posterior (dorsal) sacroiliac ligaments** *(ligamenta sacroiliaca dorsalia).* Some bands of these ligaments arise from the posterior superior iliac spine, and are attached to the transverse tubercles of the sacrum for the distance from the second to third sacral foramina. The other bands of ligaments run from the posterior superior iliac spine downwards and slightly medially to be attached to the posterior surface of the sacrum in the region of the fourth sacral vertebra.

The sacroiliac joint is related to the group of joints which permit a limited range of movements.

The hip bone is also united with the vertebral column by means of a series of strong ligaments; these are as follows.

1. The **sacrotuberous ligament** *(ligamentum sacrotuberale)* (Figs 218–220) arises from the medial surface of the ischial tuberosity, passes upwards and medially spreading fan-wise, and is attached to the lateral border of the sacrum and coccyx. Some bands pass over to the inferior part of the ischium to form the **falciform process** *(processus falciformis).*

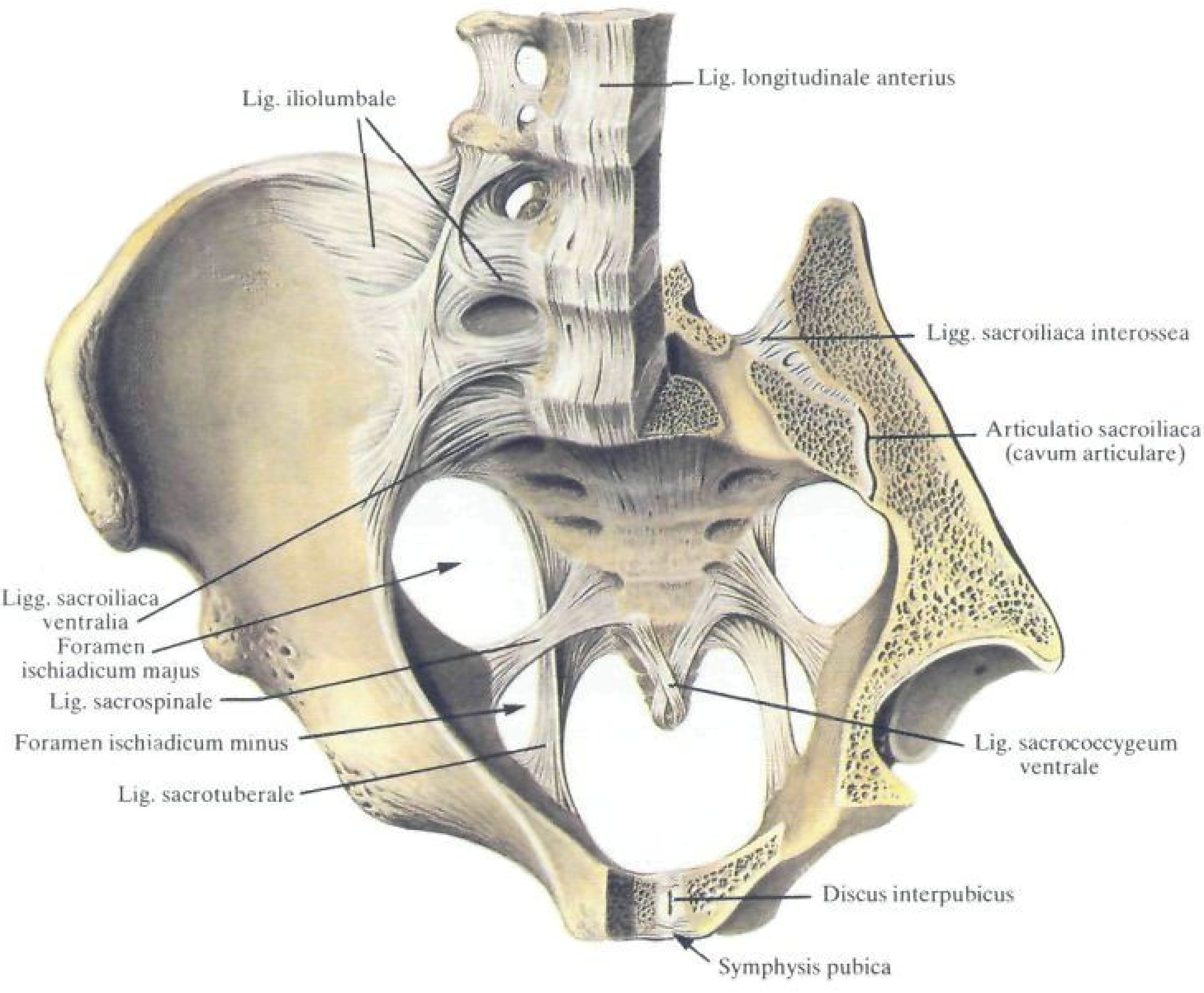
2. The **sacrospinous ligament** *(ligamentum sacrospinale)* (Figs 218–220) runs from the ischial spine medially and to the

back and is attached in front of the sacrotuberous ligament to the lateral border of the sacrum and partly to the coccyx.

Both ligaments together with the greater and lesser sciatic notches form the borders of the **greater** and **lesser sciatic foramina** *(foramen ischiadicum majus* et *foramen ischiadicum minus)* which transmit muscles as well as vessels and nerves leaving the pelvis.

3. The **iliolumbar ligament** *(ligamentum iliolumbale)* (Figs 218–219) passes from the anterior surface of the transverse processes of the fourth and fifth lumbar vertebrae laterally to the posterior parts of the iliac crest and medial surface of the ala of the ilium.

The **sacrococcygeal joint** *(junctura sacrococcygea)* (see *Articulations of the Vertebral Column*).



218. ***Pelvic ligaments and joints***; seen from above ($^2/_5$).

(Ligaments and joints of pelvic girdle [ligamenta et articulationes s. juncturae cinguli membri inferioris]. Part of left hip bone, left parts of sacrum and of third, fourth, and fifth lumbar vertebrae removed by horizontal and sagittal sections.)

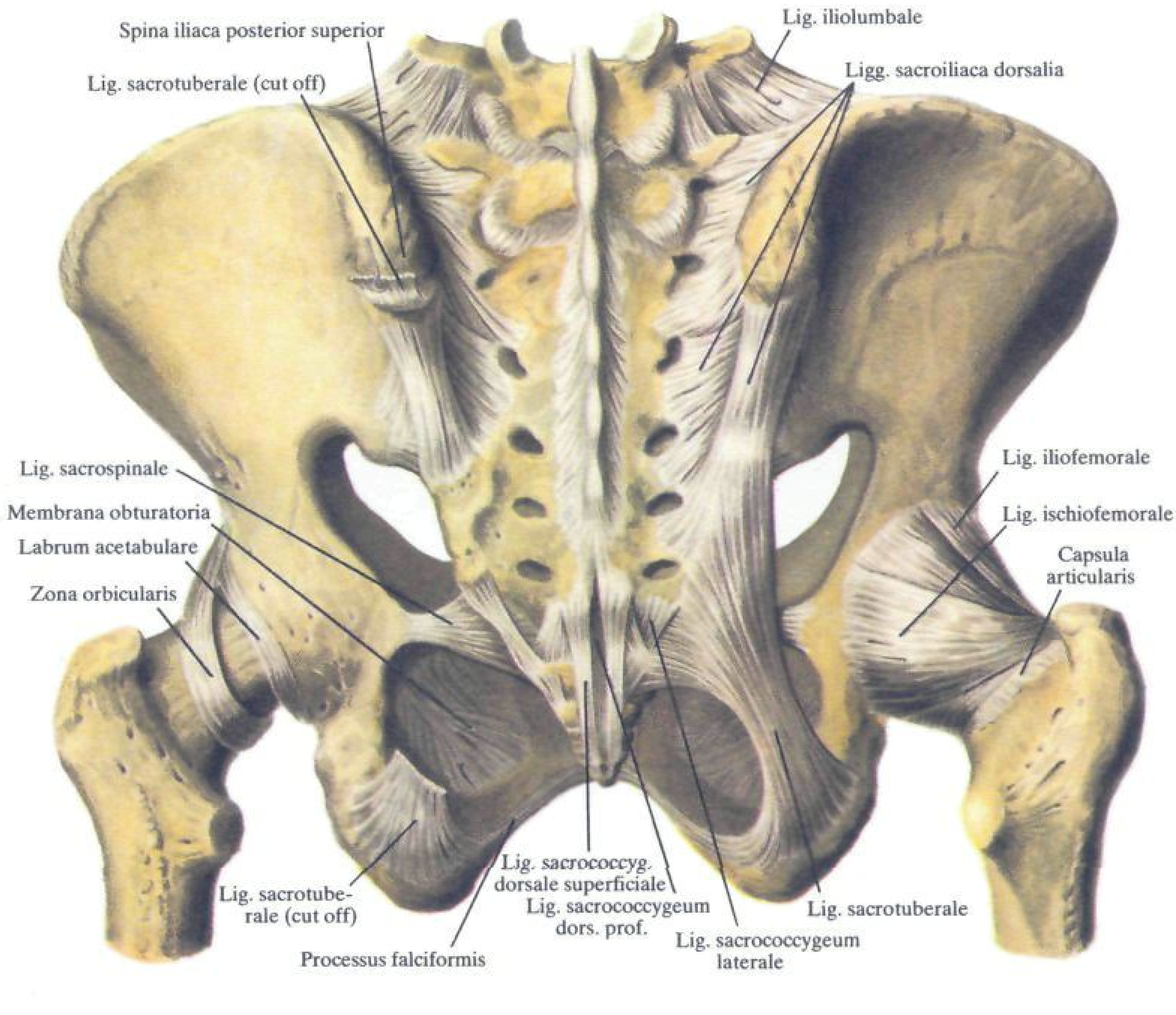
THE PUBIC SYMPHYSIS

The **pubic symphysis** *(symphysis pubica)* (Figs 218, 220) is formed by the articular **symphyseal surfaces** *(facies symphysialis)* of the pubic bones, which are covered by hyaline cartilage, and the fibrocartilaginous **interpubic disc** *(discus interpubicus)*. The disc fuses with the articular surfaces of the pubic bones and has a sagittal slit-like cavity within it. The disc is shorter in females than in males, but is thicker and has a relatively larger cavity.

The pubic symphysis is strengthened by the following ligaments.

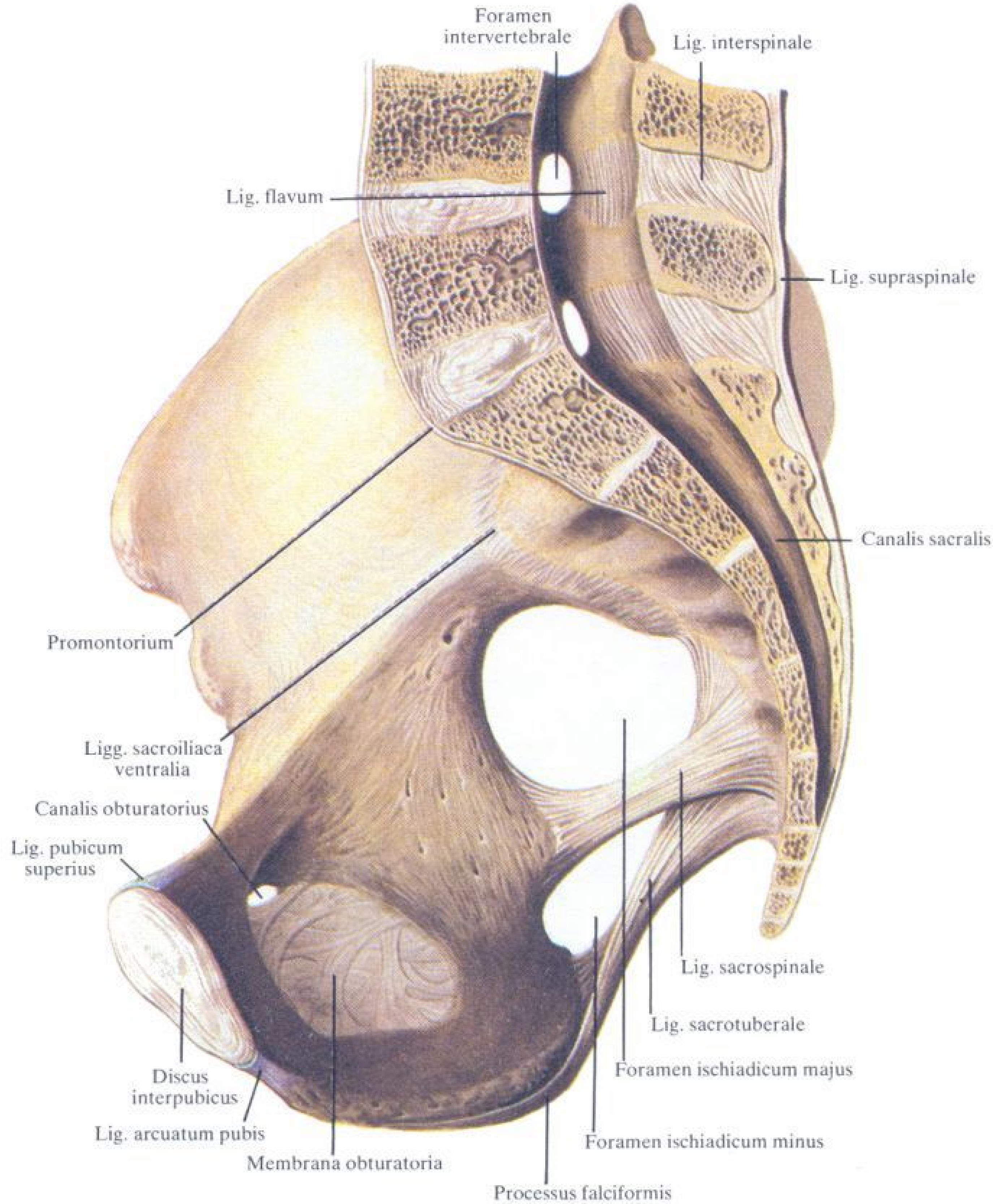
1. The **superior pubic ligament** *(ligamentum pubicum superius)* is stretched between both pubic tubercles on the superior border of the symphysis.

2. The **inferior (arcuate) pubic ligament** *(ligamentum arcuatum pubis)* passes on the inferior border of the symphysis from one pubic bone to the other.



219. *Pelvic ligaments and joints, hip joint (articulatio coxae)*; posterior view ($^2/_5$).

(Articular capsule of left hip joint is removed.)



220. *Ligaments and joints of pelvis, right side*; inner aspect ($\frac{2}{3}$).
(Sagittal-medial section.)

THE OBTURATOR MEMBRANE

The **obturator membrane** *(membrana obturatoria)* (Figs 219–221) is formed on predominantly transverse connective-tissue fibres which are attached to the borders of the obturator foramen and close it except in the obturator groove. The obturator membrane bears some small foramina. Together with the muscle arising from it and the obturator groove it borders the **obturator canal** *(canalis obturatorius)* which transmits the obturator vessels and nerves.

JOINTS OF THE FREE LOWER LIMB

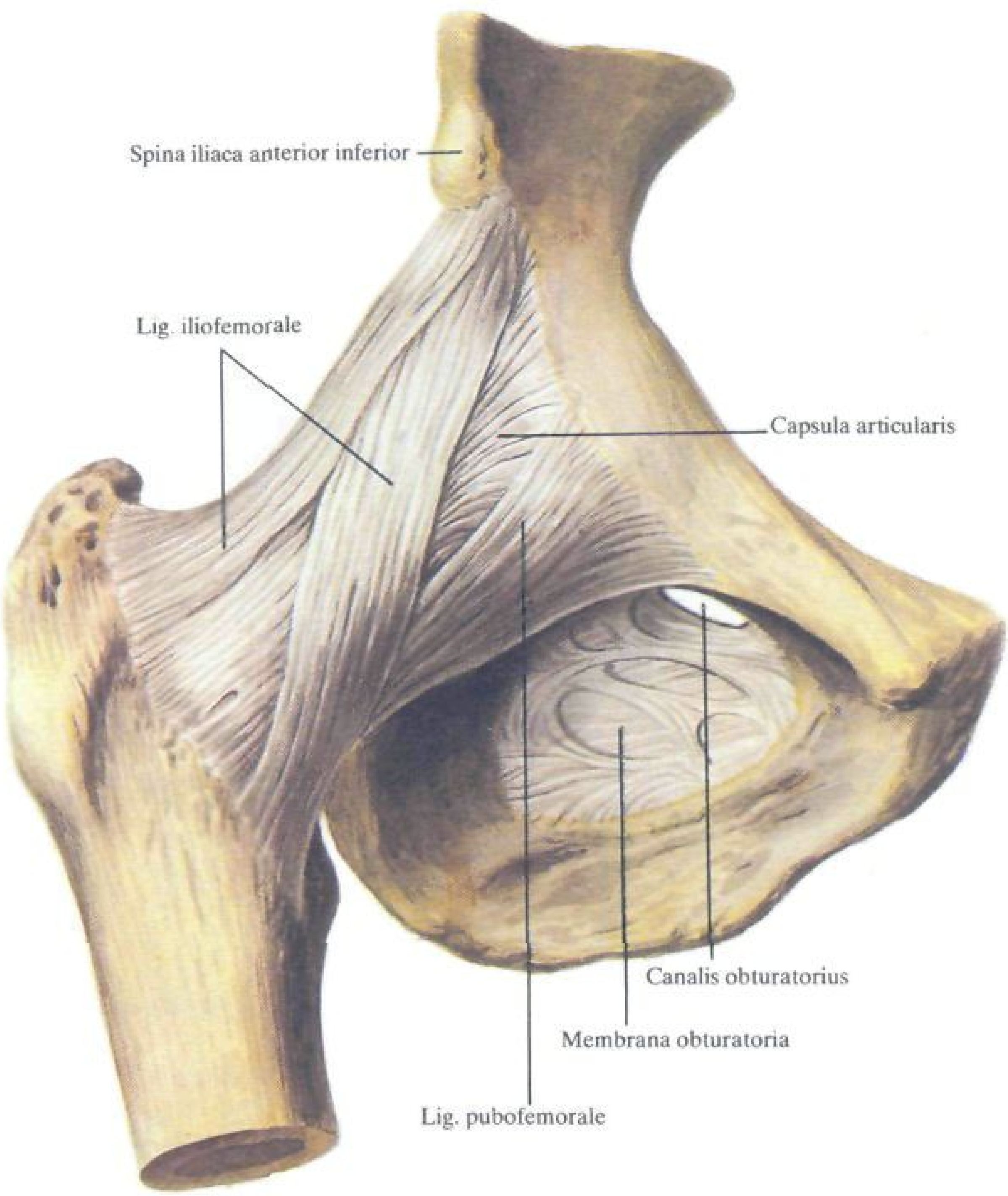
THE HIP JOINT

The **hip joint** *(articulatio coxae)* (Figs 219, 221-224) is formed by the articular surface of the femoral head (which is covered by hyaline cartilage except for the fovea capitis) and by the acetabulum of the hip bone. The acetabulum is covered by cartilage only in the region of the **articular surface** *(facies lunata)*, the rest of its surface is filled with fatty tissue and covered by a synovial membrane. Above the acetabular notch stretches the **transverse ligament of the acetabulum** *(ligamentum transversum acetabuli)*. On the free margin of the acetabulum and on this ligament is attached the **labrum acetabulare** which makes the acetabulum deeper.

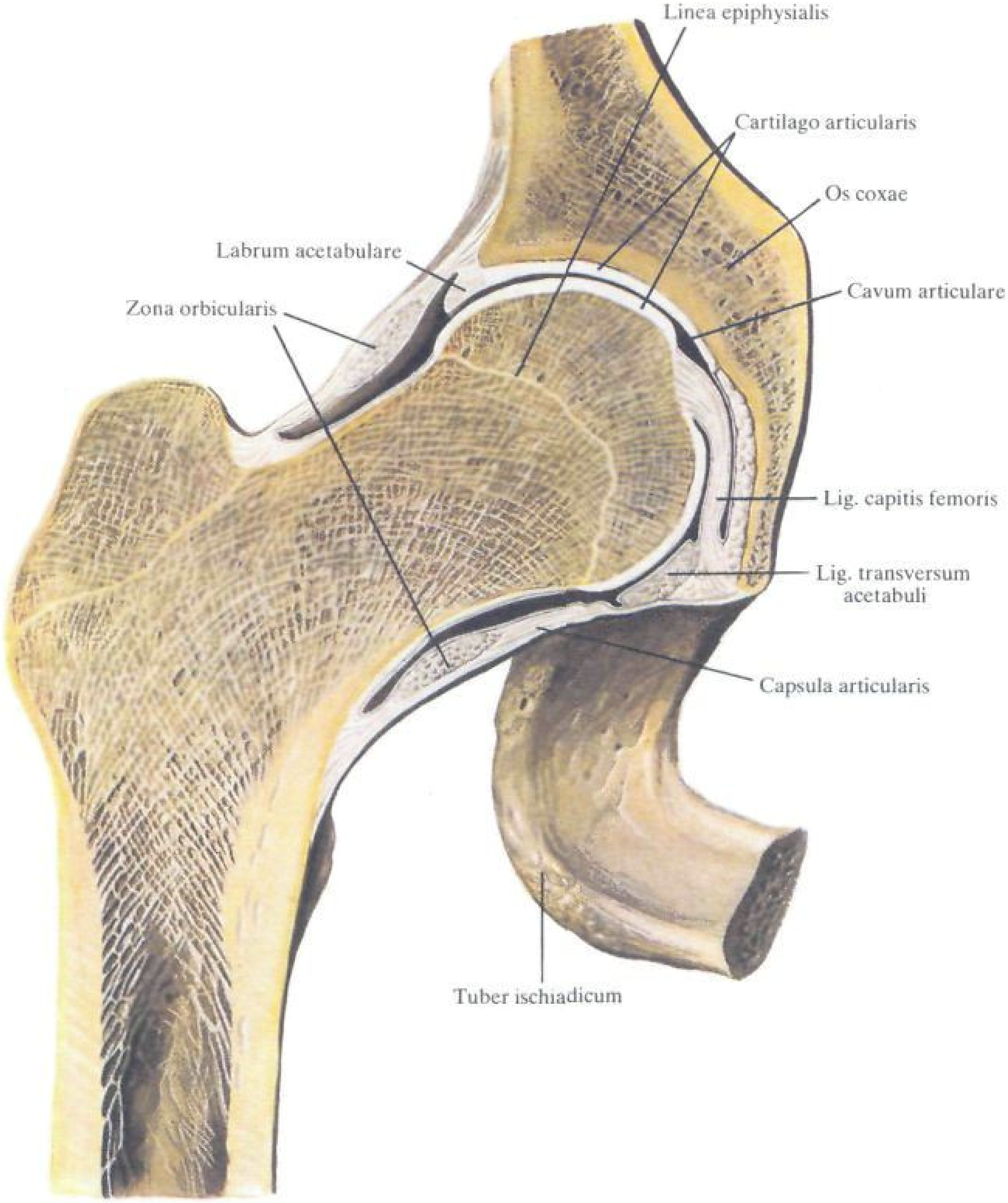
The **articular capsule** *(capsula articularis)* is attached to the hip bone along the edge of the labrum acetabulare; on the femur it is attached to the trochanteric line and embraces posteriorly two thirds of the femoral neck but does not reach the trochanteric crest.

The hip joint has the following ligaments.

1. The **iliofemoral ligament** *(ligamentum iliofemorale)* (Fig. 221) lies on the anterior surface of the hip joint. It stretches from the anterior inferior iliac spine and is attached to the trochanteric line. It checks extension at the hip joint and contributes to holding the trunk erect.



221. *Right hip joint (articulatio coxae)*; anterior aspect (⅔).



222. *Right hip joint (articulatio coxae)* (⅔).
(Cavity of hip joint opened by frontal section.)

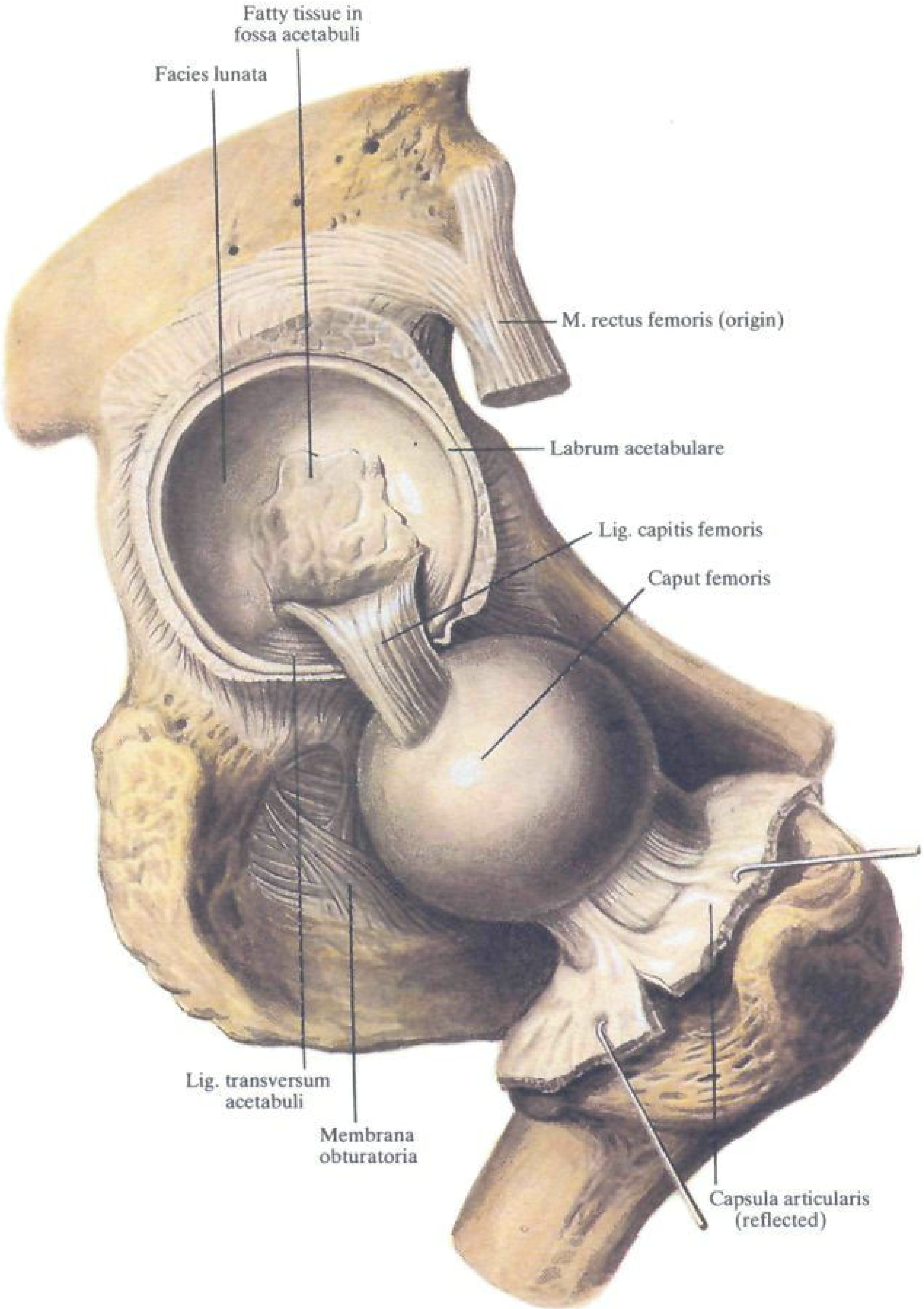
2. The **pubofemoral ligament** *(ligamentum pubofemorale)* (Fig. 221) runs downwards from the superior pubic ramus and intertwines with the capsule of the hip joint; some of its bands reach the medial part of the trochanteric line.

3. The **ischiofemoral ligament** *(ligamentum ischiofemorale)* (Fig. 219) arises on the anterior surface of the body of the ischium, runs forewards and blends with the capsule of the hip joint; some of its bundles reach the trochanteric fossa.

4. The **zona orbicularis** (Figs 219 and 222) runs in the articular capsule, loops the femoral neck, and is attached to the anterior inferior iliac spine.

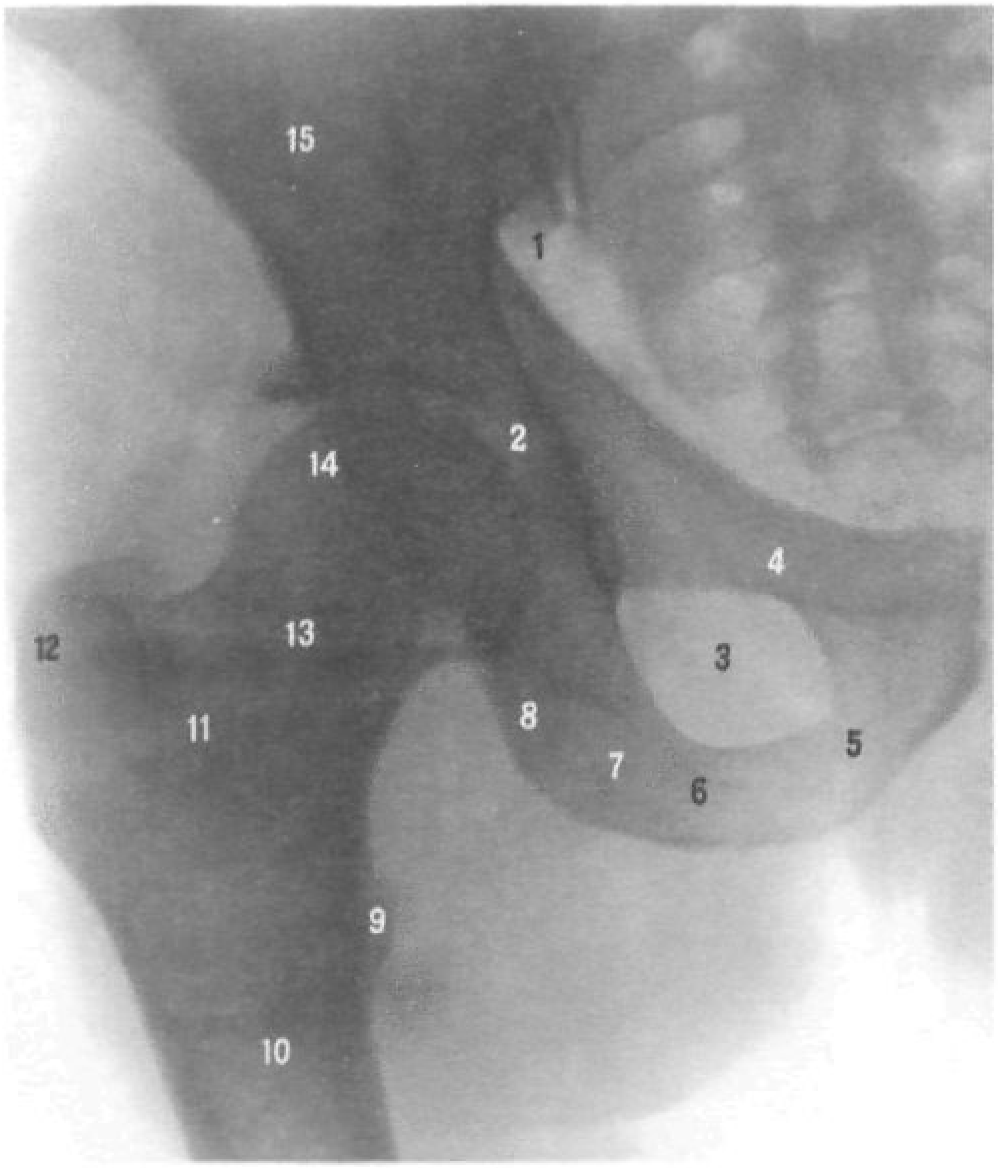
5. The **ligament of the head of the femur** *(ligamentum capitis femoris)* (Figs 222, 223) is in the joint cavity. It arises from the transverse ligament of the acetabulum and is covered by a synovial membrane; it is attached to the pit in the femoral head. Vessels pass to the head of the femur in the ligament.

The hip joint is a variety of a **ball-and-socket joint** *(articulatio cotylica).*



223. *Right hip joint (articulatio coxae)* ($^2/_3$).

(Articular capsule is cut and femoral head drawn out of acetabulum.)

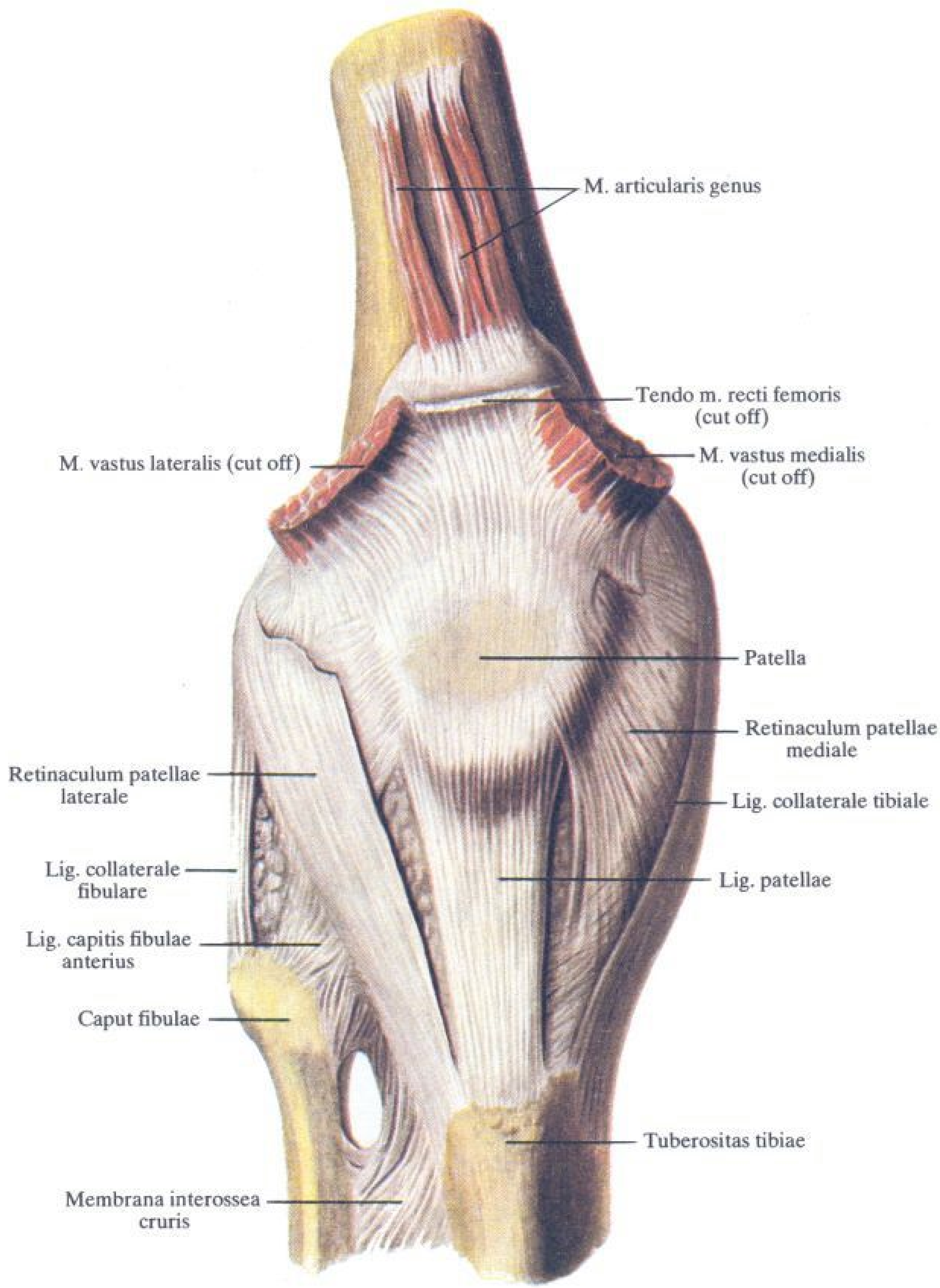


224. *Right hip joint.* Radiograph.

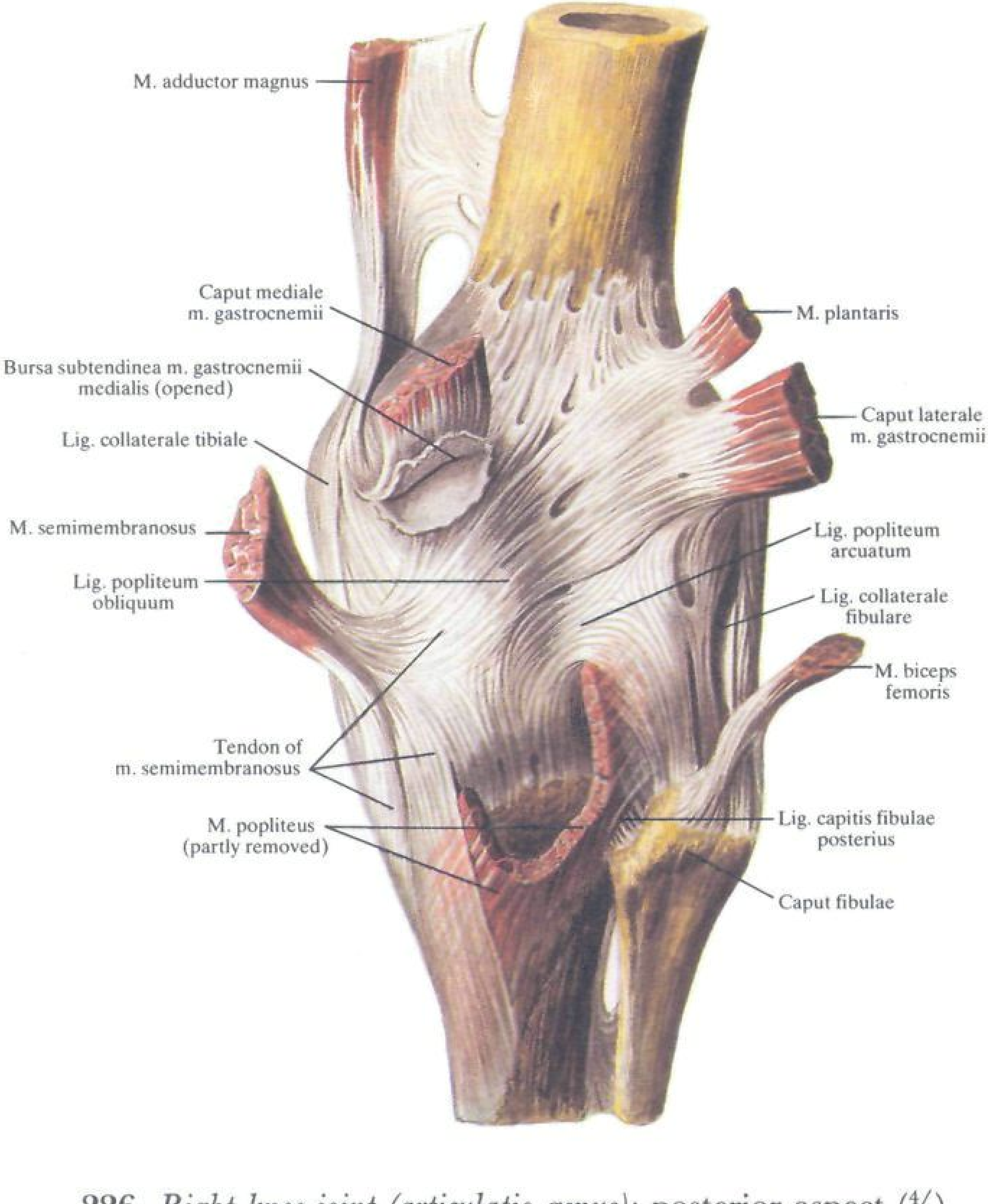
1—ischial spine
2—acetabulum
3—obturator foramen
4—superior ramus of pubis
5—inferior ramus of pubis
6 and 8—ischium
7—ischial tuberosity
9—lesser trochanter
10—femur
11—intertrochanteric crest
12—greater trochanter
13—neck of femur
14—head of femur
15—ilium

THE KNEE JOINT

The **knee joint** *(articulatio genu)* (Figs 225-233) is formed by three bones, namely, the lower end of the femur, the upper end of the tibia, and the patella. The articular surfaces of the femoral condyles are ellipsoid. The medial condyle is more convex than the lateral condyle. On the anterior surface of the bone, between the condyles, is the **patellar surface** *(facies patellaris)* which is divided by a small groove into a medial (smaller) and lateral (larger) areas. These areas articulate with the respective articular facets on the **posterior surface** *(facies articularis)* of the patella. The **superior articular surfaces** *(facies articulares superiores)* of the tibial condyles are slightly concave and are incongruent with the convex articular surfaces of the femoral condyles. This incongruence is corrected to some extent by the interarticular cartilages called the **medial semilunar cartilage** and **lateral semilunar cartilage** *(menisci medialis* et *lateralis)* or **menisci** (Figs 231-233) which are located between the femoral and tibial condyles. The menisci are cartilaginous trihe-



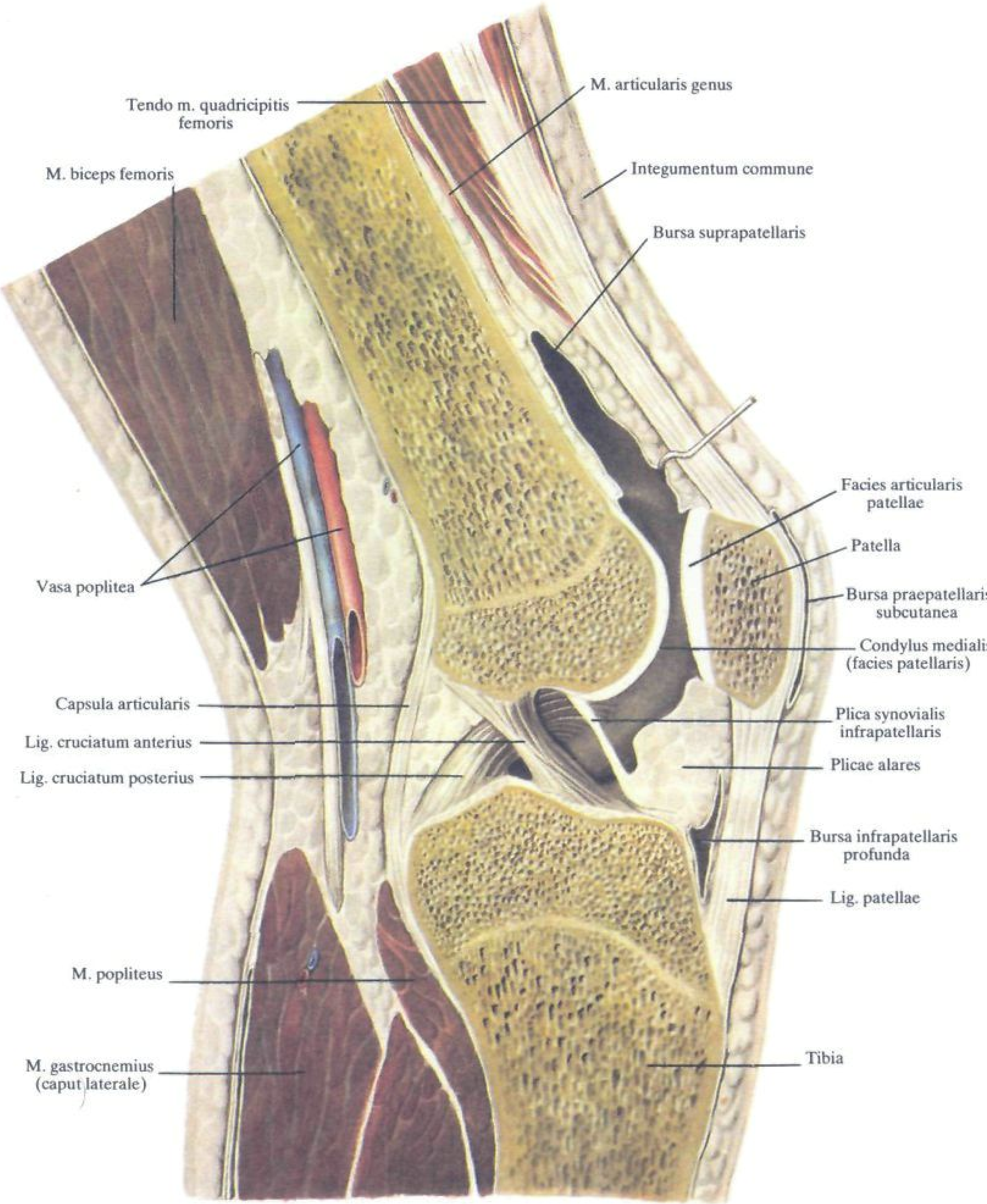
225. *Right knee joint (articulatio genus)*; anterior aspect ($^4/_5$).



226. *Right knee joint (articulatio genus)*; posterior aspect (4/5).

dral plates. Their peripheral edge is thick and fused with the articular capsule, the edge facing the joint cavity is sharpened and free. The superior surface of the meniscus is concave, the inferior surface is flat. The peripheral edges of the menisci almost copy the configuration of the superior border of the tibial condyles as the result of which the lateral meniscus resembles a part of a circumference, while the medial meniscus is crescent-shaped. The menisci are attached in front and behind to the intercondylar eminence of the tibia. The anterior parts of both menisci are joined by the **transverse ligament of the knee** *(ligamentum transversum genus)*.

The **articular capsule** *(capsula articularis)* is loosely stretched. Its posterior part is thicker than the other parts and bears some orifices which transmit vessels. In front it blends with the tendon of the quadriceps femoris muscle and is attached to the borders of the articular surface of the patella. On the femur the capsule is attached slightly above the articular cartilage in front, almost at the



227. *Right knee joint (articulatio genus)* ($1/1$).
(Cavity of knee joint opened by sagittal section)

cartilage on the sides, and on its border behind. On the tibia the capsule is attached to the borders of the articular surface. The articular capsule is lined with a synovial membrane which covers the ligaments lodged in the joint cavity and forms **synovial villi** *(villi synovialis)* and **synovial folds** *(plicae synoviales)*. The stronger developed folds are as follows: (a) the **alar folds** *(plicae alares)* (Fig. 227) which run on the sides of the patella to its apex and contain fatty tissue between their layers; the **infrapatellar synovial fold** *(plica synovialis infrapatellaris)* which is below the patella and is a continuation of the alar folds. It arises in the region of the apex of the patella, enters the cavity of the knee joint, and is attached in the region of the anterior edge of the intercondylar notch of the femur.

The capsule of the knee joint forms a series of synovial **eversions** *(eversiones synoviales)* and **synovial bursae** *(bursae synoviales)* which are situated along the distribution of muscles and tendons but do not communicate with the joint cavity (see *Muscles of the Lower Limb)*. The largest pouch of the articular capsule is the **suprapatellar bursa** *(bursa suprapatellaris)* situated above the patella between the tendon of the quadriceps femoris muscle; in some individuals it may be isolated.

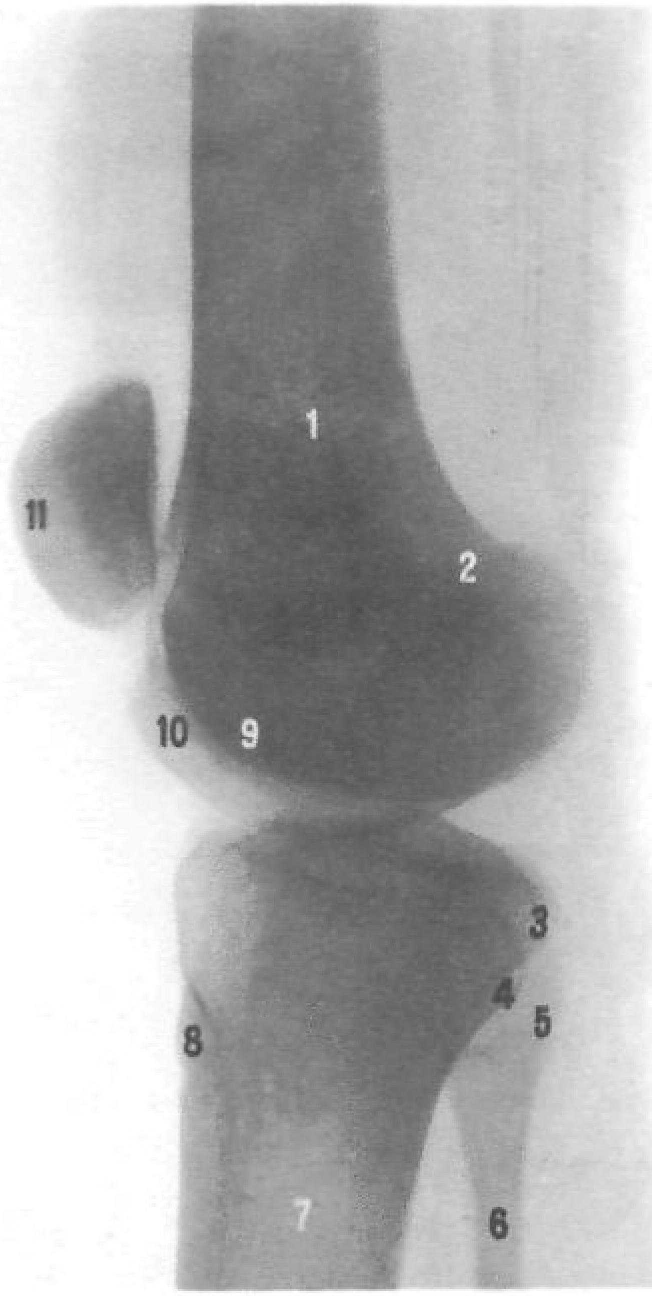
Two groups of knee joint ligaments are distinguished, one extra-articular and the other intra-articular. The following well developed ligaments are situated on the sides of the joint.

1. The **medial ligament of the knee** or **tibial collateral ligament** *(ligamentum collaterale tibiale)* (Figs 225, 226, 231, 232). It runs downwards from the medial femoral epicondyle, blends with the articular capsule and medial meniscus, and reaches the upper part of the tibia.

2. The **lateral ligament of the knee** or **fibular collateral ligament** *(ligamentum collaterale fibulare)* (Figs 225, 230-232). It is narrower than the medial ligament; it arises from the lateral epicondyle of the femur and also stretches downwards, gives off some bands to the articular capsule, and is attached to the lateral surface of the head of the fibula.

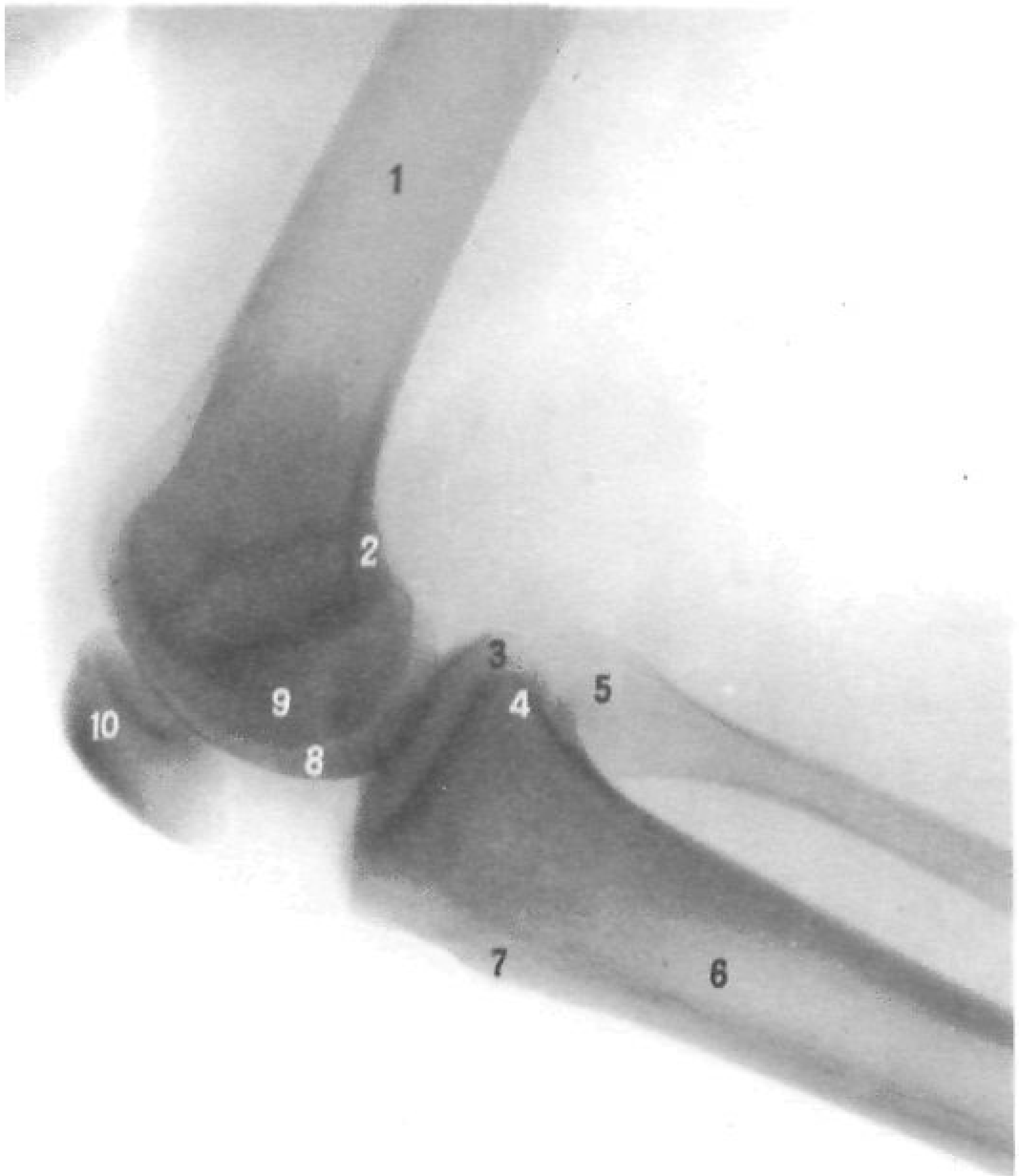
The anterior parts of the articular capsule are reinforced by ligaments related directly to the tendon of the quadriceps femoris muscle. This muscle approaches the patella to be attached to its base. Some of the bundles of the tendon are continued downwards to the tuberosity of the tibia to form below the apex of the patella the **ligamentum patellae** (Figs 225, 227, 230). Other bundles stretch vertically on the sides of the patella and its ligament and form vertical ligaments called the **lateral** and **medial retinaculi of the patella** *(retinaculum patellae laterale et retinaculum patellae mediale)*. They run from the sides of the patella to the respective femoral condyle. Under these ligaments are tendon fibres stretching horizontally from the sides of the patella to the femoral epicondyles. The posterior parts of the articular capsule are strengthened by the **oblique posterior ligament of the knee** *(ligamentum popliteum obliquum)* (Fig. 226) which is a part of the tendon of the semimembranosus muscle. The ligament runs from the medial tibial condyle to the lateral femoral condyle and some of its fibres blend on the way with the articular capsule.

In addition to the oblique ligament, another ligament called



228. *Right knee joint.* Radiograph.

1—femur
2—intercondylar notch
3—medial condyle of tibia
4—lateral condyle of tibia
5—head of fibula
6—fibula
7—tibia
8—tuberosity of tibia
9—lateral condyle of femur
10—medial condyle of femur
11—patella



229. *Right knee joint.* Radiograph made with the knee joint flexed.

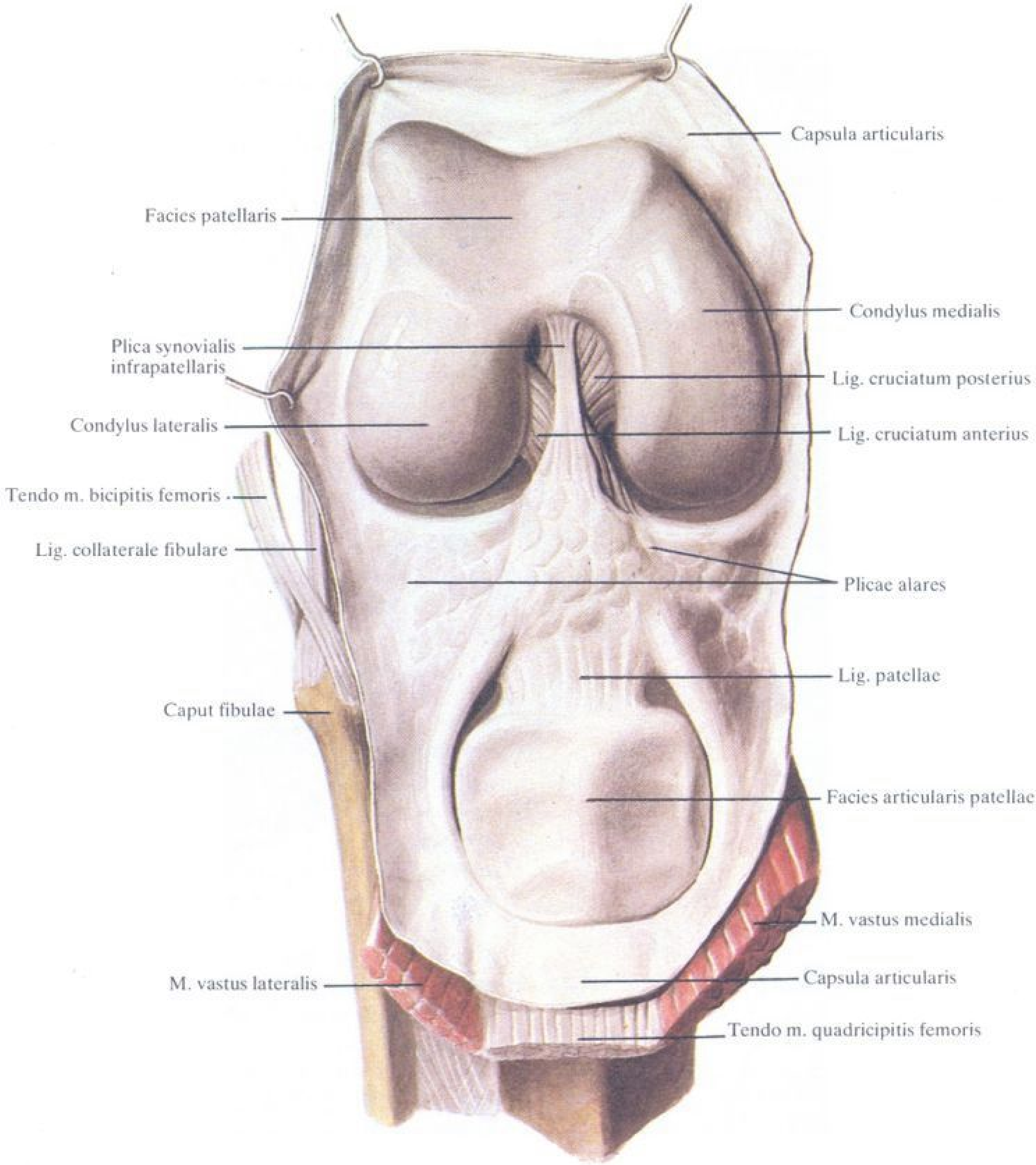
1—femur	6—tibia
2—intercondylar notch	7—tuberosity of tibia
3—lateral condyle of tibia	8—medial condyle of femur
4—medial condyle of tibia	9—lateral condyle of femur
5—head of fibula	10—patella

the **arcuate ligament of the knee** *(ligamentum popliteum arcuatum)* (Fig. 226) is always found in this part of the articular capsule. It stretches between the lateral femoral epicondyle and the middle part of the oblique ligament.

The following ligaments are in the cavity of the knee joint.

1. The **anterior cruciate ligament** *(ligamentum cruciatum anterius)* runs from the lateral condyle of the femur forwards and medially and is attached to the tibia in the anterior intercondylar area.

2. The **posterior cruciate ligament** *(ligamentum cruciatum posterius)* stretches from the medial surface of the medial femoral condyle to the back and medially, crosses the anterior cruciate ligament, and is attached to the posterior intercondylar area of the tibia.



230. *Right knee joint (articulatio genus)*; anterior aspect (4/5).

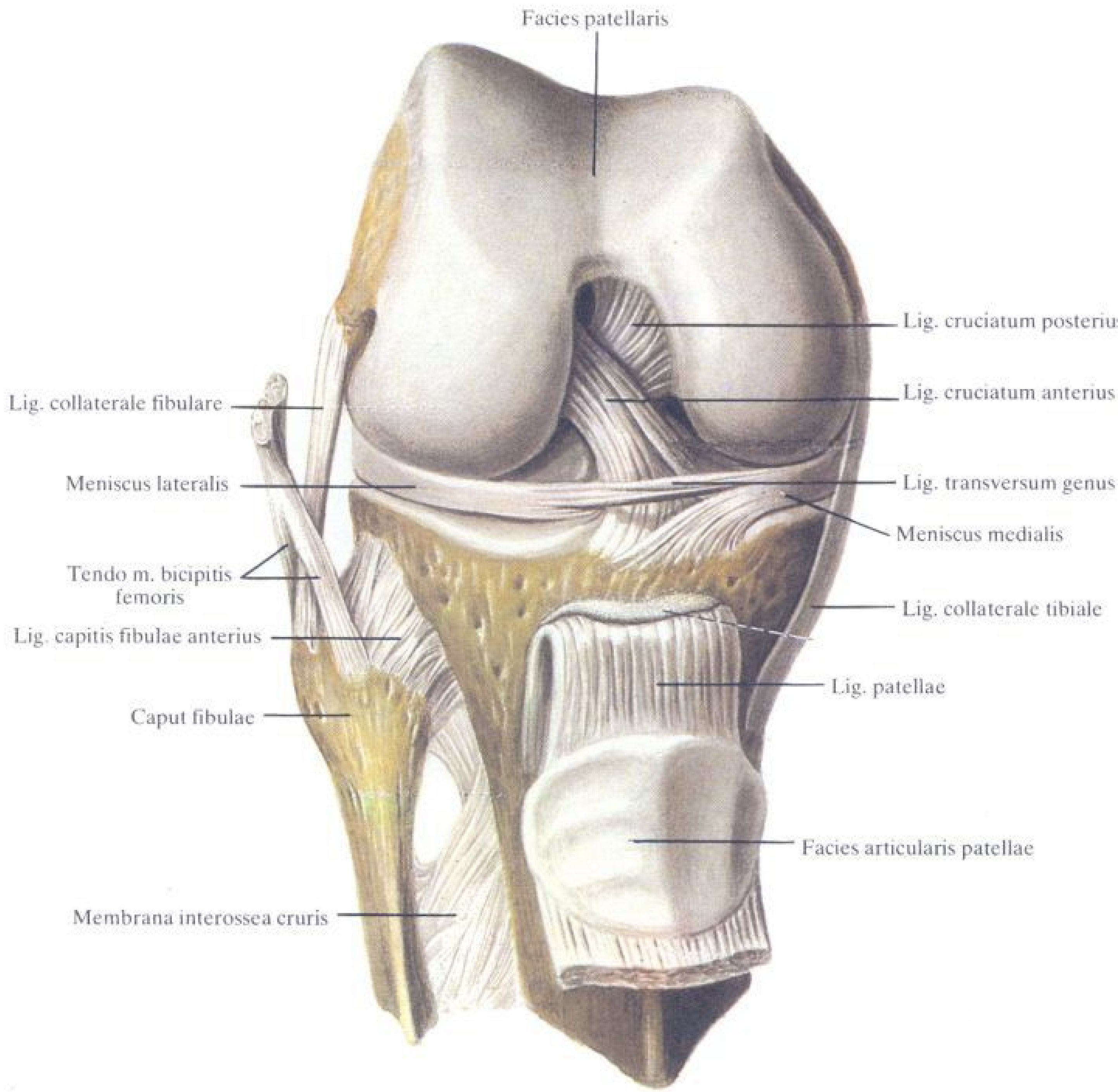
(Articular capsule cut on lateral, anterior, and medial surfaces. Quadriceps femoris muscle with patella are drawn away distally.)

3. The **transverse ligament of the knee** *(ligamentum transversum genus)* connects the anterior surface of both menisci.

4. The **anterior meniscofemoral ligament** *(ligamentum menisco-femorale anterius)* (Fig. 231) extends from the anterior part of the medial meniscus upwards and laterally to the medial surface of the lateral femoral condyle.

5. The **posterior meniscofemoral ligament** *(ligamentum menisco-femoralis posterius)* (Fig. 232) runs from the posterior part of the lateral meniscus upwards and medially to the medial surface of the medial femoral condyle.

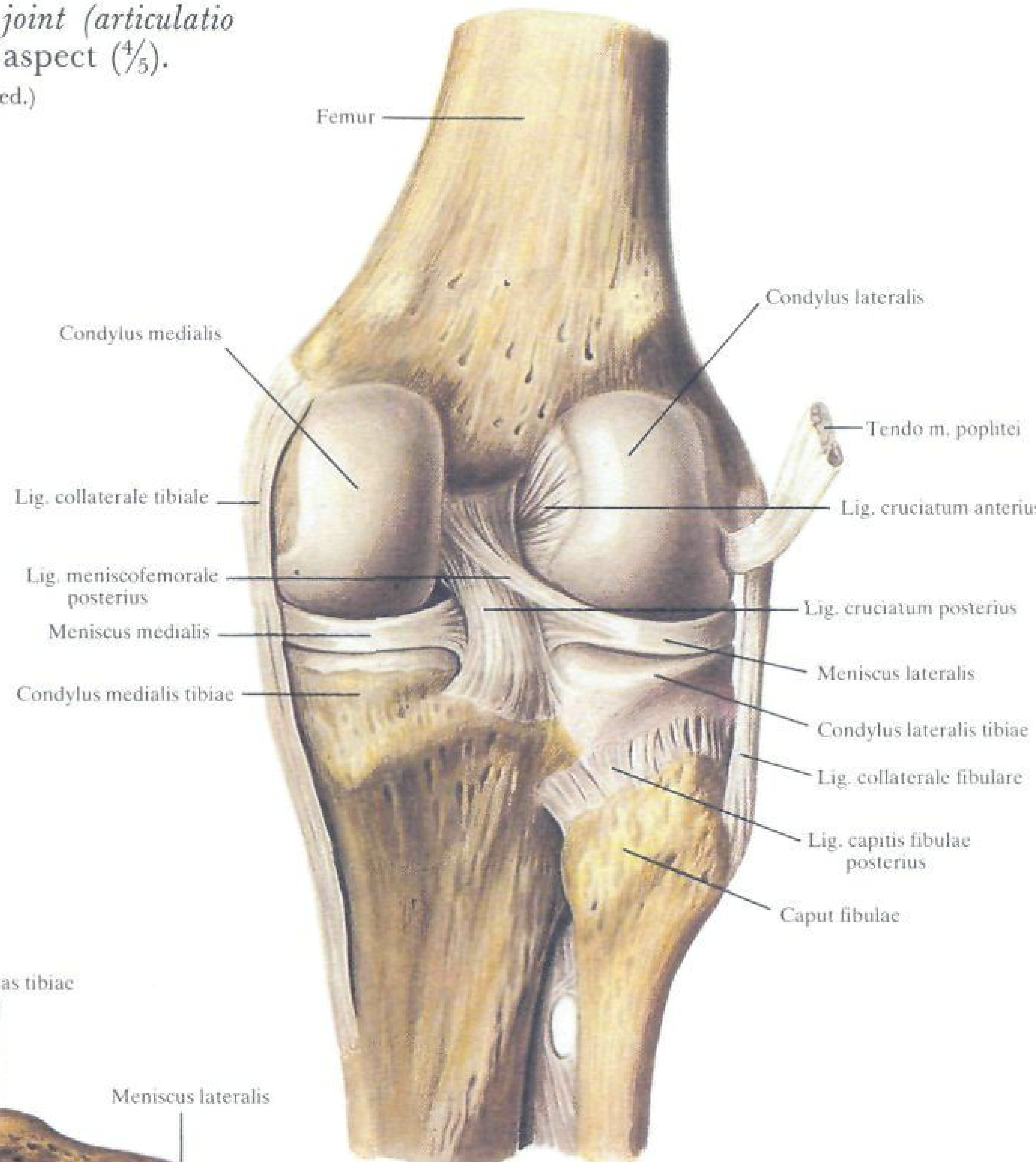
The knee joint is a combination of a **hinge** *(ginglymus)* and **pivot** *(trochoid)* joints and is related to trochoginglymus.

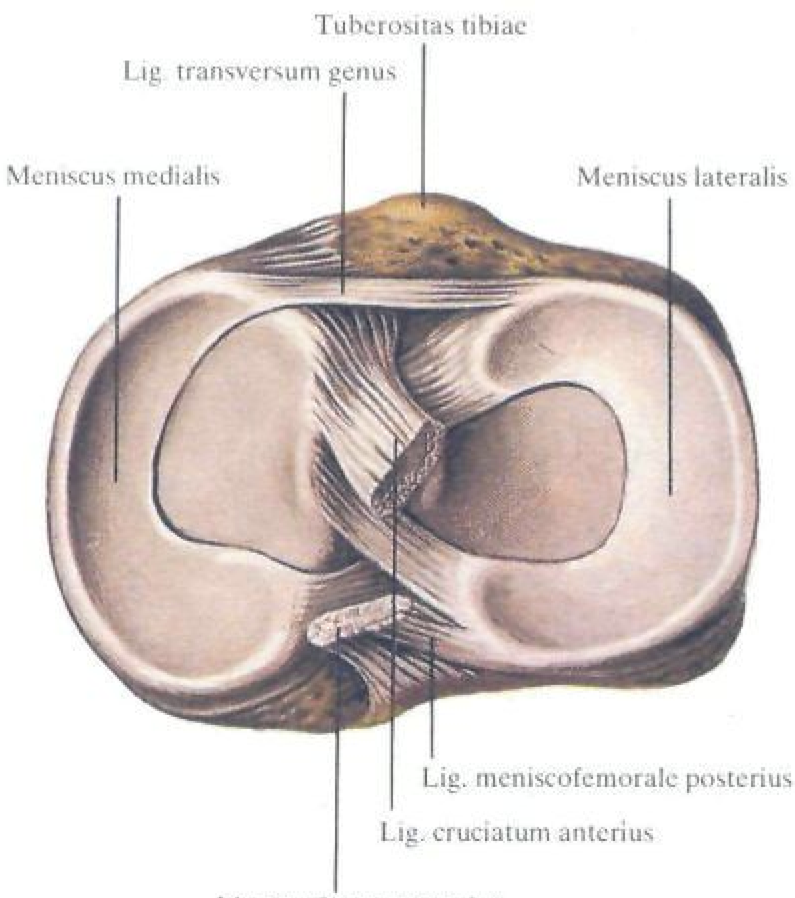


231. *Right knee joint (articulatio genus)*; anterior aspect ($^1/_1$).

(Articular capsule removed. Tendon of quadriceps femoris muscle together with patella are drawn away distally.)

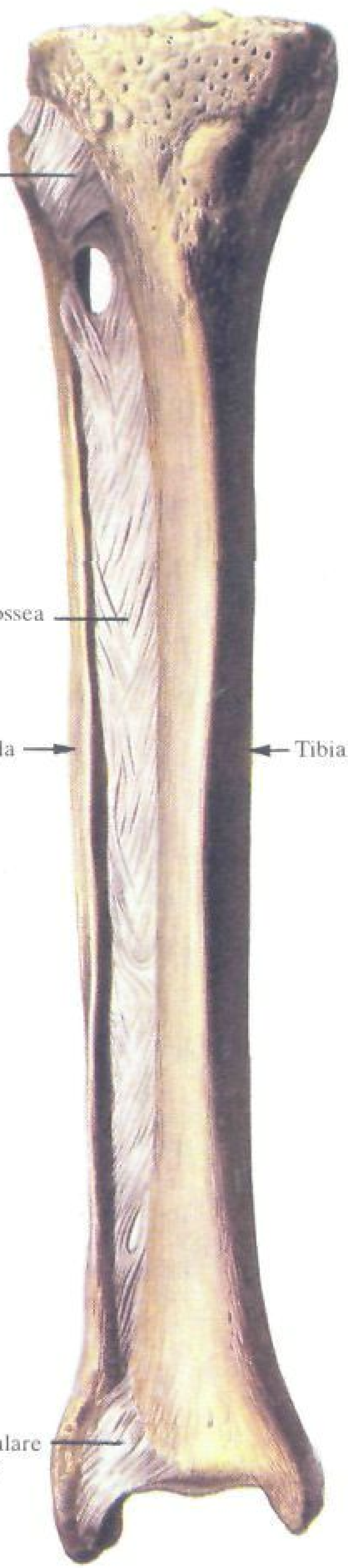
232. *Right knee joint (articulatio genus)*; posterior aspect (4/5).
(Articular capsule removed.)





233. *Right knee joint (articulatio genus)* (4/5).
(Distal surface of knee joint seen from above. Cruciate ligaments of knee are cut.)

JOINTS OF THE LEG BONES



The proximal ends of the leg bones form the **superior tibiofibular joint** *(articulatio tibiofibularis)* (Figs 232, 234, 236, 238). The articulating surfaces are the flat **articular facet of the head of the fibula** *(facies articularis capitis fibulae)* and the **fibular articular surface** of the lateral tibial condyle *(facies articularis fibularis)*.

The **articular capsule** *(capsula articularis)* is attached to the edges of the articulating surfaces; it is taut and strengthened by the **anterior** and **posterior ligaments of the superior tibiofibular joint** *(ligamenta capitis fibulae anterius* et *posterius)*. The ligaments are on the anterior and posterior surfaces of the joint and extend from the tibia to the head of the fibula. The proximal tibiofibular joint permits a small range of movements.

The space between the two leg bones is filled by the **interosseous membrane of the leg** *(membrana interossea cruris)*.

The fibres of the membrane descend and run laterally from the interosseous border of the tibia to that of the fibula. In the upper part of the membrane is a large opening transmitting vessels and nerves; in the lower part is a smaller opening transmitting vessels. The membrane is stronger in the lower part.

The distal ends of the leg bones form the **inferior tibiofibular syndesmosis (joint)** *(syndesmosis* s. *articulatio tibiofibularis)*.

On the anterior and posterior surfaces of this joint are short but strong ligaments stretching from the anterior and posterior edges of the fibular notch of the tibia to the lateral malleolus. These are the **anterior** and **posterior inferior tibiofibular ligaments** *(ligamenta tibiofibularia anterius* et *posterius)* (Figs 234-236). There are also dense bands of connective-tissue fibres stretched for the whole distance between the fibular notch of the tibia and the rough surface of the lateral malleolus facing it.

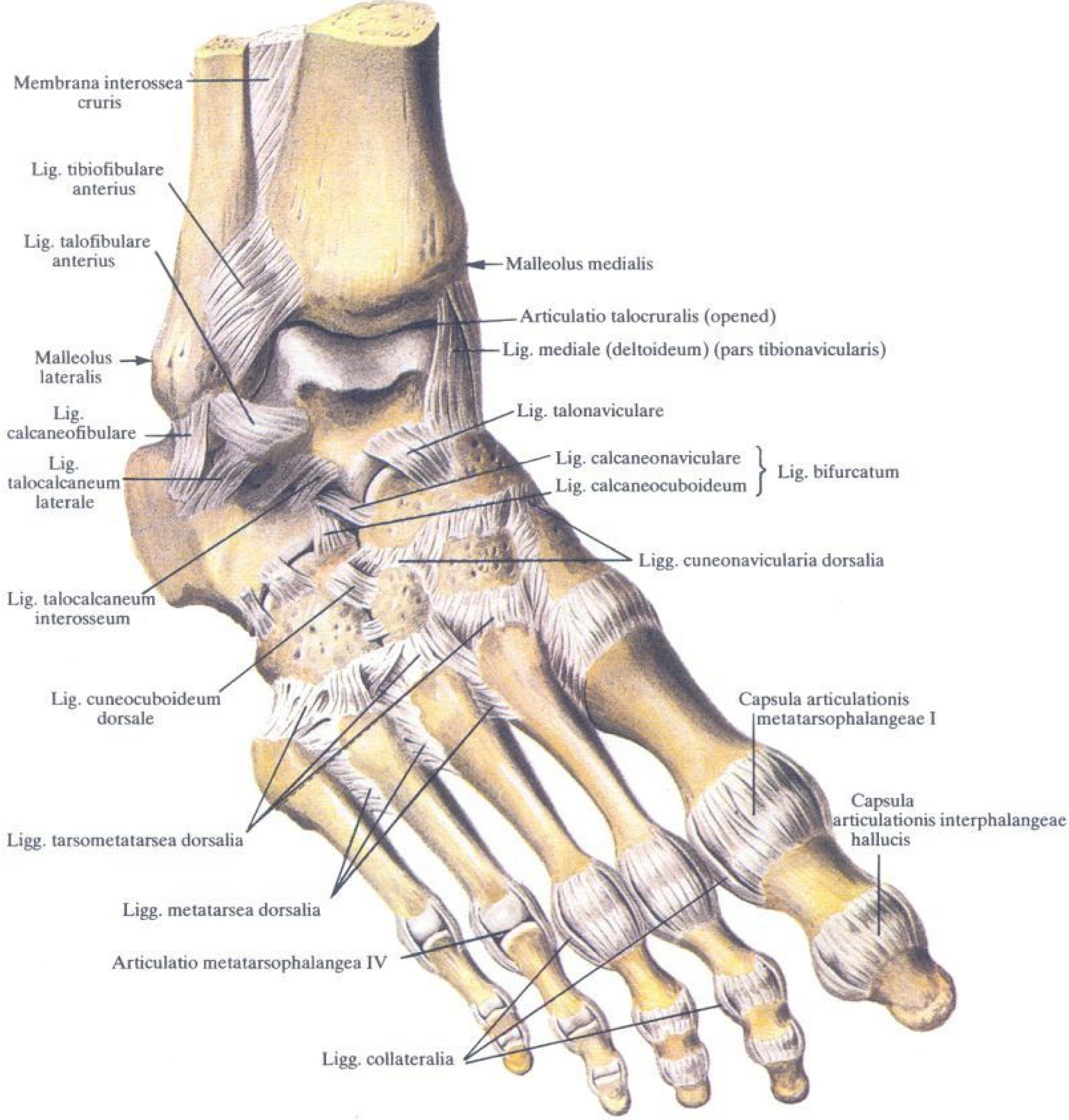
234. *Right tibiofibular joint (articulatio tibiofibularis), interosseous membrane of leg (membrana interossea cruris), and tibiofibular syndesmosis (syndesmosis tibiofibularis);* anterior aspect ($^2/_5$).

JOINTS OF THE FOOT

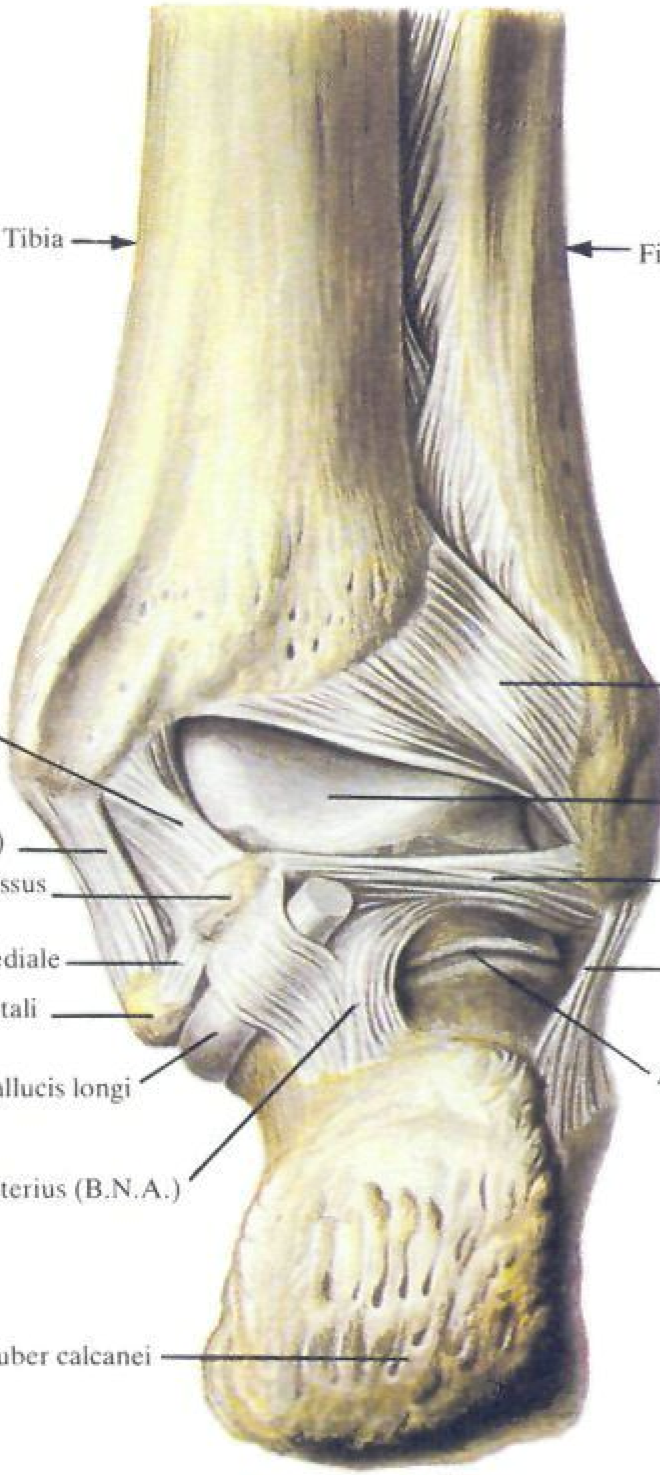
THE ANKLE JOINT

The **ankle**, or **talocrural joint** *(articulatio talocruralis)* (Figs 235, 236, 238-240) is formed between the articular surfaces of the distal ends of the tibia and fibula and the articular surface of the trochlea of the talus. The tibia articulates by means of its **inferior articular surface** *(facies articularis inferior)* and **the malleolar facet** *(facies articularis malleolaris)*. The fibula also bears an **articular facet of the lateral malleolus** *(facies articularis malleoli)*.

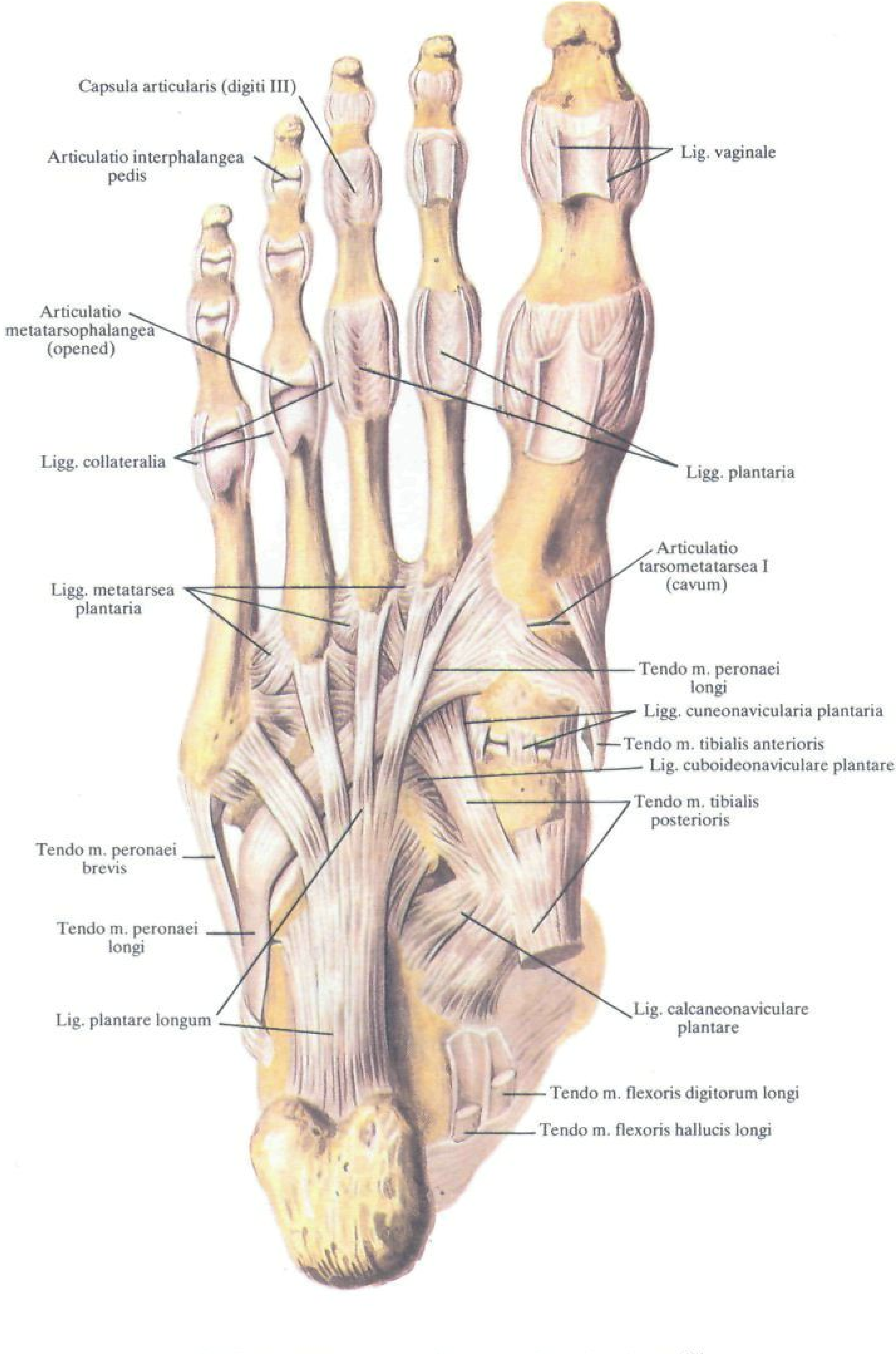
The articular surface of the talus is pulley-shaped (trochlear)



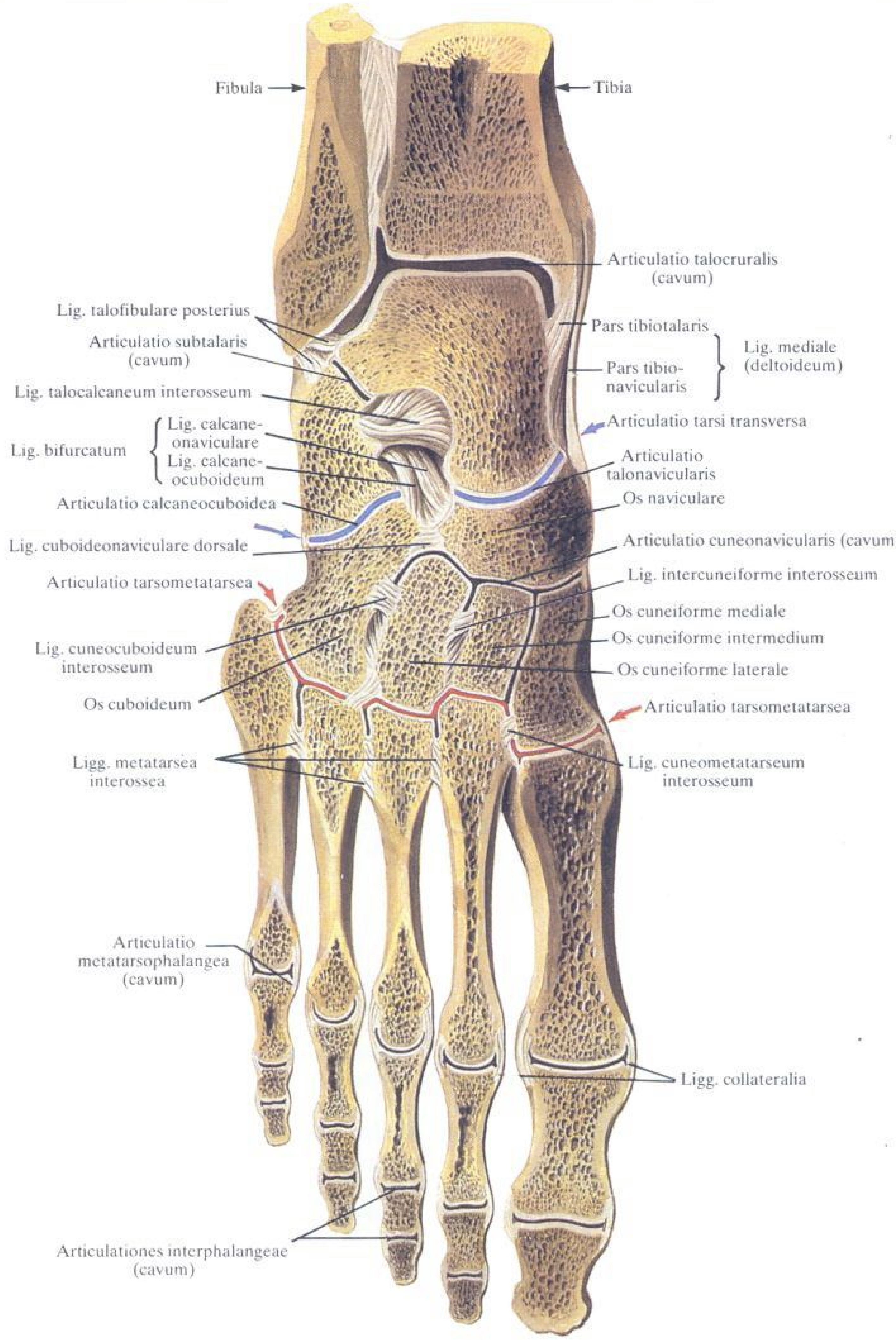
235. *Ligaments and joints of right foot* (½).
(Dorsal surface.)



236. *Ligaments and joints of right foot* (4/5).
(Articular capsules are removed.)

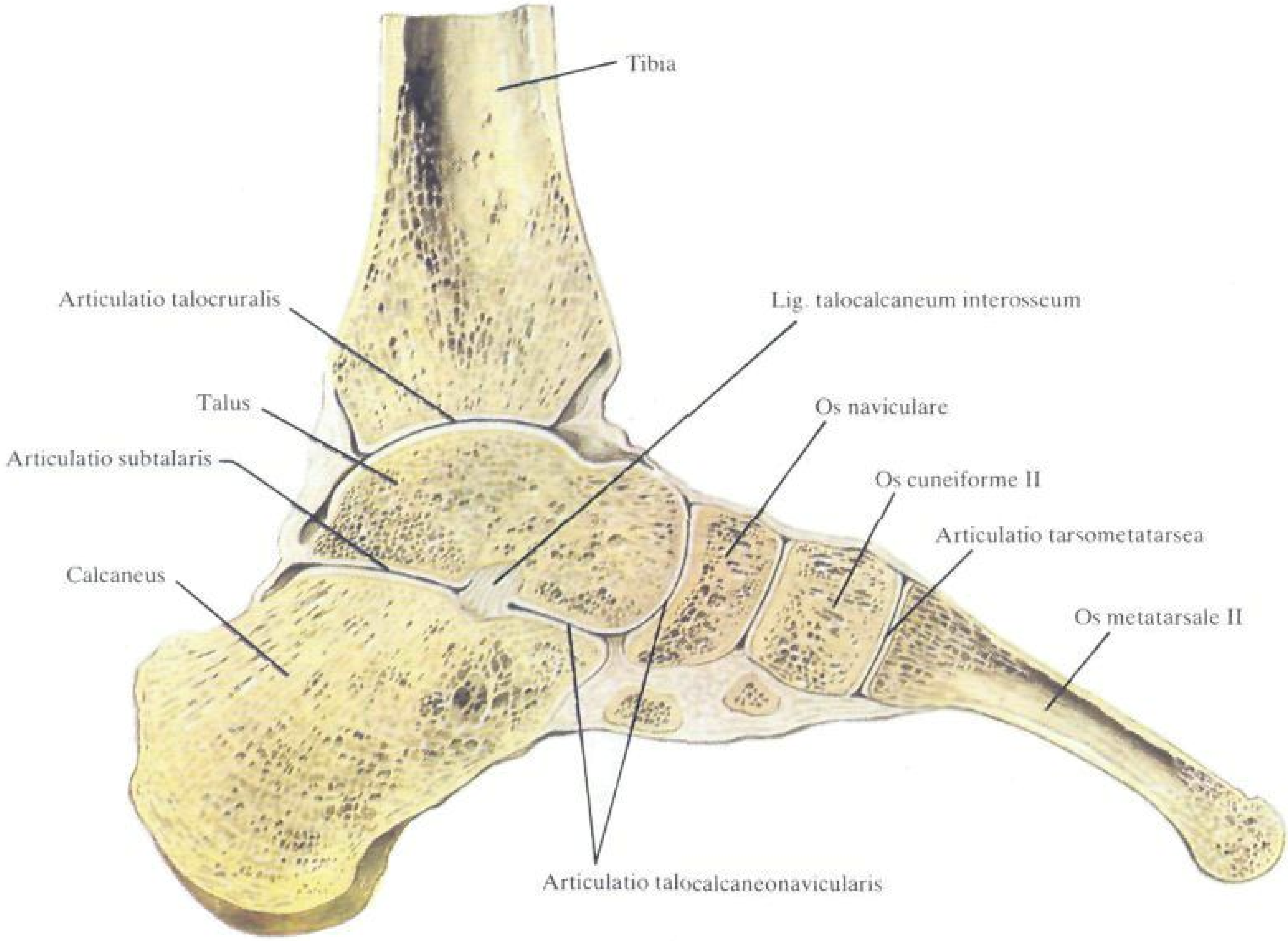


237. *Ligaments and joints of right foot* (2/3).
(Plantar surface.)



238. *Joints and ligaments of right foot* ($\frac{1}{2}$).

(Section through ankle joint and joints of foot.)



238a. ***Joints and ligaments of right foot*** **($\frac{1}{2}$).**
(Section through ankle joint and joints of foot.)

on top, while on the sides it carries flat **malleolar facet of the lateral** and **malleolar facet of the medial surface of the talus** *(facies malleolaris lateralis* et *medialis)*. The leg bones grasp the trochlea of the talus like a fork.

The **articular capsule** *(capsula articularis)* is attached for a great distance to the edge of the articular cartilage and only on the anterior surface of the body of the talus it separates from the cartilage to be attached to the neck of the talus. The anterior and posterior parts of the capsule are weak.

The ligaments of the ankle joint run on its sides.

1. The **medial (deltoid) ligament** *(ligamentum mediale [deltoideum])* (Figs 235, 236, 238). It is subdivided into the following parts:

(a) the **anterior talotibial part** *(pars tibiotalaris anterior)* running downwards and forwards from the anterior border of the medial malleolus to be attached to the posteromedial surface of the talus;

(b) the **tibionavicular part** *(pars tibionavicularis)* stretching from the medial malleolus to the dorsal surface of the navicular bone; it is longer than the aforementioned part;

(c) the **calcaneotibial part** *(pars tibiocalcanea)* stretching between the tip of the medial malleolus and the sustentaculum tali;

(d) the **posterior talotibial part** *(pars tibiotalaris posterior)* running from the posterior border of the medial malleolus downwards and laterally to be attached to the posteromedial parts of the body of the talus.

The following ligaments are on the lateral surface of the ankle joint.

1. The **anterior talofibular ligament** *(ligamentum talofibulare anterius)*. It passes from the anterior border of the lateral malleolus to the lateral surface of the neck of the talus.

2. The **calcaneofibular ligament** *(ligamentum calcaneofibulare)* which arises on the lateral surface of the lateral malleolus, runs downwards and backwards, and is attached to the lateral surface of the calcaneum.

3. The **posterior talofibular ligament** *(ligamentum talofibulare posterius)*. It stretches almost horizontally from the posterior border of the lateral malleolus to the lateral tubercle of the posterior process of the talus.

The ankle joint is a variant of the hinge joint of the cochlear type.

THE SUBTALAR JOINT

The **subtalar (talocalcanean) joint** *(articulatio subtalaris)* (Figs 236, 238, 241) is formed by the **posterior calcanean facet for the talus** *(facies articularis posterior calcanei)*, and the **posterior calcanean facet of the talus** *(facies articularis calcanea posterior tali)*.

The **articular capsule** *(capsula articularis)* is loose and is attached for the most part to the edge of the articular cartilages and only in front (on the talus) and behind (on the calcaneum) it deviates slightly from the margins of the articulating surfaces.

The joint is strengthened by the following ligaments.

1. The **interosseous talocalcanean ligament** *(ligamentum talocalcaneum interosseum)* lies in the sinus tarsi and its ends are attached to the groove of the calcaneum and the groove of the talus.

2. The **lateral talocalcanean ligament** *(ligamentum talocalcaneum laterale)* is stretched between the superior surface of the neck of the talus and the superolateral surface of the calcaneum.

3. The **medial talocalcanean ligament** *(ligamentum talocalcaneum mediale)* runs from the posterior process of the talus to the sustentaculum tali.

THE TALOCALCANEONAVICULAR JOINT

The **talocalcaneonavicular joint** *(articulatio talocalcaneonavicularis)* (Fig. 235) is formed by the articular surfaces of the talus, calcaneum, and navicular bone. The talus forms the articular head, the calcaneum and navicular bone supply the articular socket.

The **articular capsule** *(capsula articularis)* is attached to the edges of the articular cartilages.

The following ligaments reinforce the capsule.

1. The **talonavicular ligament (dorsal)** *(ligamentum talonaviculare)* stretches between the neck of the talus and the navicular bone.

2. The **plantar calcaneonavicular ligament** *(ligamentum calcaneonaviculare plantare)*. It passes from the sustentaculum tali to the plantar surface of the navicular bone. In the upper part it is continuous with the navicular fibrous cartilage which contributes to the formation of the articular socket of the joint.

According to shape, the talocalcaneonavicular joint is a **spheroid joint** *(articulatio spheroidea)* but it permits movements only in one plane, about the axis, approximately in the sagittal direction.

THE CALCANEOCUBOID JOINT

The **calcaneocuboid joint** *(articulatio calcaneocuboidea)* (Fig. 235) is formed by a **facet on the posterior surface of the cuboid bone** *(facies articularis posterior ossis cuboidei)* and a **facet on the calcaneum** *(facies articularis cuboidea calcanei)*. The articulating surfaces are saddle-shaped. The medial part of the **articular capsule** *(capsula articularis)* is attached to the edge of the articular cartilage and is taut; the lateral part is attached at some distance from the edge of the cartilage.

Ligaments, which are stronger on the plantar surface, reinforce the joint.

1. The **long plantar ligament** *(ligamentum plantare longum)* is the strongest. It arises on the inferior surface of the tuber calcanei, runs forwards, bridges the groove of the cuboid bone to form an osteofibrous canal, and reaches the bases of the four lateral metatarsal bones. The deep bundles of this ligament are shorter and are attached to the tuberosity of the cuboid bone.

2. The **short plantar ligament** *(ligamentum calcaneocuboideum plantare)* is located deeper than the long plantar ligament. Its bundles are in direct contact with the articular capsule and connect the plantar surfaces of the calcaneum and cuboid bone.

The calcaneocuboid joint resembles a **saddle joint** *(articulatio sellaris)* in shape but functions as a uniaxial joint.

THE TRANSVERSE TARSAL JOINT

The **transverse tarsal joint** *(articulatio tarsi transversa)* (Figs 235, 238) unites two joints, the **talocalcaneonavicular** *(articulatio talocalcaneonavicularis)* and the **calcaneocuboid** *(articulatio calcaneocuboidea)* joints. The line of the joint is S-shaped with the medial part being convex anteriorly and the lateral part convex posteriorly. The joints are isolated anatomically but have a common **bifurcated ligament** *(ligamentum bifurcatum)*. This ligament arises on the dorsal surface of the calcaneum at its anterior border and separates immediately into two ligaments. One is situated laterally and is called the **medial calcaneocuboid ligament** *(ligamentum calcaneocuboideum)*; it runs to the dorsal surface of the cuboid bone. The other is medial to it and is called the **lateral calcaneonavicular ligament** *(ligamentum calcaneonaviculare)*; it passes to the navicular bone.

The bifurcated ligament is also known as 'the key' to the transverse tarsal joint because with all the ligaments surrounding this joint being cut it holds the articulating bones in place and the foot can be exarticulated at this joint during operation only when this ligament is transected.

THE CUNEONAVICULAR JOINT

The **cuneonavicular joint** *(articulatio cuneonavicularis)* (Fig. 235) is a complex articulation in the formation of which the navicular, cuboid, and the three cuneiform bones take part. The following articulations form here: joints between the anterior articular surfaces of the navicular bone and the posterior articular surfaces of the medial, intermediate, and lateral cuneiform bones, and joints between the contiguous surfaces of the cuboid, navicular, and cuneiform bones.

The joint cavity between the navicular and cuneiform bones is in the frontal plane and from it branch out to the front another three joint cavities, one between the medial and intermediate cuneiform bones, another between the intermediate and lateral cuneiform bones, and the third between the lateral cuneiform and cuboid bones; a cavity also extends to the back between the navicular and cuboid bones.

The **articular capsule** *(capsula articularis)* is attached along the edge of the articular cartilage. The joint cavity communicates with the cavity of the **tarsometatarsal joint** *(articulatio tarsometatarsea)* in the region of the second metatarsal through the joint cavities between the medial, intermediate and lateral cuneiform bones.

The following ligaments strengthen the cuneonavicular joint.

1. The **dorsal cuneonavicular ligaments** *(ligamenta cuneonavicularia dorsalia)* stretch on the dorsal surface of the joint between the navicular and the three cuneiform bones.

2. The **dorsal cubonavicular ligament** *(ligamentum cuboideonaviculare dorsale)* lies laterally to the dorsal cuneonavicular ligament and connects the dorsal surfaces of the cuboid and navicular bones.

3. The **dorsal intercuneiform ligaments** *(ligamenta intercuneiformia dorsalia)* are on the dorsal surface of the joint between the medial, intermediate and lateral cuneiform bones.

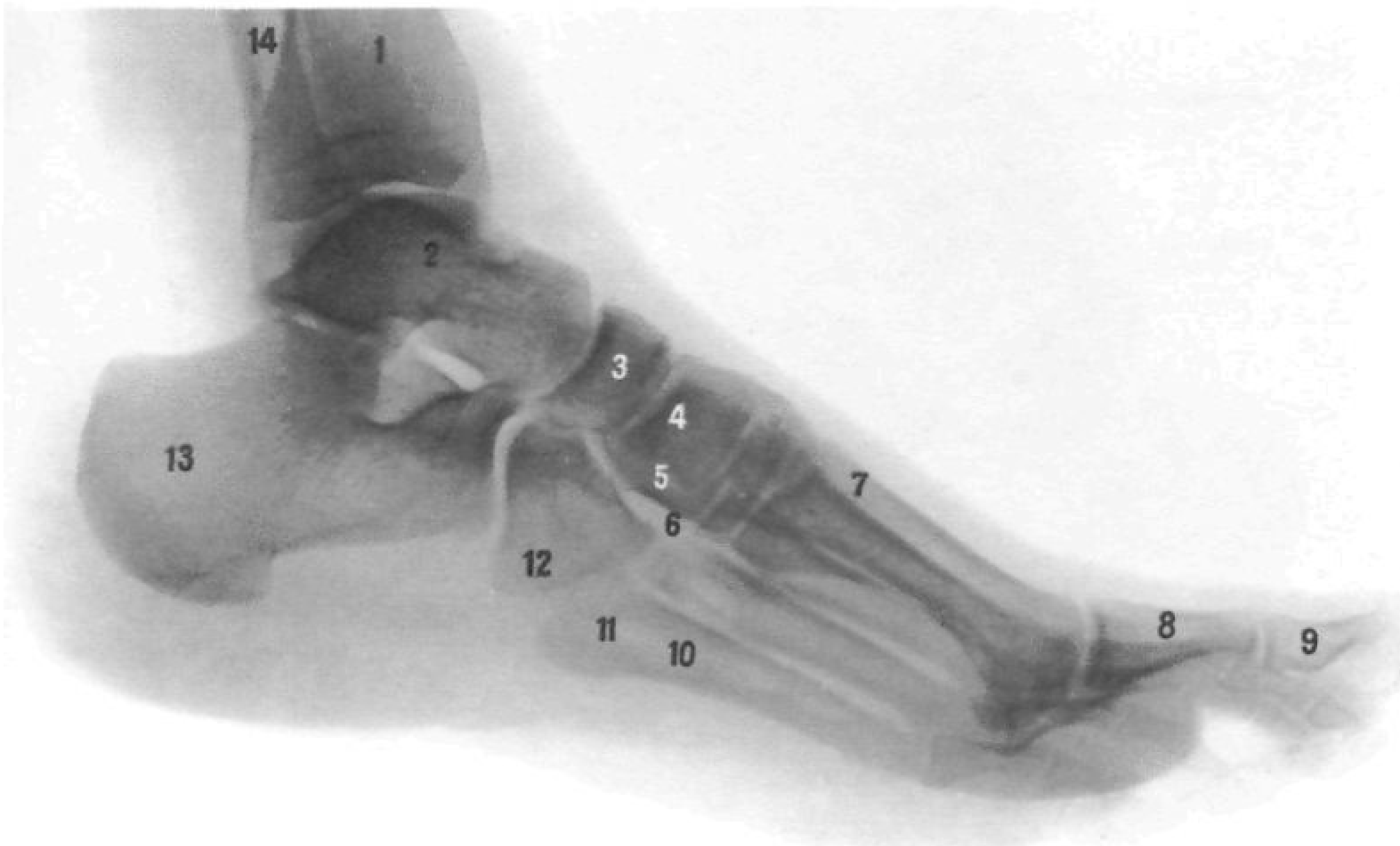
4. The **plantar cubonavicular ligament** *(ligamentum cuboideonaviculare plantare)* (Fig. 241) lies on the plantar surface of the joint between the cuboid and navicular bones.

5. The **plantar cuneocuboid ligament** *(ligamentum cuneocuboideum plantare)* connects the plantar surfaces of the lateral cuneiform and cuboid bones.

6. The **plantar cuneonavicular ligaments** *(ligamenta cuneonavicularia plantaria)* are stretched between the plantar surface of the navicular and the three cuneiform bones.

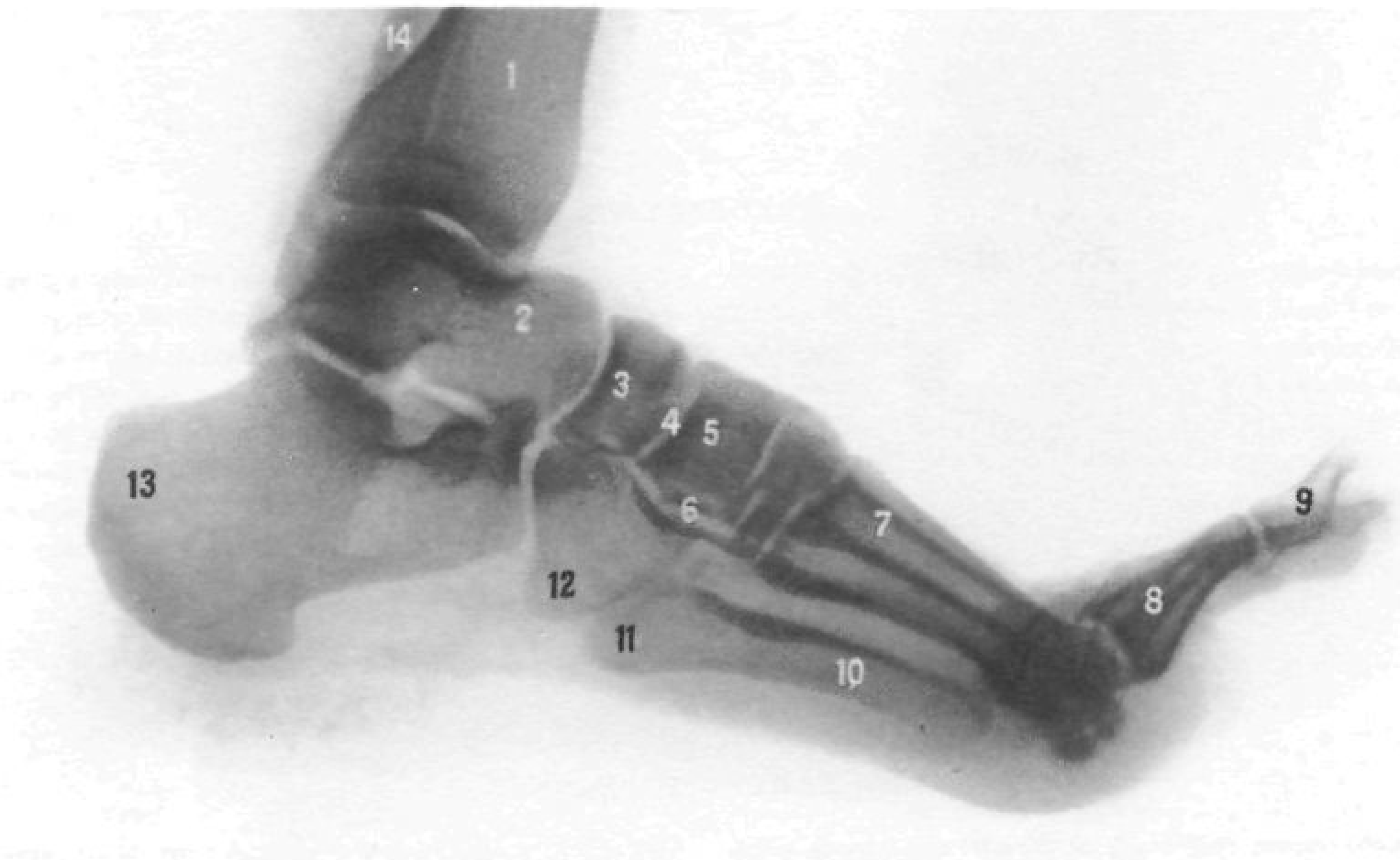
7. The **plantar intercuneiform ligaments** *(ligamenta intercuneiformia plantaria)* are situated on the plantar surface between the cuneiform bones.

In addition to the ligaments described above, a series of short strong ligaments are located between the adjacent bones in the joint cavities: the **interosseous cuneocuboid ligament** *(ligamentum cuneocuboideum interosseum)*, **interosseous intercuneiform ligaments** *(ligamenta intercuneiformia interossea)*. The cuneonavicular joint is an articulation permitting a limited range of movements.



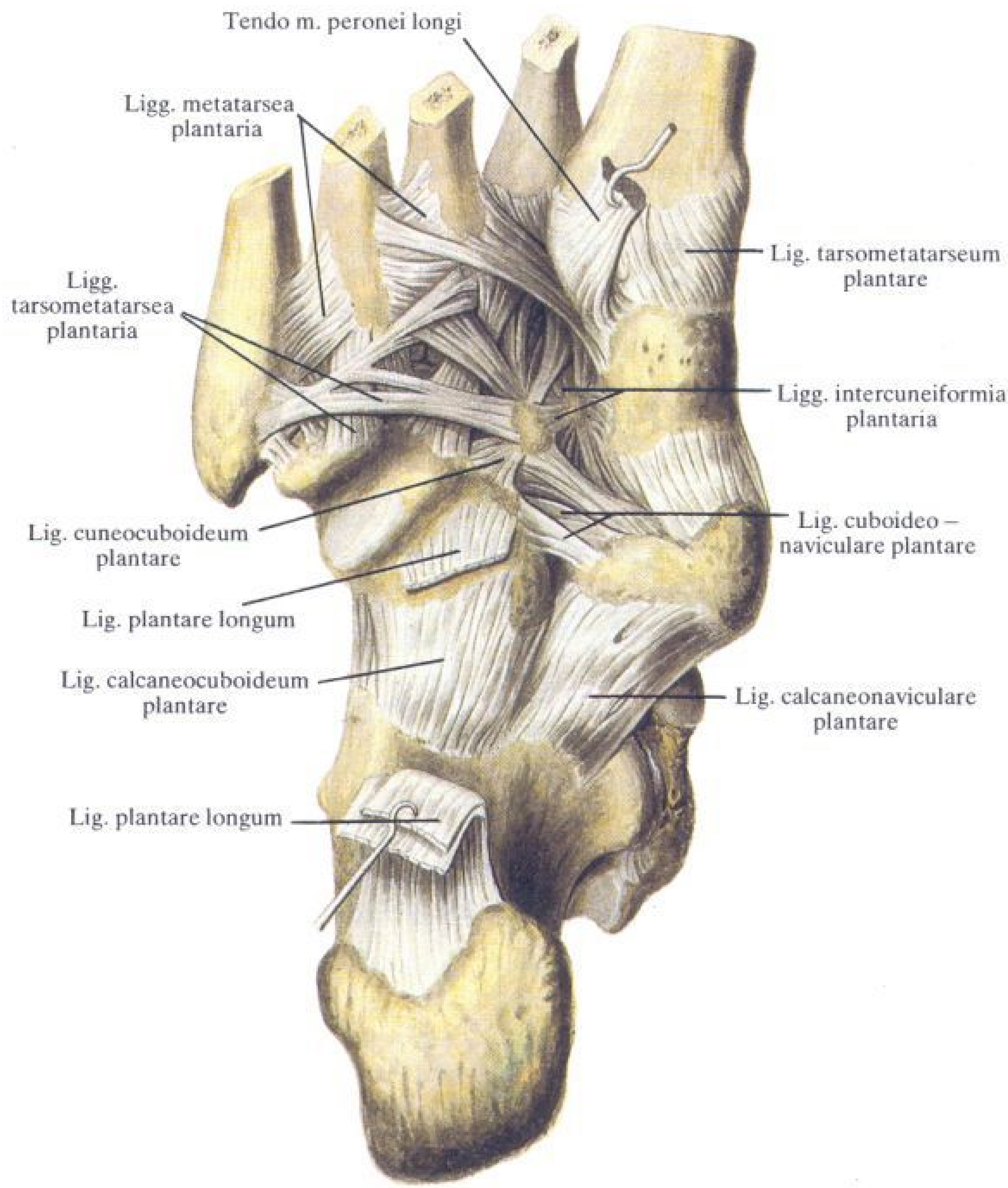
239. *Joints of right foot.* Radiograph.

1—tibia
2—talus
3—navicular bone
4—medial cuneiform bone
5—intermediate cuneiform bone
6—lateral cuneiform bone
7 and 10—metatarsal bone
8—proximal phalanx of great toe
9—distal phalanx of great toe
11—tubercle of fifth metatarsal bone
12—cuboid bone
13—calcaneum
14—fibula



240. *Joints of right foot.* Radiograph taken with the toes in dorsal flexion.

1—tibia
2—talus
3—navicular bone
4—medial cuneiform bone
5—intermediate cuneiform bone
6—lateral cuneiform bone
7 and 10—metatarsal bone
8—proximal phalanx
9—distal phalanx
11—tubercle of metatarsal bone
12—cuboid bone
13—calcaneum
14—fibula



241. *Ligaments and joints of right foot* (⅔).
(Plantar surface.)

THE TARSOMETATARSAL JOINTS

The **tarsometatarsal joints** *(articulationes tarsometatarseae)* (Figs 235, 238) join the bones of the tarsus to the bones of the metatarsus. The following three tarsometatarsal joints are distinguished: (1) between the medial cuneiform and the first metatarsal bones; (2) between the intermediate and lateral cuneiform and the second and third metatarsal bones; (3) between the cuboid and the fourth and fifth metatarsal bones. The joint between the medial cuneiform and first metatarsal bones is formed by articular surfaces which are slightly saddle-shaped, the other bones articulate by means of flat surfaces. The line formed by the cavity of the tarsometatarsal joints is irregular because the second metatarsal bone is longer than the other metatarsals, while the lateral cuneiform bone projects forwards a little as compared to the anterior part of the cuboid bone.

The **articular capsule** *(capsula articularis)* of each tarsometatarsal joint is attached along the edge of the articular cartilage and is strengthened by the following ligaments.

1. The **dorsal tarsometatarsal ligaments** *(ligamenta tarsometatarsea dorsalia)* are situated on the dorsal surface of the joints.
2. The **plantar tarsometatarsal ligaments** *(ligamenta tarsometatarsea plantaria)* which are on the plantar surface.
3. The **interosseous metatarsal ligaments** *(ligamenta metatarsea interossea)* stretch between the bases of the metatarsal bones.
4. The **interosseous tarsometatarsal ligaments** *(ligamenta cuneometatarsea interossea)* join the cuneiform bones to the metatarsal bones. The medial one joins the medial cuneiform bone to the base of the second metatarsal bone and is 'the key' to the tarsometatarsal joints. These joints permit a limited range of movements.

THE INTERMETATARSAL JOINTS

The **intermetatarsal joints** *(articulationes intermetatarseae)* form between the bases of the metatarsal bones. The direction of ligaments strengthening them is on the whole similar to that of the ligaments of the hand.

The **articular capsules** *(capsulae articulares)* are reinforced by the following ligaments: the **interosseous metatarsal ligaments** *(ligamenta metatarsea interossea)*, the **dorsal metatarsal ligaments** *(ligamenta metatarsea dorsalia)*, and the **plantar metatarsal ligaments** *(ligamenta metatarsea plantaria)*.

The gaps between the individual metatarsal bones are called **interosseous spaces of the metatarsus** *(spatia interossea metatarsi)*.

THE METATARSOPHALANGEAL JOINTS

The **metatarsophalangeal joints** *(articulationes metatarsophalangeae)* (see Figs 235, 237, 238) are formed by the articular surfaces of the heads of the metatarsals and the bases of the proximal phalanges. The heads of the second and third metatarsal bones are of an irregular spherical shape and their dorsal surface is rather narrow.

The **articular capsules** *(capsulae articulares)* are attached along the edge of the articular cartilage and are loose. The capsule is thin in the dorsal part, but is strengthened by the **plantar ligaments** *(ligamenta plantaria)* on the plantar surface and by the **collateral ligaments** *(ligamenta collateralia)* on the sides. In addition, the **deep transverse ligament of the sole** *(ligamentum metatarsea transversa profunda)* stretches between the heads of the metatarsal bones.

The metatarsophalangeal joints are of the **ball-and-socket** type *(articulatio spheroidea)*.

THE INTERPHALANGEAL JOINTS

The **interphalangeal joints of the toes** *(articulationes interphalangeae pedis)* (Figs 235, 237, 239) join the proximal phalanges to the middle phalanges and the middle phalanges to the distal ones. Their **articular capsules** *(capsulae articulares)* are thin and strengthened by the **collateral ligaments** *(ligamenta collateralia)* on the sides and by the **plantar ligaments** *(ligamenta plantaria)* on the plantar surface.

The interphalangeal joints are of the **hinge** type *(ginglymus)*.

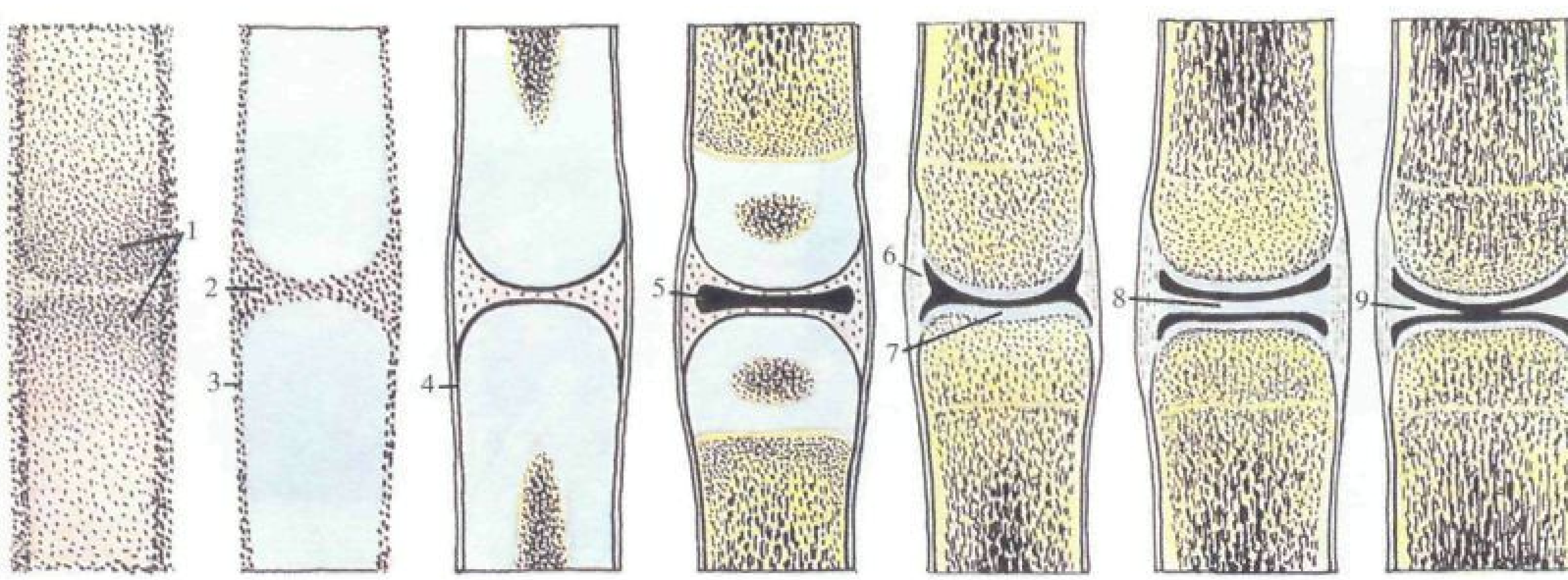
DEVELOPMENT AND AGE FEATURES OF BONE ARTICULATIONS

The bones are laid down at the end of the second month of intrauterine life as thickenings of the mesenchyme between the cartilaginous ends of the future bones (Fig. 241a). The mesenchyme resorbs and a space, i.e. the cavity of the future joint, appears in it. Thus, at the site of the joint the bones come in contact with one another by means of cartilagionous articular surfaces, whereas the mesenchyme surrounding the formed joint cavity blends with the perichondrium and gives rise to the articular capsule. When two spaces appear in the mesenchyme located between the articular surfaces, it separates these cavities to form later a disc which completely separates one cavity from the other; a bilocular joint forms. A meniscus forms if the central part of the disc fails to develop.

Almost all of the elements of the joints of adults are also present in the joints of the newborn (Figs 241b and c). The most active factor determining the formation of a joint after birth are the muscles which exert an action on the given joint, i.e. the work of the joint.

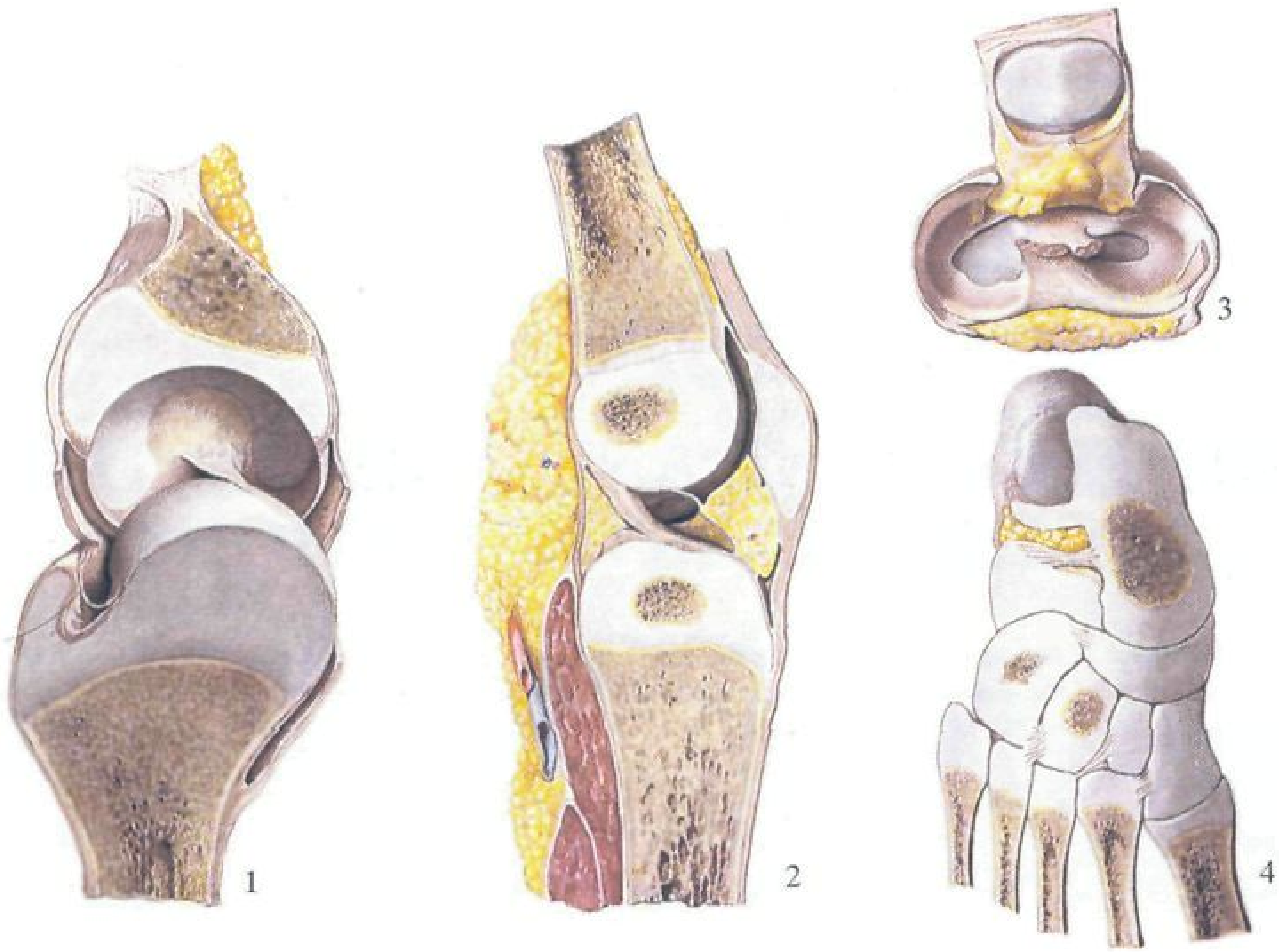
The specific features of some elements in certain joints can be seen in Figs 241b and c. In the shoulder and hip joints, for instance, the articular labrum is poorly pronounced and the glenoid cavity of the scapula and the acetabulum of the hip bone are not deep enough. The articular capsule is relatively thick.

Some age features can be found in the joints of the hand. In the newborn the articular disc in the distal radioulnar joint is still



241a. *Development of joint* (represented semischematically).

1—accumulation of mesenchymal cells (prechondral state)
2—site of cavity of future joint
3—perichondrium
4—periosteum
5—joint cavity
6—articular capsule
7—articular cartilage
8—articular disc
9—meniscus



241b. *Shoulder joint (articulatio humeri), joints of hand (articulationes manus), and mandibular joint (articulatio temporomandibularis) of the newborn.*

241c. *Joints of right lower limb (juncturae membri inferioris) of the newborn.*

1—hip joint
2—knee joint
3—menisci of knee joint
4—joints of foot

not formed, while the articular disc in the mandibular joint closely resembles that in an adult. This is determined by the functional differences between these two joints.

The development of bone articulations is directly dependent on the formation of the bony and connective-tissue structures and muscular tissue.

All elements encountered in the joints of an adult are demonstrated in the joints of the newborn (Figs 241b and c) but as if prototypes. Subsequently they continue their formation and acquire the geometrical shapes of the articular surfaces characteristic of each joint of an adult.

THE SCIENCE OF THE MUSCLES

Myologia

The **muscles** *(musculi)* form the locomotor and weight-bearing apparatus together with the bones and their joints and are its active element.

There are more than 600 **skeletal muscles** *(musculi skeleti)* in the human body and their total mass accounts for up to 28-35 per cent of the body mass in females, up to 40-45 per cent in males, and up to 45-55 per cent in athletes. Up to 50 per cent of the total weight of the skeletal muscles fall to the share of the muscles of the lower limbs, up to 30 per cent to those of the upper limbs, and up to 20 per cent to the share of the muscles of the head and trunk.

Most muscles (Figs 244, 248) have a **belly** *(venter)* and a **head** *(caput)*. The head is that end of the muscle which faces the proximal part of the body. The ends of the head and belly are tightly fused with **tendons** *(tendae)* by means of which the muscle is attached to the bone. The attachment occurs mostly through tendon fibres perforating the periosteum to enter the bone tissue (perforating fibres).

Most muscles have one belly and two tendons (Fig. 244) and, accordingly, two points of attachment, one proximal (origin of the muscle) and the other distal (insertion of the muscle). In analysing the positions and movements of the human body it is important to differentiate the **mobile point** and the **fixed point**. The fixed point often coincides with the point of origin of the muscle, the mobile point with the point of insertion. When a person is working or is engaged in sports the mobile point often becomes the fixed point and vice versa, and such differentiation is therefore conditional.

Tendons are usually long, but tendinous expansions, called **aponeuroses** (Fig. 245), are encountered. The aponeuroses are the tendons of the broad muscles, e.g. the oblique muscles of the abdomen. Some muscles (e.g. the rectus abdominis muscle) have **tendinous intersections** *(intersectiones tendineae)* (Fig. 250) dividing them into parts.

As an organ the muscle consists of a foundation of skeletal striated muscular tissue, a connective-tissue framework forming its internal soft skeleton, and the vessels and nerves.

The structural-functional tissue unit is the **muscle fibre** *(myofibra)*, in which functions the apparatus of muscular contraction.

The muscle fibre is a cell which may reach 10-12 cm in length and 70-80 μ in thickness. Each fibre is covered by a membrane called **sarcolemma** and contains sarcoplasm and many nuclei. In the sarcoplasm are the organoids of the muscle cells, among which are organoids possessing specific function. These are **myofibrils** *(myofibrillae)* containing **myofilaments** *(myofilamenta)* which are minutest thread-like structures of protein nature capable of contracting. The physico-optical properties of the myofibrils differ along the distance of the muscle fibre and make it striated (striped) due to the presence of alternating bands. Under polarized light some of them glisten, these are anisotropic discs double-refracting light, others fail to refract light and are dark isotropic discs. Each muscle fibre and small groups of fibres are surrounded by a connective-tissue membrane called the **endomysium**. Larger complexes of muscle fibres, or **muscle bands** or **fasciculi** *(fasciculi musculares)*, and the whole muscle are enclosed in a connective tissue membrane known as the **perimysium**. Vessels and nerves pass to the muscle fibres in the layers of the connective tissue.

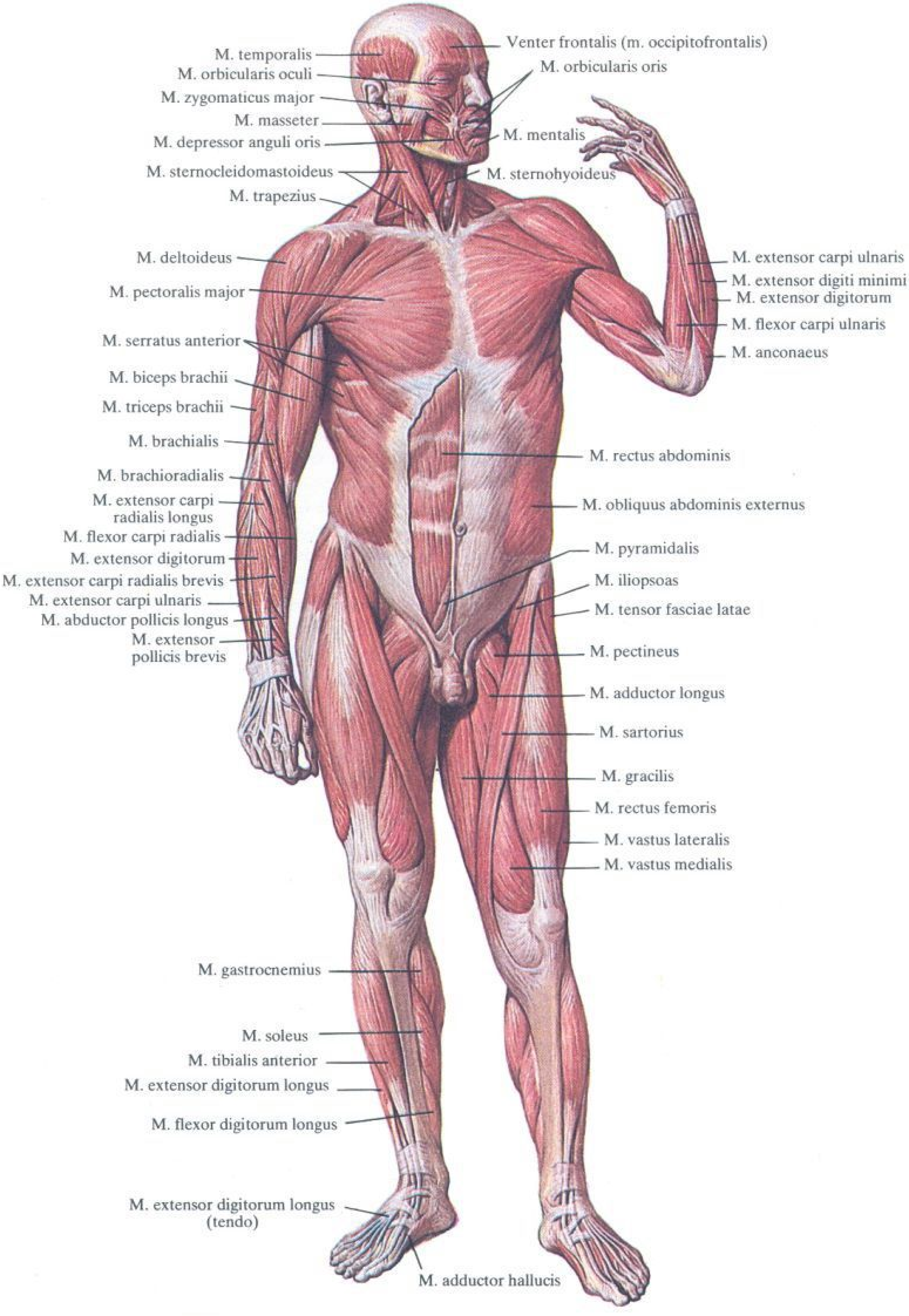
Each muscle has a developed network of blood vessels. The contraction of a muscle promotes rapid flow of blood, i.e. the muscle is a peculiar 'pump' which forces the blood forward. Under conditions of reduced motor activity (hypokinesia) in an inactive mode of life or when prolonged bed-rest is necessary this function of the skeletal muscles is excluded as a result of which the blood flows slower, metabolic processes are reduced and stasis occurs. In contrast, under conditions of motor activity the reserve capillaries open, new capillaries form, and nutrition of the skeletal muscles improves.

The nerve apparatus of the skeletal muscles are represented by receptors which perceive stimulation, and effectors which transmit the stimulus from the central nervous system to the muscle. The number of nerve endings in the muscle is determined by the degree of its functional activity. Physical exertion of a dynamic character increases their number.

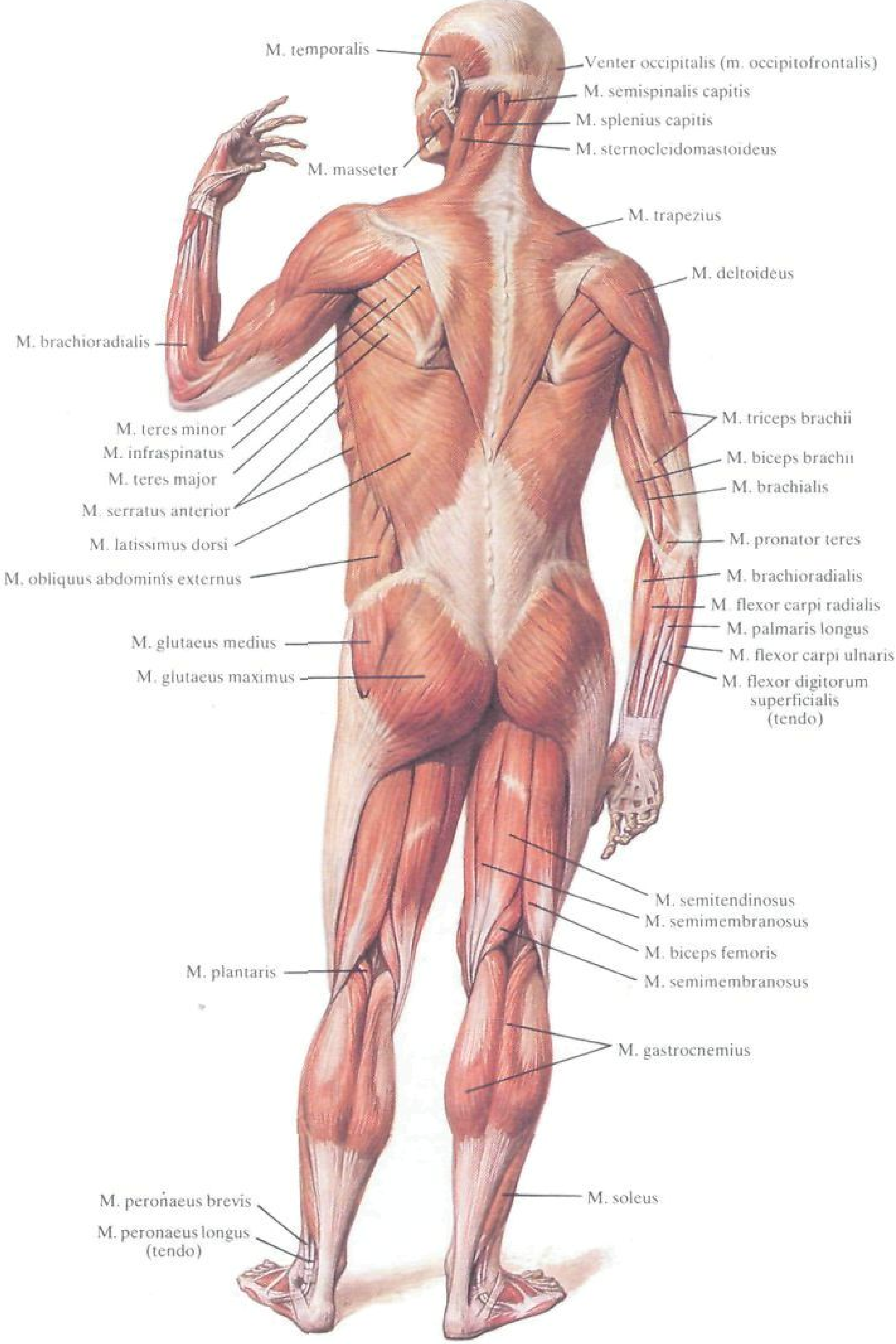
The skeletal muscles differ in shape, relation to the joints, location, inner structure, etc.

Topographically, the muscles are separated into those of the head, neck, back, chest, abdomen, upper limbs, and lower limbs.

According to the inner structure, the following muscles are distinguished (Fig. 271): **fusiform**, or **spindle-sphaped** *(musculi fusiformes)*, the greater part of whose fibres run parallel to the long axis of the muscle, and **penniform** muscles *(musculi pennati)* which resemble a feather because of the manner in which the fibres are attached to the tendon. In this group are distinguished **unipennate muscles** *(musculi unipennati)* (Fig. 246) in which the muscle fibres approach the tendon from only one direction, **bipennate** muscles *(musculi bipennati)* (Fig. 247) in which the fibres approach the tendon form both sides, and **multipennate** muscles (*musculi multipen-*

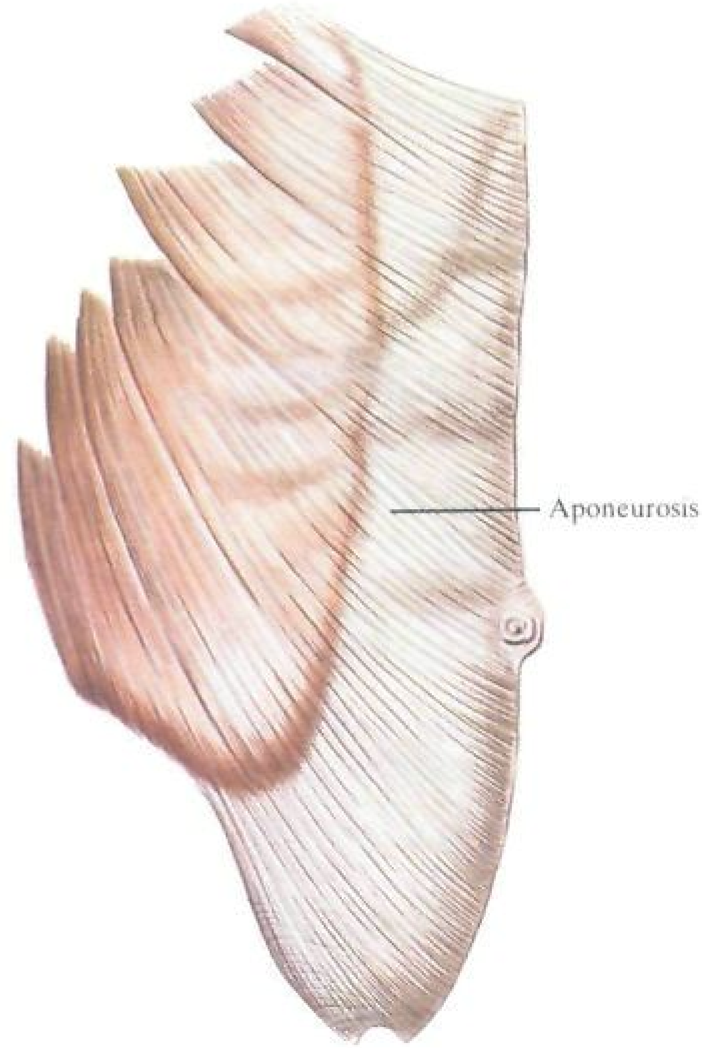


242. *Muscles of the human body* (anterior aspect).



243. *Muscles of the human body* (posterior aspect).

244. *Spindle-shaped, or fusiform muscle (musculus fusiformis).*
(Extensor carpi radialis brevis muscle shown in illustration.)



245. *Broad muscle.*
(Obliquus externus abdominis muscle shown in illustration.)

nati) which have a complex tendinous framework while the muscle fibres are attached to its numerous septa by bands.

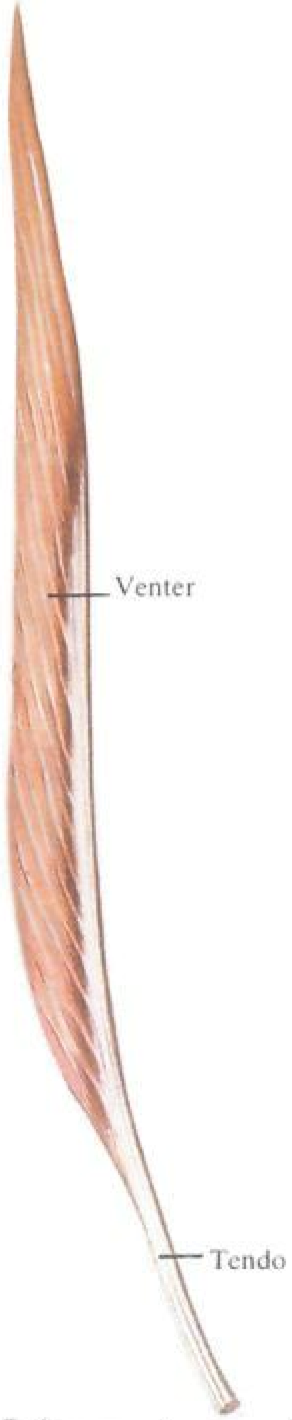
The shape of the muscles is diverse (Fig. 271). Muscles can be **quadrate** *(musculi quadrati)*, **triangular** *(musculi triangulares)*, **cruciate** *(musculi cruciati)*, **circular** *(musculi orbiculares)*, muscles with two heads *(biceps)* (Fig. 248) and more *(triceps, quadriceps)*, muscles with two bellies *(biventer)* (Fig. 249); muscles which are attached by means of several slips *(serrate muscles)* or by means of aponeurosis *(broad muscles)*, etc.

According to function, the following muscles are distinguished: **flexors** *(musculi flexores)*, **extensors** *(musculi extensores)*, **adductors** *(musculi adductores)*, **abductors** *(musculi abductores)*, **rotators** *(musculi rotatores)*, **levators** *(musculi levatores)*, **depressors** *(musculi depressores)*, **erectors** *(musculi erectores)*, **sphincters** *(musculi sphincteres)*, **articular muscles** *(musculi articulares)* which reinforce a joint and pass into it or are attached to the articular capsule, **cutaneous muscles** *(musculi cutanei)* which are inserted into the skin and move it, **pronators** *(musculi pronatores)*, **supinators** *(musculi supinatores)*, **tensors** *(musculi tensores)*, and others.

Functionally muscles are united to form groups responsible for motor activity of one type. These are functional working groups.

Each axis of rotation at a joint has its own pair of functional working groups. Uniaxial joints have one pair (or two functional working groups), biaxial joints have two pairs (four groups of muscles), triaxial joints have three pairs (six groups of muscles).

Muscles which act in concert as components of one functional working group, i.e. which accomplish a single-type action, are called **synergists**. Muscles which act in opposition to another

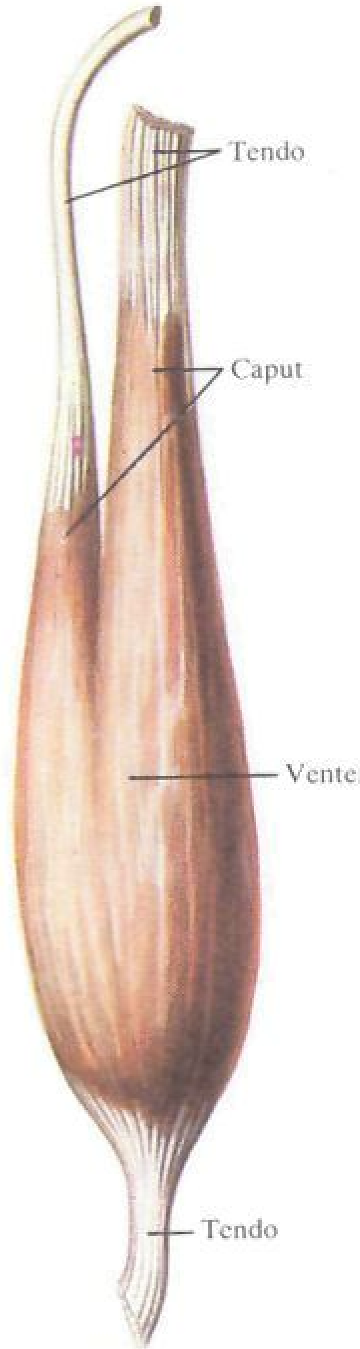


246. *Unipennate muscle (musculus unipennatus).*

(Flexor pollicis longus muscle shown in illustration.)

247. *Bipennate muscle (musculus bipennatus).*

(Flexor hallucis longus muscle shown in illustration.)



248. *Biceps muscle.*

(Biceps brachii muscle shown in illustration.)

group of muscles and are a component of another functional working pair are called **antagonists**. Such differentiation is conditional because in some movements synergists may act as antagonists and vice versa.

The skeletal muscles have an auxiliary apparatus (Fig. 250a) which makes their functioning easier. It includes fasciae, synovial bursae, sheaths of tendons, trochlea of muscles, tendinous arches, and sesamoid bones.

The **fasciae** are fibrous membranes which form linings for body cavities and cover muscles (with the exception of the muscles of the face) and organs. Superficial fasciae passing in the subcutaneous fat and deep (proper) fasciae are distinguished. The deep fasciae form the following structures for the skeletal muscles:

(1) fibrous canals;

(2) osteofibrous canals;

(3) interosseous septa;

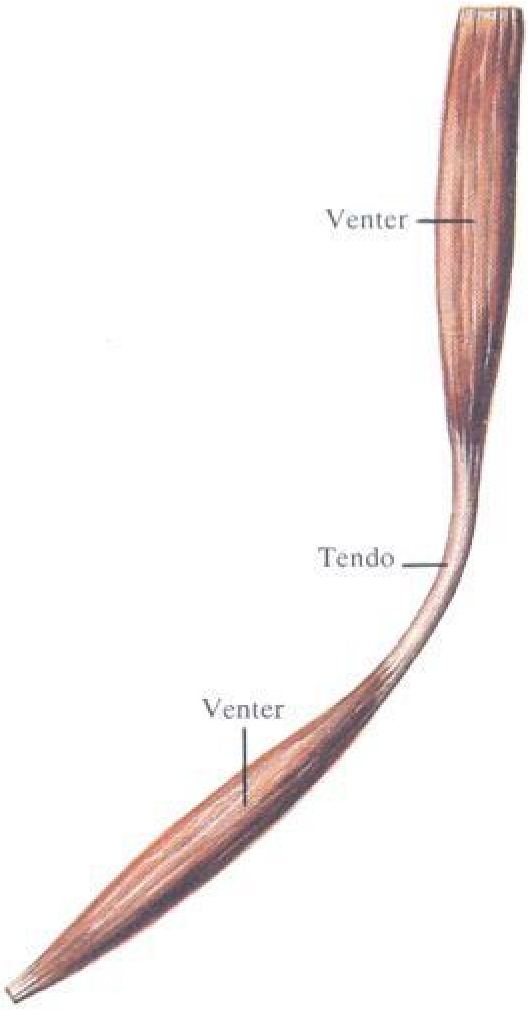
(4) retinacula of tendons.

Thus, the fasciae isolate groups of muscles and provide conditions for their free independent contraction.

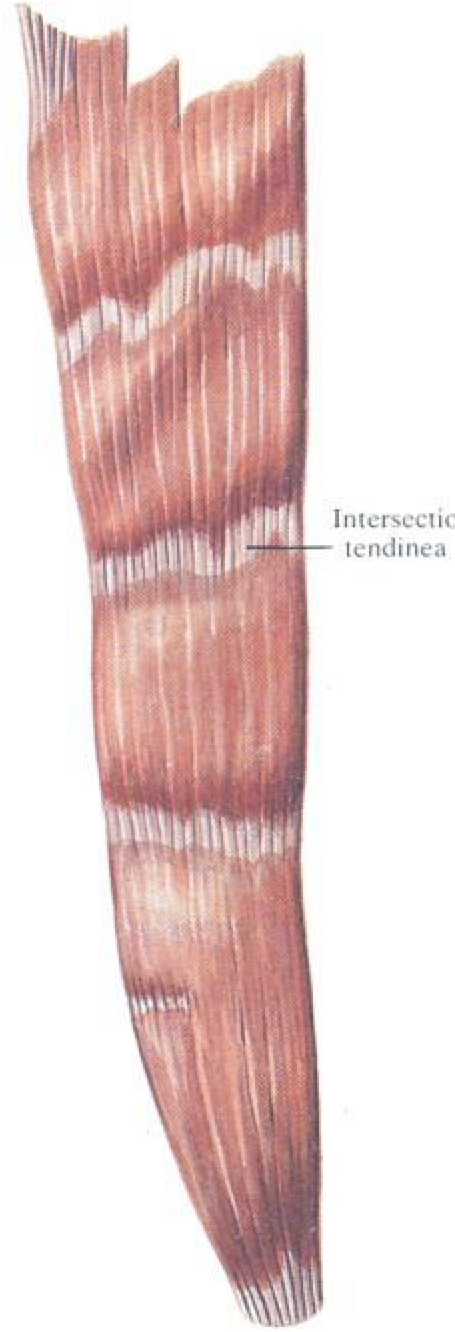
The supporting function lends fasciae particular significance, they are the site of origin and insertion of many muscles.

In case of local inflammation the fasciae limit the focus of affection and prevent its extension to the adjacent group of muscles. The interfascial spaces, in contrast, often serve as paths for the spread of the inflammatory process.

The **synovial bursae** *(bursae synoviales)* are thin-walled isolated sacs which do not communicate with the joint cavity. They are formed of a synovial membrane and contain synovial fluid. They



249. *Digastric (biventer) muscle (musculus digastricus).*
(Omohyoid muscle shown in illustration.)



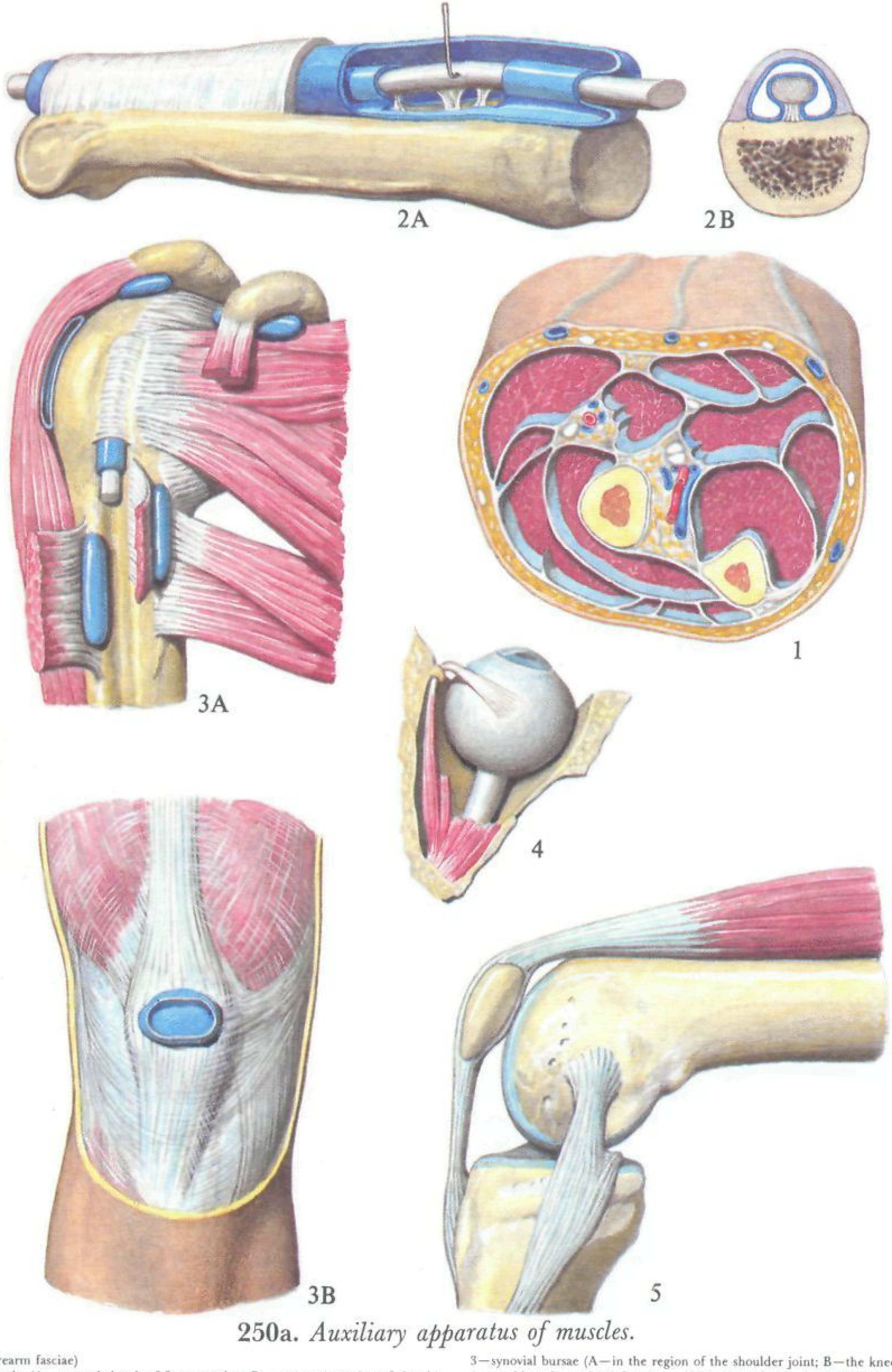
250. *Multigastric muscle.*
(Rectus abdominis muscle shown in illustration.)

may be located under the skin (**subcutaneous synovial bursa,** *bursa synovialis subcutanea*), under fasciae (**subfascial synovial bursa,** *bursa synovialis subfascialis*), between or under the muscles (**submuscular synovial bursa,** *bursa synovialis submuscularis*), and under tendons (**subtendinous synovial bursa,** *bursa synovialis subtendinea*). The bursae reduce friction and protect the muscle from injury and, as a result, make the work of the muscles easier.

The **sheaths of tendons** *(vaginae tendines)* are protective devices for muscle tendons at the places of their closest contact with the bone, mainly on the hand and foot. They reduce friction, make the work of the muscles easier, and reduce the risk of injury to that part of the tendon which borders upon the bone. The sheaths of tendons have an external **fibrous layer** *(stratum fibrosum)* to the formation of which contributes the fascia forming the osteofibrous canal, and an internal **synovial layer** *(stratum synoviale)*, in view of which they are called **synovial sheaths of tendons** *(vaginae synoviales tendinum).*

The synovial layer forms a duplicature lining the tendon itself and the inner surface of the fibrous layer. A **synovial cavity** *(cavitas synovialis)* containing synovial fluid forms between the two synovial surfaces of the synovial layer. The site of junction of the synovial surfaces is called the **mesotendon** *(mesotendineum).* The part of the synovial layer investing the tendon itself is known as the **peritendineum.**

Muscular pulleys *(trochleae musculari)* are encountered on the bone in some parts of the skeleton. A **tendinous arch** *(arcus tendi-*



250a. *Auxiliary apparatus of muscles.*

1—fasciae (forearm fasciae)
2—tendon sheaths (A—opened sheath of finger tendon; B—transverse section of sheath)
3—synovial bursae (A—in the region of the shoulder joint; B—the knee)
4—trochlea of muscles (of superior oblique muscle) 5—sesamoid bones (patella)

neus) forms here above the notch in a bone covered with a thin layer of cartilage. Passing under the arch over the trochlea, the tendon is held fast in place and changes its direction. A synovial bursa reducing friction is lodged between the tendon and the trochlea.

Sesamoid bones are present in the tendons of some muscles. One of the surfaces of such a bone is covered by cartilage and articulates with the articular surface of the other bone. The sesamoid bones are located close to the site of attachment of the tendon and increase the angle of the attachment, thus contributing to the improvement of the conditions for the work of the muscle and increasing the lever of action of the muscular traction. The patella is the largest sesamoid bone.

The structure of skeletal muscles characteristic of an adult takes shape gradually. The muscles of a newborn possess all the components, but still resemble the foetal muscles in structure. The contractile apparatus of a skeletal muscle develops particularly intensively from the age of 3-4 years, and by the age of 7-8 the muscles are almost similar in structure to those of adults. The physiological properties of the muscles, however, begin to be established from the age of 12-14 years and the process is completed only by the second decade of life. The development of muscles reaches its peak by the third decade of life when the diameter of the muscle fibres is the greatest and the network of blood vessels, the nerve apparatus, and the connective-tissue framework are developed well.

Involution of the skeletal muscle begins at old age. The ratio of its components is disturbed: the striated muscular tissue atrophies, some of the blood vessels become empty, the number of nerve apparatus decreases. This is accompanied by growth of fibrous connective and fatty tissue. Physical exertion delays the development of involutional changes in the skeletal muscle.

MUSCLES OF THE TRUNK AND HEAD

Musculi trunci et capitis

MUSCLES AND FASCIAE OF THE TRUNK

The human body except for the head and limbs is called the **trunk** *(truncus).*

The muscles of the trunk are grouped as follows: (1) the **muscles of the back** *(musculi dorsi)*; (2) the **muscles of the neck** *(musculi colli)*; (3) the **muscles of the chest** *(musculi thoracis)*; (4) the **muscles of the abdomen** *(musculi abdominis).*

MUSCLES AND FASCIAE OF THE BACK

REGIONS OF THE BACK

The following **regions of the back** *(regiones dorsi)* (Fig. 252) are distinguished:

(a) the **nuchal region** *(regio colli posterior)*, an unpaired region occupying the posterior (occipital) parts of the neck;

(b) the **vertebral region** *(regio vertebralis)*, an unpaired region corresponding to the contours of the vertebral column;

(c) the **scapular region** *(regio scapularis)*, corresponding to the contours of the scapula;

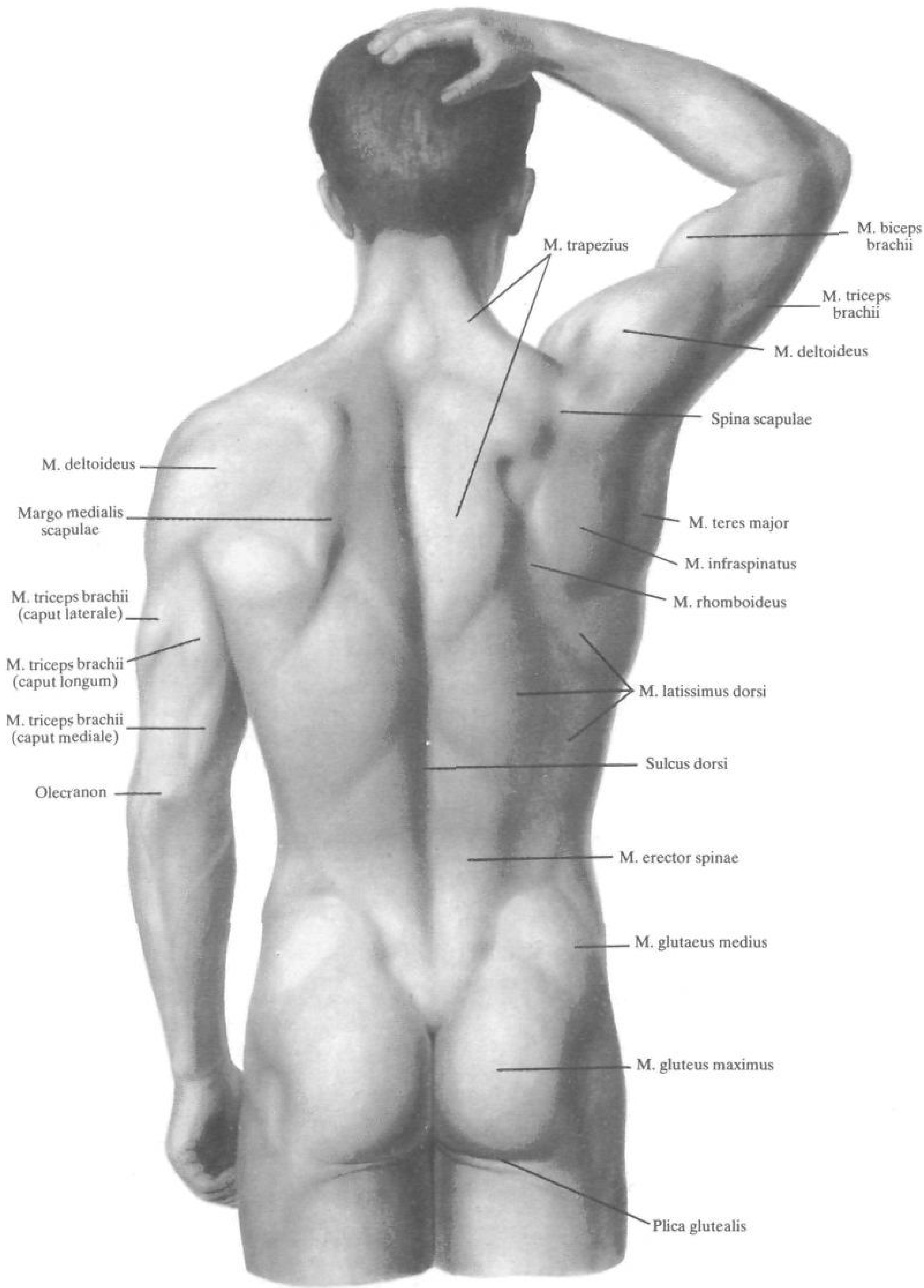
(d) the **infrascapular region** *(regio infrascapularis)*, right and left, located below the scapula;

(e) the **lumbar region** *(regio lumbalis)*, right and left, bounded by the twelfth rib above and by the iliac crest below;

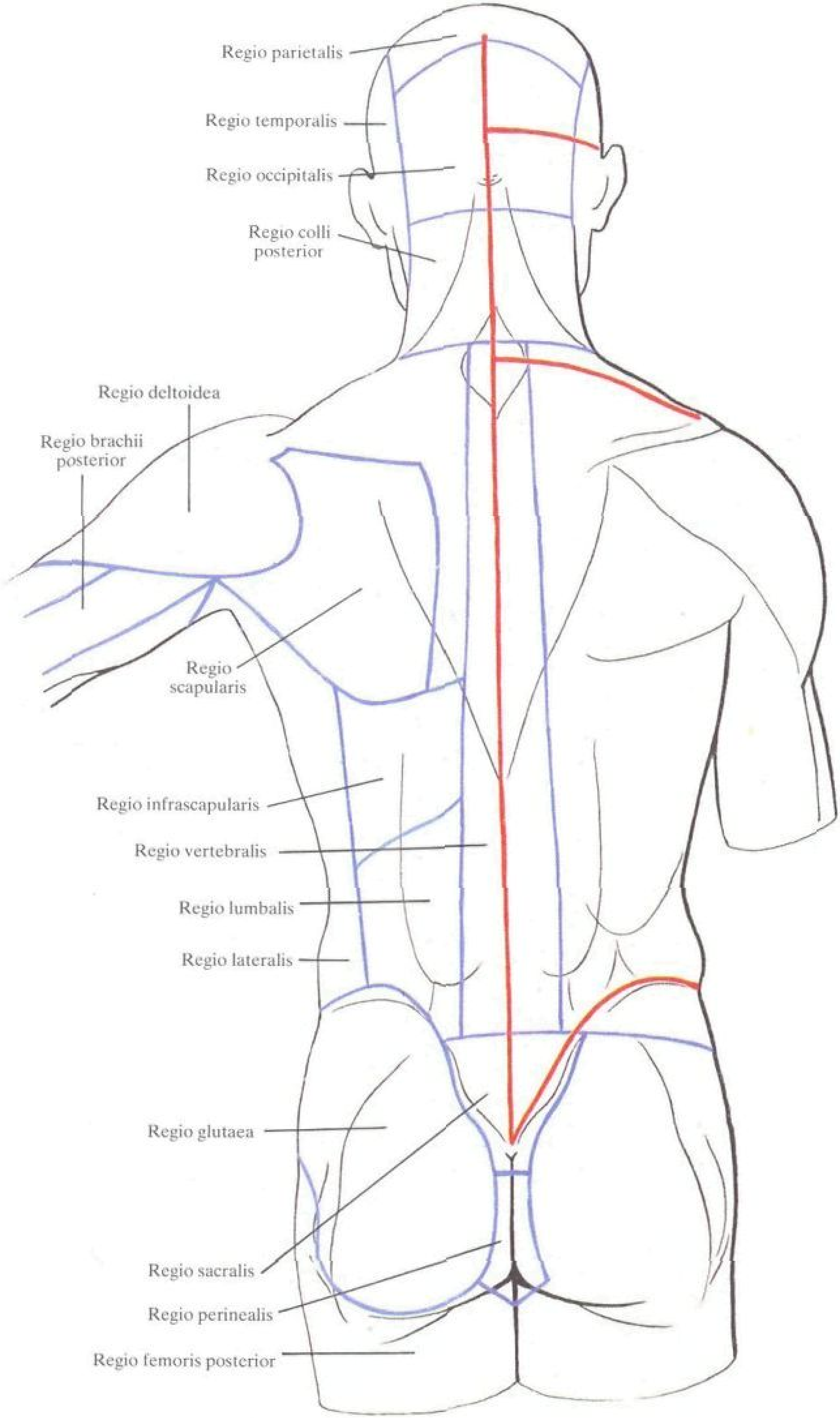
(f) the **sacral region** *(regio sacralis)*, an unpaired region corresponding to the contours of the sacrum.

A longitudinal **sulcus dorsi** passing on the midline is seen on inspection of the back; the spinous process of the vertebra prominens and of the vertebrae distal to it are palpated along the sulcus. To the sides of the sulcus the contours of the sacrospinalis muscle are visible, in the upper part are also seen the contours of the scapula and its **spine** *(spina scapulae).* The superior border of the scapula is on the level with the second rib, the inferior angle is on the level with the seventh rib. On contraction of well-developed musculature a depression, a rhomboid area, is noticeable in the upper part of the back, in the centre of which is located the spine of the vertebra prominens.

This depression corresponds to the expanded part of the tendon of the trapezius muscle. The iliac crests can be felt in the lower part of the back. Another rhomboid depression is outlined here and bounded above by the spinous process of the fifth lumbar vertebra, on the sides by the posterior superior iliac spine, and below by the coccyx.



251. *Outlines of trunk muscles* (posterior aspect).



252. *Regions of the trunk and lines of skin incisions.*

(Blue line—boundaries of regions; red line—skin incisions most suitable for exposure of muscles which are being prepared.)

MUSCLES OF THE BACK

Superficial and deep **muscles of the back** *(musculi dorsi)* are distinguished.

I. *Superficial muscles of the back.*

A. Muscles of the back related to the upper limb:

1. The **trapezius muscle** *(musculus trapezius).*

2. The **latissimus dorsi muscle** *(musculus latissimus dorsi).*

3. The **rhomboid major** and **minor muscles** *(musculi rhomboidei major* et *minor).*

4. The **levator scapula muscle** *(musculus levator scapulae).*

B. Muscles of the ribs:

5. The **serratus posterior superior muscle** *(musculus serratus posterior superior).*

6. The **serratus posterior inferior muscle** *(musculus serratus posterior superior).*

II. *Deep (proper) muscles of the back.*

A. Long muscles:

1. The **splenius capitis muscle** *(musculus splenius capitis).*

2. The **splenius cervicis muscle** *(musculus splenius cervicis).*

3. The **sacrospinalis muscle** *(musculus erector trunci spinae).*

4. The **transversospinalis muscle** *(musculus transversospinalis).*

B. Short muscles:

1. The **interspinales muscles** *(musculi interspinales).*

2. The **intertransverse muscles** *(musculi intertransversarii).*

3. The **levatores costarum muscles** *(musculi levatores costarum).*

4. The group of suboccipital muscles.

The deep muscles of the back are covered by the **lumbar fascia** *(fascia thoracolumbalis).*

SUPERFICIAL MUSCLES OF THE BACK

1. The **trapezius muscle** *(musculus trapezius)* (see Figs 243, 253) is a flat and broad muscle occupying a superficial position on the back of the neck and upper part of the back. It is triangular with the base facing the vertebral column and the apex directed to the acromion of the scapula. The trapezius muscles of both sides meet to form a trapezoid. The muscle takes origin from the external occipital protuberance, the superior nuchal line, ligamentum nuchae and supraspinous ligament of all thoracic vertebrae. The tendinous bundles of the muscle are short and only in the region of the lower cervical and upper thoracic vertebrae they are very long and form a diamond-shaped tendinous area.

The muscular fibres pass radially to the scapula and are inserted into the spine of the scapula, the acromion, and the acromial part of the clavicle.

Action: on contraction all the fibres draw the scapula to the vertebral column; contraction of the upper fibres raises the scapula, contraction of the lower fibres lowers it. When the scapula is fixed, both trapezius muscles pull the head backwards; contraction of one of the muscles tilts the head to the corresponding side.

Innervation: branch of accessory nerve to sternomastoid muscle and cervical nerves (C_3-C_4).

Blood supply: transverse cervical, occipital, suprascapular, and intercostal arteries.

2. The **latissimus dorsi muscle** (see Figs 243, 253, 254) is a flat muscle located superficially in the lower part of the back, but its superior fibres are covered in the initial part by the trapezius muscle. It arises from the spinous processes of the lower five or six thoracic vertebrae, the superficial (posterior) layer of the thoracolumbar fascia, the posterior part of the outer lip of the iliac crest, and lower four ribs. The lateral border of the tendinous part of this muscle, the posterior border of the external oblique muscle of the abdomen and the iliac crest below form the **lumbar triangle** *(trigonum lumbale)*, or Petit's triangle; the floor (anterior wall) of the triangle is the internal oblique muscle of the abdomen. Above this triangle is a small rhomboid area covered posteriorly by the latissimus dorsi muscle and bounded above by the twelfth rib and lower border of the serratus posterior inferior muscle, medially by the sacrospinalis muscle and laterally by the upper border of the internal oblique muscles of the abdomen; the floor (anterior wall) of this area is formed by the aponeurosis of the transversus abdominis muscle.

The upper fibres of the latissimus dorsi muscle pass laterally and the lower fibres ascend obliquely and laterally to cover the posterior surface of the lower ribs. The muscle receives here accessory fibres in the form of three or four slips and also covers the inferior angle of the scapula and the inferior margin of the **teres major muscle** *(musculus teres major)* (sometimes receiving an additional fibre). Proximally the latissimus dorsi muscle forms the posterior wall of the axillary fossa, approaches the humerus and is inserted in the crest of its lesser tubercle. The **bursa of the latissimus dorsi muscle** *(bursa subtendinea musculi latissimi dorsi)* is located here.

Action: draws the arm to the trunk and pulls the upper limb backwards to the midline and at the same time rotates it medially (pronation). When the arm is fixed the muscle pulls the trunk up on the arm or contributes to upward displacement of the lower ribs in respiratory excursions and is thus an accessory muscle of respiration.

Innervation: nerve to the latissimus dorsi muscle (C_7, C_8).

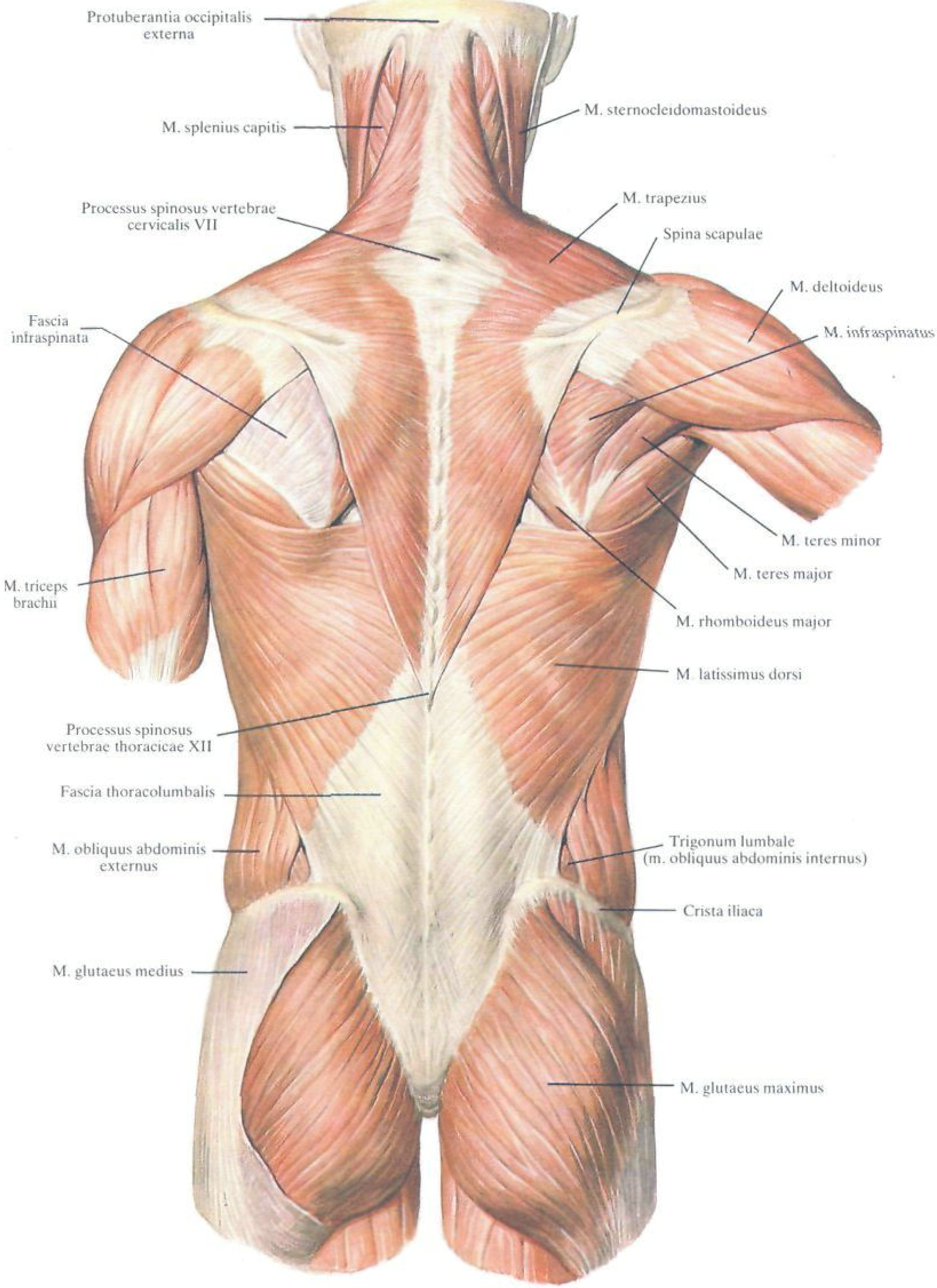
Blood supply: the thoracodorsal, circumflex humeral, and intercostal arteries.

3. The **rhomboid major muscle** *(musculus rhomboideus major)* (Figs 254, 257) is a muscle of the second layer. It lies under the trapezius muscle between the scapulae and is shaped like a flat and wide rhomboid plate. It arises from the spinous processes of the upper four thoracic vertebrae. Its fibres pass laterally and slightly downwards to be inserted into the medial border of the scapula.

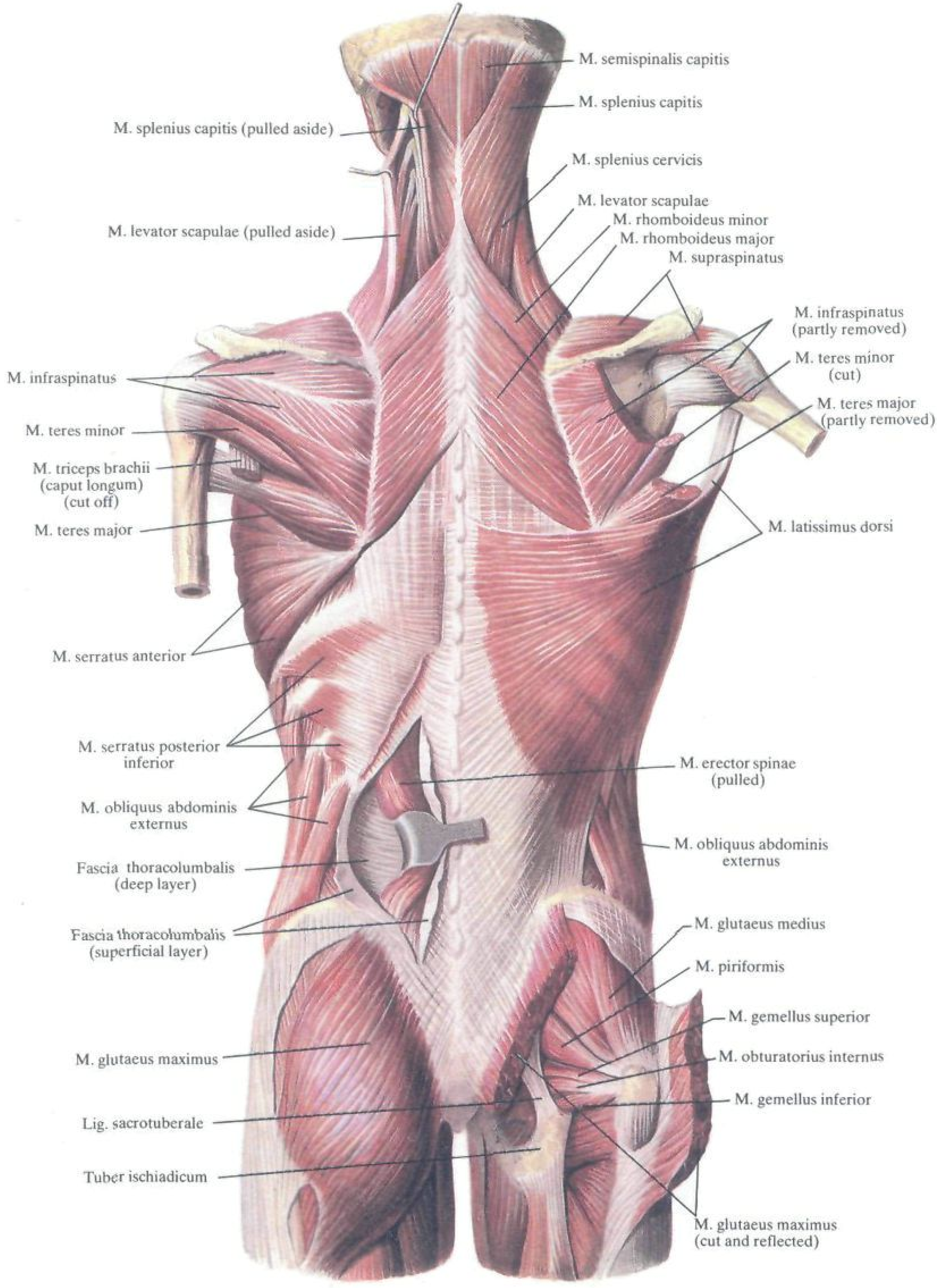
3a. The **rhomboid minor muscle** *(musculus rhomboideus minor)* arises from the spinous processes of the lower two cervical vertebrae and is inserted into the medial border of the scapula. Both rhomboid muscles are often separated by a small layer of connective tissue.

Action: draw the scapula closer to the vertebral column along an oblique line directed to the midline and upwards.

Innervation: nerve to the rhomboids (C_4-C_6).

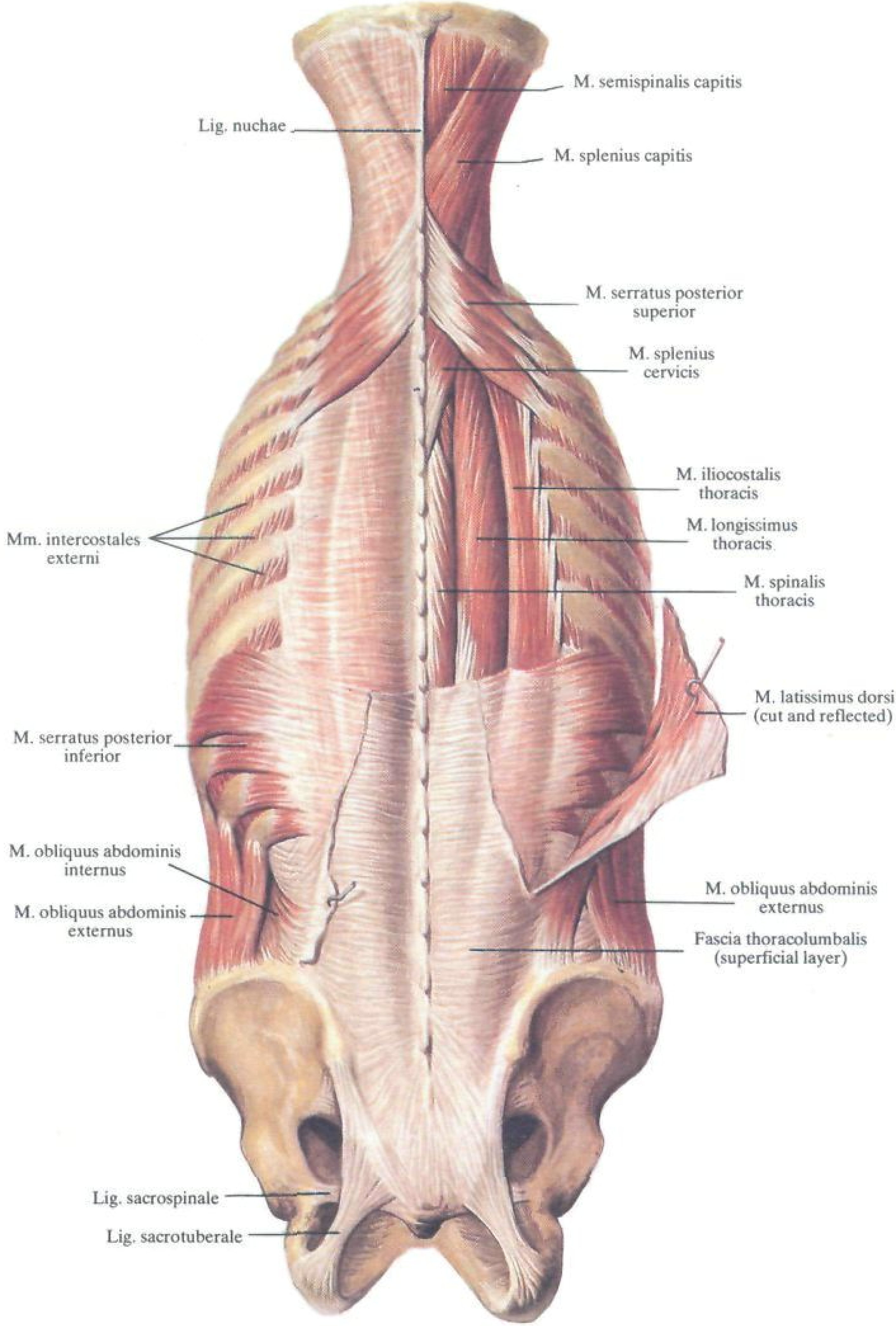


253. *Superficial muscles of the back (musculi dorsi)* (1/6).



254. *Superficial muscles of the back and posterior region of the neck ($^1/_6$).*

(First, second, and third layers. The trapezius muscles and left latissimus dorsi muscle are removed.)



255. *Muscles of the back and posterior region of the neck* ($^1/_6$).

(Third layer of superficial muscles. First and second layers of deep muscles. Muscles and bones of shoulder girdle are removed.)

Blood supply: the transverse cervical, suprascapular, and intercostal arteries.

4. The **levator scapulae muscle** *(musculus levator scapulae)* (Figs 254, 257) is a muscle of the second layer. It is elongated, thick and located in the posterolateral parts of the neck under the trapezius muscle. It originates as four separate slips from the posterior tubercles of the transverse processes of the upper four cervical vertebrae and runs downwards and slightly laterally to be inserted into the upper part of the medial border of the scapula and its superior angle.

Action: raises the scapula, its upper angle in particular, causing rotation as a result of which the lower angle is displaced towards the vertebral column; when the scapula is fixed the cervical part of the vertebral column is inclined backwards and to the side of the contracting muscle.

Innervation: nerve to the rhomboids (C_4, C_5).

Blood supply: the transverse cervical, superficial cervical, and ascending cervical arteries.

5. The **serratus posterior superior muscle** *(musculus serratus posterior superior)* (Fig. 255) is thin and covered by the rhomboid muscle.

It arises from the lower part of the ligamentum nuchae and the spinous processes of the lower two cervical and upper two thoracic vertebrae. It runs obliquely downwards and laterally and is inserted by means of four slips into the external surface of the second, third, fourth, and fifth ribs slightly laterally of their angles.

Action: raises the upper ribs, takes part in the act of inspiration.

Innervation: intercostal nerves (Th_1-Th_4).

Blood supply: intercostal and deep cervical arteries.

6. The **serratus posterior inferior muscle** *(musculus serratus posterior inferior)* (see Figs 254, 255, 257), like the posterior superior muscle, is flat and thin and is located under the latissimus dorsi muscle. It arises from the superficial layer of the lumbar fascia at the level of the lower two thoracic and upper two lumbar vertebrae. Its fibres pass upwards obliquely and laterally and are inserted as four slips into the external surface of the lower four ribs.

Action: lowers the lower ribs and thus takes part in the act of respiration.

Innervation: the intercostal nerves (Th_9-Th_{12}).

Blood supply: the intercostal arteries.

DEEP MUSCLES OF THE BACK

The deep (proper) muscles of the back are classified as long and short muscles.

LONG MUSCLES OF THE BACK

I. The **splenius capitis muscle** *(musculus splenius capitis)* (see Figs 254, 255, 257) arises from the ligamentum nuchae and the spinous processes of the lower five cervical and upper three thoracic vertebrae and is inserted into the lateral parts of the superior nuchal line and the posterior border of the mastoid process.

II. The **splenius cervicis muscle** *(musculus splenius cervicis)* arises from the spinous processes of the lower five cervical and upper five thoracic vertebrae and is inserted into the posterior tubercles of the transverse processes of the upper two or three cervical vertebrae.

Action: bilateral contraction pulls the head and neck backwards. In unilateral contraction the head and neck are rotated to the side of the acting muscle.

Innervation: the greater occipital nerve and third and fourth cervical nerves (C_2-C_4).

III. The **sacrospinalis muscle** *(musculus erector spinae)* (see Figs 255-257) is the strongest and longest muscle of the back. It fills completely the depression in the back formed to the sides of the spinous processes and extending to the angles of the ribs. The muscle takes origin from the posterior part of the iliac crest, the dorsal surface of the sacrum, the spinous processes of the lower lumbar vertebrae, and partly from the superficial layer of the lumbar fascia. Ascending, the muscle separates in the lumbar region into the following three parts: (1) the laterally located iliocostocervicalis muscle; (2) the medially situated spinalis muscle and (3) the longissimus muscle located between them.

1. The **iliocostocervicalis muscle** *(musculus iliocostalis)* (see Figs 255-257) is inserted by numerous muscular and tendinous slips into the angles of all the ribs and the transverse processes of the lower cervical vertebrae; it is divided topographically into the musculi iliocostalis lumborum, thoracis, and cervicis:

(a) the **iliocostalis muscle** *(musculus iliocostalis lumborum)* takes origin from the posterior part of the transverse tubercles of the sacrum and lumbar fascia, passes laterally and upwards, giving off eight or nine slips which are inserted into the angles of the lower eight or nine ribs by thin and narrow tendons;

(b) the **costalis muscle** *(musculus iliocostalis thoracis)* arises near the angles of the lower five or six ribs, ascends slightly obliquely and laterally and is inserted by thin, narrow tendons into the angles of the upper five or seven ribs;

(c) the **costocervicalis muscle** *(musculus iliocostalis cervicis)* takes origin from the angles of the upper five or seven ribs, also ascends obliquely and laterally, and is inserted by three slips into the posterior tubercles of the transverse processes of the fourth, fifth, and sixth cervical vertebrae.

Innervation: the spinal nerves (C_3-C_8; Th_1-Th_{12}; L_1).

2. The **longissimus muscle** *(musculus longissimus)* (see Figs 255-257) is medial of the costocervicalis muscle and stretches from the sacrum to the base of the skull. The following three parts are distinguished in it topographically:

(a) the **longissimus thoracis muscle** *(musculus longissimus thora-*

cis) arises from the transverse processes of the lumbar and lower six or seven thoracic vertebrae and passes upwards to be inserted into the angles of the lower ten ribs and posterior parts of the transverse processes of all thoracic vertebrae;

(b) the **longissimus cervicis muscle** *(musculus longissimus cervicis)* originates from the transverse processes of the upper four or five thoracic and lower cervical vertebrae, stretches upwards, and is inserted into the transverse processes of the second, third, fourth, and fifth cervical vertebrae;

(c) the **longissimus capitis muscle** *(musculus longissimus capitis)* takes origin from the transverse processes of the upper three thoracic and lower three or four cervical vertebrae, extends upwards, and is inserted into the posterior border of the mastoid process.

Innervation: the spinal nerves (C_1-C_8; Th_1-Th_{12}; L_1-L_5; S_1-S_2).

3. The **spinalis muscle** *(musculus spinalis)* (see Figs 255-257) runs along the spinous processes and is divided topographically into the following three parts:

(a) the **spinalis thoracis muscle** *(musculus spinalis thoracis)* takes origin from the spinous processes of the upper two or three lumbar and lower two or three thoracic vertebrae and extending upwards is inserted into the spinous processes of the eighth to second thoracic vertebrae;

(b) the **spinalis cervicis muscle** *(musculus spinalis cervicis)* arises from the spinous processes of the upper two thoracic and lower two cervical vertebrae, runs upwards, and is inserted into the spinous processes of the fourth, third, and second cervical vertebrae;

(c) the **spinalis capitis muscle** *(musculus spinalis capitis)* is a poorly developed part of the spinalis muscle and is often absent. It takes origin from the spinous processes of the upper thoracic and lower lumbar vertebrae and extends upwards to be inserted near to the external occipital protuberance.

Action: the whole erector spinae muscle acts as a strong extensor of the vertebral column on bilateral contraction. It holds the trunk erect. In contraction on one side the vertebral column bends to the same side. The upper fibres pull the head to the side of the contracting muscle. Some of the fibres (the costalis muscle) pull the ribs downwards.

Innervation: the spinal nerves (C_1-C_8; Th_1-Th_{12}; L_1-L_5; S_1-S_2).

4. The **transversospinalis muscle** *(musculus transversospinalis)* (Figs 258-260) is covered by the erector spinae muscle and fills the depression between the spinous and transverse processes for the whole distance of the vertebral column. Its relatively short muscular fibres run obliquely from the transverse processes of one vertebra to the spinous processes of the contiguous vertebra above. According to the length of the muscle fibres, i.e. the number of vertebrae that they bridge, the following three parts are distinguished in the transversospinalis muscle: (1) the semispinalis muscle whose fibres bridge five and more vertebrae; (2) the multifidus muscle whose fibres bridge two to four vertebrae and are covered by the semispinalis muscle; (3) the rotatores muscles occupying the deepest position.

1. The **semispinalis muscle** *(musculus semispinalis)* (Figs 258-260) is separated into three parts topographically:

(a) the **semispinalis thoracic muscle** *(musculus semispinalis thoracis)*. Its fibres run between the transverse processes of the lower six and the spinous processes of the upper seven thoracic vertebrae, each bridging six or seven vertebrae;

(b) the **semispinalis cervicis muscle** *(musculus semispinalis cervicis)*; its fibres are stretched between the transverse processes of the upper thoracic and the spinous processes of the lower seven cervical vertebrae and bridge five vertebrae;

(c) the **semispinalis capitis muscle** *(musculus semispinalis capitis)*; it is lodged between the transverse processes of the upper five thoracic and the lower three or four cervical vertebrae and extends to the nuchal area of the occipital bone. A medial and lateral parts are distinguished in this muscle. The venter of the medial part is interrupted by a tendinous intersection.

Action: contraction of all parts of the semispinalis muscle extends the upper segments of the vertebral column and pulls the head back or holds it in this position. Contraction of the muscle on one side causes slight rotation.

Innervation: the spinal nerves (C_2-C_8; Th_1-Th_{12}).

2. The **multifidus muscle** *(musculus multifidus)* (Figs 258-260) is covered by the semispinalis muscle and in the lumbar region by the longissimus muscle. Its fibres run for the whole distance of the vertebral column between the transverse and spinous processes of the vertebrae (up to the second cervical) and bridges two, three or four vertebrae. It arises from the posterior surface of the sacrum, the posterior part of the iliac crest, the mamillary processes of the lumbar vertebrae, the transverse processes of the thoracic vertebrae, and the articular processes of the lower four cervical vertebrae and is inserted into the spinous processes of all vertebrae with the exception of the atlas.

3. The **rotatores muscles** *(musculi rotatores)* (Figs 259, 260) are the deepest part of the transversospinalis muscle and are separated into the following parts topographically:

(a) the **cervical rotatores muscles** *(musculi rotatores cervicis)*;

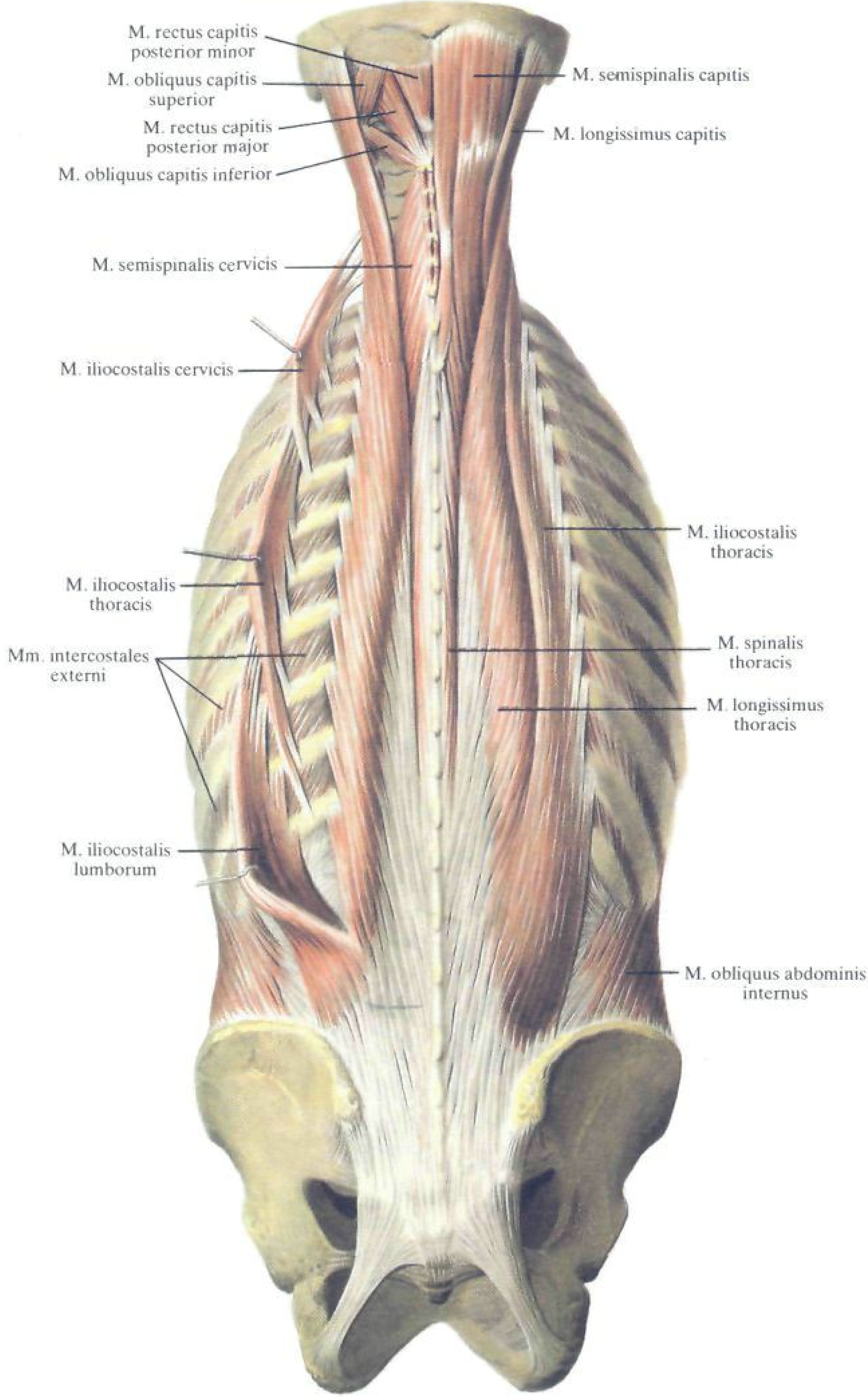
(b) the **thoracic rotatores muscles** *(musculi rotatores thoracis)*;

(c) the **lumbar rotatores muscles** *(musculi rotatores lumborum)*.

They take origin from the transverse processes of all vertebrae (except the atlas) and the mamillary process of the lumbar vertebrae; overlapping one vertebra, they are inserted into the spinous processes of the next vertebrae above, the adjacent parts of their arches, and the base of the arches of two contiguous vertebrae.

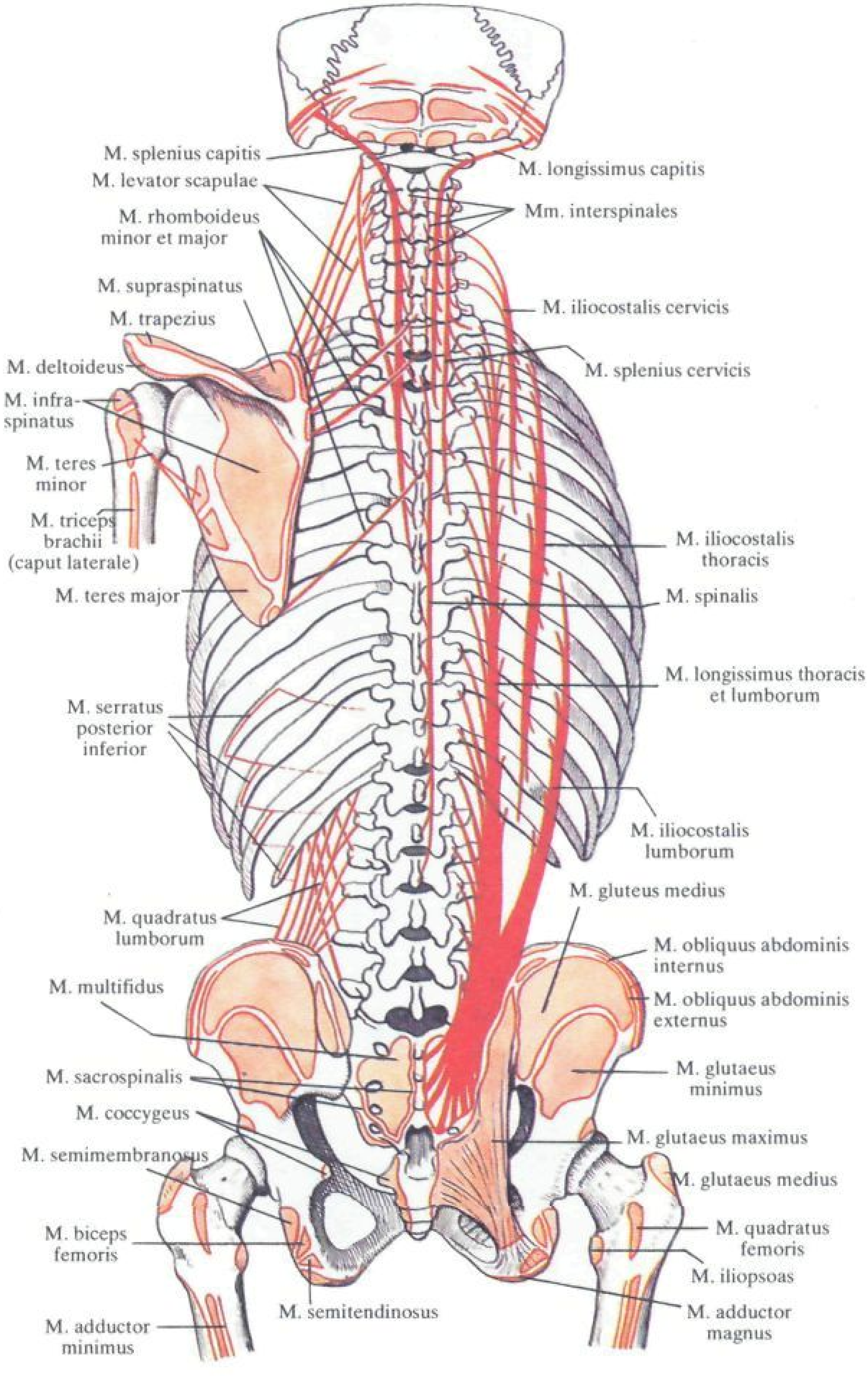
Action: contraction of the transversospinalis muscles on both sides extends the vertebral column; contraction of a muscle on one side rotates the column to the contralateral side.

Innervation: the spinal nerves (C_2-C_8; Th_1-Th_{12}; L_1-L_5).

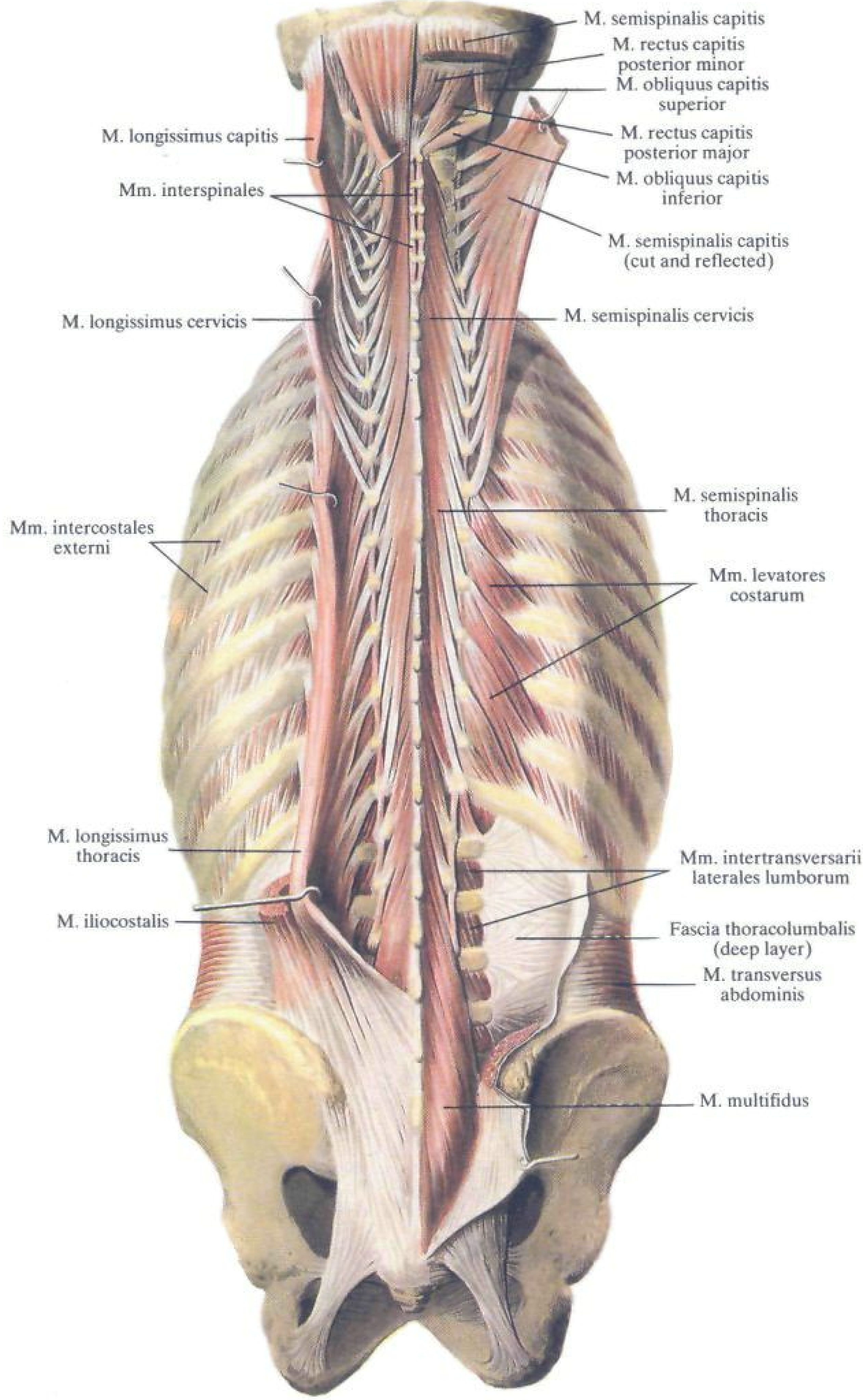


256. *Muscles of the back and posterior region of the neck* (1/6).

(Long deep muscles of the back; second superficial layer.)

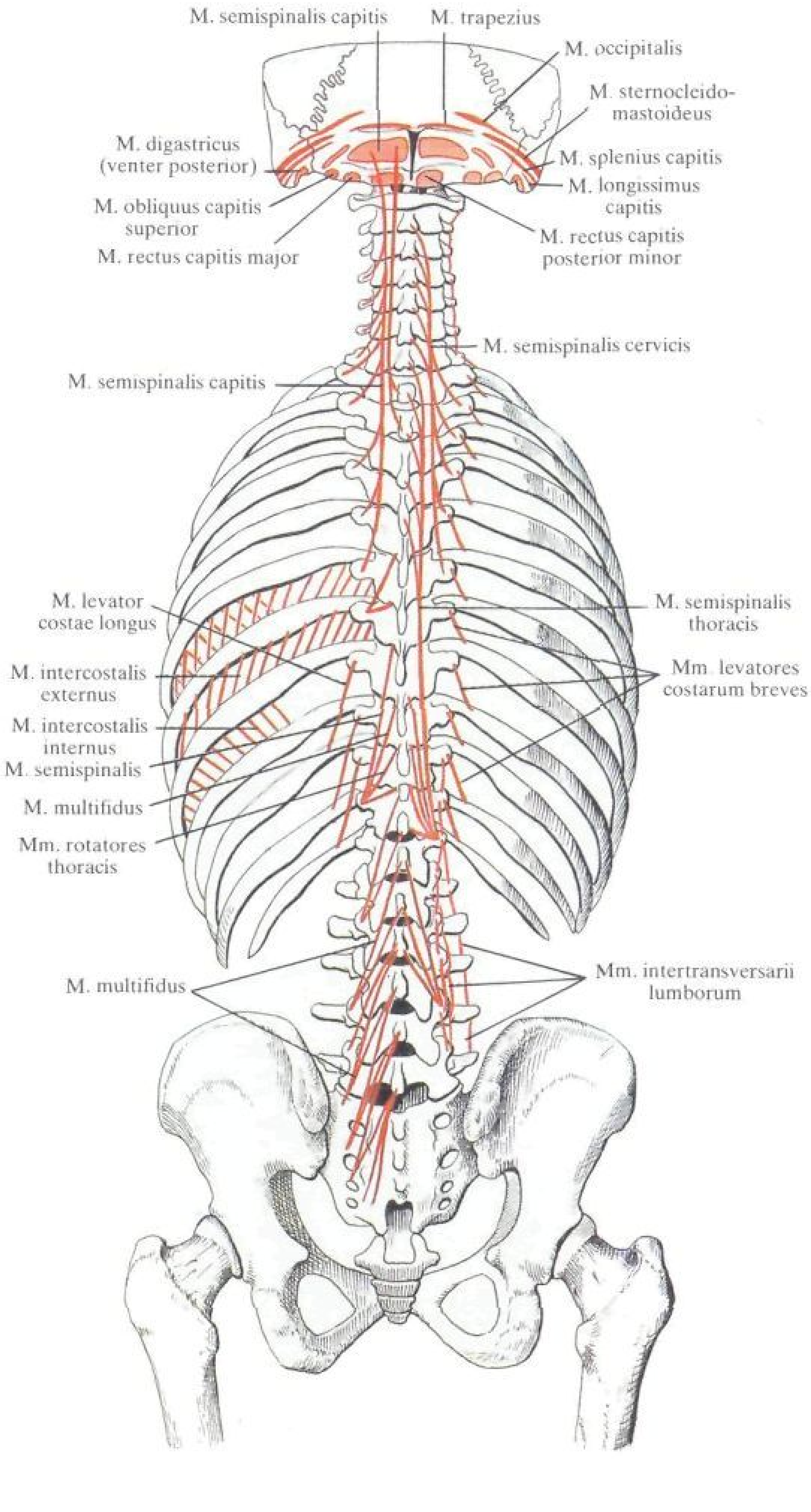


257. *Sites of origin and insertion of muscles of the back* (schematical representation).



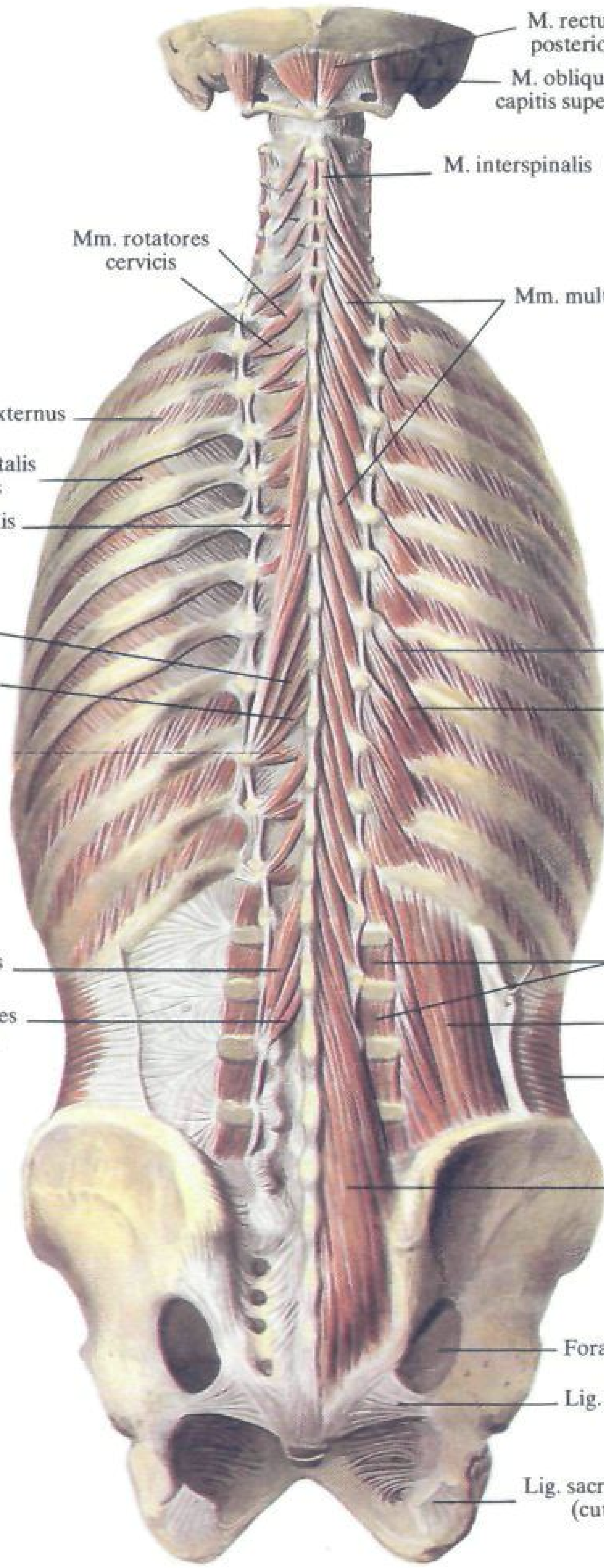
258. *Muscles of the back and posterior region of the neck* ($\frac{1}{6}$).

(Deep muscles of the back; second deep layer.)



259. *Sites of origin and insertion of muscles of the trunk* (schematical representation).

(Deep muscles of the back; second deep layer.)



260. *Muscles of the back and posterior region of the neck* (1/6).

(Deep muscles; second deep layer. Short muscles of the back and posterior region of the neck.)

SHORT MUSCLES OF THE BACK

1. The **interspinales muscles** *(musculi interspinales)* (Figs 257, 258, 260) are short paired muscular fibres stretching between the spinous processes of two contiguous vertebrae.

The **cervical interspinales muscles** *(musculi interspinales cervicis)*, the **thoracic interspinales muscles** *(musculi interspinales thoracis)* (which are often absent), and the **lumbar interspinales muscles** *(musculi interspinales lumborum)* are distinguished.

Action: extend the vertebral column and hold it erect.

Innervation: the spinal nerves (C_3–L_5).

2. The **intertransverse muscles** *(musculi intertransversarii)* (Figs 259, 260) are short and stretch between the transverse processes of two contiguous vertebrae. The following parts are distinguished: the **anterior** and **posterior intertransverse muscles** *(musculi intertransversarii anteriores* et *posteriores cervicis)*, the **thoracic intertransverse muscles** *(musculi intertransversarii thoracis)*, and the **lateral** and **medial intertransverse muscles** *(musculi intertransversarii laterales* et *mediales lumborum)*.

Action: hold the vertebral column erect; unilateral contraction of the muscles bends the column to the side.

Innervation: the spinal nerves (C_1–C_6; L_1–L_4).

3. The **levatores costarum muscles** *(musculi levatores costarum)* (Figs 258–260) are present only in the thoracic segment of the vertebral column. They are covered by the erector spinae muscle. The muscular fibres arise from the transverse processes of the vertebra prominens and the upper eleven thoracic vertebrae and run downwards obliquely and laterally, diverging fan-wise, to be inserted to the angles of the ribs below. In the lower thoracic segment of the vertebral column there are muscular fibres which overlap one rib. These are called the **levatores costarum longi muscles** *(musculi levatores costarum longi)* in distinction from the **levatores costarum breves muscles** *(musculi levatores costarum breves)* passing to the rib next below.

Action: raise the ribs.

Innervation: the spinal and intercostal nerves (C_8; Th_1–Th_{11}).

4. The group of **suboccipital muscles** (Figs 256, 258–260; 261, 262) consists of short, weak muscles occupying the deepest position. These are as follows:

(a) the **rectus capitis posterior major muscle** *(musculus rectus capitis posterior major)* runs between the spinous process of the axis and the lateral segment of the inferior nuchal line;

(b) the **rectus capitis posterior minor muscle** *(musculus rectus capitis posterior minor)* passes from the posterior tubercle of the atlas to the medial segment of the inferior nuchal line;

(c) the **obliquus capitis inferior muscle** *(musculus obliquus capitis inferior)* stretches between the spinous process of the axis and the transverse process of the atlas;

(d) the **obliquus capitis superior muscle** *(musculus obliquus capitis superior)* runs from the transverse process of the atlas to the lateral segments of the inferior nuchal line.

Action: contraction of muscles on both sides bends the head backwards; contraction of muscles on one side bends the head backwards and to the side; at the same time the obliquus capitis inferior muscle and partly the rectus capitis posterior major muscle rotate the head.

Innervation: the first cervical (suboccipital) and second cervical nerves.

Blood supply: all the deep (proper) muscles of the back are supplied with blood by the intercostal, lumbar and sacral arteries while the muscles of the back of the neck are supplied by the occipital, deep cervical, and vertebral arteries.

FASCIAE OF THE BACK

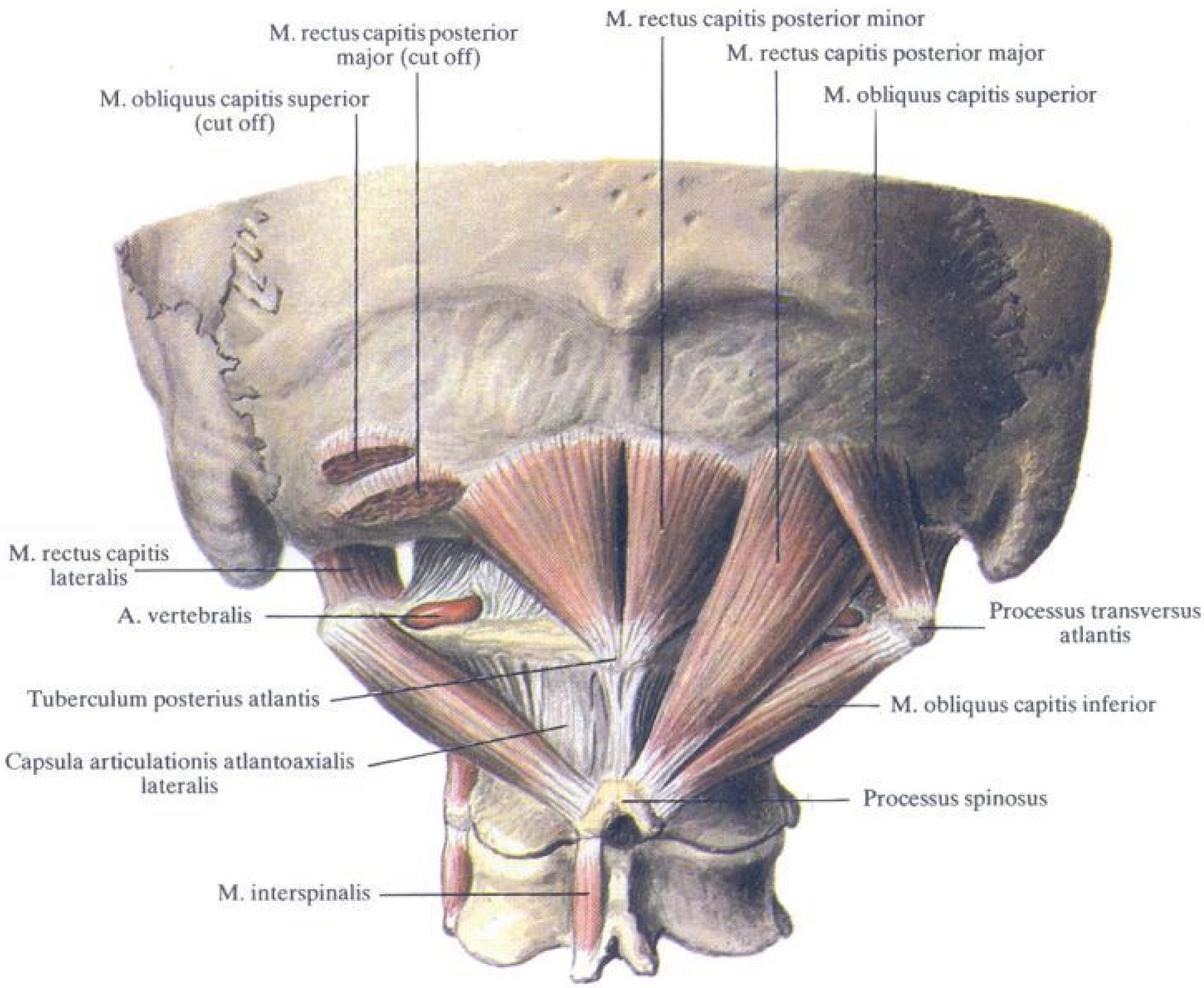
The following fasciae of the back are distinguished.

1. The **superficial fascia of the back** is a thin connective-tissue layer (part of the general subcutaneous fascia) covering the superficial muscles of the back.

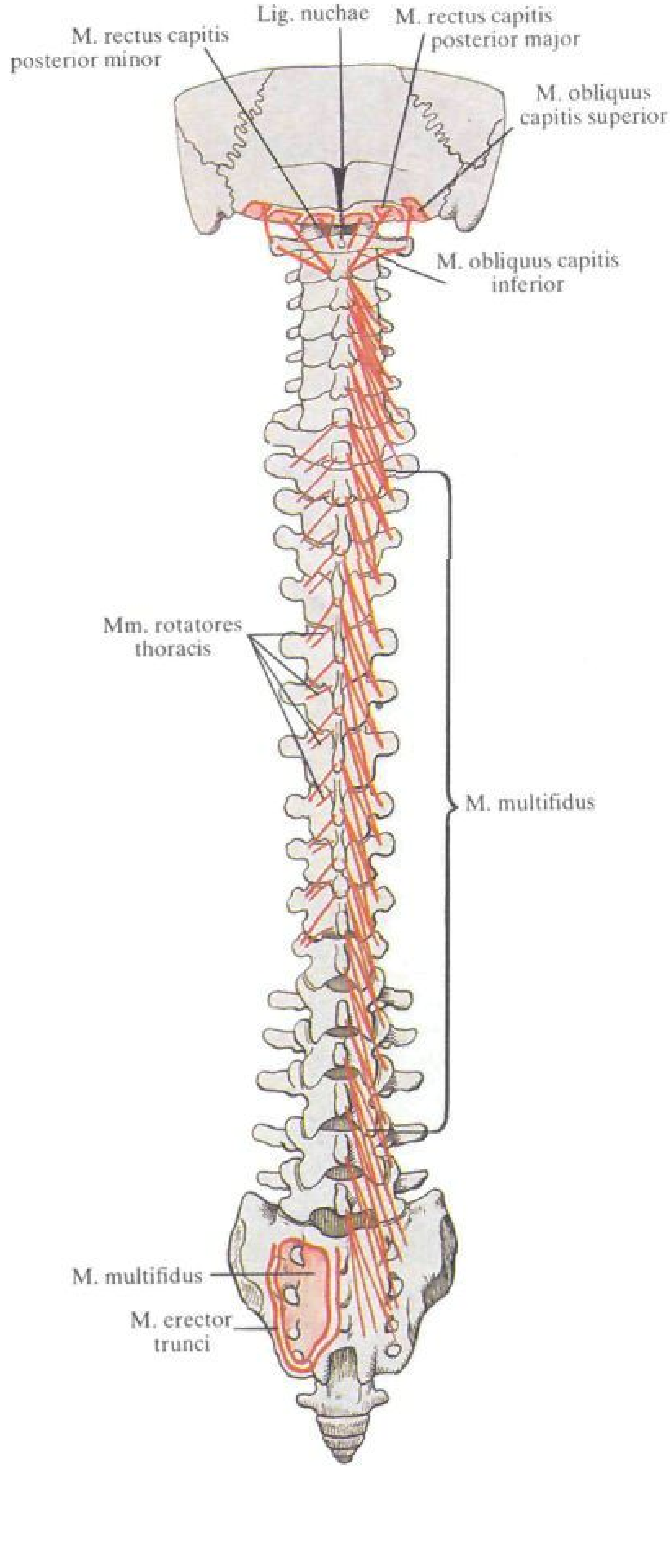
2. The **fascia nuchae** is located on the dorsal surface of the neck between the superficial and deep layers of muscles. It fuses with the ligamentum nuchae medially (Fig. 255) and is continuous with the superficial layer of the cervical fascia laterally; it is attached above to the superior nuchal line.

3. The **lumbar fascia** *(fascia thoracolumbalis)* (Figs 253–255; 258) forms a dense fibrous sheath in which the deep muscles of the back are lodged. This fascia consists of two layers; superficial (posterior) and deep (anterior). The superficial layer is attached below to the iliac crests, laterally it reaches the angles of the ribs, and is attached medially to the spinous processes of all the vertebrae, with the exception of the cervical vertebrae. It is the thickest in the lumbar region and much thinner in the upper parts. The superficial layer fuses with the deep layer laterally on the lateral border of the erector spinae muscle. As a result a fibrous sheath forms which invests the lumbar part of this muscle whose upper parts are lodged in the osteofibrous sheath of the back.

The superficial layer gives rise to the latissimus dorsi and serratus posterior inferior muscles. The deep layer of the lumbar fascia stretches between the transverse processes of the lumbar vertebrae, the iliac crest, and the twelfth rib; it fuses laterally with the superficial layer. The deep layer is present only in the lumbar region, in the space between the quadratus lumborum and the erector spinae muscles. The **transversus abdominis muscle** *(musculus transversus abdominis)* takes origin from the deep layer and from its junction with the superficial layer.



261. *Short muscles of posterior region of the neck* ($^4/_5$).



262. *Sites of origin and insertion of muscles of the back* (schematical representation).

(Deep muscles of the back; second deep layer. Short muscles of the posterior region of the neck.)

MUSCLES AND FASCIAE OF THE HEAD

The following *regions of the head and face* are distinguished (Fig. 264).

REGIONS OF THE HEAD

1. The **frontal region** *(regio frontalis)* is unpaired and reaches the nasofrontal suture (the root of the nose) and the supraorbital margins anteriorly, the parietal region posteriorly, and the temporal regions laterally.

2. The **parietal region** *(regio parietalis)* is unpaired and corresponds to the contours of the parietal bones.

3. The **temporal region** *(regio temporalis)* is paired and is situated on the sides of the head below the parietal region. It corresponds to the contours of the squamous part of the temporal bone.

4. The **occipital region** *(regio occipitalis)* is unpaired and is situated to the back of the parietal region. It stretches to the posterior region of the neck.

5. The **infratemporal region** *(regio infratemporalis)*.

REGIONS OF THE FACE

1. The **orbital region** *(regio orbitalis)* is paired and corresponds to the boundaries of the orbit.

2. The **nasal region** *(regio nasalis)* is unpaired and corresponds to the contours of the nose.

3. The **infraorbital region** *(regio infraorbitalis)* is paired and is located lateral to the nasal region and below the orbital region.

4. The **zygomatic region** *(regio zygomatica)* corresponds to the contours of the body of the zygomatic bone.

5. The **buccal region** *(regio buccalis)* is paired and is separated from the nasal and oral region by the **nasolabial groove** *(sulcus nasolabialis)*.

6. The **parotideomasseteric region** *(regio parotideomasseterica)* is paired and corresponds to the contours of the parotid gland and the masseter muscle. The posterior parts of this region are called the retromandibular fossa.

7. The **oral region** *(regio oralis)* is an unpaired region.

8. The **mental region** *(regio mentalis)* is unpaired and is separated from the oral region by the **mentolabial groove** *(sulcus mentolabialis)*.

MUSCLES OF THE HEAD

The **muscles of the head** *(musculi capitis)* are divided into two groups: the muscles of facial expression and the muscles of mastication.

The **muscles of facial expression**, or the facial muscles are located under the skin and, in contrast to the other skeletal muscles, are devoid of fasciae. Most of them arise on the bones or fasciae of the head and are inserted into the skin.

On contraction, the muscles of facial expression displace certain areas of the skin on the head and thus lend the face a variety of expressions, hence their name.

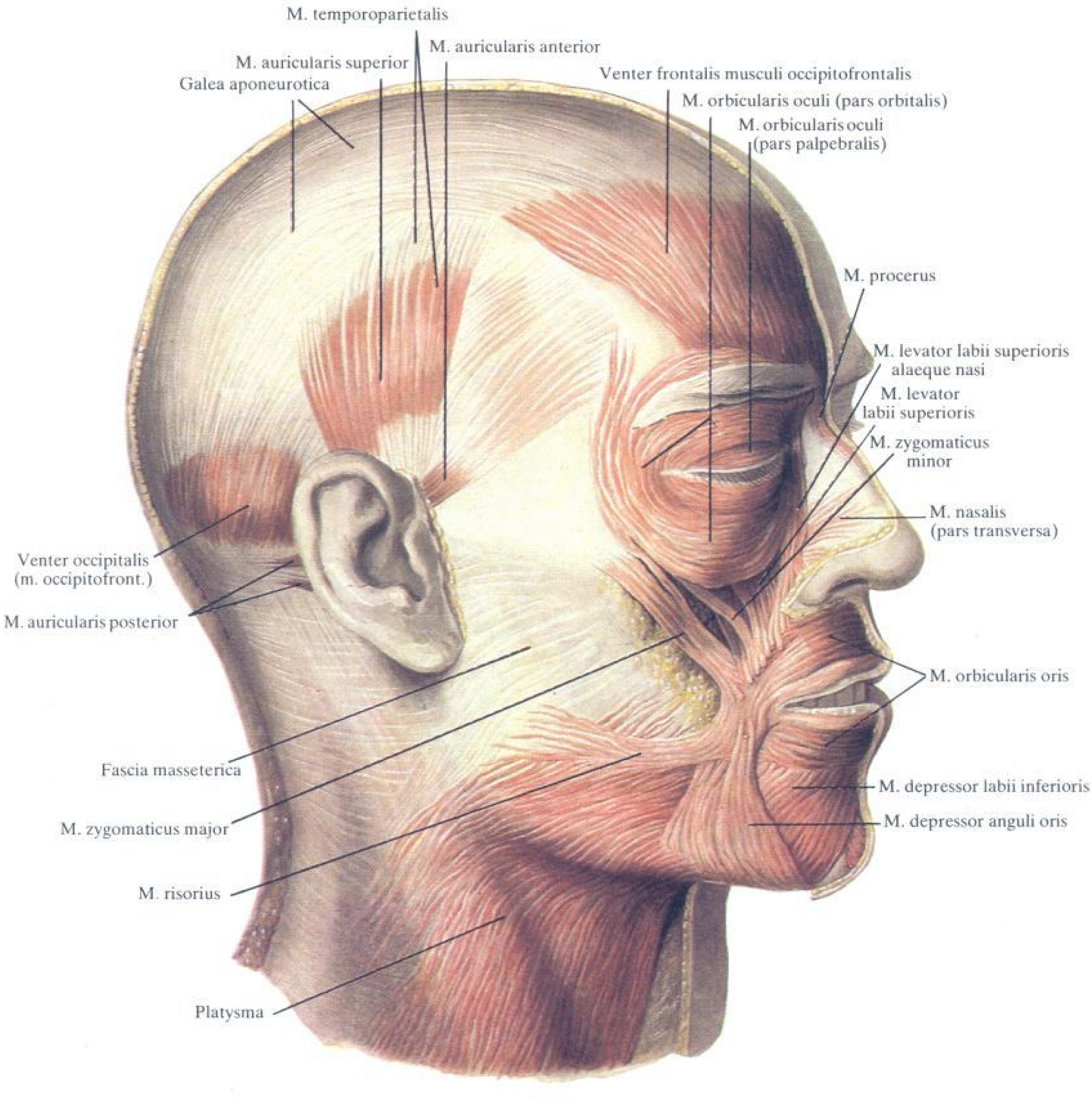
They are predominantly grouped around the natural orifices of the face (the palpebral fissure, oral fissure, orifices of the nose and ear) which either become smaller and even closed completely by the action of the muscles or become larger, i.e. dilate. In accordance with this, all muscles of facial expression are divided into the following four groups.

1. Muscles of the scalp.
2. Muscles surrounding the eyes.
3. Muscles surrounding the mouth.
4. Muscles surrounding the nose.

The **muscles of mastication** move the mandible on contraction and thus cause the act of mastication. They have a mobile point, or the point of insertion, on the mandible and a fixed point, the point of origin, on the skull bones.

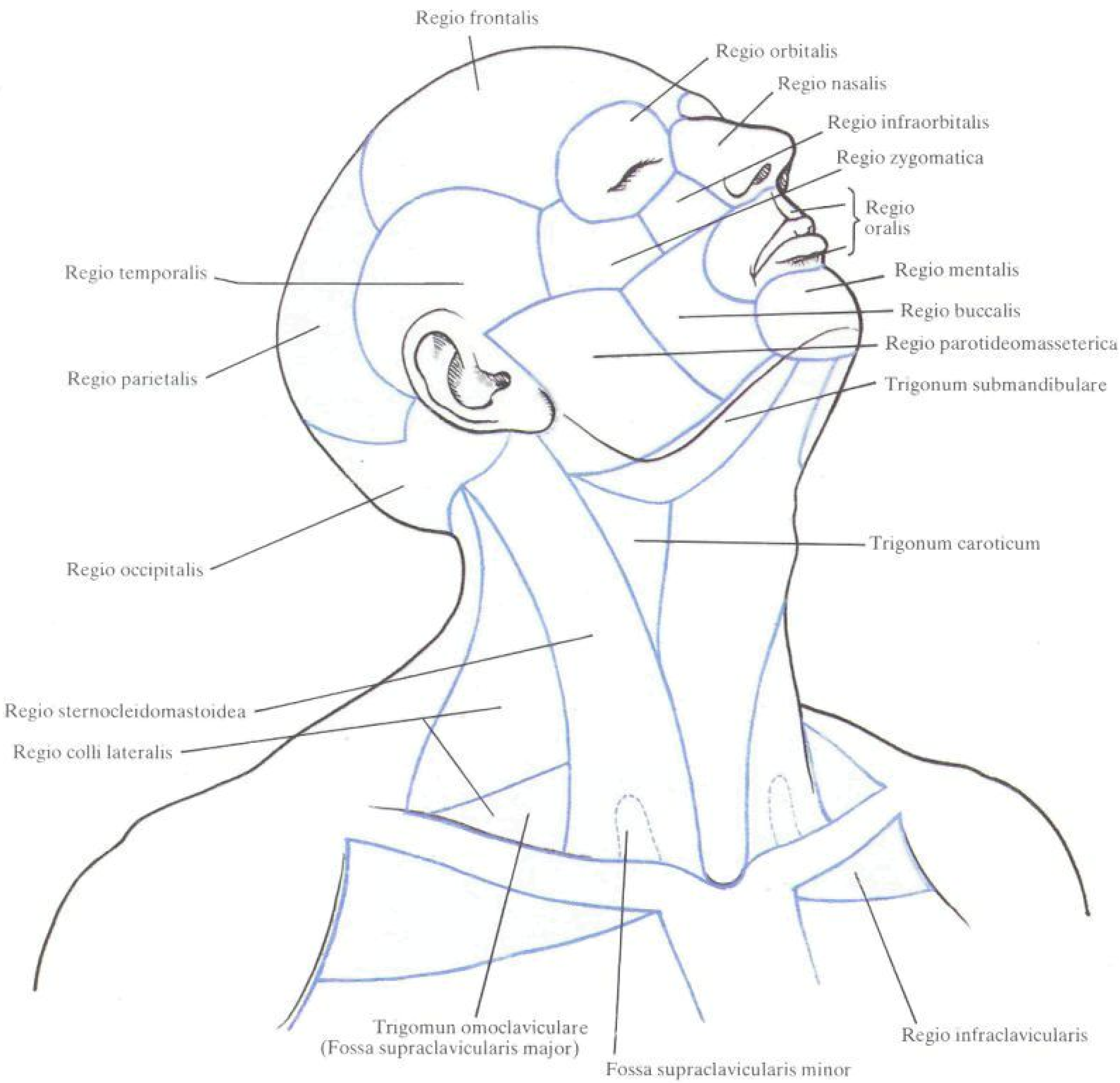
The following four pairs of muscles of mastication are distinguished.

1. The **masseter muscle** *(musculus masseter)*.
2. The **temporal muscle** *(musculus temporalis)*.
3. The **medial pterygoid muscle** *(musculus pterygoideus medialis)*.
4. The **lateral pterygoid muscle** *(musculus pterygoideus lateralis)*.

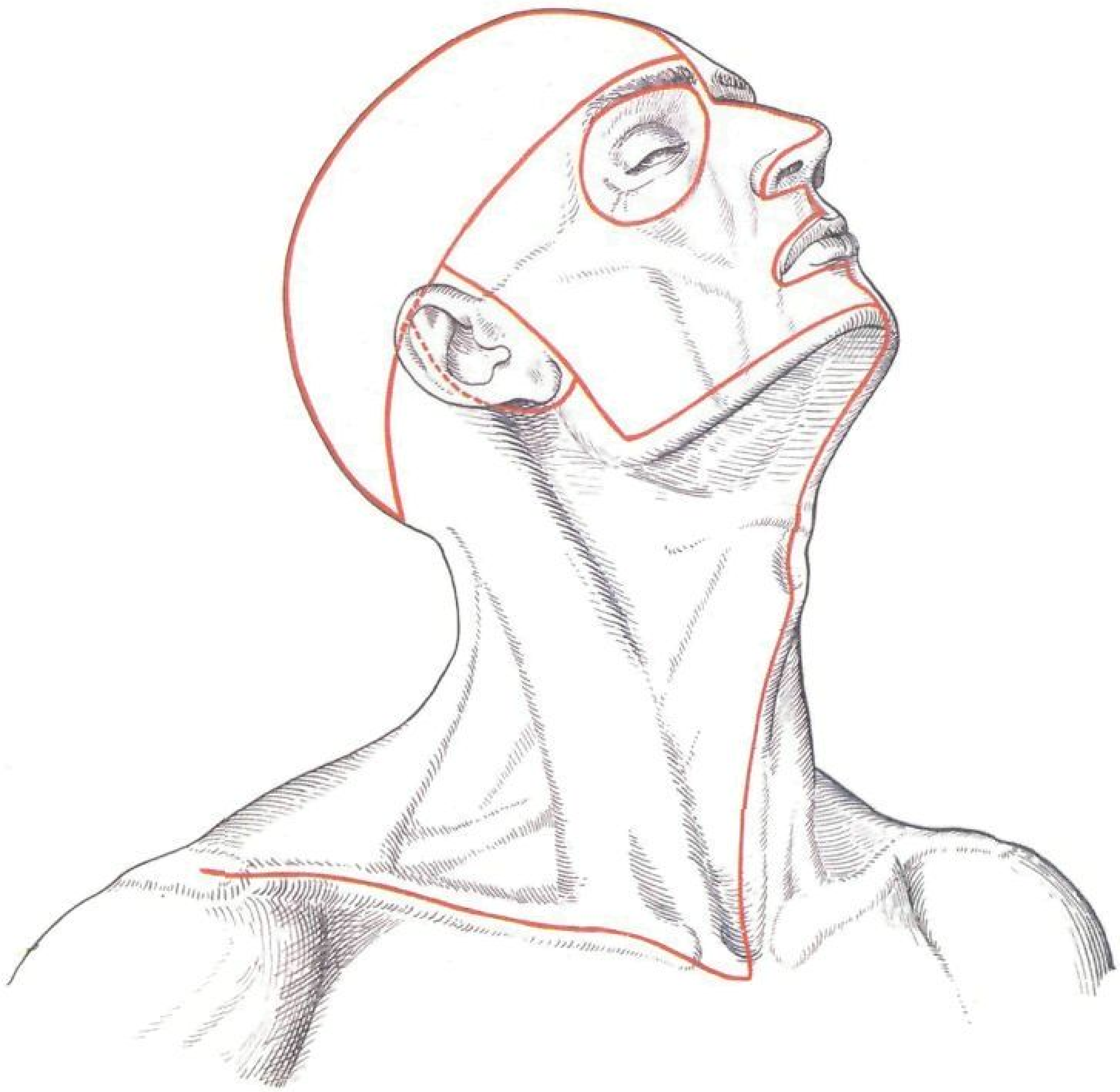


263. *Muscles of the head*; right side (½).

(Muscles of facial expression.)



264. *Regions of the head and neck.*



265. *Lines of skin incisions on the head and neck.*
(Most suitable for exposing the muscles which are being dissected.)

MUSCLES OF FACIAL EXPRESSION

MUSCLES OF THE SCALP

1. A broad tendinous plate, called the **epicraneal aponeurosis** *(galea aponeurotica* s. *aponeurosis epicranialis)* (Figs 263, 266), lies under the skin of the scalp between the frontal and occipital bones and is fused tightly with the skin of the scalp and loosely with the periosteum of its bones.

The anterior parts of the aponeurosis include the frontal belly, the posterior parts include the occipital belly. The two bellies form the **occipitofrontalis muscle** *(musculus occipitofrontalis)*.

(a) The **frontal belly** *(venter frontalis)* (Figs 263, 266) is under the skin of the forehead. It is formed of vertical fibres originating from the epicranial aponeurosis slightly above the frontal tubers and passing downwards to be intertwined with the skin of the forehead at the level of the superciliary arches.

(b) The **occipital belly** *(venter occipitalis)* (Figs 263, 266, 270) is made up of relatively short muscle fibres which originate in the region of the highest nuchal line, stretch upwards, and intertwine with the posterior parts of the epicranial aponeurosis.

The epicranial aponeurosis and the muscular parts connected with it form the **epicranius muscle** *(musculus epicranius)*.

Action: contraction of the occipital belly displaces to the back the epicranial aponeurosis and, together with it, the skin of the scalp; contraction of the frontal belly displaces forwards the epicranial aponeurosis and the part of the skin of the scalp connected with it; with the aponeurosis fixed, the muscle raises the eyebrows and widens the palpebral fissure.

Blood supply: frontal belly—the superficial temporal, supraorbital, lacrimal, and angular arteries; occipital belly—the occipital and posterior auricular arteries.

2. The **auricularis anterior muscle** *(musculus auricularis anterior)* (Fig. 263) originates from the temporal fascia and epicranial aponeurosis, runs to the back and downwards, becomes slightly narrower, and is inserted into the skin of the auricle above the tragus.

Action: pulls the auricle forwards and upwards.

Blood supply: the superficial temporal artery.

3. The **auricularis superior muscle** *(musculus auricularis superior)* (Fig. 263) is next to the auricularis anterior muscle. It arises above the auricle from the epicranial aponeurosis, extends downwards, and is inserted into the upper part of the auricular cartilage.

A bundle of fibres of this muscle is interlaced into the epicranial aponeurosis and is called the **temporoparietal muscle** *(musculus temporoparietalis)*.

Action: pulls the auricle upwards and tenses the epicranial aponeurosis.

Blood supply: the superficial temporal, posterior auricular, and occipital arteries.

4. The **auricularis posterior muscle** *(musculus auricularis posterior)* (Fig. 263) is poorly developed. It originates dorsally from the fascia nuchae and, passing forwards, reaches the base of the auricle.

Action: pulls the auricle backwards.

Blood supply: the posterior auricular artery.

5. The **transversus nuchae muscle** *(musculus transversus nuchae)* is an inconstant muscle. It arises from the external occipital protuberance, extends laterally to the point of insertion of the sternocleidomastoid muscle and reaches the mastoid process. It is inserted here into the tendon of the sternocleidomastoid muscle and sometimes gives off some fibres to the occipital fascia and the platysma muscle.

Action: tenses the fascia and, with it, the skin of the occipital region.

Blood supply: the occipital artery.

MUSCLES SURROUNDING THE EYES

1. The **corrugator muscle of the eyebrow** *(musculus corrugator supercilii)* (Fig. 266) arises from the frontal bone above the lacrimal bone, passes upwards in line with the superciliary arch, and is inserted into the skin of the eyebrow, in which its bundles are interlaced with the muscle fibres of the frontal belly of the occipitofrontal muscle.

Action: draws the skin of the eyebrows towards the midline to form vertical folds in the region of the bridge of the nose.

Blood supply: the angular, supraorbital, and superficial temporal arteries.

2. The **procerus muscle** *(musculus procerus)* arises on the ridge of the nose by elongated flat fibres from the nasal bone or the aponeurosis of the nasal muscle and is inserted into the skin.

Action: contraction of the muscle on both sides produces transverse folds at the root of the nose.

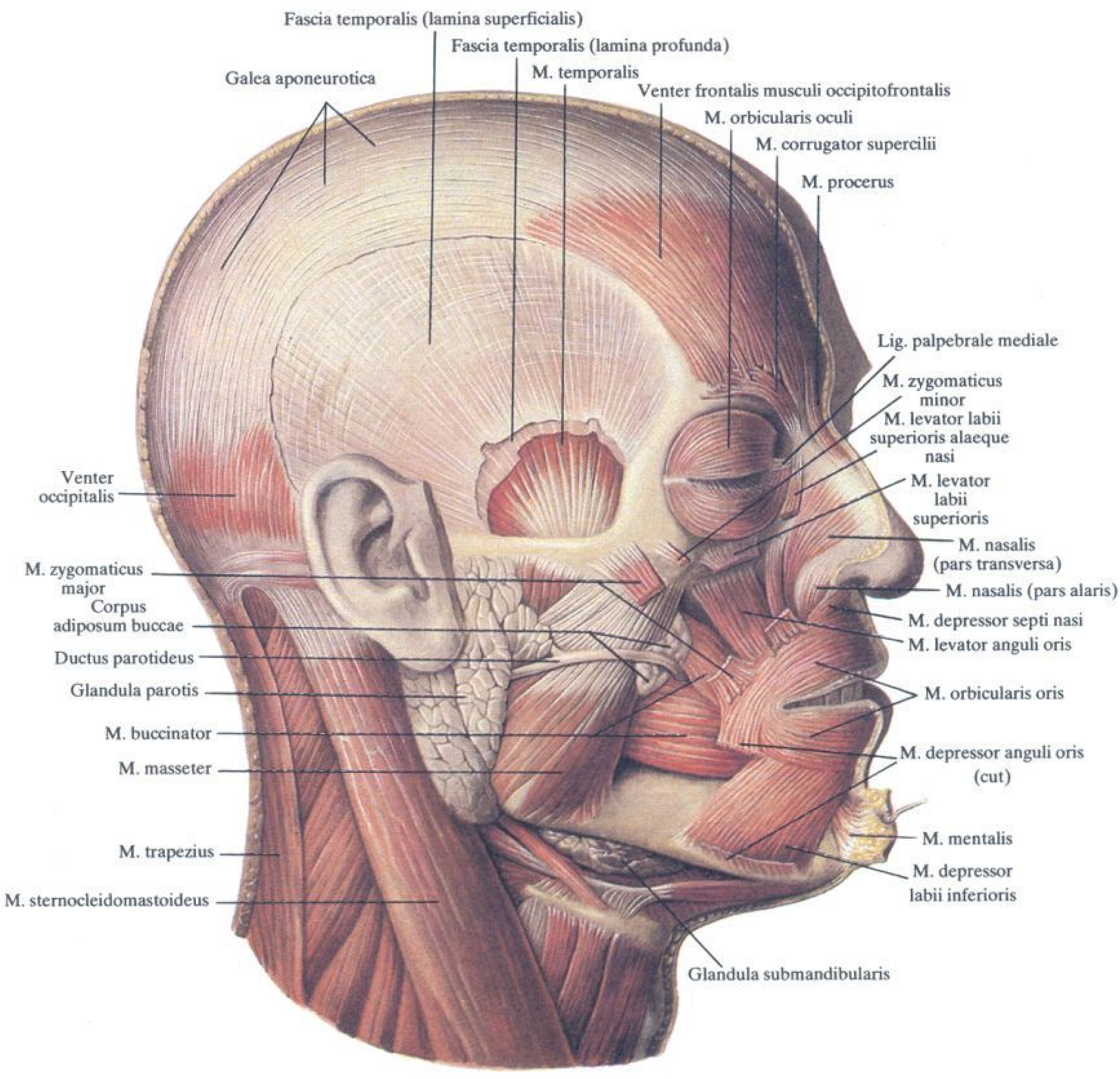
Blood supply: the angular and ethmoidal arteries.

3. The **orbicularis oculi muscle** *(musculus orbicularis oculi)* (Figs 263, 266) lies under the skin overlying the anterior parts of the orbit. Three parts are distinguished in the muscle: orbicular, palpebral, and lacrimal which arise in the region of the medial angle of the eye:

(a) the **orbital part** *(pars orbitalis)* takes origin from the medial palpebral ligament, the frontal process of the maxilla, and the nasal part of the frontal bone and stretches along the superior and inferior margins of the orbit to form a muscular ring.

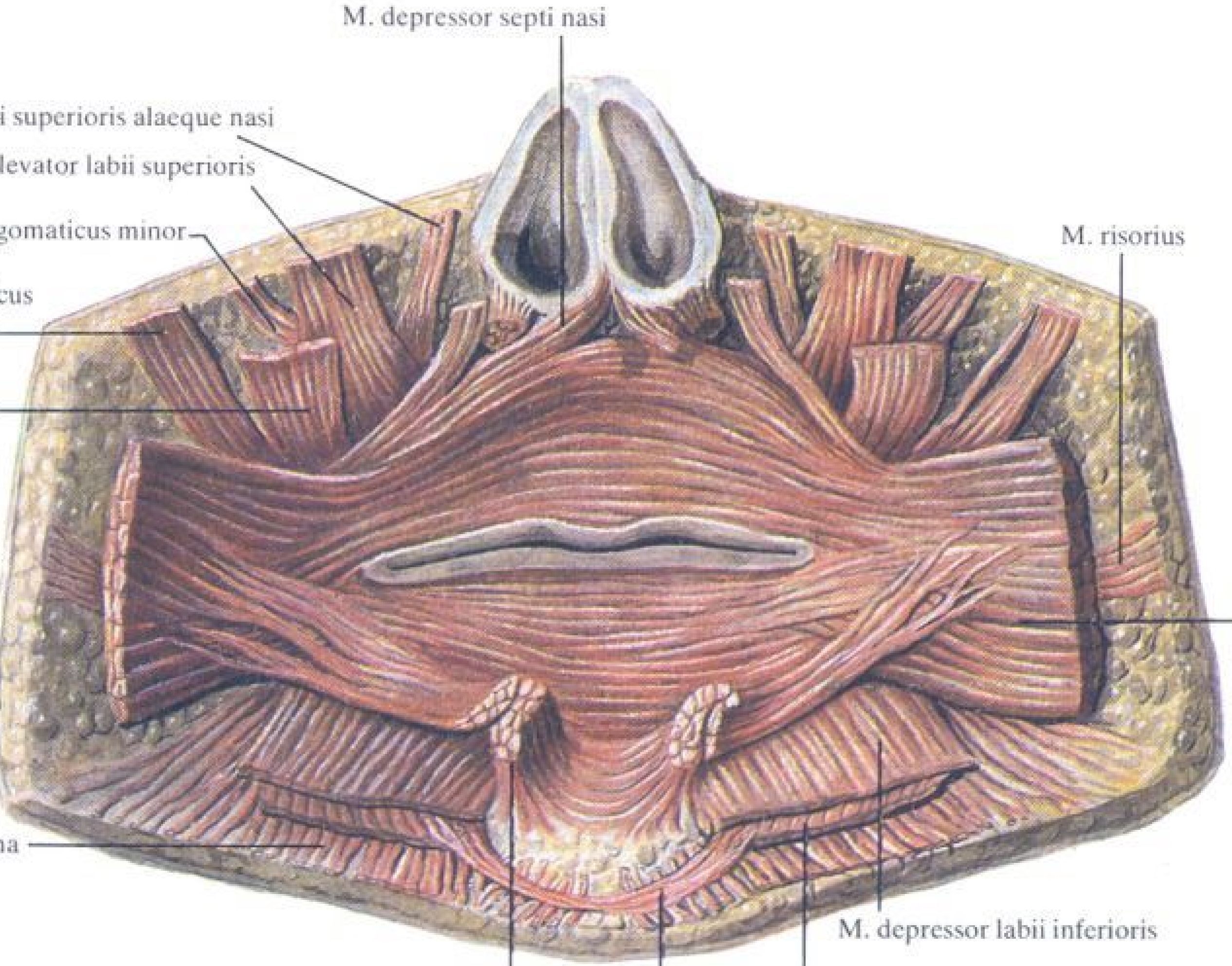
In the region of the lateral palpebral ligament, the inner fibres of the muscle form the **lateral palpebral raphe** *(raphe palpebralis lateralis)*;

(b) the **palpebral part** *(pars palpebralis)* is a direct continuation of the orbital part of the muscle and is found right under the skin of the eyelid. It has two parts, **superior** and **inferior** *(pars palpebralis superior* et *inferior)*. They take origin from the upper and lower



266. *Muscles of the head*; right side ($\frac{1}{2}$).

(Muscles of facial expression and muscles of mastication).



267. *Muscles surrounding the mouth*; inner aspect ($^1/_1$).

(The skin with the muscles surrounding the mouth is separated from the bones of the face. The mucous membrane of the cheeks and lips is removed.)

edges of the medial palpebral ligament, respectively, and pass to the lateral angle of the eye to be inserted into the lateral palpebral ligament;

(c) the **lacrimal part** *(pars lacrimalis)* arises from the posterior crest of the lacrimal bone and separates into two parts which embrace the **lacrimal sac** *(saccus lacrimalis)* anteriorly and posteriorly and are lost between the muscle fibres of the palpebral part.

Action: the palpebral part narrows the palpebral fissure and smoothes out the transverse folds in the skin of the forehead; the palpebral part closes the palpebral fissure; the lacrimal part dilates the lacrimal sac.

Blood supply: the facial, superficial temporal, infraorbital, and supraorbital arteries.

MUSCLES SURROUNDING THE MOUTH

The muscles surrounding the oral fissure are divided into two groups: one is represented by the orbicularis oris muscle whose contraction narrows the oral fissure, while the other group is made up of muscles stretching radially in relation to the oral fissure; their contraction widens it.

1. The **orbicularis oris muscle** *(musculus orbicularis oris)* (Figs 263, 266, 267) is formed of circular muscle fibres lying in the thickness of the lips. The muscle fibres are fused closely with the skin. The superficial layers of this muscle receive the fibres of muscles approaching the oral fissure. A **marginal part** *(pars marginalis)* and a **labial part** *(pars labialis)* are distinguished in the muscle.

Action: narrows the oral fissure and pulls the lips forward.

Blood supply: the labial, mental, and infraorbital arteries.

2. The **zygomaticus major muscle** *(musculus zygomaticus major)* (Figs 263, 266, 267) takes origin from the lateral surface of the zygomatic bone. Some of the muscle fibres are a continuation of the orbicularis oris muscle. Stretching downwards and medially, the zygomaticus major muscle is inserted into the orbicularis muscle and the skin of the angle of the mouth.

Action: pulls the angle of the mouth upwards and laterally.

Blood supply: the infraorbital and buccal arteries.

3. The **zygomaticus minor muscle** *(musculus zygomaticus minor)*

(Figs 263, 266, 267) takes origin from the anterior surface of the zygomatic bone. Its medial fibres intertwine with the fibres of the orbicularis oris muscle.

4. The **levator labii superioris muscle** *(musculus levator labii superioris)* arises from the infraorbital margin above the infraorbital foramen.

5. The **levator labii superioris alaeque nasi muscle** *(musculus levator labii superioris alaeque nasi)* is next to the levator labii superioris muscle; it takes origin from the base of the frontal process of the maxilla.

The three last muscles stretch downwards, converge a little, and form a quadrangular muscular plate whose bundles are inserted into the skin of the upper lip, partly into the orbicularis oris muscle and into the skin of the ala nasi.

Action: the levator labii superioris alaeque nasi muscle raises the upper lip and pulls upwards the ala of the nose.

Blood supply: the infraorbital, superior labial, and angular arteries.

6. The **levator anguli oris muscle** *(musculus levator anguli oris)* (Figs 266, 267) lies deeper than the last named muscle. It takes origin below the infraorbital foramen from the canine fossa and, extending downwards, is inserted into the skin at the angle of the mouth and into the orbicularis oris muscle.

Action: pulls the angle of the mouth upwards and laterally.

Blood supply: the infraorbital and buccal arteries.

7. The **buccinator muscle** *(musculus buccinator)* (Figs 266, 267, 273) takes origin from the buccinator crest of the mandible, the pterygomandibular ligament, and the external surfaces of the maxilla and mandible in the region of the sockets of the second molars. Passing forwards, the fibres of the buccinator muscle are continuous with the upper and lower lips and are inserted into the skin of the lips and the angle of the mouth, and the mucous membrane of the vestibule of the mouth.

A **buccal pad of fat** *(corpus adiposum buccae)* lies external to the muscle, the mucous membrane of the vestibule of the mouth adjoins the inner surface of the muscle. The **parotid duct** *(ductus parotideus)* pierces the middle parts of the buccinator muscle at the level of the anterior border of the masseter muscle.

Action: pulls the angle of the mouth laterally; in bilateral contraction the oral fissure is stretched and the inner surface of the cheek is pressed to the teeth.

Blood supply: the buccal artery.

8. The **risorius muscle** *(musculus risorius)* (Figs 263, 267) is an inconstant muscle and partly a continuation of the platysma fibres. Some fibres of the muscle arise from the masseteric fascia and the skin in the region of the nasolabial fold. It stretches medially to be inserted into the skin of the angle of the mouth.

Action: pulls the angle of the mouth laterally.

Blood supply: the facial, transverse facial, buccal, and infraorbital arteries.

9. The **depressor anguli oris muscle** *(musculus depressor anguli oris)* (Fig. 263) takes origin as a wide base from the anterior surface of the mandible inferior to the mental foramen. On extending upwards it narrows and reaches the angle of the mouth; some of its fibres are inserted into the skin here, others are inserted into the upper lip and the levator anguli oris muscle.

Action: pulls the angle of the mouth downwards and laterally.

Blood supply: the inferior labial, mental, and submental arteries.

10. The **depressor labii inferioris muscle** *(musculus depressor labii inferioris)* (Figs 263, 266, 267) is partly covered by the depressor anguli oris muscle. It arises from the anterior surface of the mandible above the origin of the depressor anguli oris anteriorly of the mental foramen, passes upwards, and is inserted into the skin of the lower lip and chin.

The medial fibres of the muscle intertwine with those of the contralateral muscle at the lower lip.

Action: pulls the lower lip downwards.

Blood supply: the inferior labial, mental, and submental arteries.

11. The **mentalis muscle** *(musculus mentalis)* (Figs 266, 267) arises next to the depressor labii inferioris muscle from the alveolar juga of the mandibular incisors, passes downwards, and is inserted into the skin of the chin.

Action: pulls the skin of the chin upwards and pulls out the lower lip.

Blood supply: the inferior labial and mental arteries.

12. The **transversus menti muscle** *(musculus transversus menti)* is a small inconstant muscle which crosses the midline directly under the chin. It is often a continuation of the depressor anguli oris muscle.

MUSCLES SURROUNDING THE NOSE

1. The **nasal muscle** *(musculus nasalis)* (Figs 263, 266) takes origin from the maxilla above the alveoli of the canine and lateral incisor teeth, stretches upwards, and separates into two parts, medial and lateral:

(a) the lateral, or **transverse part** *(pars transversus)* curves around the ala nasi, becomes slightly wider, and is continuous with a tendon in the midline. The tendon joins that of the contralateral muscle;

(b) the medial, or **alar part** *(pars alaris)* is inserted into the posterior end of the cartilage of the ala nasi.

Action: narrows the nostrils.

Blood supply: the superior labial and angular arteries.

2. The **depressor septi nasi muscle** *(musculus depressor septi nasi)* (Fig. 266) arises from the alveolar juga of the maxillary medial incisor and partly includes fibres of the orbicularis oris. It is inserted into the inferior surface of the cartilage of the nasal septum.

Action: pulls the nasal septum downwards.

Blood supply: the superior labial artery.

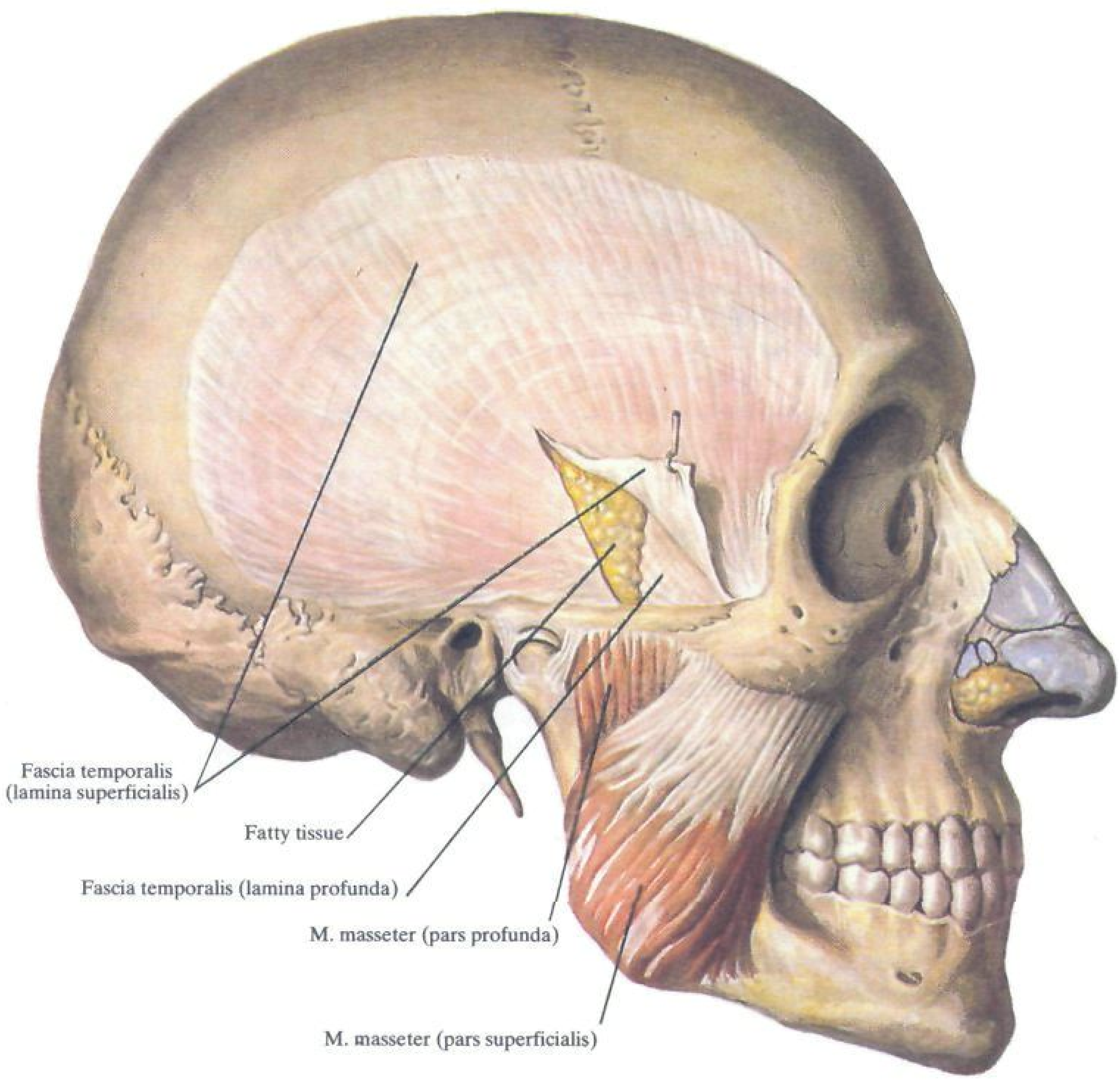
Innervation: all the muscles of facial expression are innervated by branches of the facial nerve.

MUSCLES OF MASTICATION

1. The **masseter muscle** *(musculus masseter)* (Figs 266, 268–270) takes origin from the inferior border of the zygomatic arch by superficial and deep parts.

The **superficial part** *(pars superficialis)* arises as tendinous fibres from the anterior and middle parts of the zygomatic arch; the **deep part** *(pars profunda)* takes origin as a muscle from the middle and posterior areas of the zygomatic arch. The bands of muscle fibres of the superficial part pass obliquely, downwards and to the back; those of the deep part stretch downwards and to the front. Both parts of the masseter muscle unite to be inserted into the external surface of the ramus of the mandible and its angle in the region of the masseteric tuberosity.

Action: raises the lowered mandible; the superficial part of the muscle contributes to forward protrusion of the mandible.



268. *Muscles of mastication*; right side (⅔).

(The superficial layer of temporal fascia partly cut and drawn aside.)

Blood supply: the facial, masseteric, and transverse facial arteries.

Innervation: nerve to the masseter (trigeminal nerve).

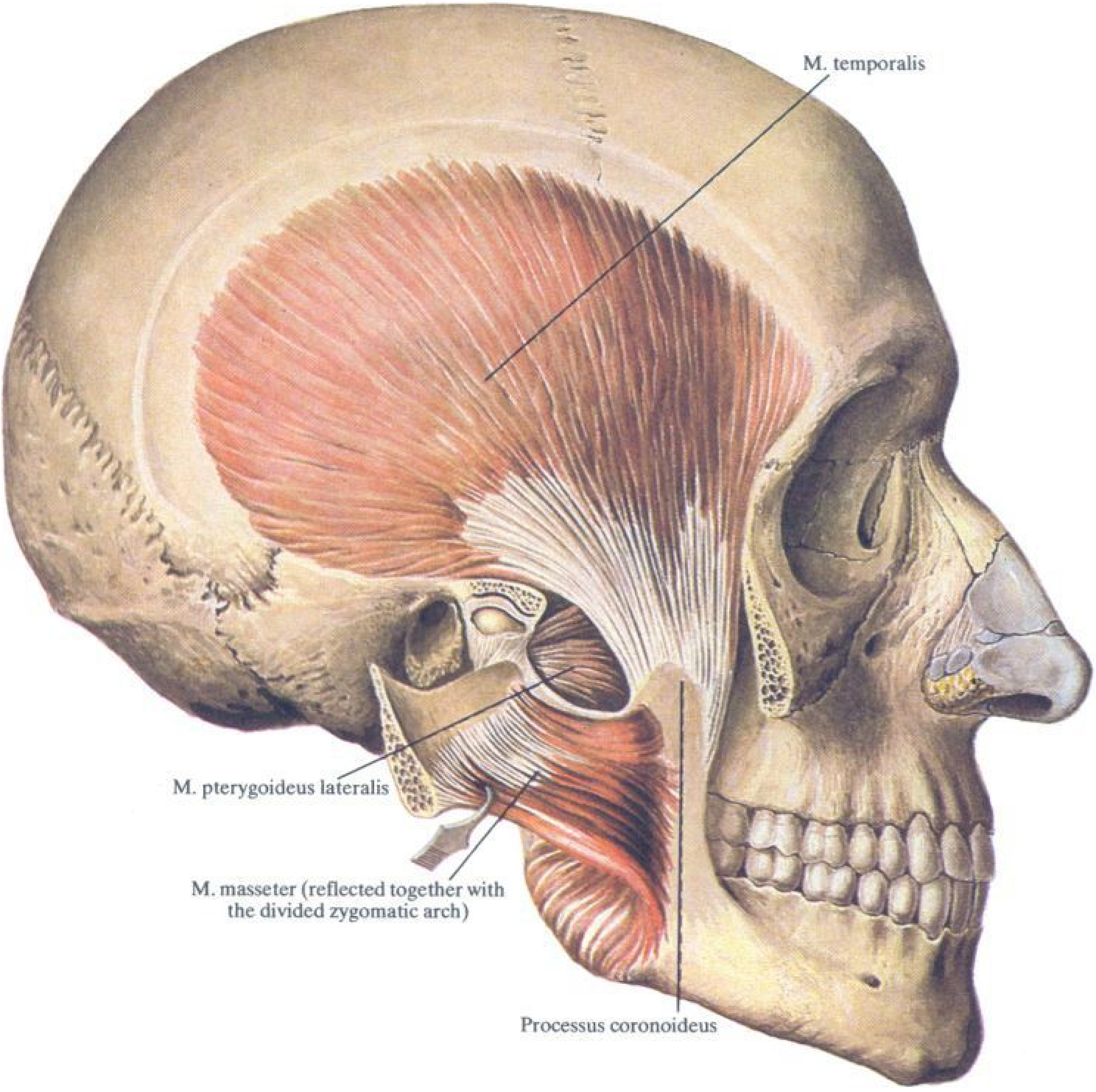
2. The **temporal muscle** *(musculus temporalis)* (Figs 266, 269-271) occupies the **temporal fossa** *(fossa temporalis)*. It takes origin from the temporal surface of the greater wing of the sphenoid bone and the squamous part of the temporal bone. Passing downwards, the fibres of the muscle converge to form a strong tendon which passes medially of the zygomatic arch and is inserted into the coronary process of the mandible.

Action: contraction of all fibres raises the lowered mandible; the posterior fibres pull backwards the anteriorly protruded mandible.

Blood supply: the deep temporal and superficial arteries.

Innervation: the deep temporal nerves (trigeminal nerve).

3. The **lateral pterygoid muscle** *(musculus pterygoideus lateralis)*



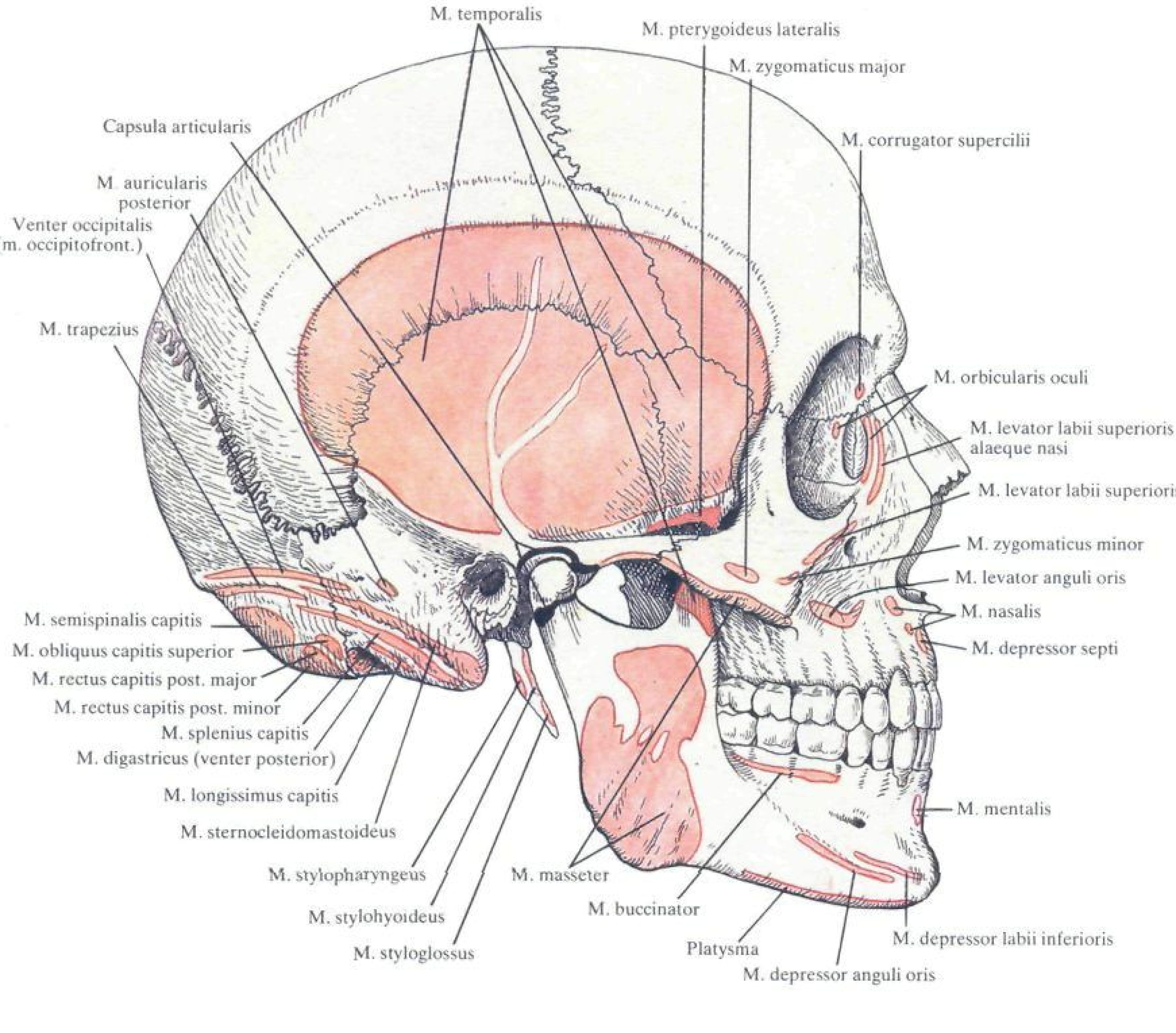
269. *Muscles of mastication*; right side ($\frac{2}{3}$).

(The zygomatic arch is divided and turned aside together with the masseter muscle.)

(Figs 269–271; 272–274) arises by two parts, or heads, upper and lower.

The upper head of the muscle takes origin from the inferior surface and infratemporal crest of the greater wing of the sphenoid bone and is inserted into the medial surface of the articular capsule of the mandibular joint and into the articular disc. The lower head arises from the lateral surface of the lateral plate of the pterygoid process of the sphenoid bone and passes backwards to be inserted into the pterygoid pit of the mandible. A small slit transmitting the buccal nerve is left between the upper and lower heads of the muscle.

Action: displaces the mandible to the contralateral side. Bilateral contraction of the muscle causes the mandible to protrude forwards.



270. *Sites of origin and insertion of the muscles of the head* (schematical representation).

Blood supply: the maxillary artery.

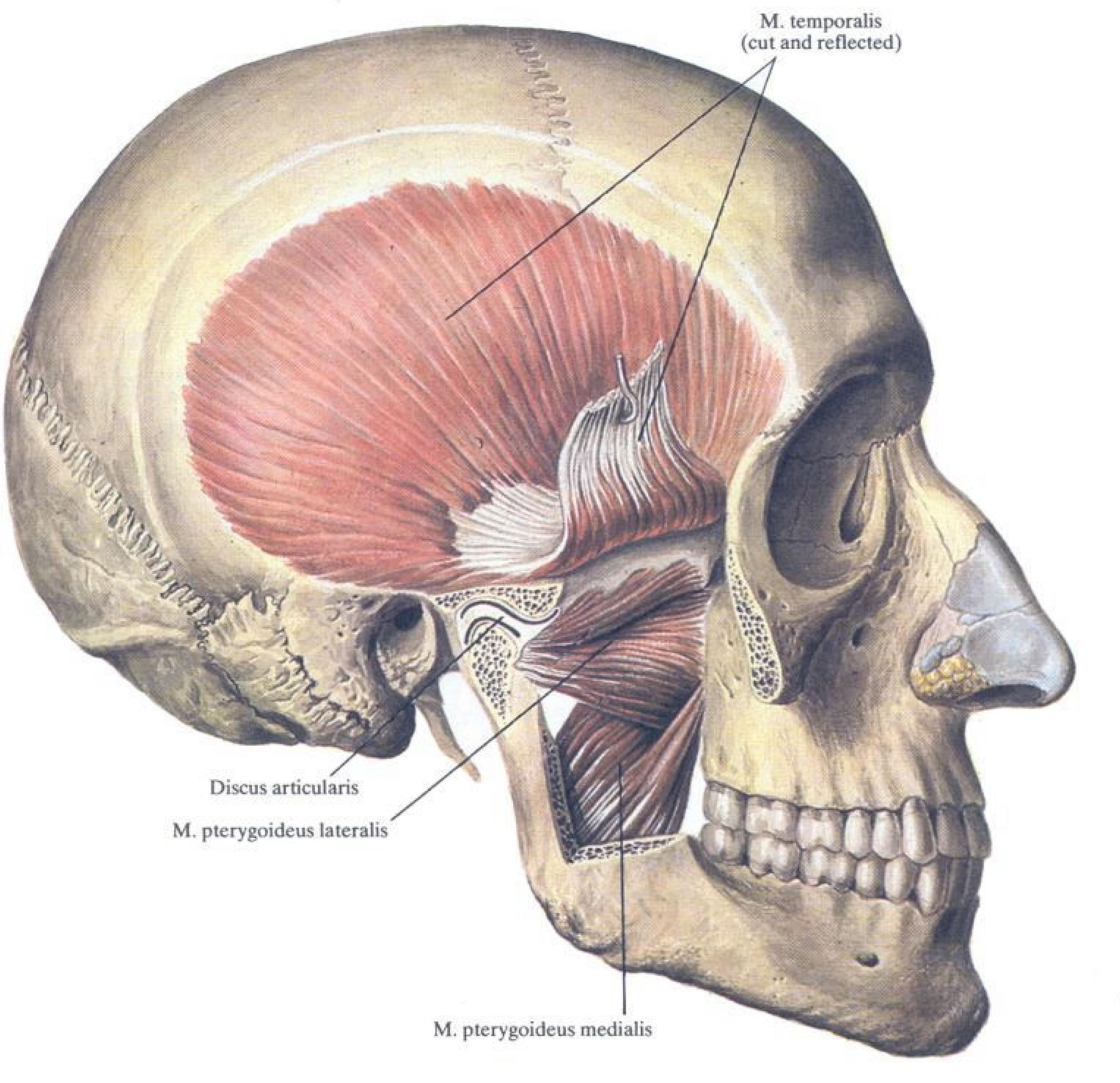
Innervation: the lateral pterygoid (trigeminal) nerve.

4. The **medial pterygoid muscle** *(musculus pterygoideus medialis)* (Figs 271–274). Takes origin from the walls of the pterygoid fossa of the sphenoid bone, stretches backwards and downwards, and is inserted into the pterygoid tuberosity of the mandible.

Action: displaces the mandible to the contralateral side. Bilateral contraction causes forward protrusion and raises the lowered mandible.

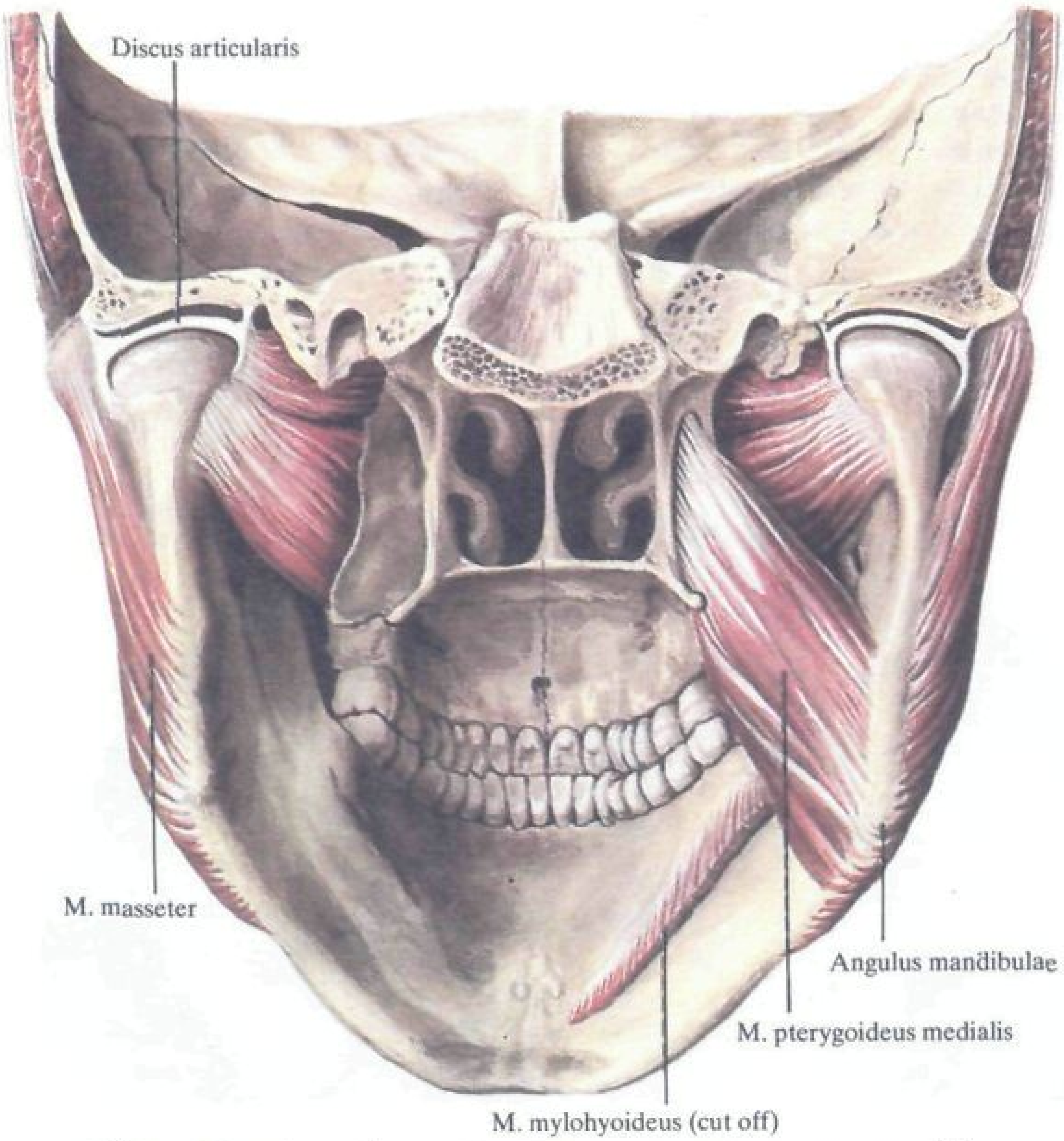
Blood supply: the alveolar, buccal, and facial arteries.

Innervation: nerve to the medial pterygoid muscle (trigeminal nerve).

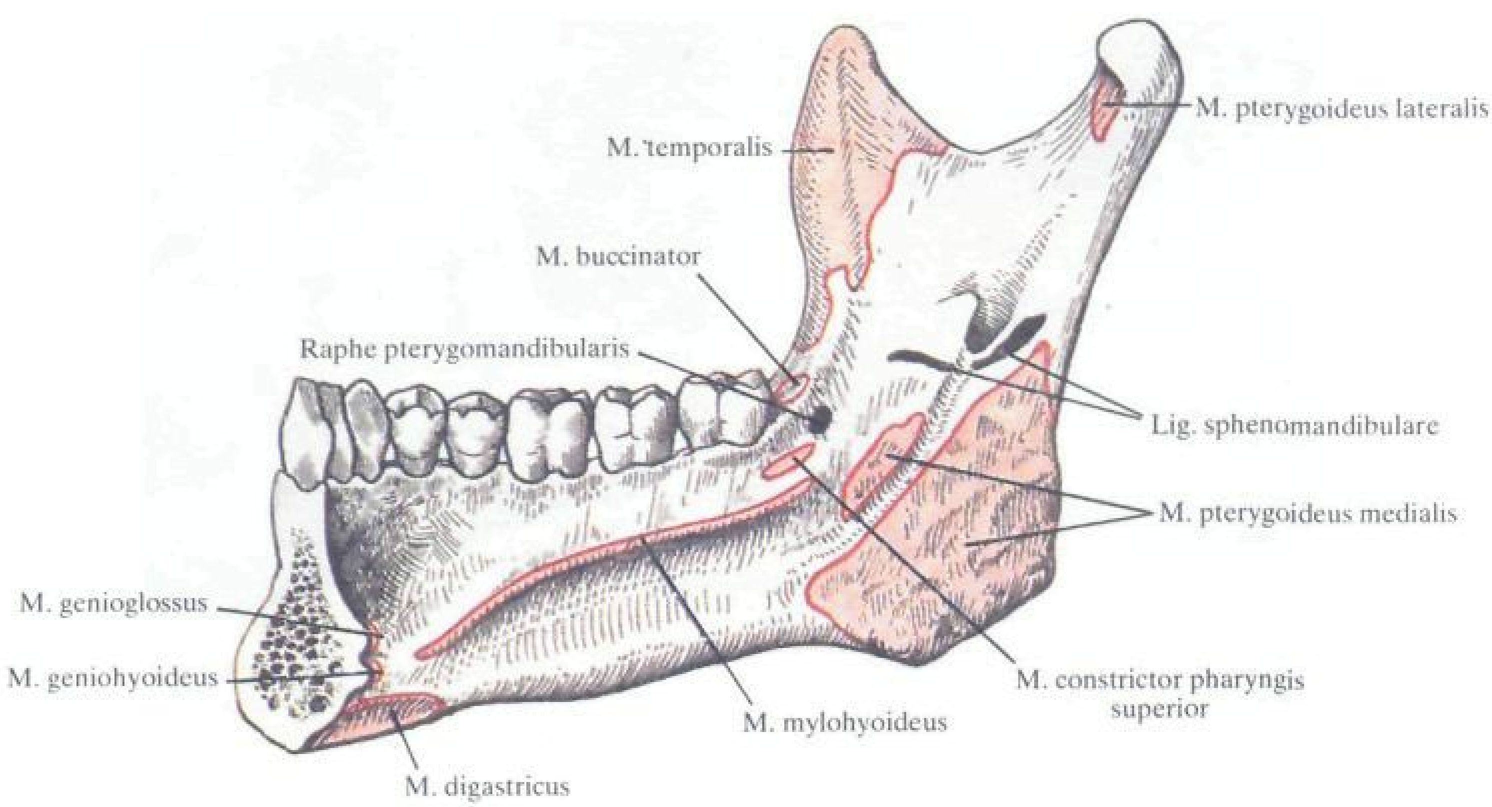


271. *Muscles of mastication*; right side (⅔).

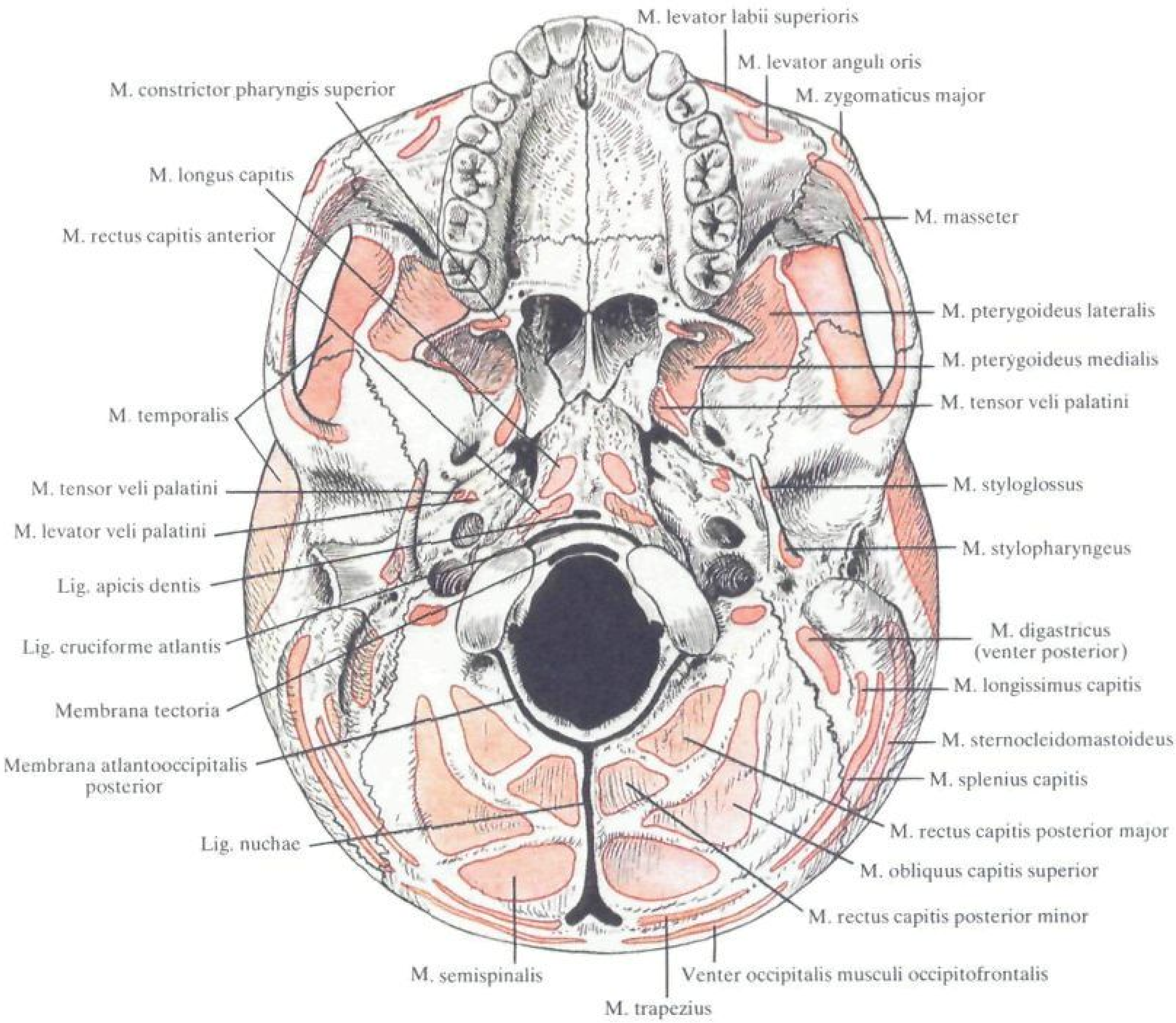
(The cavity of the mandibular joint is opened by sagittal section; part of mandibular ramus is removed.)



272. *Muscles of mastication*; posterior aspect ($\frac{2}{3}$).



273. *Sites of origin and insertion of the muscles of mastication* (schematical representation).



274. *Sites of origin and insertion of muscles and ligaments on base of skull* (schematical representation).

FASCIAE OF THE HEAD

The fasciae of the head (Figs 263, 266, 268) are as follows: the temporal, masseteric, parotid, and buccopharyngeal.

1. The **temporal fascia** *(fascia temporalis)* extends from the periosteum of the skull bones in the region of the temporal line and epicranial aponeurosis, covers the temporal muscle and separates into two layers close to the zygomatic arch. One is the **superficial layer** *(lamina superficialis)* which is attached to the superior margin and outer surface of the zygomatic arch, the other is the **deep layer** *(lamina profunda)* which passes over to the inner surface of the zygomatic arch. Vessels and fatty tissue are lodged between these two layers.

2. The **masseteric fascia** *(fascia masseterica)* is continuous with the temporal fascia on the zygomatic arch, and it then passes downwards. Posteriorly it is attached to the cartilage of the external acoustic meatus and passes over to the mastoid process. Inferiorly it is continuous with the cervical fascia; anteriorly it covers the masseter muscle after which it is continuous with the buccopharyngeal fascia.

3. The **parotid fascia** *(fascia parotidea)* is connected posteriorly with the masseteric fascia and separates into two layers which invest on both sides the parotid gland.

4. The **buccopharyngeal fascia** *(fascia buccopharyngea)* covers the buccinator muscle and at the anterior border of the masseter muscle passes over to the medial surface of the mandibular ramus where it covers the medial pterygoid muscle and then stretches over to the pharyngeal wall.

MUSCLES AND FASCIAE OF THE NECK

REGIONS OF THE NECK

The following **regions of the neck** *(regiones colli)* (Fig. 264) are distinguished.

1. The **anterior cervical region** *(regio colli anterior)* includes:

(a) the **submaxillary triangle** *(trigonum submandibulare)*;

(b) the **carotid triangle** *(trigonum caroticum)*.

2. The paired **sternocleidomastoid region** *(regio sternocleidomastoideae)* corresponds to the contours of the sternocleidomastoid muscle.

The paired **lesser supraclavicular fossa** *(fossa supraclavicularis minor)* is bounded by the heads (slips) of the sternocleidomastoid muscle and the corresponding border of the clavicle.

3. The paired **lateral cervical region** *(regio colli lateralis)* is bounded by the posterior border of the sternocleidomastoid muscle anteriorly, by the border of the trapezius muscle posteriorly, and by the border of the clavicle inferiorly. This region includes the **omoclavicular triangle** *(trigonum omoclaviculare)* in which the **greater supraclavicular fossa** *(fossa supraclavicularis major)* is situated.

4. The **posterior cervical region** *(regio colli posterior)* is bounded by the lateral borders of the trapezius muscle.

MUSCLES OF THE NECK

The **cervical muscles** *(musculus colli)* cover one another to form three groups—superficial, middle, and deep.

The deep muscles may be divided into a lateral and prevertebral groups.

I. The superficial muscles of the neck: the platysma and the sternocleidomastoid muscles *(musculus sternocleidomastoideus)*.

II. The middle group:

1. The **suprahyoid muscles** *(musculi suprahyoidei)*: the **digastric muscle** *(musculus digastricus)*, the **stylohyoid muscle** *(musculus stylohyoideus)*, the **mylohyoid muscle** *(musculus mylohyoideus)*, and the **geniohyoid muscle** *(musculus geniohyoideus)*.

2. The **infrahyoid muscles** *(musculi infrahyoidei)*: the **sternohyoid** *(musculus sternohyoideus)*, the **sternothyroid** *(musculus sternothyroideus)*, the **thyrohyoid** *(musculus thyrohyoideus)*, and the **omohyoid** *(musculus omohyoideus)* **muscles.**

III. The deep muscles of the neck:

1. The lateral group: the **scalenus anterior** *(musculus scalenus anterior)*, **medius** *(musculus scalenus medius)*, and **posterior** *(musculus scalenus posterior)* **muscles.**

2. The prevertebral group: the **longus capitis** *(musculus longus capitis)*, the **longus cervicis** *(musculus longus colli)*, the **rectus capitis anterior** *(musculus rectus capitis anterior)*, and the **rectus capitis lateralis** *(musculus rectus capitis lateralis)* muscles.

SUPERFICIAL MUSCLES OF THE NECK

1. The **platysma** *(platysma)* (Figs 275, 280, 281) is a thin muscular sheet lying under the skin with which it is closely fused. The muscle fibres arise on the chest on the level of the second rib and pass upwards and medially. On reaching the border of the mandible the medial fibres intertwine with those of the contralateral muscle and are inserted into the border of the mandible; the lateral fibres of the muscle extend to the face on which they interlace with the parotid and masseteric fasciae and reach the angle of the mouth.

Action: tenses the skin of the neck and partly of the chest, lowers the mandible, and pulls the angle of the mouth laterally and downwards.

Blood supply: the superficial cervical and facial arteries.

Innervation: cervical branch of the facial nerve.

2. The **sternocleidomastoid muscle** *(musculus sternocleidomastoideus)* (Figs 275, 276, 280, 281) is behind (under) the platysma. It is a rather thick, slightly flattened muscular band which crosses the neck obliquely and spiral-like from the mastoid process to the sternoclavicular joint. It arises by two heads, one lateral taking origin from the sternal end of the clavicle, and the other medial arising from the anterior surface of the manubrium sterni.

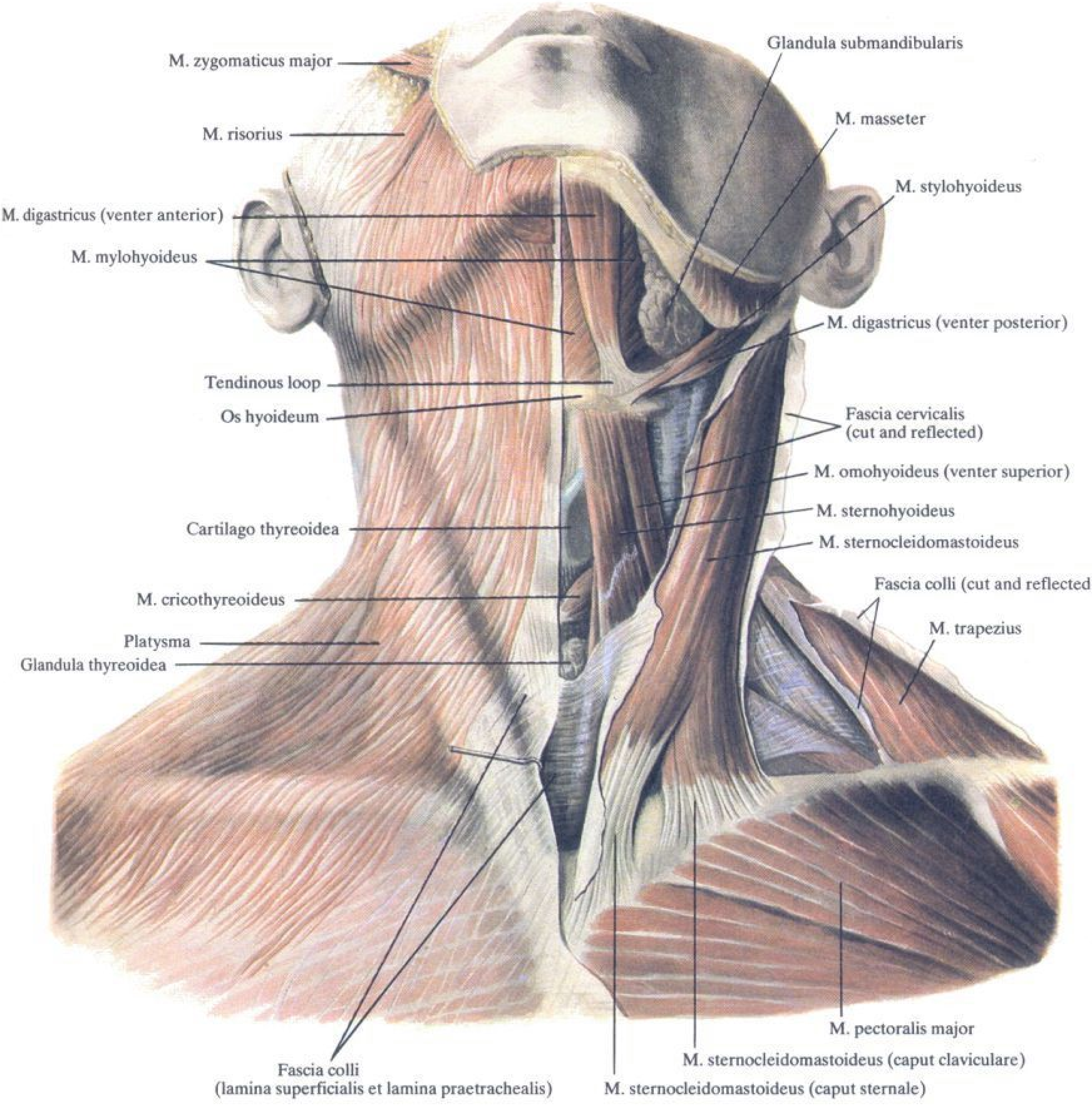
Both heads join at a right angle in such a manner that fibres of the medial head lie closer to the surface. The formed muscular belly stretches upwards and to the back to be inserted into the mastoid process of the temporal bone and the superior nuchal line.

Between the lateral and medial heads of the muscle is a small depression called the **lesser supraclavicular fossa** *(fossa supraclavicularis minor)*, while between the medial heads of the right and left *sternocleidomastoid muscles above the jugular notch of the ma*nubrium sterni is the **jugular fossa** *(fossa jugularis)*.

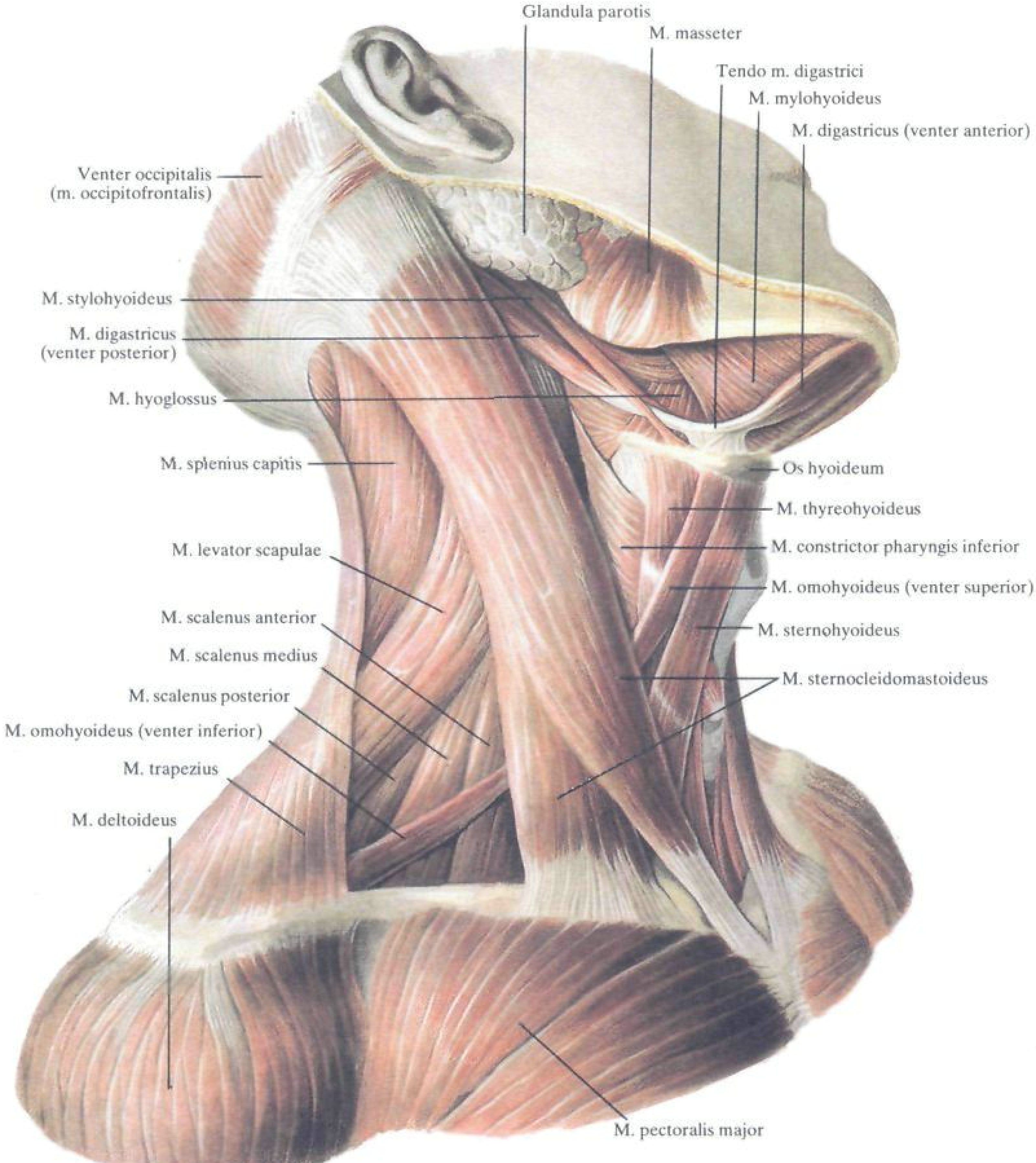
Action: when the chest is fixed contraction of one muscle inclines the head to the same side but turns the face to the opposite side; contraction of both muscles draws the head to the back and moves it slightly forward; with the head fixed the muscle pulls the clavicle and sternum upwards.

Blood supply: the occipital, sternocleidomastoid, and superior thyroid arteries.

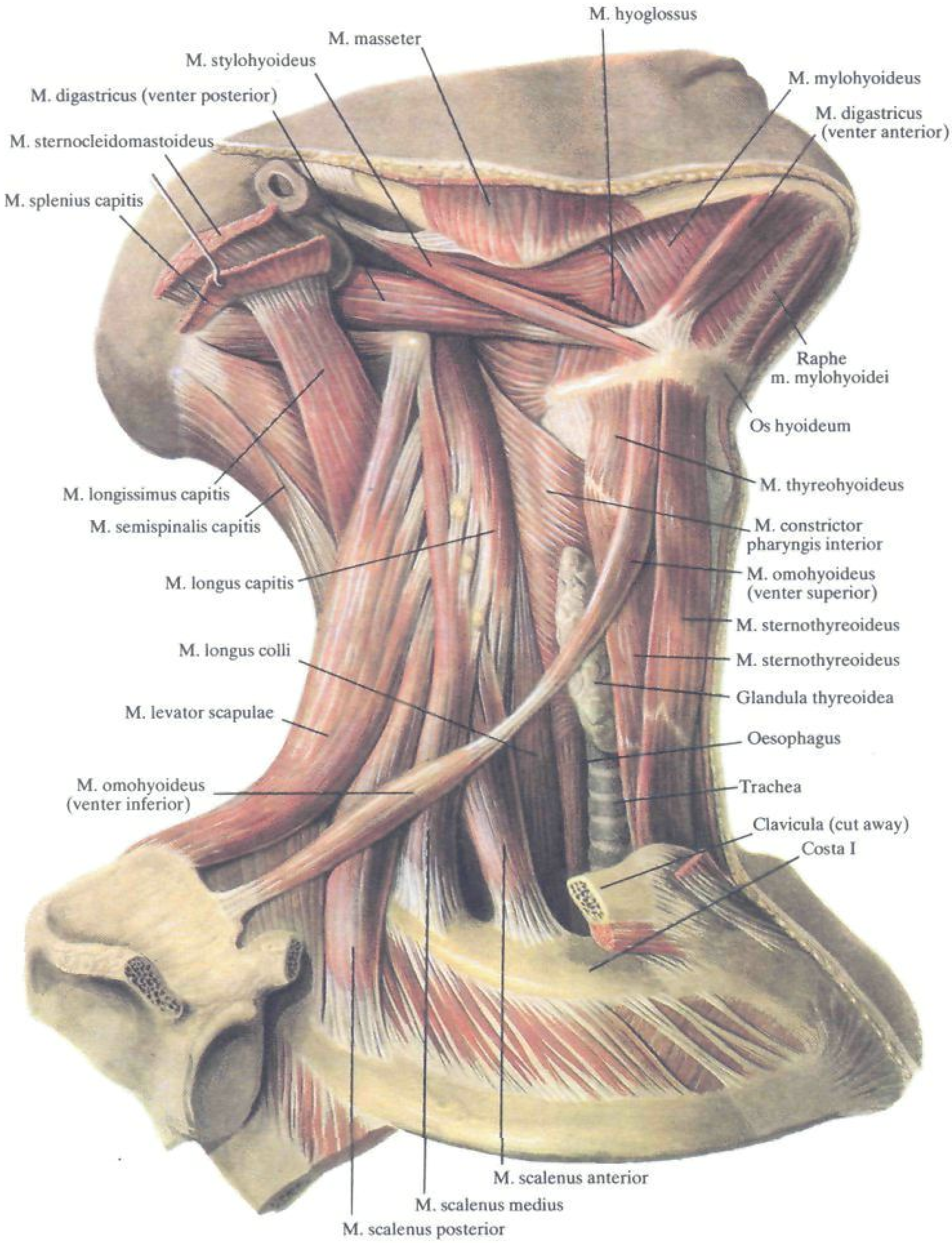
Innervation: branch of accessory nerve to the sternomastoid muscle and second pair of cervical nerves (C_2-C_4).



275. *Superficial muscles of the neck*; anterior aspect ($\frac{2}{5}$).



276. *Muscles of the neck*; right side (½).
(Superficial muscles and the middle group.)



277. *Muscles of the neck*; right side (½).

(Middle group and deep muscles, lateral group.)

THE MIDDLE GROUP OF MUSCLES OF THE NECK

THE SUPRAHYOID MUSCLES

1. The **digastric muscle** *(musculus digastricus)* (Figs 275-278) has two bellies, anterior and posterior, which are connected by a tendon.

The **anterior belly** *(venter anterior)* arises from the mandibular digastric fossa and passes downwards and backwards to be continuous with the tendon which is fastened to the body of the hyoid bone by a process of the cervical fascia. This tendon, curving backwards and upwards, is continuous with the **posterior belly** *(venter posterior)* which is inserted into the mastoid notch of the temporal bone. Between the two bellies and the border of the mandible is the **submandibular fossa** *(fossa submandibularis)* lodging the submandibular gland.

Action: when the hyoid bone is fixed the muscle lowers the mandible; with the mandible fixed the muscle pulls the hyoid bone upwards.

Blood supply: anterior belly—the submental artery; posterior belly—the occipital and posterior auricular arteries.

Innervation: anterior belly—the trigeminal nerve *(nervus trigeminus)* (third division); posterior belly—the facial nerve *(nervus facialis)*.

2. The **stylohyoid muscle** *(musculus stylohyoideus)* (Figs 275-278) has a thin flat belly which takes origin from the styloid process of the temporal bone, stretches forwards and downwards, and lies on the anterior surface of the posterior belly of the digastric muscle. The distal end of the muscle separates into two slips embracing the tendon of the digastric muscle and is inserted into the body and greater horn of the hyoid bone.

Action: pulls the hyoid bone backwards, upwards, and laterally.

Blood supply: the occipital, facial arteries and the suprahyoid branch of the lingual artery.

Innervation: the facial nerve.

3. The **mylohyoid muscle** *(musculus mylohyoideus)* (Figs 275-278) is flat and of an irregular triangular shape. It arises from the mylohyoid line on the mandible. Its fibres pass downwards and slightly to the front and meet the fibres of the contralateral muscle to form the raphe of the mylohyoid muscle.

The posterior fibres of the muscle are inserted into the anterior surface of the body of the hyoid bone. Both mylohyoid muscles contribute to the formation of the floor of the oral cavity and are called the diaphragm of the mouth.

Action: when the mandible is fixed the muscle pulls the hyoid bone upwards and forwards; when the hyoid bone is fixed the muscle helps to lower the mandible.

Blood supply: the sublingual and submental arteries.

Innervation: the mylohyoid nerve from the trigeminal nerve.

4. The **geniohyoid muscle** *(musculus geniohyoideus)* (see Fig. 278) arises from the spina mentalis of the mandible, passes downwards and slightly to the back above the mylohyoid muscle, and is inserted into the anterior surface of the body of the hyoid bone.

Action: pulls the hyoid bone forwards and upwards; when the hyoid bone is fixed the muscle takes part in lowering the mandible.

Blood supply: the sublingual and submental arteries.

Innervation: the hypoglossal nerve and first and second pairs of cervical nerves (C_1-C_2).

THE INFRAHYOID MUSCLES

1. The **sternohyoid muscle** *(musculus sternohyoideus)* (Figs 275-278, 281) is thin and flat and arises from the posterior surface of the clavicle, the capsule of the sternoclavicular joint, and the manubrium sterni. Stretching upwards it reaches the body of the hyoid bone into which it is inserted below the mylohyoid muscle. Between the muscle and the bone are located here the **retrohyoid bursa** *(bursa retrohyoidea)* and the **infrahyoid bursa** *(bursa infrahyoidea)*. Sometimes the muscle is crossed by one or two **tendinous intersections** *(intersectiones tendineae)*.

Action: pulls the hyoid bone downwards.

Innervation: superior branch of the ansa cervicalis [C_1-C_3(C_4)].

2. The **sternothyroid muscle** *(musculus sternothyroideus)* (Figs 277, 281) is flat and lies behind the sternohyoid muscle. It takes origin from the posterior surface of the first costal cartilage and manubrium sterni, and is directed upwards to be inserted into the oblique line of the thyroid cartilage.

Action: pulls the larynx downwards.

Innervation: superior branch of ansa cervicalis [C_1-C_3(C_4)].

3. The **thyrohyoid muscle** *(musculus thyrohyoideus)* (Figs 276-278) seems to be a continuation of the sternothyroid muscle. It arises from the oblique line of the thyroid cartilage, passes upwards, and is inserted into the edge of the greater horns of the hyoid bone.

Action: pulls the hyoid bone closer to the larynx; raises the larynx when the hyoid bone is fixed.

Innervation: thyrohyoid branch of the ansa cervicalis (C_1-C_2).

4. The **levator glandulae thyroideae muscle** *(musculus levator glandulae thyroideae)* is a thin muscular slip stretching on the medial border of the thyrohyoid muscle from the body of the hyoid bone or the thyroid cartilage to the capsule of the thyroid gland (in the region of its isthmus or the lateral or the pyramidal lobe).

This muscular slip can separate from the thyrohyoid or cricothyroid muscle or from the inferior constrictor muscle of the pharynx.

Action: pulls the capsule together with the thyroid upwards.

5. The **omohyoid muscle** *(musculus omohyoideus)* (Figs 257-278, 281) is long and flat. It has two bellies, superior and inferior, which are joined by an intermediate tendon approximately in the middle of the length of the muscle.

The **superior belly** *(venter superior)* arises from the lower border of the body of the hyoid bone lateral to the insertion of the sternohyoid muscle and passes downwards along the lateral border of this muscle. It then deviates to the back, lies behind the sternocleidomastoid muscle and is continuous here with the intermediate tendon which fuses with the fascial sheath of the cervical neurovascular bundle.

The **inferior belly** *(venter inferior)* arises from the intermediate tendon, comes out from under the lateral border of the sternocleidomastoid muscle, stretches backwards and slightly downwards, and reaches the suprascapular notch to be inserted into the superior border of the scapula and the suprascapular ligament.

Action: when the scapula is fixed the muscle pulls the hyoid bone downwards and laterally and also pulls at the sheath of the cervical neurovascular bundle thus dilating the lumen of the internal jugular vein.

Blood supply: all muscles which are situated below the hyoid bone are supplied with blood by the inferior thyroid, superficial cervical, and transverse cervical arteries.

Innervation: superior branch of the ansa cervicalis (C_1-C_3).

DEEP MUSCLES OF THE NECK

THE LATERAL GROUP

1. The **scalenus anterior muscle** *(musculus scalenus anterior)* (Figs 276, 277, 279) arises from the anterior tubercles of the third, fourth, fifth, and sixth cervical vertebrae and stretches downwards and to the front to be inserted into the scalene tubercle of the first rib.

Action: when the vertebral column is fixed the muscle pulls the first rib upwards; with the chest fixed contraction of the muscle on one side flexes the cervical spine to the same side, bilateral contraction flexes it forward.

Blood supply: the ascending cervical and inferior thyroid arteries.

Innervation: the cervical nerves (C_5-C_7).

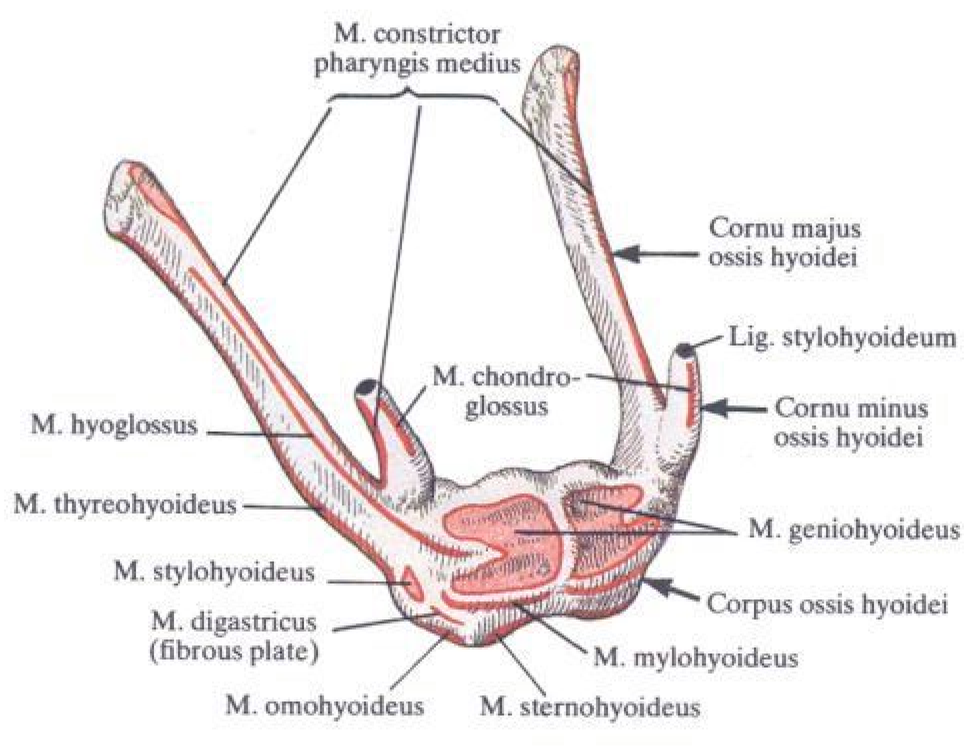
2. The **scalenus medius muscle** *(musculus scalenus medius)* (Figs 276, 277, 279) takes origin from the anterior tubercles of the upper six cervical vertebrae, passes downwards behind the scalenus anterior muscle, and is inserted into the superior surface of the first rib behind the groove for the subclavian artery. Above this groove, between the scalenus anterior and medius muscles, is a triangular **interscalenus space** *(spatium interscalenum)* lodging the subclavian artery and the nerves of the branchial plexus.

Action: with the vertebral column fixed the muscle raises the first rib; when the chest is fixed it flexes the cervical spine forwards.

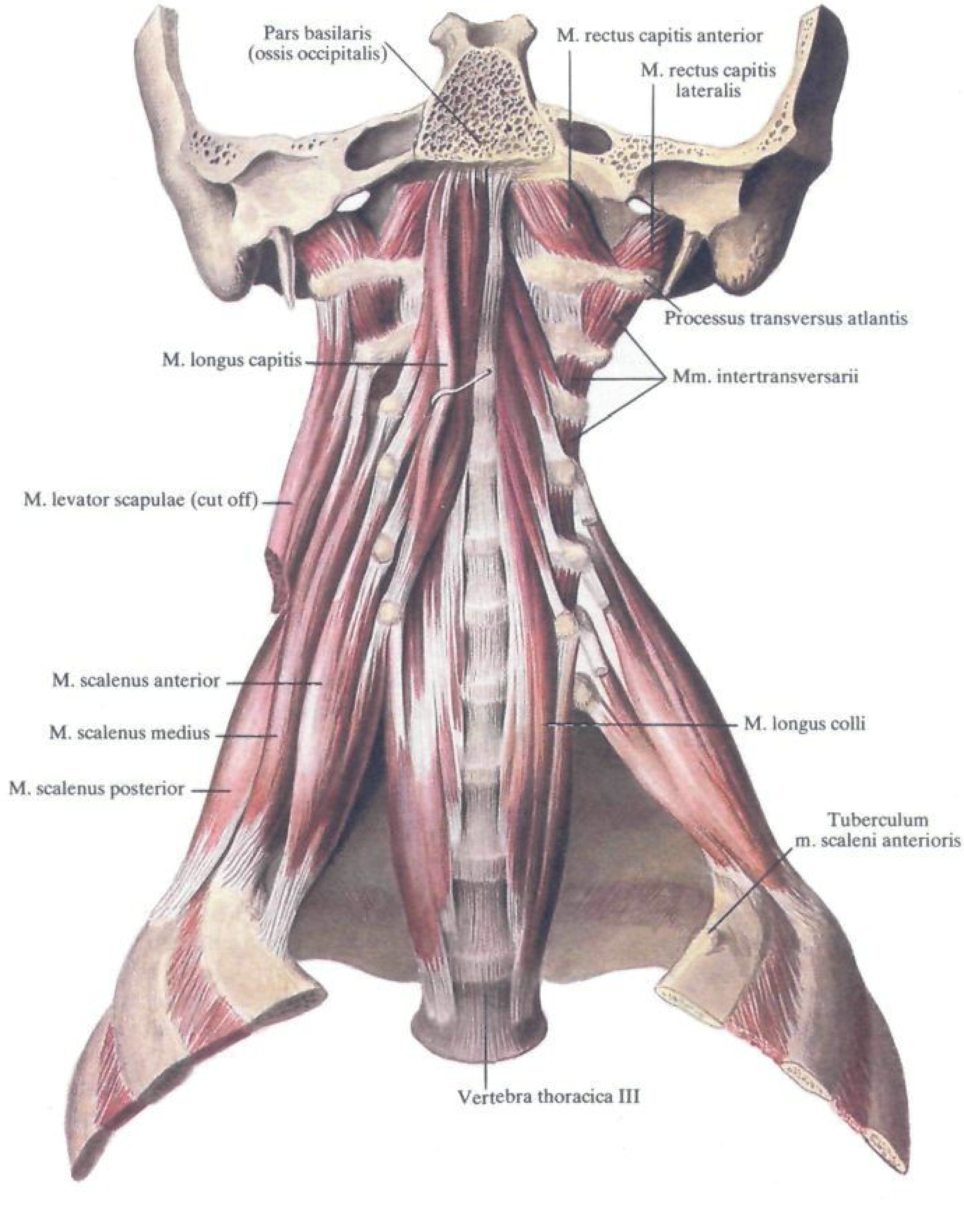
Blood supply: the vertebral and deep cervical arteries.

Innervation: the cervical nerves (C_5-C_8).

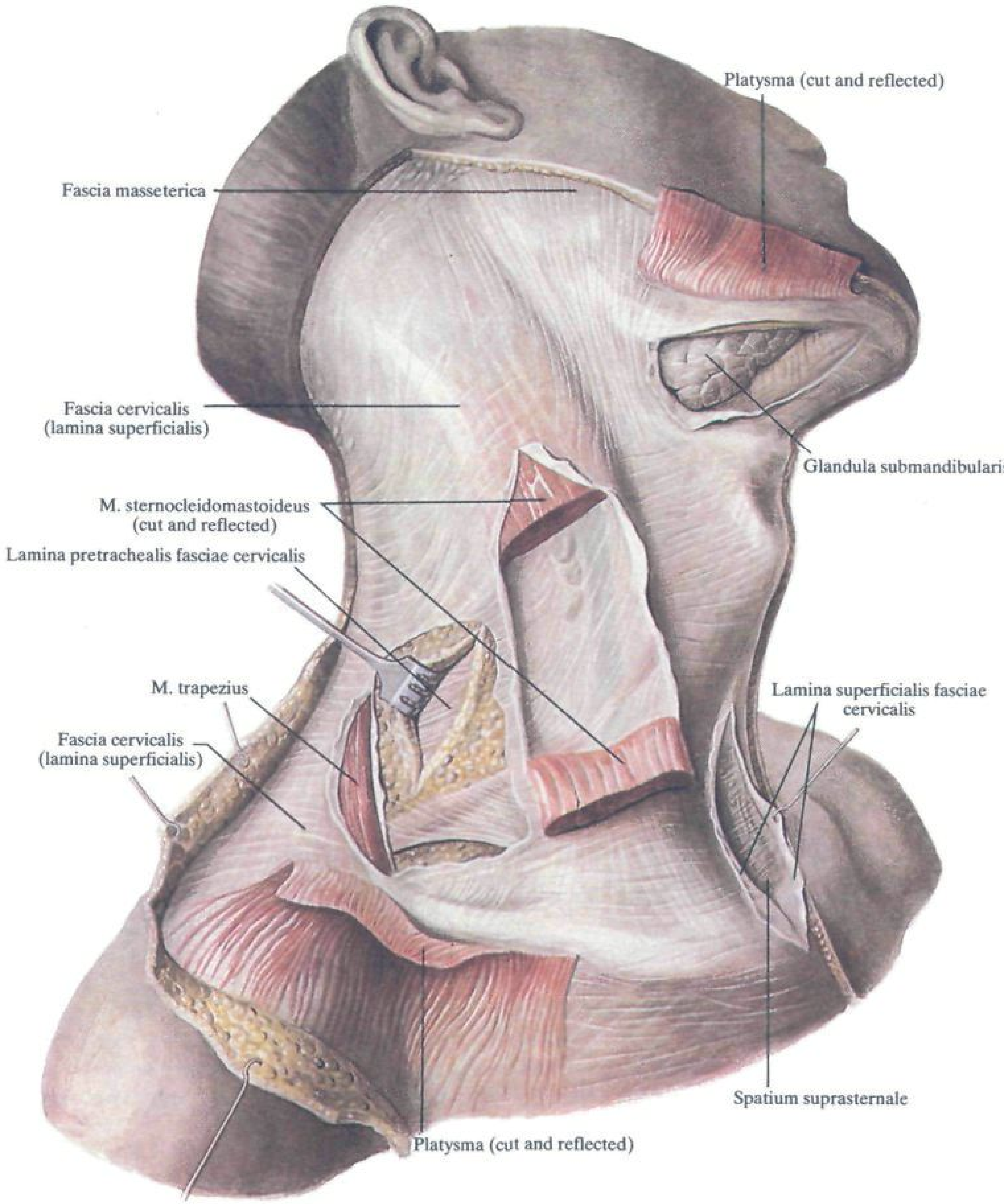
3. The **scalenus posterior muscle** *(musculus scalenus posterior)*



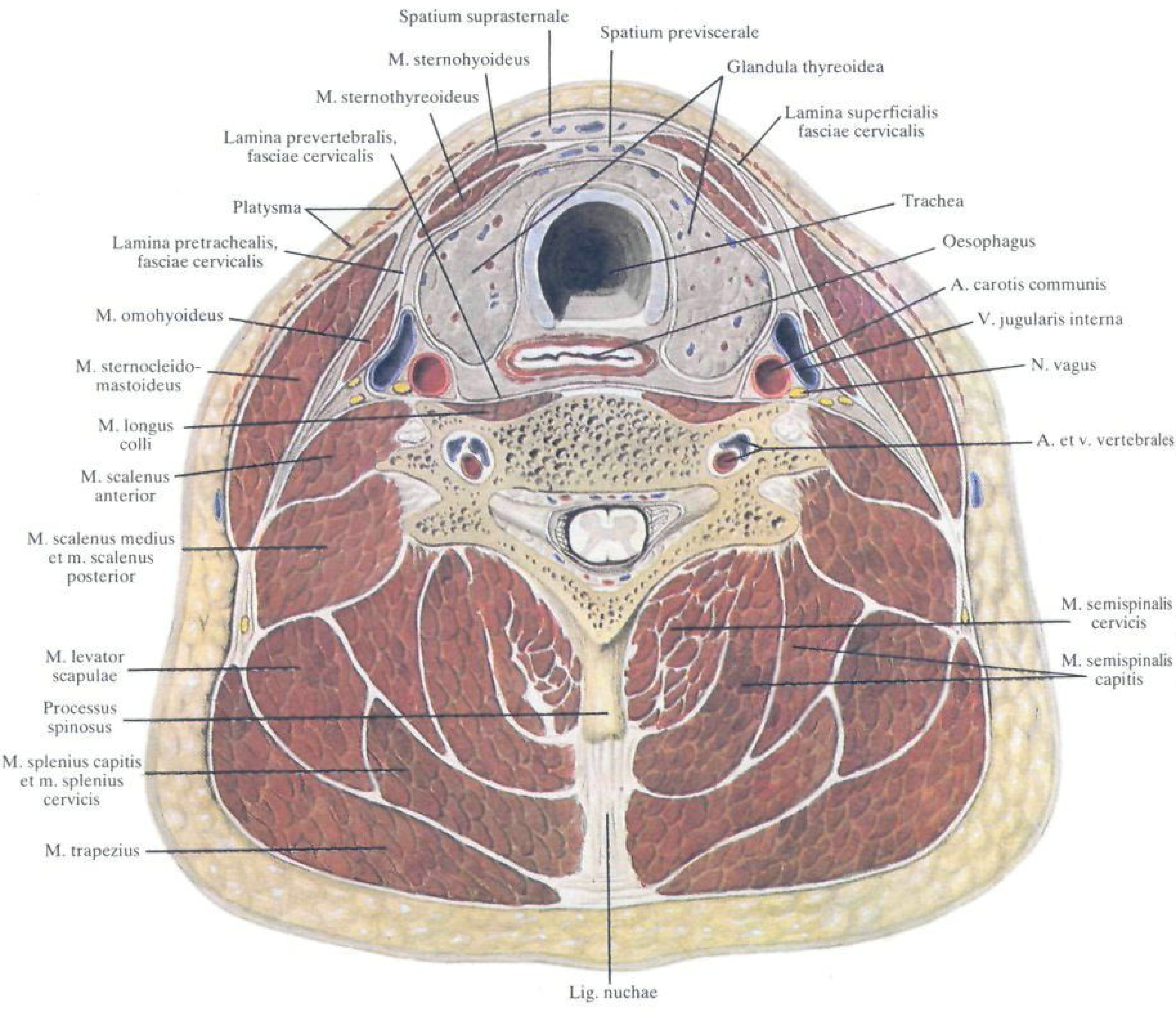
278. *Sites of origin and insertion of muscles on the hyoid bone* (schematical representation).



279. *Deep muscles of the neck*; anterior aspect (½).



280. *Fasciae of the neck*; right side (½).



281. *Muscles and fasciae of the neck* (3/4).

(Horizontal section of the neck through the seventh cervical vertebra.)

(Figs 276, 277, 279) takes origin from the posterior tubercles of the fifth and sixth (sometimes from the prominens) cervical vertebrae, stretches downwards behind the scalenus medius muscle, and is inserted into the external surface of the second rib.

Action: raises the second rib when the vertebral column is fixed; when the chest is fixed contraction of the muscle on both sides flexes forward the cervical spine.

Blood supply: the deep and transverse cervical arteries, first intercostal artery.

Innervation: the cervical nerves (C_7–C_8).

THE PREVERTEBRAL GROUP

1. The **longus capitis muscle** *(musculus longus capitis)* (Fig. 279) arises from the anterior tubercles of the third, fourth, fifth, and sixth cervical vertebrae and runs upwards to be inserted into the inferior surface of the basilar part of the occipital bone slightly behind the pharyngeal tubercle.

Action: flexes forward the head and cervical spine.

Innervation: the cervical nerves (C_1–C_8).

2. The **longus cervicis muscle** *(musculus longus colli)* (Figs 279, 281) occupies the anterolateral surface of all the cervical and the first, second, third, and fourth thoracic vertebrae. The middle parts of the muscle are slightly wider. The muscle fibres differ in length in view of which three parts are distinguished in the muscle:

(a) the mediovertical part takes origin from the bodies of the fifth, sixth, seventh cervical and first, second, and third thoracic vertebrae and stretches upwards and medially to be inserted into the anterior surface of the bodies of the third and second cervical vertebrae and the anterior tubercle of the atlas;

(b) the superior oblique part extends from the anterior tubercles of the transverse processes of the second, third, fourth, and fifth cervical vertebrae to the body of the second cervical vertebra and the anterior tubercle of the atlas;

(c) the inferior oblique part arises from the bodies of the upper three thoracic vertebrae and is directed upwards and laterally to be inserted into the anterior tubercles of the transverse processes of the lower three cervical vertebrae (fifth, sixth, and seventh).

Action: flexes the cervical spine forwards and to the side of the contracting muscle.

Blood supply of both muscles: the vertebral and the ascending and deep cervical arteries.

Innervation: the cervical nerves (C_2–C_6).

3. The **rectus capitis anterior muscle** *(musculus rectus capitis anterior)* (Fig. 279) is short and takes origin from the anterior surface of the transverse process and lateral mass of the atlas, passes upwards, and is inserted into the inferior surface of the basilar part of the occipital bone in front of the foramen magnum.

Action: flexes the head to the side of the contracting muscle; bilateral contraction flexes the head forwards.

Blood supply: the vertebral and ascending pharyngeal arteries.

Innervation: the cervical nerves (C_1–C_2).

4. The **rectus capitis lateralis muscle** *(musculus rectus capitis lateralis)* (Fig. 279) is square in shape. It arises from the anterior periphery of the transverse process of the atlas and is directed upwards and laterally to be inserted into the jugular process of the occipital bone.

Action: flexion of the head to the side of the contracting muscle; contraction of both muscles flexes the head forwards.

Blood supply: the vertebral and occipital arteries.

Innervation: the cervical nerves (C_1–C_2).

TRIANGLES OF THE NECK

The two sternocleidomastoid muscles divide the **anterior region of the neck** *(regio colli anterior)* into three triangles, one anterior and two lateral (Fig. 282).

To the side of the midline each half of the neck is divided by the sternocleidomastoid into two triangles, medial and lateral.

The medial triangle is bounded by the inferior border of the mandible, the midline of the neck, and the anterior border of the sternocleidomastoid muscle. In this manner the right and left medial triangles form together one anterior triangle of the neck.

The lateral triangle of the neck is bounded by the posterior border of the sternocleidomastoid muscle, the clavicle, and the border of the trapezius muscle.

Each of these triangles is divided by the muscles of the neck into some smaller triangles.

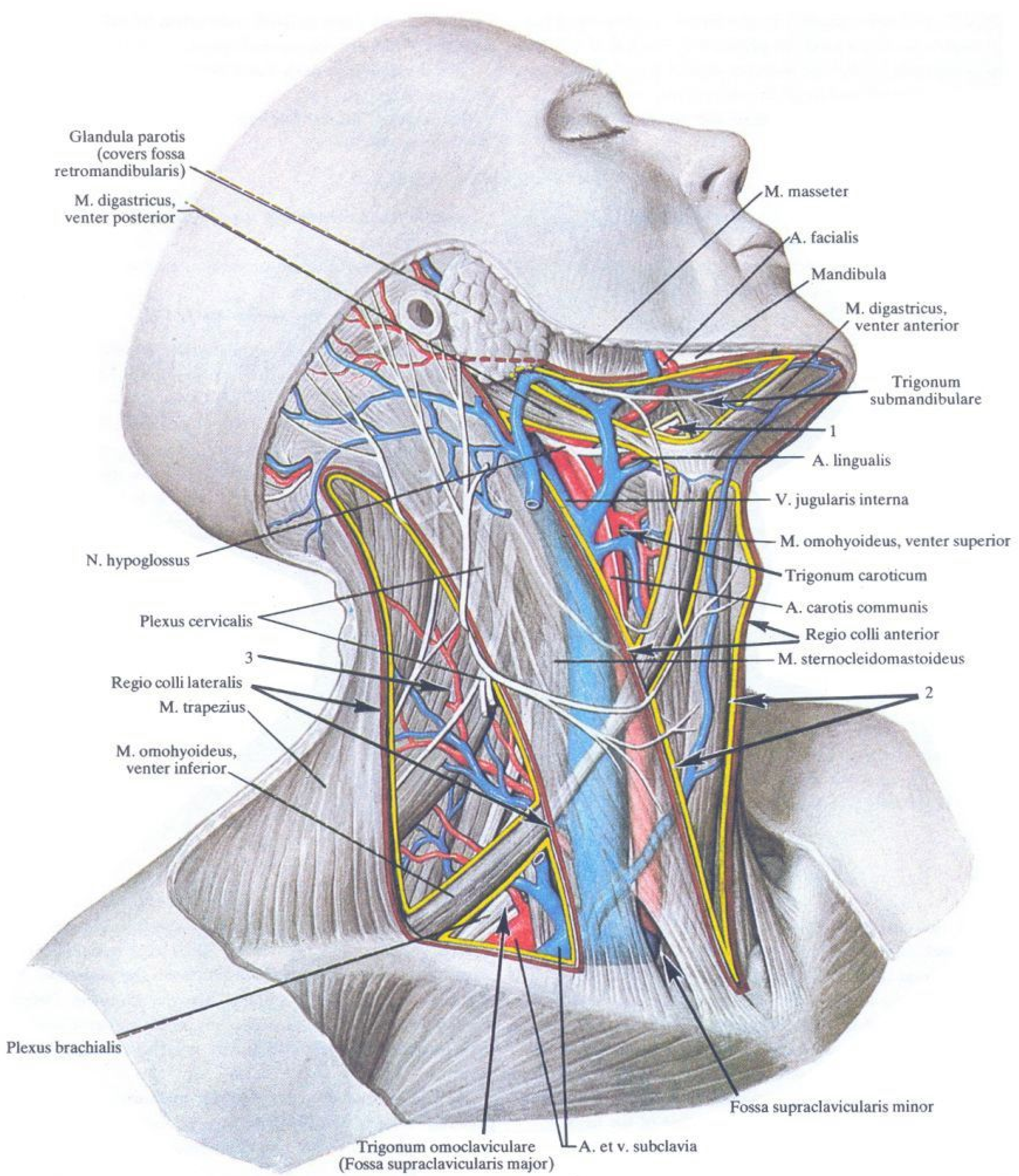
The digastric muscle and the superior belly of the omohyoid muscle divide the medial triangle into the submaxillary and carotid triangles.

1. The **submaxillary (submandibular) triangle** *(trigonum submandibulare)* is bounded by the anterior and posterior bellies of the digastric muscle and the inferior border of the mandible. A small **trigonum linguale** or Pirogoff's triangle *(trigonum Pirogowi)* is marked out in it by the posterior border of the myohyoid muscle, the posterior belly of the digastric muscle, and the hypoglossal nerve.

2. The **carotid triangle** *(trigonum caroticum)* is limited by the posterior belly of the digastric muscle, the superior belly of the omohyoid muscle, and the anterior border of the sternocleidomastoid muscle.

The lateral triangle includes the omoclavicular triangle.

3. The **omoclavicular triangle** *(trigonum omoclaviculare)* is bounded by the posterior border of the sternocleidomastoid muscle, the clavicle, and the inferior belly of the omohyoid muscle; it corresponds to the greater supraclavicular fossa.



282. *Triangles of the neck* (semischematical representation).

Arrows indicate the triangles. The triangles are outlined brown and yellow; the relation of the trunks of the main nerves and blood vessels to the triangles is shown.

1—Pirogoff's triangle
2—omotracheal triangle
3—omotrapezium triangle

FASCIAE OF THE NECK

The **cervical fascia** *(fascia cervicalis)* is composed of the following three layers: the **superficial layer** *(lamina superficialis)* investing, like a sock, all the cervical muscles and the submandibular gland; the **pretracheal fascia** *(lamina pretrachealis)* forming a sheath for the infrahyoid group of muscles and investing the neurovascular bundles and some of the organs of the neck; the **prevertebral fascia** *(lamina prevertebralis)* forming a sheath for the prevertebral group of muscles.

1. The anterior part of the **superficial layer** of the cervical fascia *(lamina superficialis)* is a continuation of the fascia proper of the chest and neck. The lower part of the fascia is attached to the anterior border of the clavicle and the manubrium sterni. Ascending, it splits to form a sheath for the sternocleidomastoid muscles and on reaching the hyoid bone it is attached here and then invests the suprahyoid group of the cervical muscles. Having formed the sheath for these muscles and for the submandibular gland, the superficial layer passes over to the face where it is continuous with the **masseteric** and **parotid fasciae** *(fascia masseterica* et *fascia parotidea)*.

At the back of the neck the superficial layer is continuous with the fascia proper of the shoulder and back. It splits at the lateral margin of the trapezius muscle to invest this muscle, and is attached to the ligamentum nuchae and reaches the superior nuchal line and the external occipital protuberance.

2. The **pretracheal fascia** *(lamina pretrachealis)* arises from the posterior surface of the clavicles and the manubrium sterni and ascends to form a sheath for the thyroid gland and the group of infrahyoid muscles. The upper parts of this fascia blend with the superficial layer at the level of the hyoid bone, the lateral parts give off processes to the organs of the neck (the larynx, trachea, pharynx, oesophagus) and also form a sheath for the neurovascular bundle of the neck (for the internal jugular vein, the common carotid artery, and the vagus nerve), which is called the carotid sheath. The pretracheal fascia blends with the superficial layer at the posterior border of the sternocleidomastoid muscle. An area of the pretracheal fascia between the two omohyoid muscles which is limited above by the hyoid bone and below by the clavicles and manubrium sterni is dense and forms the omoclavicular aponeurosis.

3. The **prevertebral fascia** *(lamina prevertebralis)* arises from the base of the skull and descends to cover the group of prevertebral muscles. Its lateral parts blend with the costal processes of the cervical vertebrae. As a result the prevertebral fascia with the cervical vertebrae form an osteofibrous sheath for the prevertebral muscles. Approximately at the level of the third thoracic vertebra the lower parts of the fascia are continuous with the **endothoracic fascia** *(fascia endothoracica)*. On the periphery the fascia passes over to the scalenus muscles.

Spaces filled with loose fatty tissue form between the fasciae of the neck and between the fasciae and the viscera.

1. The **suprasternal interaponeurotic space** *(spatium interaponeuroticum suprasternale)* is above the jugular notch of the manubrium sterni, between the superficial layer and pretracheal fascia.

This space is continuous with the right and left lateral recesses behind the sternocleidomastoid muscle.

2. The **previsceral space** *(spatium previscerale)* is between the pretracheal fascia and the viscera of the neck.

3. The **retrovisceral space** *(spatium retroviscerale)* forms between the prevertebral fascia and the viscera of the neck.

MUSCLES AND FASCIAE OF THE CHEST

REGIONS OF THE CHEST

The anterolateral thoracic wall is composed of the following regions *(regiones pectorales)* (Fig. 285).

1. The **pectoral region** *(regio pectoralis)* (the **region of the mammary gland,** or *regio mammaria*) is limited by the inferior border of the pectoralis major muscle, superiorly it borders on the infraclavicular fossa. This region is also called the anterosuperior region of the chest.

2. The **presternal region** *(regio presternalis)* occupies an extreme medial position stretching from the anterior median line to the parasternal line. It is also called the anterior median region of the chest.

3. The **axillary region** *(regio axillaris)* includes the **axillary fossa** *(fossa axillaris)* (see *Muscles of the Upper Limb. The Axillary fossa*).

4. The **inframammary region** *(regio inframammaria)* occupies the lower part of the pectoral region and borders upon **hypochondriac region** *(regio hypochondriaca).* It is also the inferior part of the pectoral region.

The following vertical lines are marked on the thoracic wall (see Vol. II. *Respiratory Apparatus*).

1. The **anterior median line** *(linea mediana anterior)* runs on the middle of the sternum.

2. The **sternal line** *(linea sternalis)* corresponds to the lateral border of the sternum.

3. The **parasternal line** *(linea parasternalis)* runs midway between the sternum and the medioclavicular line.

4. The **medioclavicular line** *(linea mamillaris* s. *medioclavicularis)* runs through the middle of the clavicle. It is also called the **mamillary line** *(linea mamillaris)* but the variable position of the mammary gland makes the name inaccurate.

5. The **anterior axillary line** *(linea axillaris anterior)* corresponds to the **anterior axillary fold** *(plica axillaris anterior)* which is projected along the superolateral border of the pectoralis major and pectoralis minor muscles.

6. The **posterior axillary line** *(linea axillaris posterior)* corresponds to the **posterior axillary fold** *(plica axillaris posterior)* formed by the anterior borders of the teres major and latissimus dorsi muscles.

7. The **middle axillary line** *(linea axillaris media)* passes between the anterior and posterior axillary lines.

8. The **scapular line** *(linea scapularis)* passes vertically through the inferior angle of the scapula

9. The **paravertebral line** *(linea paravertebralis)* is projected along the transverse vertebral processes.

10. The **posterior median line** *(linea mediana posterior)* runs on the midline of the back along the vertebral spinous processes.

Inspection and palpation of the chest determine the regions of the clavicles on the superior border and the right and left costal arches and the infrasternal angle on the inferior border. The angle of the scapula is also well palpated, it corresponds to the articulation of the second costal cartilage with the sternum. The nipple in males is usually in line with the fourth rib.

MUSCLES OF THE CHEST

The **muscles of the chest** *(musculi thoracis)* are separated into two groups, one is composed of superficial muscles (those related to the shoulder girdle) and the other is formed by deep muscles (muscles of the chest proper).

The superficial muscles are as follows.

1. The **pectoralis major muscle** *(musculus pectoralis major).*
2. The **pectoralis minor muscle** *(musculus pectoralis minor).*
3. The **subclavius muscle** *(musculus subclavius).*
4. The **serratus anterior muscle** *(musculus serratus anterior).*

The following are the deep muscles.

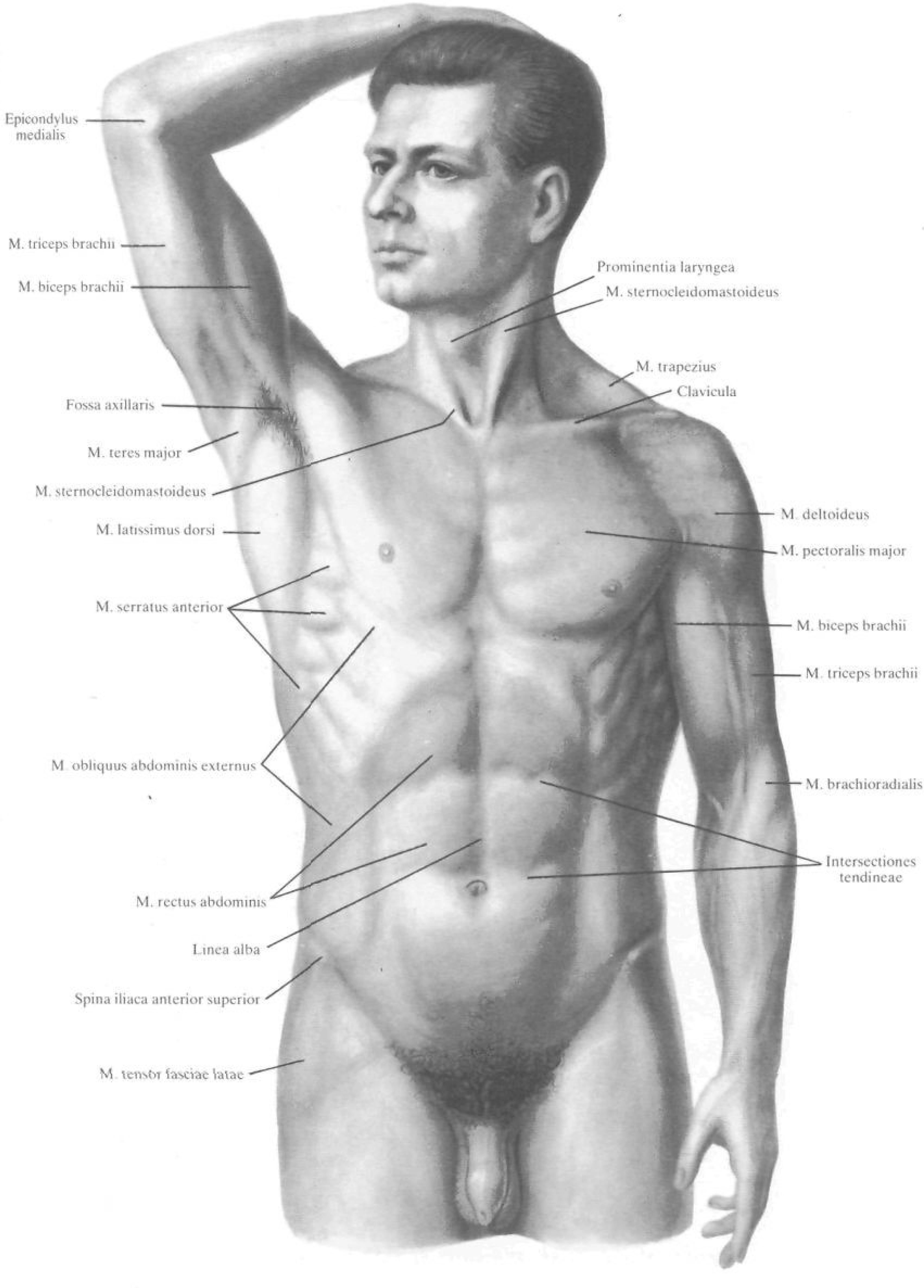
1. The **external intercostal muscles** *(musculi intercostales externi).*
2. The **internal intercostal muscles** *(musculi intercostalis interni).*
3. The **intercostales intimi muscles** *(musculi intercostales intimi).*
4. The **subcostal muscles** *(musculi subcostales).*
5. The **transversus thoracis muscle** *(musculus transversus thoracis).*

The musculotendinous sheet separating the thoracic and abdominal cavities and which is called the **diaphragm** *(diaphragma)* is also related to the chest muscles.

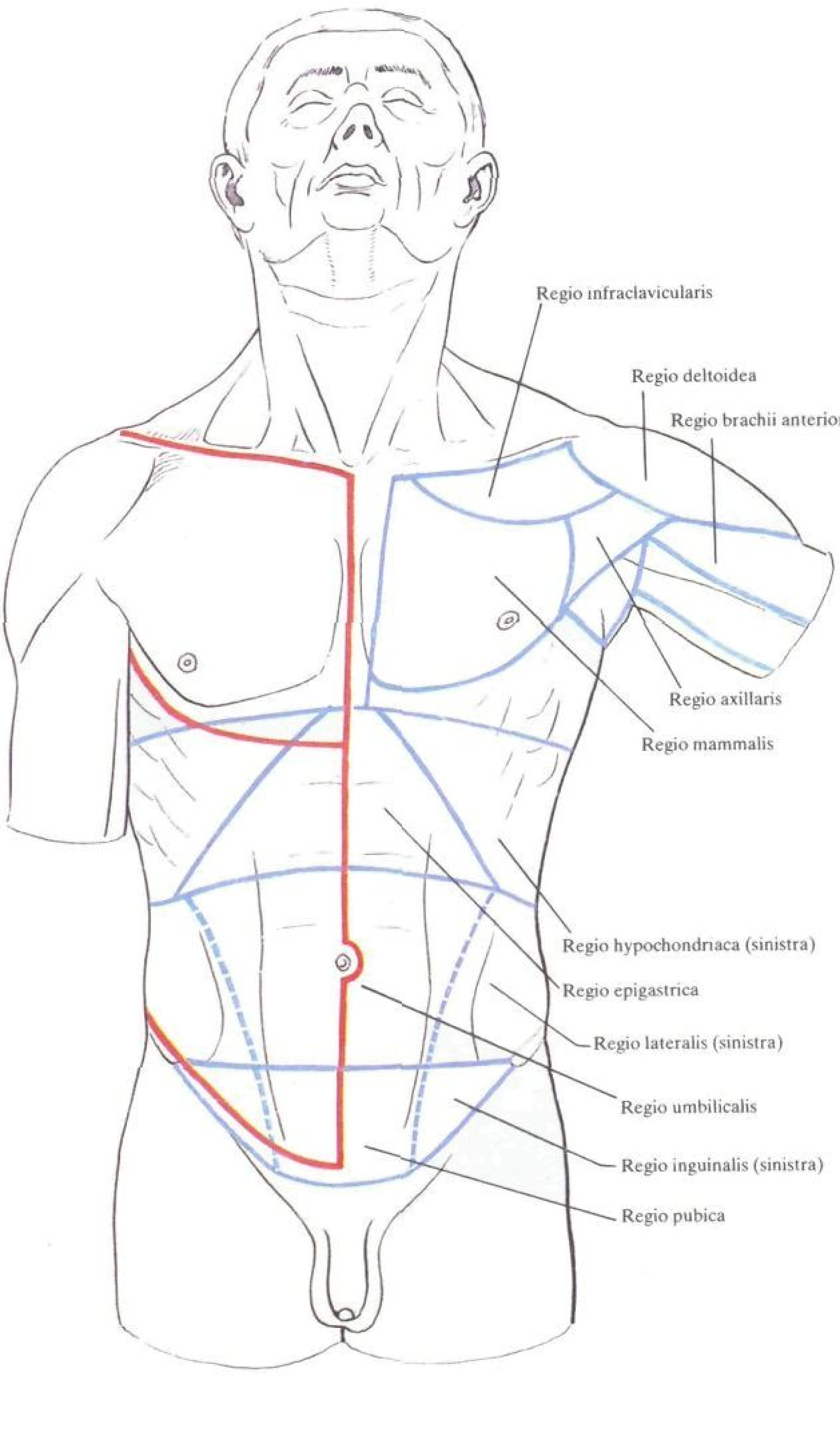
SUPERFICIAL MUSCLES OF THE CHEST

1. The **pectoralis major muscle** *(musculus pectoralis major)* (Figs 283, 285-287, 290, 292) is a wide paired muscle located in the anterosuperior parts of the thoracic wall.

The superolateral border of the muscle meets the anterior border of the deltoid muscle to form the deltoideopectoral groove which is continuous upwards with the infraclavicular fossa. The inferolateral border of the pectoralis major muscle is sometimes clearly outlined under the skin. The muscle arises on the medial half of the clavicle (the **clavicular part,** or *pars clavicularis*), the anterior surface of the sternum and second to seventh costal carti-

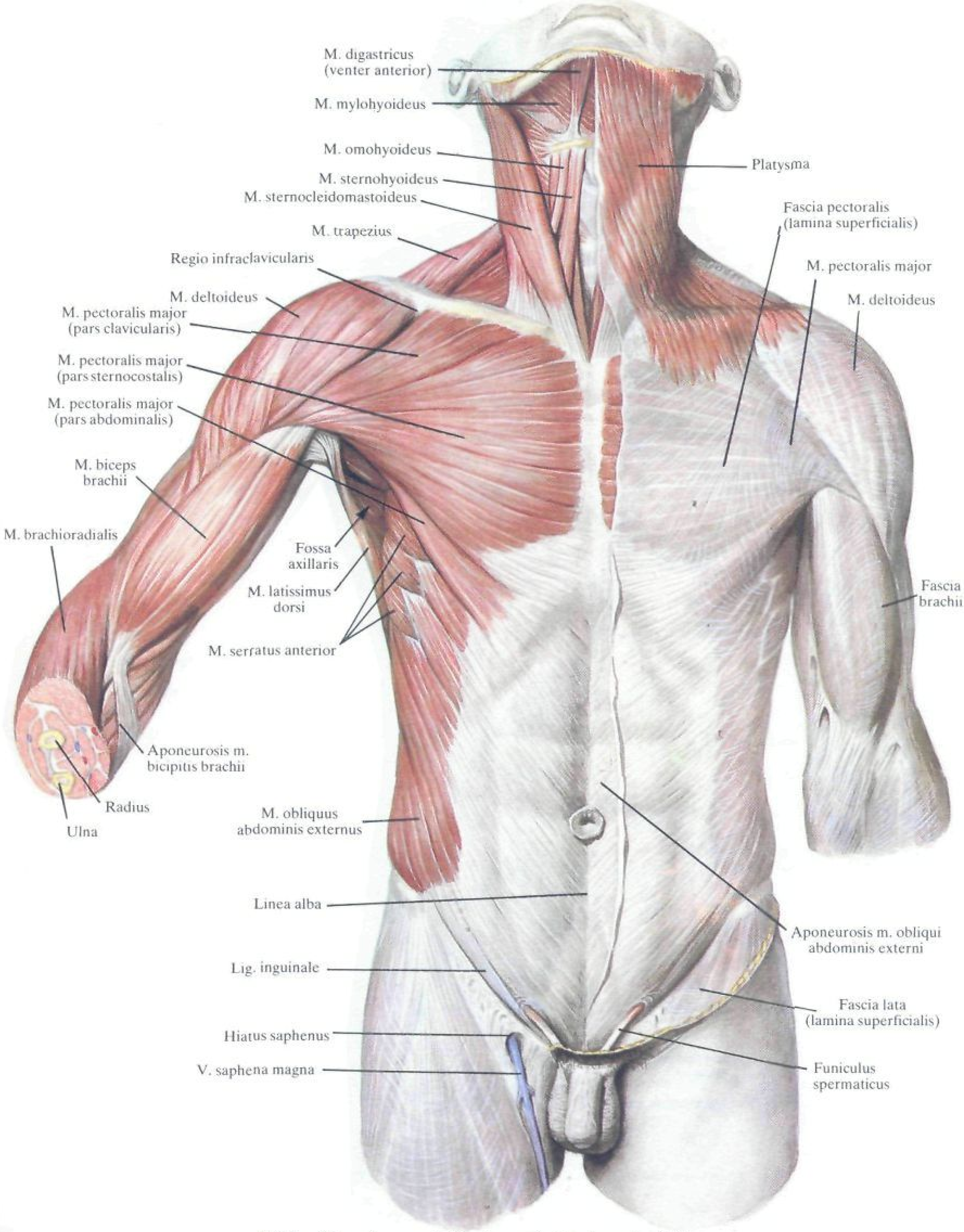


283. *Outlines of trunk muscles* (anterior aspect).

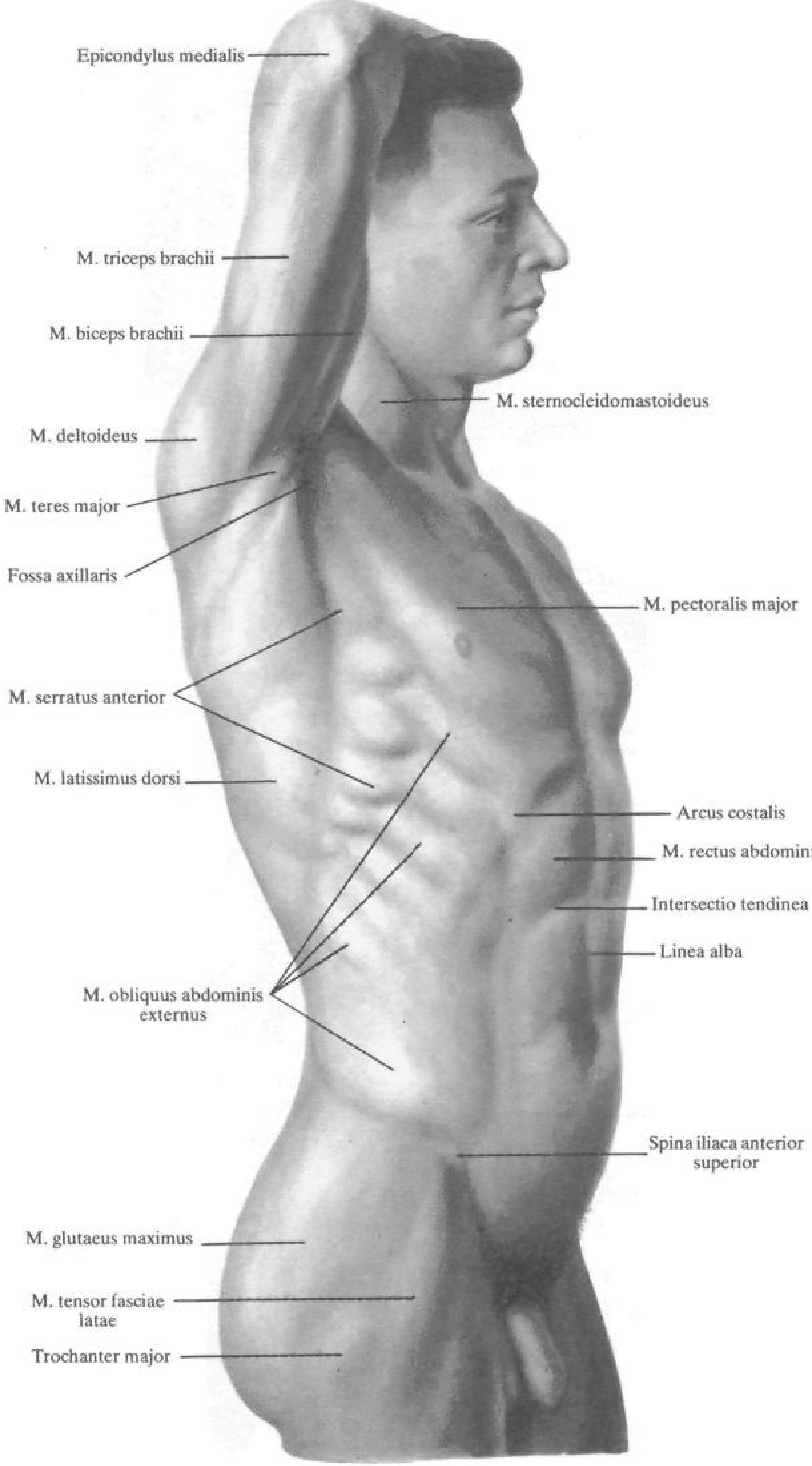


284. *Regions of the trunk and lines of skin incisions.*

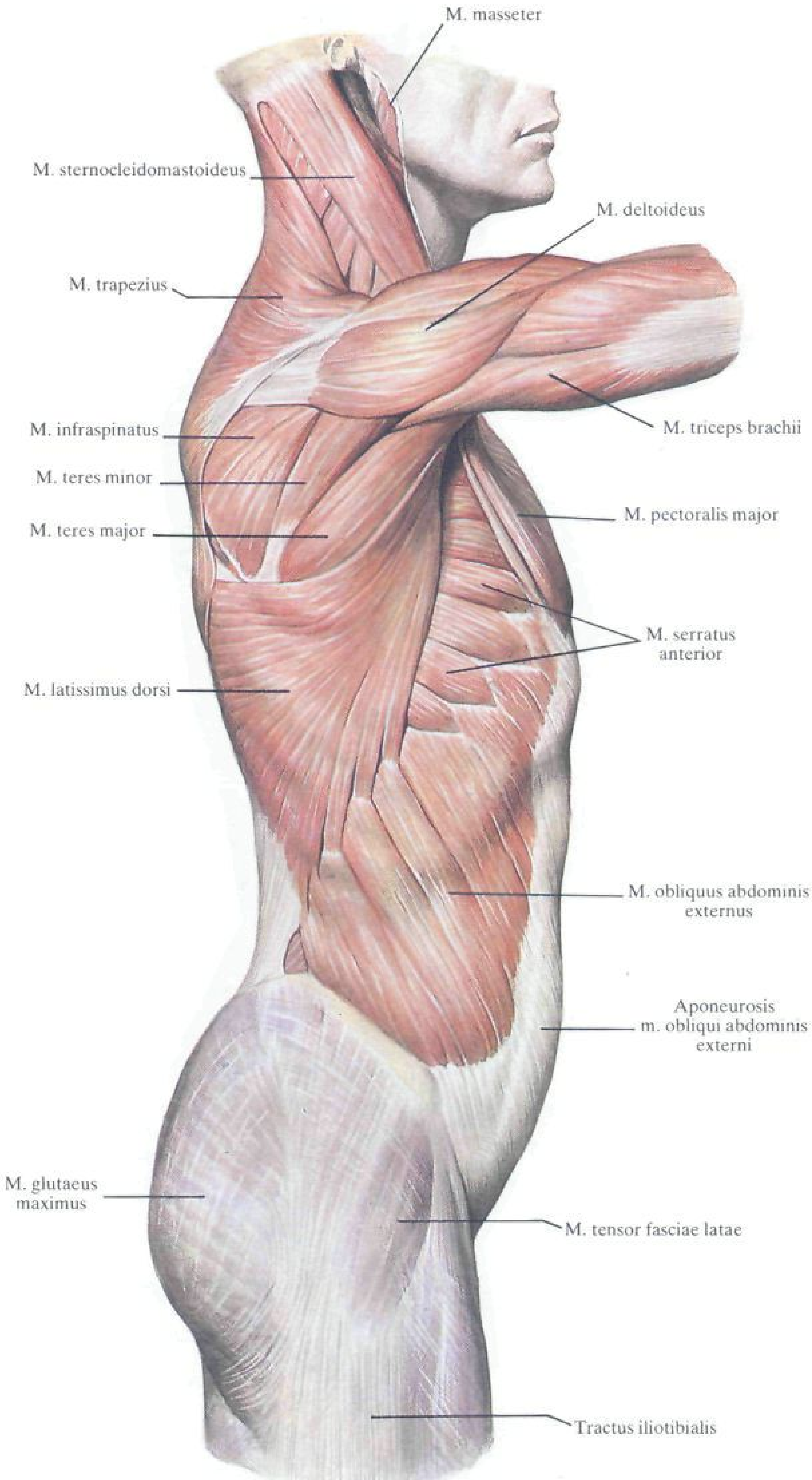
(Blue line—boundaries of regions; red line—skin incisions most suitable for exposing muscles in dissection.)



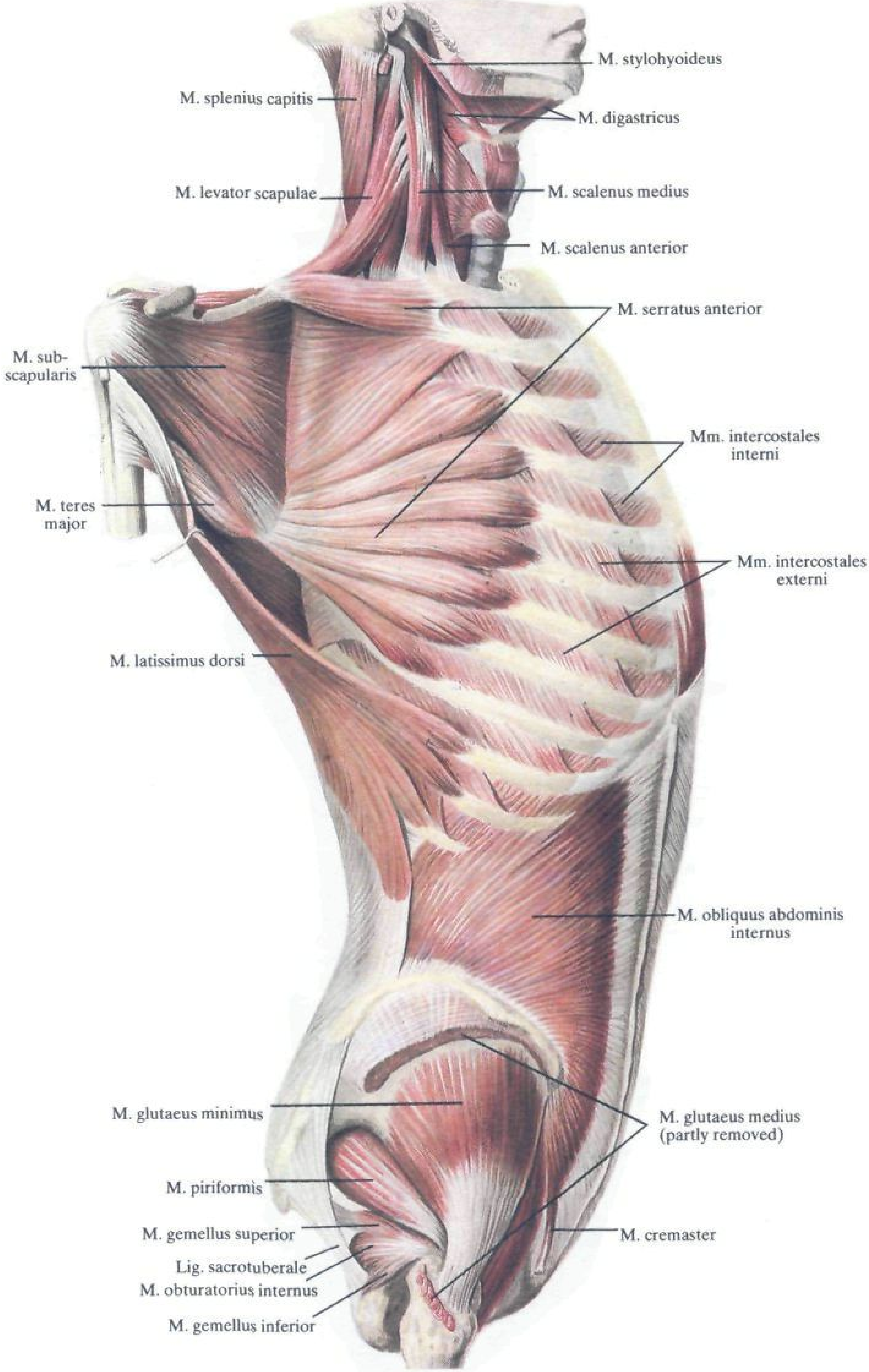
285. *Muscles and fasciae of the trunk* ($^1/_5$).
(Superficial muscles of neck, chest, and abdomen.)



286. *Outlines of the trunk muscles* (lateral aspect).

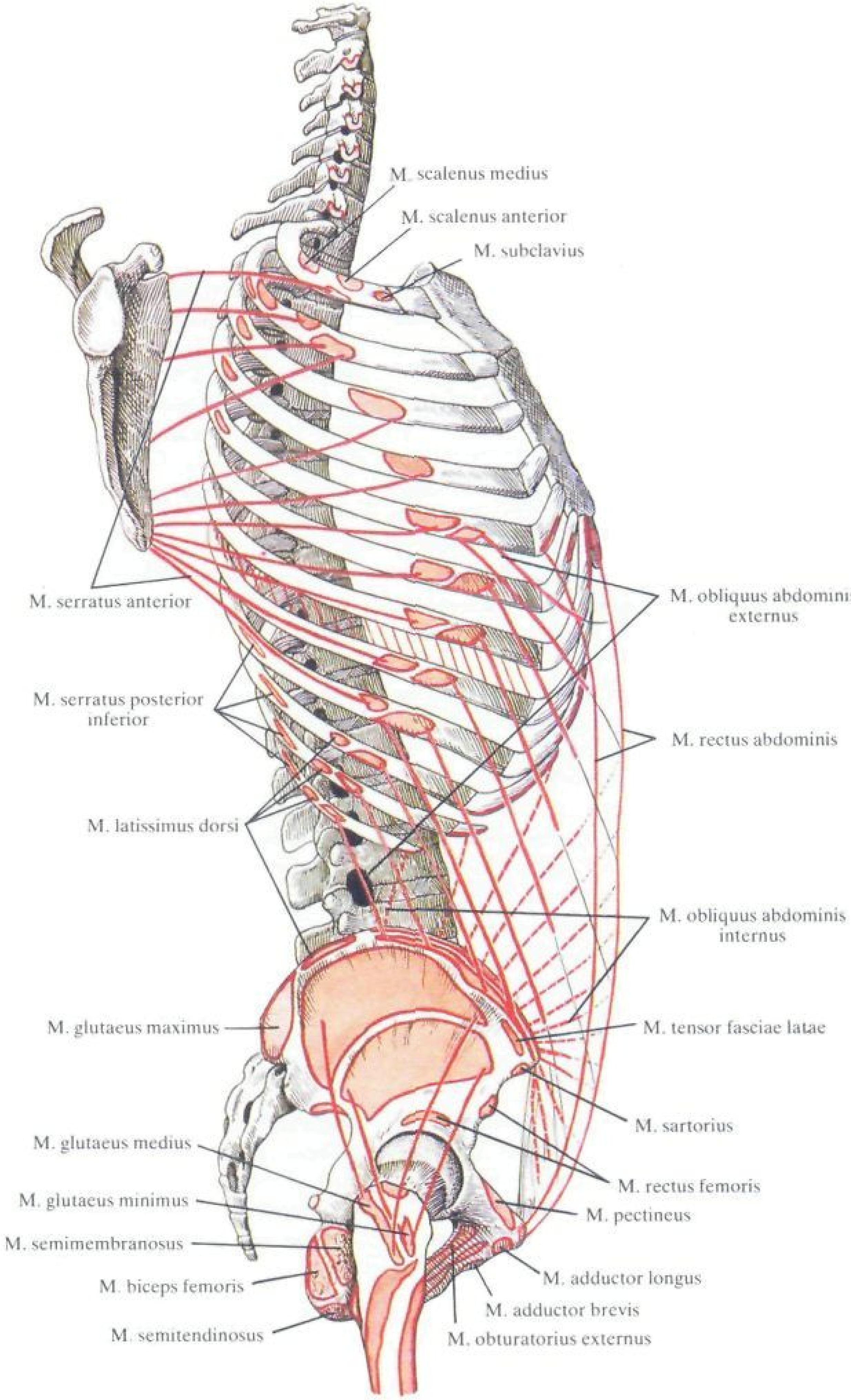


287. *Superficial muscles of the trunk*; right side ($^1/_5$).



288. *Muscles of the trunk*; right side ($^1/_5$).

(The scapula is pulled backwards. The pectoralis major and minor muscles and the internal oblique muscle of the abdomen are removed.)



289. *Sites of origin and insertion of the trunk muscles* (schematical representation).

lages (the **sternocostal part**, or *pars sternocostalis*), and the anterior wall of the sheath of the rectus abdominis muscle (the **abdominal part**, or *pars abdominalis*).

Passing laterally and upwards, the fibres of the muscles converge in such a manner that those of the lower part of the muscle lie behind the fibres of the upper part as a result of which the muscle is much thicker here. This narrowed, but thicker part of the muscle passes over to the humerus and thus forms the anterior wall of the axillary fossa, and is continuous with a tendon which is inserted into the lateral lip of the bicipital groove, the lower fibres being attached at a higher and the upper fibres at a lower level.

Action: draws the arm to the trunk and rotates it medially (pronation); when the limb is held horizontally the muscle pulls it to a sagittal position (anteversion); when the arm is fixed the sternocostal part of the muscle assists in expanding the thoracic cage during respiration.

Blood supply: the acromiothoracic, lateral and superior thoracic, and intercostal arteries.

Innervation: medial and lateral pectoral nerves (C_5-Th_1).

2. The **pectoralis minor muscle** *(musculus pectoralis minor)* (Figs 291, 292) is flat, triangular, and located in the second layer being covered by the pectoralis major muscle. It arises from the second, third, fourth and fifth ribs near to the junction of their cartilaginous and bony parts. Running upwards and laterally the fibres of the muscle converge to be inserted by a short tendon into the coracoid process of the scapula.

Action: pulls the scapula forwards and downwards; when the scapula is fixed raises the ribs being thus an auxiliary muscle of respiration.

Blood supply: the acromiothoracic, intercostal and superior thoracic arteries.

Innervation: the medial and lateral pectoral nerves (C_7-Th_1).

3. The **subclavius muscle** *(musculus subclavius)* (Figs 291, 294) is small and elongated and lies below and almost parallel to the clavicle. It is covered by the pectoralis major muscle. The subclavius muscle takes origin from the bony and cartilaginous parts of the first rib and is directed laterally and upwards to be inserted into the inferior surface of the acromial part of the clavicle.

Action: pulls the clavicle downwards and medially and in this manner holds it fast in the sternoclavicular joint; when the shoulder girdle is fixed the muscle raises the first rib and thus acts as an auxiliary muscle of respiration.

Blood supply: the transverse scapular (suprascapular) and acromiothoracic arteries.

Innervation: the subclavian nerve (C_5).

4. The **serratus anterior muscle** *(musculus serratus anterior)* (Figs 285, 287-291) is flat and wide and situated on the anterolateral part of the thoracic wall. Its upper part is under the pectoralis major muscle, while the lower part lies superficially and is covered by the pectoral fascia. The muscle arises by eight or nine slips from the external surface of the upper eight or nine ribs and from the tendinous arch between the first and second ribs. Passing upwards and backwards it covers the outer surface of the ribs and runs under the scapula to be inserted into its medial border and inferior angle. Fibres which are inserted into the inferior angle of the scapula are developed best.

Action: pulls the scapula away from the vertebral column; the inferior fibres, in addition, displace the inferior angle of the scapula laterally and cause its rotation about the sagittal axis. Together with the rhomboid muscle the serratus anterior muscle presses the scapula to the thoracic wall. When the shoulder girdle is fixed the serratus anterior muscle also acts as an auxiliary muscle of respiration (during inspiration).

Blood supply: the thoracodorsal, lateral thoracic, and intercostal arteries.

Innervation: nerve to the serratus anterior muscle (C_5-C_7).

DEEP (PROPER) MUSCLES OF THE CHEST

The intercostal muscles are short and flat and fill the intercostal spaces. External, internal, and intimi (innermost) intercostal muscles are distinguished.

1. The **external intercostal muscles** *(musculi intercostales externi)* (see Figs 258-260, 291) arise from the lower border of the rib lateral of the costal groove, run obliquely downwards and forewards, and are inserted into the upper border of the rib next below. The external intercostal muscles are absent in the region of the costal cartilages which is filled by the external **anterior intercostal membrane** *(membrana intercostalis externa)*. In the posterior parts of the thoracic wall they adjoin the levatores costarum muscles (see *Muscles of the Back*).

Action: participate in the act of respiration (inspiration).

Blood supply: the intercostal, internal mammary, and musculophrenic arteries.

Innervation: intercostal nerves (Th_1-Th_{11}).

2. The **internal intercostal muscles** *(musculi intercostales interni)* (see Figs 259, 260, 295) take origin from the upper border of the rib, pass obliquely upwards and forwards, and are inserted into the lower border of the rib next above medially of the costal groove. They are absent in the posterior part of the intercostal space to the back of the angle of the rib. This part is filled by the internal **posterior intercostal membrane** *(membrana intercostalis interna)*.

The sources of blood supply and innervation are the same as those for the external intercostal muscles.

3. The **intercostalis intimi muscles** *(musculi intercostales intimi)* are on the inner surface of the internal intercostal muscles and their fibres pass in the same direction and are inserted into the internal surface of adjacent ribs. These muscles fill half of the intercostal space and their posterior border touches the subcostal muscles.

Blood supply: the same as for the external intercostal muscles.

Innervation: intercostal nerves (Th_1-Th_{11}).

4. The **subcostal muscles** *(musculi subcostales)* (Fig. 298) lie on the internal surface of the lower ribs in the region of their posterior ends. They have the same sites of origin and direction of fibres as the internal intercostal muscles, but their fibres, in contrast, pass over one rib to the next above.

Action: the internal intercostal and subcostal muscles take part in the act of respiration (expiration).

Blood supply: the intercostal arteries.

Innervation: intercostal nerves (Th_1-Th_{11}).

5. The **transversus thoracis muscle** *(musculus transversus thoracis)* (Fig. 259) is flat, thin, fan-shaped, and lies on the internal surface of the anterior thoracic wall. It takes origin from the inner surface of the xiphoid process and the lower part of the body of the sternum. Its fibres radiate obliquely upwards and laterally to be inserted into the internal surfaces of the third and fourth ribs.

Action: takes part in the respiratory act (expiration).

Blood supply: the intercostal arteries.

Innervation: intercostal nerves (Th_2-Th_6).

FASCIAE OF THE CHEST

1. The **pectoral fascia** *(fascia pectoralis)* (Figs 285, 290). The **superficial layer** *(lamina superficialis)* of this fascia covers the external surface of the pectoralis major muscle. It fuses with the clavicle superiorly and with the sternum medially, and is continuous laterally with the fascia covering the serratus anterior muscle and inferiorly with the fascia of the abdominal wall. In the infraclavicular region it sinks and as the deep layer invests the pectoralis minor and subclavius muscles and then fuses with the clavicle and the coracoid process of the scapula. In the axillary fossa it runs as a dense structure from the lower border of the pectoralis major muscle over to the lower border of the latissimus dorsi muscle to form the **axillary fascia** *(fascia axillaris)*. In the infraclavicular region part of the pectoral fascia forms a thick area called the **clavipectoral fascia** *(fascia clavipectoralis)* which fuses with the vessels passing under it (the subclavian artery and vein).

2. The **endothoracic fascia** *(fascia endothoracica)* covers the internal surface of the thoracic wall.

THE DIAPHRAGM

The **diaphragm** *(diaphragma)* (Figs 295-297) is an unpaired broad muscle closing the outlet of the thorax like a dome.

The fibres of the muscular part of the diaphragm arise from the inner border of the outlet of the thorax, according to which the sternal, costal, and lumbar parts are distinguished in it.

The **sternal part of the diaphragm** *(pars sternalis diaphragmatis)* is the smallest. It arises from the posterior surface of the xiphoid process and is continuous with the central tendon.

The **costal part of the diaphragm** *(pars costalis diaphragmatis)* is also small and originates by slips from the inner surface of the bony and cartilaginous parts of the lower six ribs. Its fibres run upwards and inwards and are continuous with the central tendon.

The **vertebral part of the diaphragm** *(pars lumbalis diaphragmatis)* arises from the lumbar vertebrae and consists of two, **right** and **left, crura** *(crus dextrum* et *crus sinistrum)*.

Each crus arises from the anterolateral surface of the bodies of the first three (on the right side the first four) lumbar vertebrae and from the medial and lateral arcuate ligaments.

The **medial arcuate ligament** *(ligamentum arcuatum mediale)* stretches arch-like as a thick connective-tissue band over the anterior surface of the psoas major muscle from the body to the transverse process of the first lumbar vertebra.

The **lateral arcuate ligament** *(ligamentum arcuatum laterale)* runs over the quadratus lumborum muscle from the transverse process of the first lumbar vertebra to the twelfth rib.

The **median arcuate ligament** *(ligamentum arcuatum medianum)* is in front of the aortic opening.

The medial muscle fibres of the diaphragmatic crura pass upwards and converge to form the **aortic opening** *(hiatus aorticus)* (Fig. 297) transmitting the aorta and thoracic duct. A little higher the medial muscular bundles of both crura split again to form the **oesophageal opening** *(hiatus esophageus)* (Figs 296, 297) transmitting the oesophagus and vagus nerves, and then pass to the centre.

Besides, two paired slits form in the crura of the vertebral part of the diaphragm. One pair transmits the greater and lesser splanchnic nerves and the azygos (on the right side) and hemiazygos (on the left side) veins. The other paired slit transmits the sympathetic trunk.

More or less clearly outlined triangular slits form between the sternal and costal and between the costal and vertebral parts of the diaphragm; diaphragmatic hernias often occur here.

The muscular fibres of the diaphragm which are directed to the centre continue as tendons to form the **central tendon** *(centrum tendineum)*. This area of the diaphragm is trifoliate in shape, with one leaf directed forwards (on which the heart lies) and the other two directed to the sides (the lungs are located on them). In the posterior part of the central tendon to the right of the midline is the **vena-caval opening** *(foramen venae cavae inferioris)* (Figs 296, 297) which transmits the inferior vena cava.

The thoracic and abdominal surfaces of the diaphragm are covered by fasciae which in turn are covered by connective tissue, the subpleural and subperitoneal fatty tissue, respectively. This is the foundation for the serous membrane, namely, the parietal peritoneum in the abdominal cavity and the parietal layer of the pleura and pericardium in the thoracic cavity. The lungs and heart lie on the thoracic surface of the diaphragm; the liver, stomach, and spleen are in contact with the abdominal surface; and the pancreas, duodenum, kidneys, and adrenals touch areas of the abdominal surface of the diaphragm which are not covered by the parietal peritoneum.

A relaxed diaphragm has the shape of a bevelled spherical convexity facing the thoracic cavity with two domes, right and left, distinguished in it. The apex of the domes rises on the medioclavicular line to the level of the fourth intercostal space on the right side, and to the level of the fifth intercostal space on the left side. When the diaphragm contracts its domes flatten out as a result of which the capacity of the thoracic cavity increases.

Action: the diaphragm is the main muscle of respiration which on contraction becomes flat and thus promotes inspiration but becomes spherically convex during expiration.

Blood supply: the pericardiacophrenic artery, phrenic branches of the descending thoracic aorta, inferior phrenic, and musculophrenic arteries.

Innervation: phrenic nerves (C_3-C_5).

MUSCLES AND FASCIAE OF THE ABDOMEN

REGIONS OF THE ABDOMEN

The following **regions of the abdomen** *(regiones abdominis)* are distinguished (see Fig. 284). The upper part of the abdomen (epigastrium) has an **epigastric region** *(regio epigastrica)* and two lateral, **right** and **left hypochondriac regions** *(regio hypochondriaca dextra* et *sinistra).* In the middle part of the abdomen (mesogastrium) are distinguished two **lateral abdominal** (**right** and **left**) **regions** *(regio lateralis dextra* et *sinistra)* and a middle, **umbilical region** *(regio umbilicalis).* The lower part of the abdomen (hypogastrium) has two lateral regions called the **inguinal** (**right** and **left**) **regions** *(regio inguinalis dextra* et *sinistra*) and a middle, **pubic region** *(regio pubica).*

Right and **left costal arches** *(arcus costalis dexter* et *sinister)* are clearly outlined when the abdominal wall is pulled in. The xiphoid process is felt in the angle formed by the cartilaginous costal arches, which is called the **infrasternal angle** *(angulus infrasternalis).* The inguinal folds corresponding to the position of the inguinal ligaments are distinctly seen in the lower part of the abdominal wall. When the abdominal muscles are tensed a groove forms on the midline which corresponds to the **linea alba abdominis.** The **umbilicus** is on the linea alba on the level of the articulation between the third and fourth lumbar vertebrae.

The rectus abdominis muscles are outlined to both sides of the midline; the **tendinous intersections** *(intersectiones tendineae)* of these muscles are defined clearly as three or four transverse constrictions.

The slips of the external oblique muscle alternating with slips of the serratus anterior muscle and longissimus dorsi muscle are outlined on the upper part of the anterolateral portion of the thoracic wall.

MUSCLES OF THE ABDOMEN

The **muscles of the abdomen** *(musculi abdominis)* may be separated topographically into muscles of the lateral, anterior, and posterior abdominal wall.

The muscles of the lateral abdominal wall are as follows: (1) the **external oblique muscle** *(musculus obliquus abdominis externus)*; (2) the **internal oblique muscle** *(musculus obliquus abdominis internus)*; (3) the **transversus abdominis muscle** *(musculus transversus abdominis).* The muscles of the anterior abdominal wall are: (1) the **rectus abdominis muscle** *(musculus rectus abdominis)*; (2) the **pyramidalis muscle** *(musculus pyramidalis).*

The **quadratus lumborum muscle** *(musculus quadratus lumborum)* is related to the muscles of the posterior abdominal wall.

MUSCLES OF THE LATERAL ABDOMINAL WALL

The muscles of the lateral abdominal wall are arranged in three layers. The external oblique muscle lies superficially, the internal oblique muscle lies deeper, and the transversus abdominis muscle occupies the deepest position.

All these muscles are related to the broad muscles of the abdomen. On the anterior abdominal wall they are continuous with aponeuroses.

1. The **external oblique muscle** of the abdomen *(musculus obliquus abdominis externus)* (Figs 285, 287, 289, 299) is flat and broad and arises from the lateral surface of the lower eight ribs by eight slips. On the anterolateral surface of the thorax the upper five slips are wedged between the lower slips of the serratus anterior muscle, while the lower three slips are between those of the longissimus dorsi muscle. The fibres of the external oblique muscle are directed obliquely downwards and forwards to be continuous with the aponeurosis. The upper part of the aponeurosis extends to the midline and contributes to the formation of the anterior wall of the sheath of the rectus abdominis muscle. The bundles of the aponeurosis of the external oblique muscle, like those of all the broad abdominal muscles, interlace with the bundles of the aponeuroses of the contralateral muscle and thus help to form the linea alba.

The lower slips of the external oblique muscle are inserted into the anterior part of the outer lip of the iliac crest. The middle fibres of the aponeurosis bridge the anterior notch of the hip bone and are stretched between the anterior superior iliac spine and the pubis; the lower border of the aponeurosis folds back on itself (it is reflected) to form a groove. This thick lower border of the aponeurosis stretching between the anterior superior iliac spine and the pubic tubercle and symphysis is called the **inguinal ligament** *(ligamentum inguinale).* The fibres of this ligament separate at the pubic bone to form two crura. One is the **medial,** or **superior crus** *(crus mediale)* which is attached to the symphysis with some of the fibres passing over to the contralateral side, the other is the **lateral,** or **inferior crus** *(crus laterale)* and is attached to the pubic tubercle on the same side. A triangular cleft forms between the crura; the superolateral angle of the cleft is rounded by curving **intercrural fibres** *(fibrae intercrurales).* Fibres separate from the inner part of the inferior crus and pass inwardly and medially to the anterior layer of the sheath of the rectus abdominis muscle; this is the **reflected**

part of the inguinal ligament *(ligamentum reflexum)*. The oval opening formed in the aponeurosis of the external oblique muscle by the two crura of the inguinal ligament, the intercrural fibres, and the reflected part is the **superficial inguinal ring** *(anulus inguinalis superficialis)*. It transmits the **spermatic cord** *(funiculus spermaticus)* in males (Fig. 301) and the **round ligament of the uterus** *(ligamentum teres uteri)* in females (Fig. 302). (In pathological cases organs may protrude from this opening and inguinal hernia forms.) A bundle separates from the medial end of the lateral crus and runs backwards and laterally on the border of the superior pubic ramus. It rounds off the sharp angle between the inguinal ligament and the pubic bone and is called the **lacunar ligament** *(ligamentum lacunare)*, or **pectineal part** of the inguinal ligament.

A triangular area forms in the wall of the trunk to the back of the posterior border of the external oblique muscle above the iliac crest; it is called the **lumbar triangle** *(trigonum lumbale)* (see *Muscles of the Back*).

Action: the external oblique muscle is a muscle of the prelum abdominale; contraction of one muscle rotates the trunk to the other side; with the pelvis fixed contraction of both muscles pulls the chest and flexes the vertebral column.

Blood supply: the intercostal, lateral thoracic, and the superficial circumflex iliac arteries.

Innervation: intercostal nerves (fifth to twelfth), the lumbar nerve (Th_5-Th_{12}, L_1).

2. The **internal oblique muscle** *(musculus obliquus abdominis internus)* (Figs 288-290, 299, 304) is broad and flat and located medially of the external oblique muscle in the anterolateral part of the abdominal wall. It arises from the lateral two thirds of the inguinal ligament, intermediate area of the iliac crest, and the lumbar fascia (at the junction of its two layers). Its fibres spread fan-like, mainly obliquely, upwards and forwards; the lower fibres run almost horizontally and obliquely downwards and forwards. They give off fine fibres which descend along the spermatic cord and form part of the **cremaster muscle** (see Fig. 304) which elevates the testis. The posterior fibres of the internal oblique muscle run almost vertically to be inserted into the external surface of the lower three or four ribs. The remaining fibres end as an aponeurosis which extends to the lateral border of the rectus abdominis muscle and separates into two layers investing the muscle anteriorly and posteriorly to take part in the formation of its sheath. The aponeurosis of the internal oblique muscle contributes to the formation of the posterior wall of the rectus abdominis sheath only in the upper two thirds, to the level of the **arcuate line** *(linea arcuata)*. On the midline the bands of the anterior and posterior layers intertwine with those of the fellow layers on the contralateral side to form the linea alba (see *Sheath of the Rectus Abdominis Muscle*).

Action: the internal oblique muscle is part of the prelum abdominale; contraction of one muscle rotates the trunk to the same side.

Blood supply: the intercostal, inferior and superior epigastric, and musculophrenic arteries.

Innervation: intercostal nerves (eighth to twelfth), iliohypogastric and ilioinguinal nerves.

3. The **transversus abdominis muscle** *(musculus transversus abdominis)* (Figs 290-292, 295, 299, 305) is flat and broad and occupies the deepest position in the anterolateral part of the abdominal wall. It arises from the inner surfaces of the lower six costal cartilages (where its slips are wedged between the slips of the costal part of the diaphragm), the lumbar fascia, the inner lip of the iliac crest, and the lateral two thirds of the inguinal ligament. Its fibres run horizontally forwards and end in an aponeurosis before they reach the lateral border of the rectus abdominis muscle. Above the arcuate line the aponeurosis lies behind the rectus abdominis, below the line it extends over the anterior surface of the muscle. On the midline the fibres of the aponeurosis contribute to the formation of the **linea alba.** A few fibres separate from the lower parts of the transversus muscle and meet similar fibres of the internal oblique muscle to form the cremaster muscle.

A laterally convex line forms at the junction of the muscular fibres with the aponeurosis; it is called the **linea semilunaris** (Fig. 291). It is behind the rectus abdominis muscle in the upper part and lateral to the lateral border of the muscle for the remaining distance.

Action: the transversus abdominis muscle is part of the prelum abdominale; it flattens the abdominal wall and brings the lower parts of the chest closer to each other.

Blood supply: the superior and inferior epigastric and musculophrenic arteries.

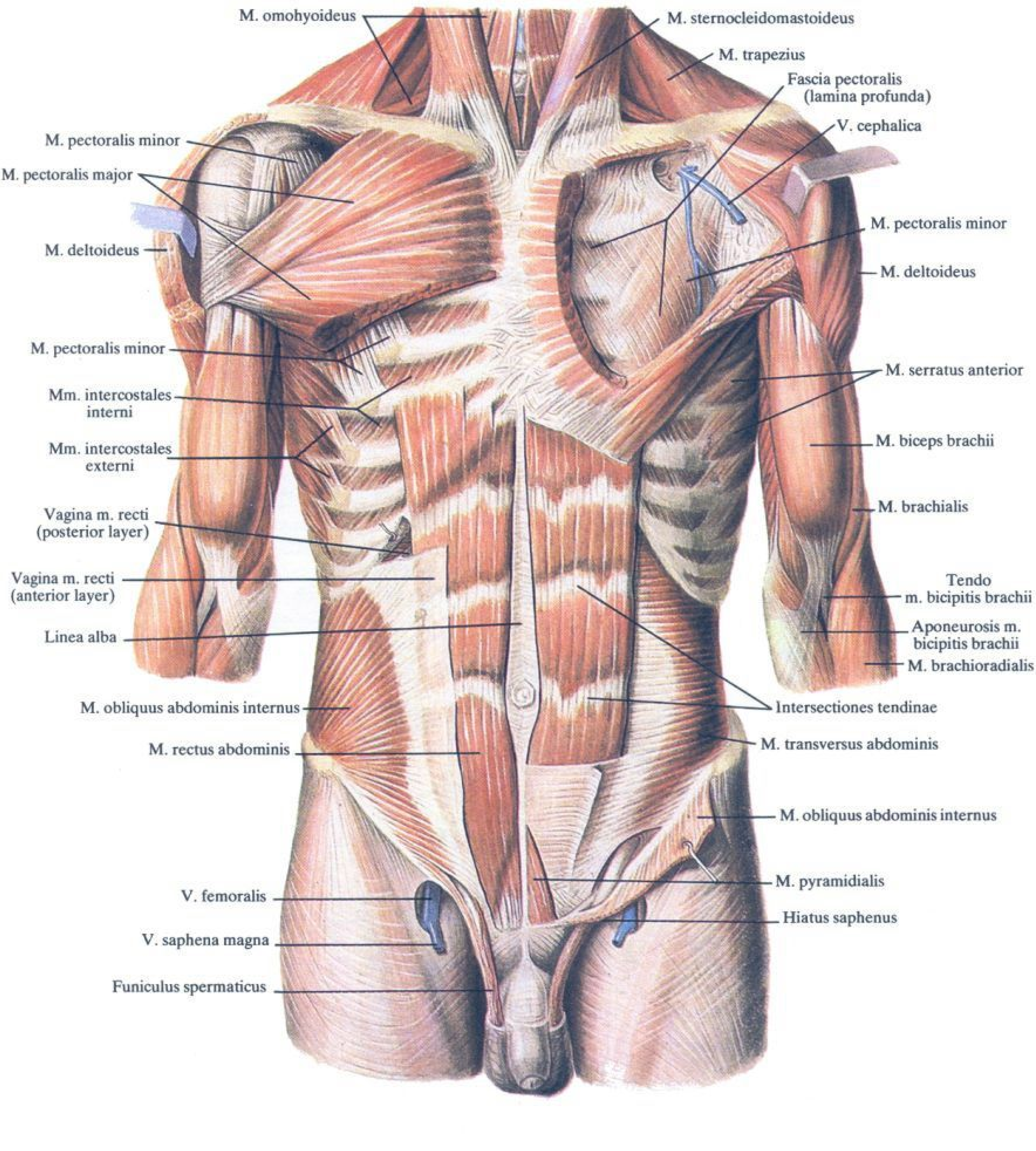
Innervation: intercostal (seventh to twelfth), iliohypogastric, and ilioinguinal nerves.

MUSCLES OF THE ANTERIOR ABDOMINAL WALL

1. The **rectus abdominis muscle** *(musculus rectus abdominis)* (Figs 290-292, 295, 306, 307) is paired, flat and related to the long muscles of the abdomen. It is in the anterior part of the abdominal wall to both sides of the linea alba which stretches on the midline from the xiphoid process to the pubic symphysis. The rectus abdominis muscle arises from the fifth, sixth, and seventh costal cartilages and the xiphoid process; running downwards it becomes narrower and is inserted into the pubic bone in the space between the pubic symphysis and tubercle. The muscle fibres are interrupted by three or four transverse **tendinous intersections** *(intersectiones tendineae)*, two of which are above the umbilicus, one is on the level with it, while the poorly developed fourth intersection is sometimes below the umbilicus.

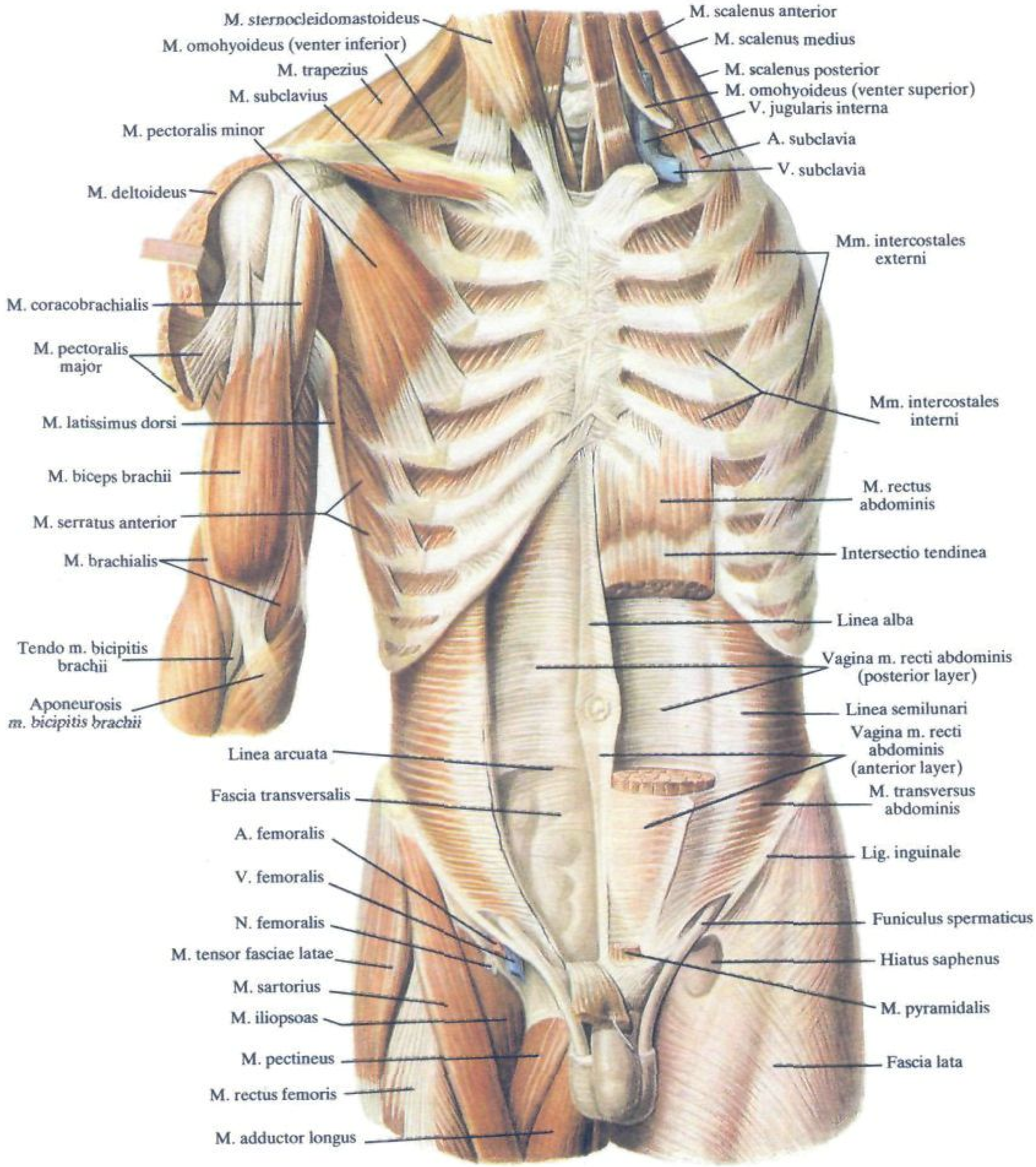
2. The **pyramidalis muscle** *(musculus pyramidalis)* (Figs 290-292, 300, 304, 306) is paired, triangular, and varies in size. It arises from the pubic bone in front of the insertion of the rectus abdominis muscle. Its fibres converge and run upwards to be inserted into the lower parts of the linea alba at various levels.

Both muscles, the rectus and the pyramidalis, are enclosed in the **sheath of the rectus abdominis muscle** *(vagina musculi recti ab-*



290. *Muscles of the trunk*; anterior aspect ($^1/_4$).

(The external oblique muscle and part of the pectoralis major muscle are removed on the right; the external and internal oblique muscles and part of the pectoralis major muscle are removed on the left; the greater part of the anterior layer of the sheath of the rectus abdominis muscles is also removed.)



291. *Muscles of the trunk*; anterior aspect (¼).

(The pectoralis major, external and internal oblique, and rectus abdominis muscles are removed on the right; the superficial muscles of the chest, the external and internal oblique muscles, and part of the rectus abdominis muscle are removed on the left.)

dominis) (Figs 285, 290, 291, 295, 300, 306) which is formed by the aponeuroses of the broad abdominal muscles.

Action: they are part of the prelum abdominale; flex the trunk forwards; the pyramidalis muscle, in addition, tenses the linea alba.

Blood supply: rectus abdominis muscle—the superior and inferior epigastric arteries; pyramidalis muscle—the cremasteric and inferior epigastric arteries.

Innervation: intercostal and lumbar nerves (Th_5-Th_{12}; L_1).

The broad and long muscles of the abdominal wall are the muscles of the trunk and cause the following movements: by lowering the ribs they take part in the act of respiration; they change the position of the vertebral column; contraction of all muscles (except for the transversus abdominis) pulls the chest downwards and flexes the vertebral column forwards; contraction of muscles on one side flexes the vertebral column laterally. Unilateral contraction of the external oblique muscle rotates the vertebral column to the contralateral side; contraction of the internal oblique muscle rotates it to the side of the contracting muscle. The muscles of the abdominal wall and the diaphragm maintain the intra-abdominal pressure at a certain level by their tonus, which is important for holding the abdominal organs in a definite position. When the tonus of the muscles of the abdominal wall reduces (atony) intra-abdominal pressure drops as a result of which the organs are displaced downwards (ptosis) by their own weight and their function is disturbed as a consequence. Contraction of the muscles of the abdominal wall reduces the capacity of the abdominal cavity and the organs are compressed, which helps in their evacuation (defaecation, urination, childbirth). In view of this the muscles of the abdominal wall are called **prelum abdominale**.

MUSCLES OF THE POSTERIOR ABDOMINAL WALL

The **quadratus lumborum muscle** *(musculus quadratus lumborum)* (Figs 292, 297, 298, 299) is flat and fills the space between the twelfth rib and the iliac crest; it lies on the posterior abdominal wall and is separated from the deep muscles of the back by the deep layer of the lumbar fascia. The muscle is made up of two parts, anterior and posterior. The anterior part stretches from the internal lip of the iliac crest and iliolumbar ligament to the twelfth rib and twelfth thoracic vertebra and also to the medial arcuate ligament. The posterior part extends from the iliac crest and iliolumbar ligament to the transverse processes of the upper four lumbar vertebrae.

Action: pulls the ilium upwards and the twelfth rib downwards; contributes to lateral flexion of the lumbar vertebral column; contraction of both muscles pulls the lumbar spine backwards.

Blood supply: the subcostal, lumbar, and iliolumbar arteries.

Innervation: intercostal and lumbar nerves (Th_{12}, L_1-L_3).

APONEUROSES AND FASCIAE OF THE ABDOMEN

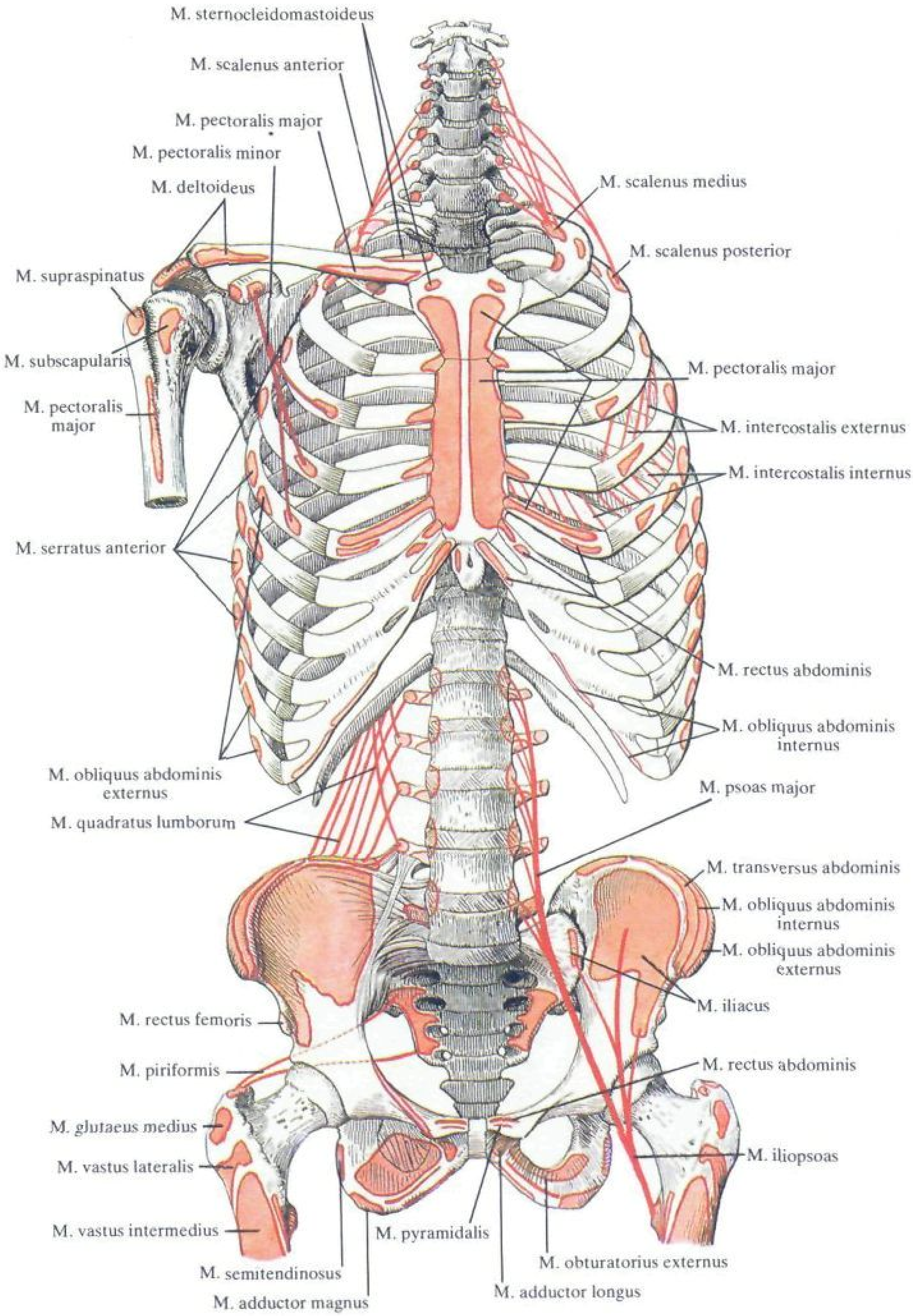
THE SHEATH OF THE RECTUS ABDOMINIS MUSCLE

Each of the two rectus abdominis muscles is invested in its **sheath** *(vagina musculi recti abdominis)* (Figs 285, 290, 291, 295, 300, 306, 307) formed by the aponeuroses of the three broad muscles of the abdominal wall. The sheath has an **anterior** and a **posterior lamina** *(laminae anterior* et *posterior)*; the posterior lamina exists only in the upper two thirds of the muscle but is absent in the lower part below the arcuate line (Figs 291, 295, 300, 307) so that the posterior surface of the rectus abdominis muscles rests here on the fascia transversalis (Figs 295, 306). The arcuate line is convex upwards and is 4-5 cm below the umbilicus.

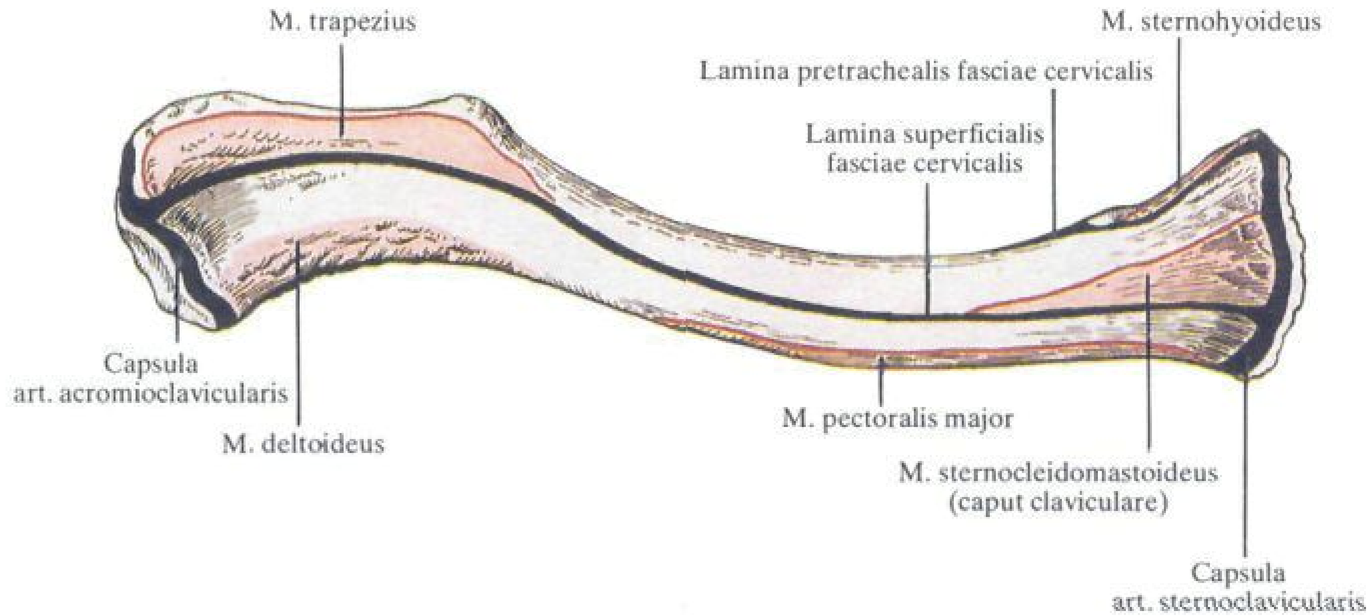
Above the arcuate line the anterior wall of the sheath is formed by fibres of the aponeurosis of the external oblique muscle and the anterior layer of the aponeurosis of the internal oblique muscle; the posterior wall is formed by the posterior layer of the aponeurosis of the internal oblique muscle, the aponeurosis of the transversus abdominis muscle and uppermost by muscle fibres of this muscle. Below the arcuate line the aponeuroses of the three muscles form a thicker anterior wall of the sheath, but there is no posterior layer below this line and only the fascia transversalis is found here.

THE LINEA ALBA

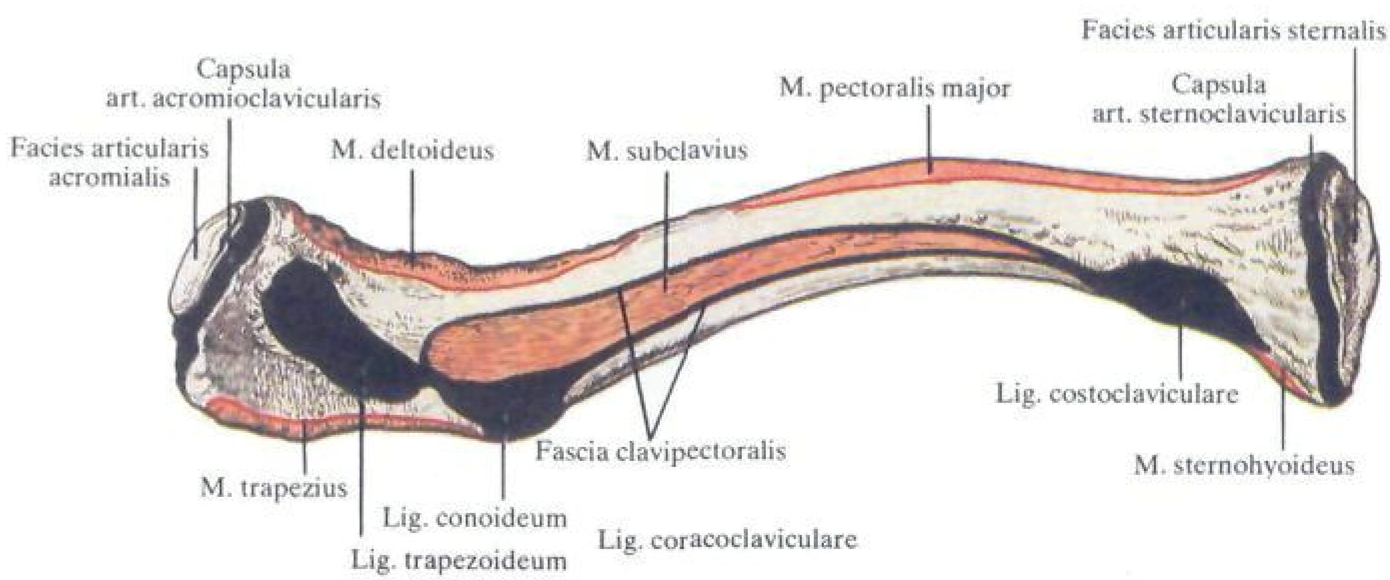
The **linea alba** (Figs 285, 300, 302, 303) has the appearance of a tendinous band stretching from the xiphoid process to the pubic symphysis. It is 1-2 cm wide in the upper part of the abdominal wall and considerably narrows in the lower parts but is thicker here being reinforced on the inner surface by a connective-tissue structure called the **adminiculum lineae albae**. The linea alba is formed by interlacing fibres of the aponeuroses of the three pairs of broad abdominal muscles. In the upper part, where it is thinner and wider, more or less defined slits are left between the interlacing fibres, through which herniations may occur. Approximately on the middle of the linea alba is the **umbilical ring** *(anulus umbilicalis)* which is filled by loose cicatricial tissue called the **navel** *(umbilicus* s. *umbo)*. In the intrauterine developmental period in place of the navel was a round opening transmitting the umbilical vein and arteries. A hernia often occurs here.



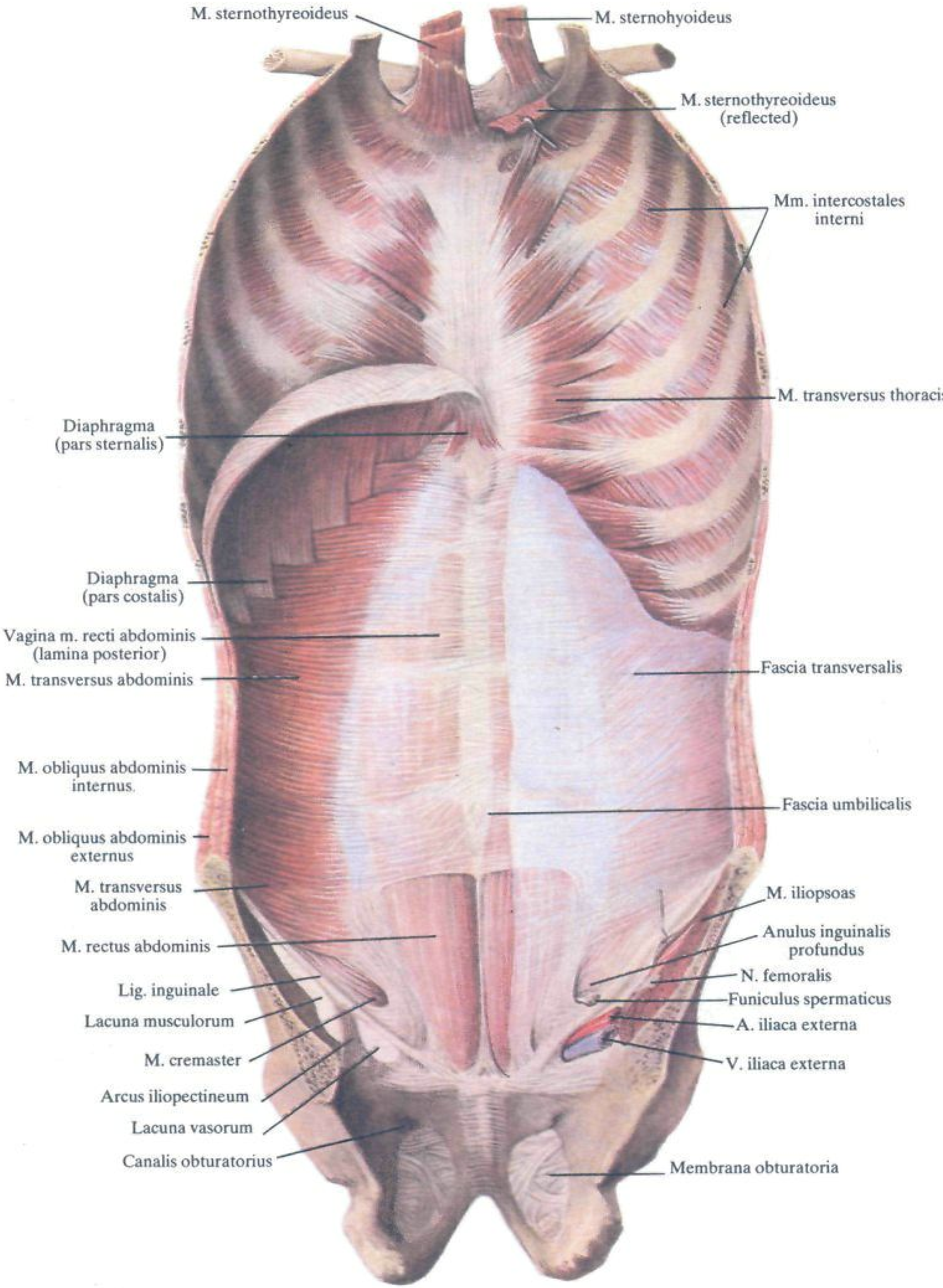
292. *Sites of origin and insertion of the trunk muscles* (schematical representation).



293. *Sites of origin and attachment of muscles, fasciae, and articular capsule on the clavicle*; superior aspect (schematical representation).

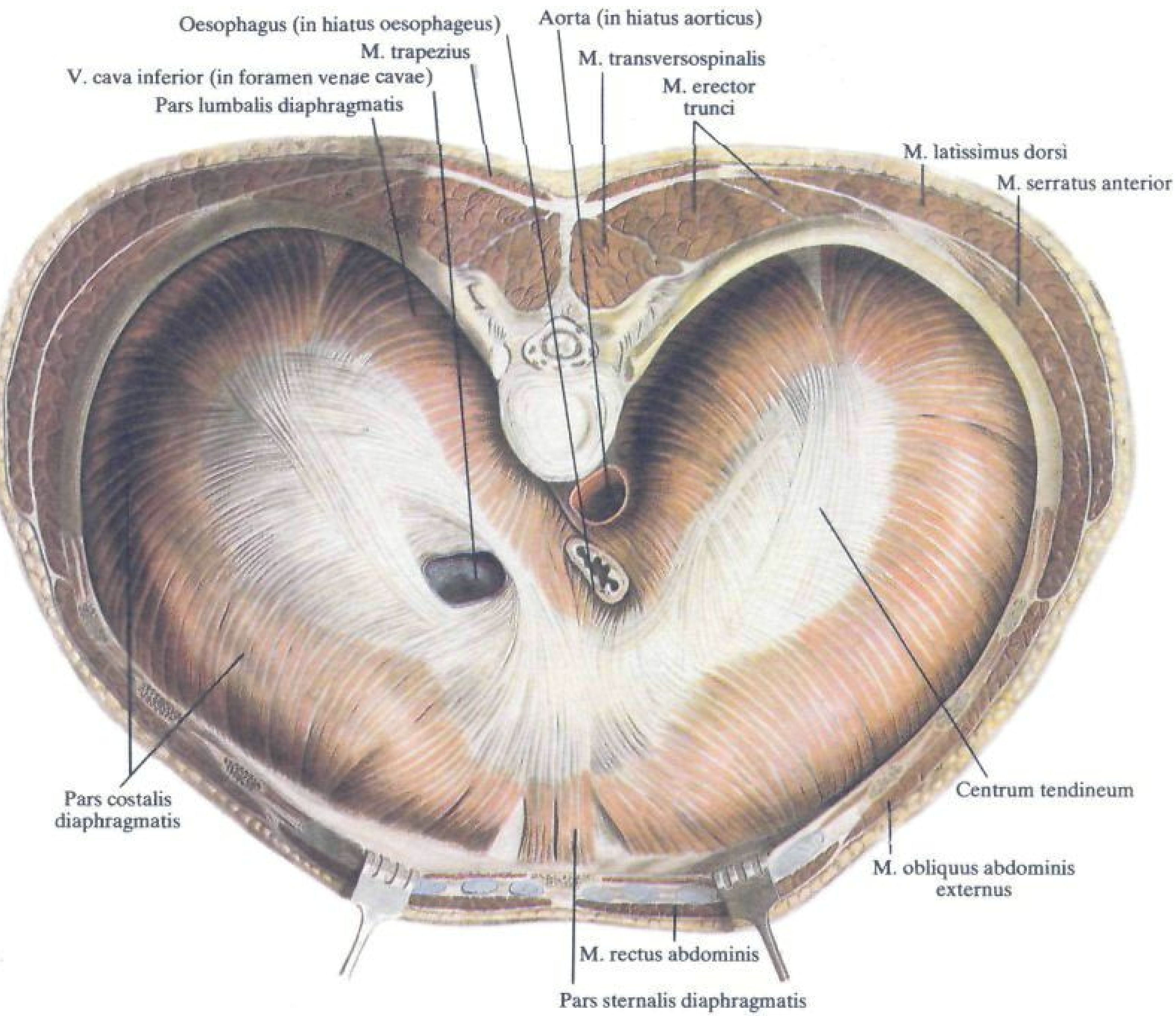


294. *Origin and attachment of muscles, fasciae, and articular capsule on the clavicle*; inferior aspect (schematical representation).

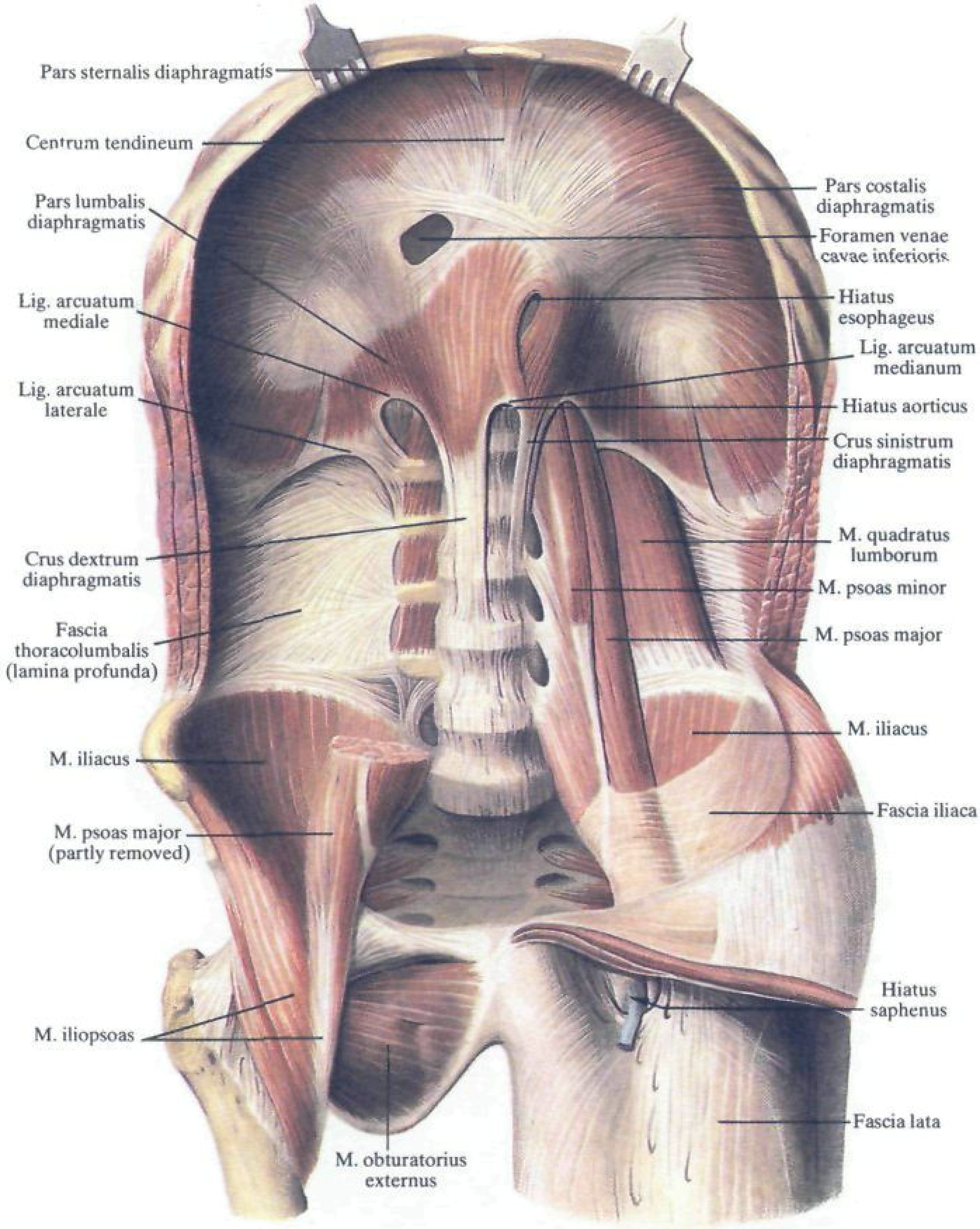


295. *Muscles and fasciae of the trunk* (1/4).

(Anterior thoracic and abdominal wall; inner aspect.)



296. *Diaphragm*; superior aspect ($\frac{1}{2}$).



297. *Diaphragm and muscles of posterior abdominal wall*; inner aspect ($\frac{1}{3}$).

(The quadratus lumborum muscle and part of the pectoralis major and minor muscles are removed on the right.)

FASCIAE OF THE ABDOMEN

The following fasciae are developed best in the abdominal wall (Figs 285, 295, 299).

1. The **superficial fascia of the abdomen** is thin in the upper part of the abdominal wall but much thicker in the lower parts and is distinguished by the presence of elastic fibres. It fuses with the linea alba on the midline and with the inguinal ligament inferiorly. Two thick bands form in the lower part above the symphysis, these are called the ligaments of the penis. There are two of them: (a) the **fundiform ligament of the penis** *(ligamentum fundiforme penis)* arising from the pubic symphysis and giving off two crura which pass on the sides of the penis, and (b) the **suspensory ligament of the penis** (the **suspensory ligament of the clitoris** in females) *(ligamentum suspensorium penis* et *ligamentum suspensorium clitoridis)* stretching from the pubic symphysis to the dorsal surface of the penis (clitor). The fascial bands in the region of these ligaments are reinforced partly by tendinous bands of the rectus abdominis and external oblique muscles.

2. The **fascia iliaca** (see *Fasciae of the Pelvis and Thigh*).

3. The **transversalis fascia** *(fascia transversalis)* covers the inner surface of the transversus abdominis muscle and the inner surface of the posterior lamina of the rectus abdominis sheath; below the arcuate line it covers the inner, posterior, surface of the rectus abdominis. Inferiorly it fuses with the borders of the inguinal ligament which is reflected to the back and upwards. The transversalis fascia is thicker in the region of the umbilicus and is called here the umbilical fascia. Concentrated longitudinal bands in the lower part of the linea alba form the **adminiculum lineae albae** for its support. In the inguinal region the transversalis fascia forms a funnel-like protrusion lodging the **processus vaginalis** of the peritoneum which passes along the spermatic cord into the scrotum; investing the spermatic cord and testis this protrusion of the transversalis fascia is called the **internal spermatic fascia** *(fascia spermatica interna)*. The dilated oval depression on the surface of the transversalis fascia is the **deep inguinal ring** (opening of the inguinal canal) *(anulus inguinalis profundus)*. The medial border of this ring, which is most pronounced due to thickening of the fascia, is called the **interfoveolar ligament** *(ligamentum interfoveolare)*. On the inner surface of the subperitoneal fascia lies the **peritoneum**. A series of folds (Fig. 307) are seen on the peritoneum of the anterior abdominal wall along the distribution of the ligaments and vessels in the preperitoneal fatty tissue. An unpaired **median umbilical fold** *(plica umbilicalis mediana)* passes on the midline from the apex of the urinary bladder to the umbilicus; it forms along the course of the obliterated embryonal **urachus**. To each side of the median folds is a **medial umbilical fold** *(plica umbilicalis medialis)* which runs from the lateral surface of the bladder to the umbilicus; it forms along the course of the obliterated embryonal umbilical artery. Still further laterally is the paired **lateral umbilical fold** *(plica umbilicalis lateralis)* stretching along the distribution of the inferior epigastric artery and veins.

Depressions called fossae are seen between the folds in the lower part of the inner surface of the anterior abdominal wall. Lateral to the lateral umbilical fold is the **lateral inguinal fossa** *(fossa inguinalis lateralis)* which corresponds to the deep inguinal ring. Between the medial and lateral folds is the **middle inguinal fossa** *(fossa inguinalis medialis)* corresponding to the superficial inguinal ring. The **supravesical fossa** *(fossa supravesicalis)* is between the medial and median umbilical folds. Viscera may protrude (hernias) through these fossae and after passing through the abdominal wall the herniation emerges through the external (superficial) inguinal ring.

THE INGUINAL CANAL

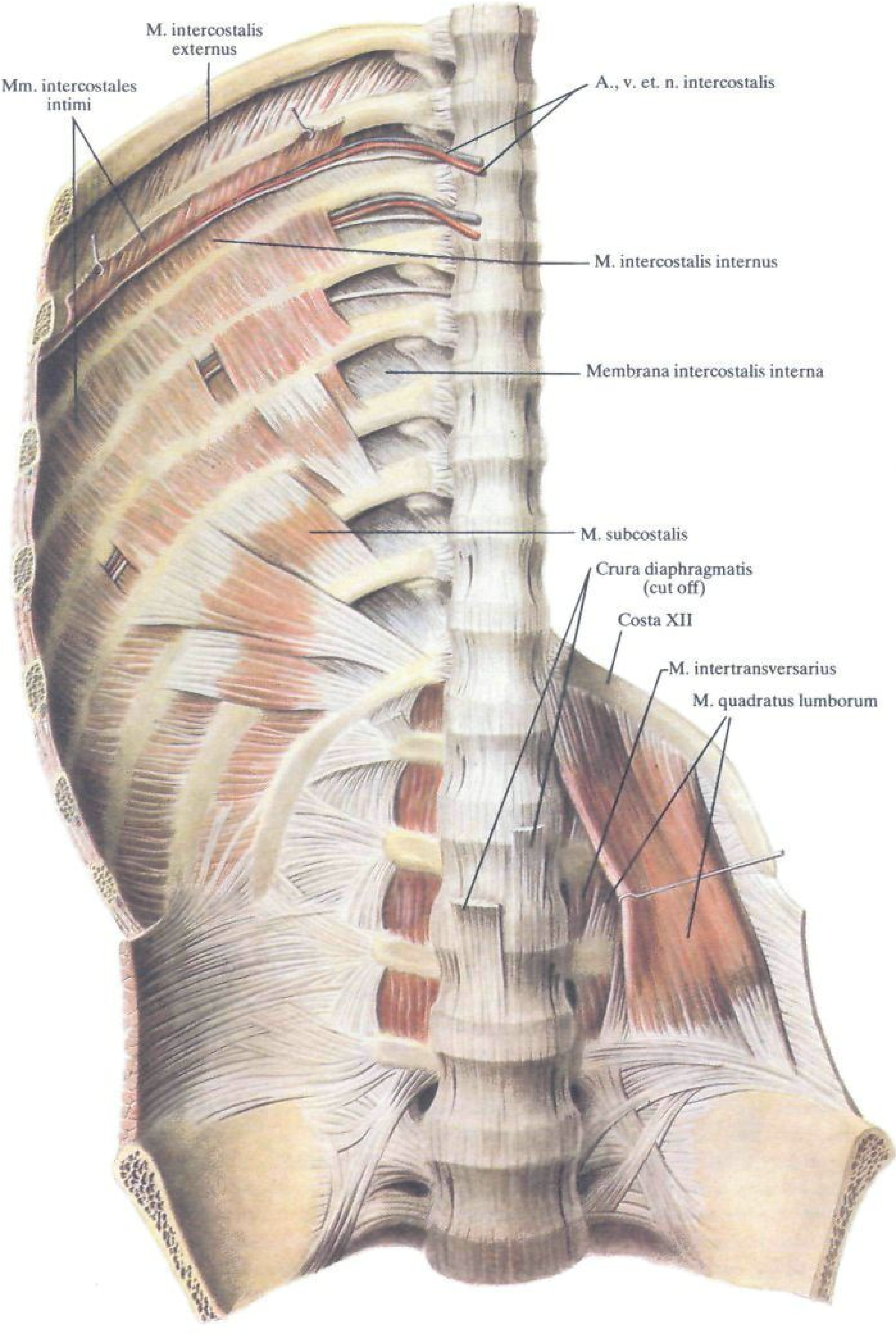
The **inguinal canal** *(canalis inguinalis)* (Figs 301-307) is a passage on the lower part of the abdominal wall. It contains the spermatic cord in the male and the round ligament of the uterus in the female. The canal runs obliquely. From the superficial inguinal ring above the anterior part of the superior ramus of the pubic bone it passes laterally, upwards and slightly backwards to the deep inguinal ring located 1-1.5 cm above the medial part of the inguinal ligament. The canal is 4-5 cm long.

The walls of the inguinal canal are as follows: (a) the anterior wall formed by the aponeurosis of the external oblique muscle; (b) the posterior wall formed by the transversalis fascia; (c) the inferior wall formed by the reflected part of the inguinal ligament; (d) the superior wall formed by the lower borders of the internal oblique and transversus abdominis muscles.

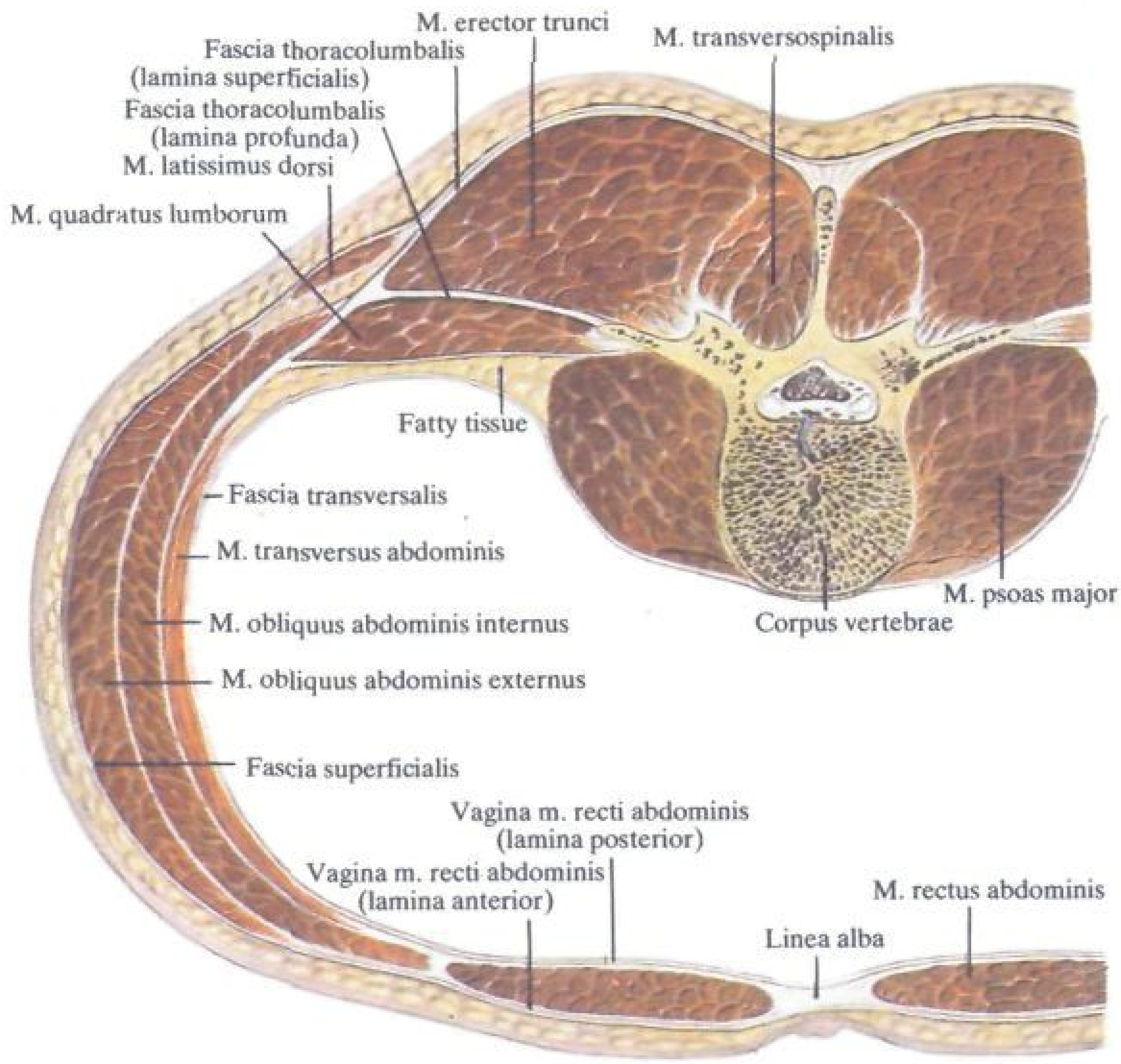
The **superficial (external) inguinal ring** *(anulus inguinalis superficialis)* is an oval opening (2.5-3 × 1-2.5 cm) above the pubic bone. It is bounded anteriorly and inferiorly, respectively, by the **superior** and **inferior crura of the inguinal ligament** *(crus mediale* et *crus laterale)*, laterally by the **intercrural fibres** *(fibrae intercrurales)*, and medially and downwards by the **reflected part of the inguinal ligament** *(ligamentum reflexum)* (Figs 303, 304).

The opening transmits the spermatic cord in males and the round ligament of the uterus in females. The opening can be examined: the entrance into the inguinal canal can be felt by pushing the skin on the scrotum upwards and laterally with the little finger. Normally only the tip of the little finger passes through the opening; a larger opening is interpreted as dilation of the superficial inguinal ring.

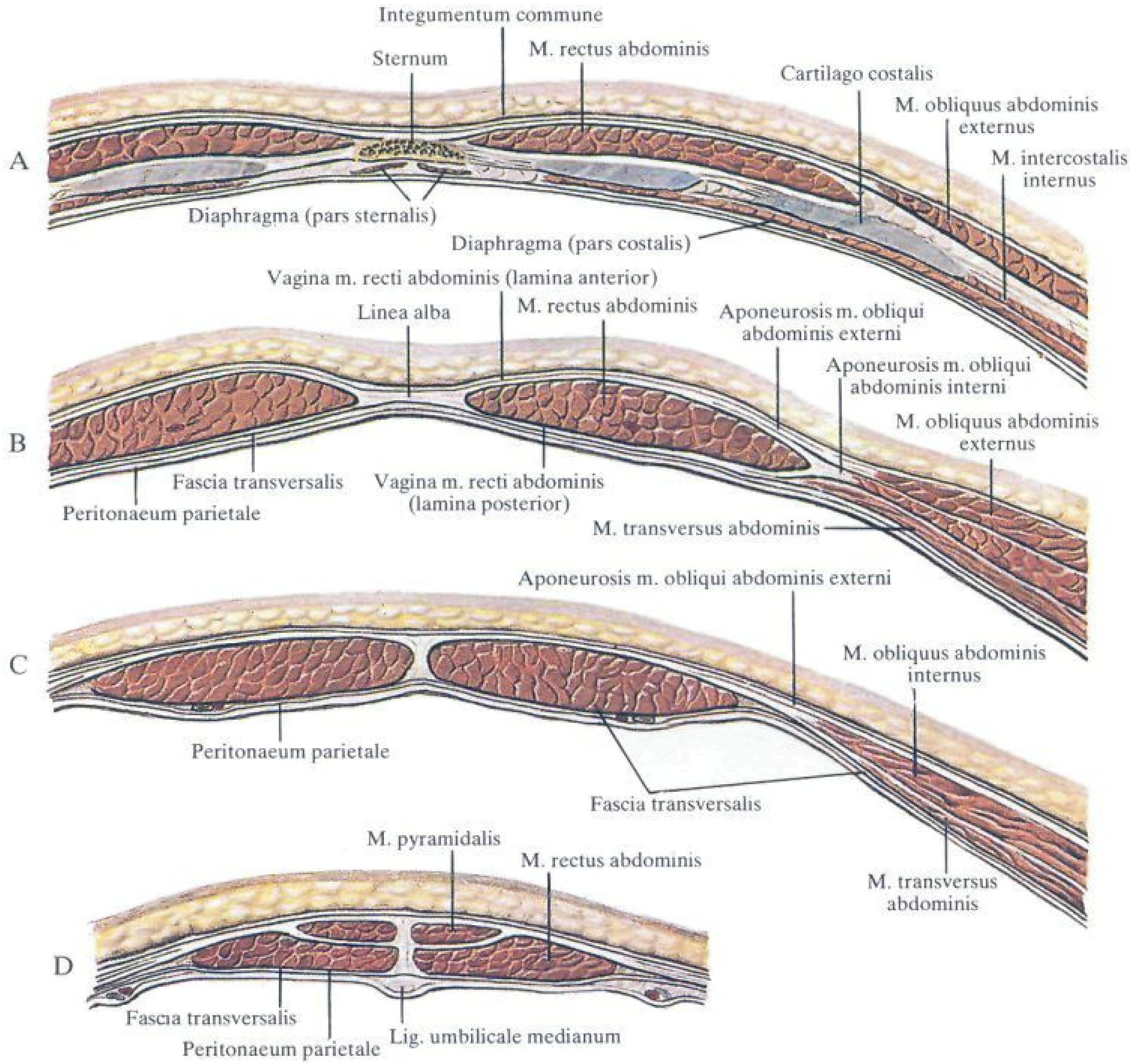
The **deep (internal) inguinal ring** *(anulus inguinalis profundus)* is a funnel-like depression of the transversalis fascia bounded medially by the **interfoveolar ligament** *(ligamentum interfoveolare)* (Fig. 305). Medially of this ligament the posterior wall of the inguinal canal is reinforced by the fibres of the inferior border of the aponeurosis of the transversus abdominis muscle which, curving downwards are attached to the pubic tubercle and crest to form the **conjoint tendon** *(falx inguinalis s. tendo conjunctivus)* (Figs 305, 307). Vessels (inferior epigastric artery and veins), to which the lateral umbilical fold corresponds, run medially of the deep inguinal ring; this circumstance must be borne in mind when the deep inguinal ring has to be cut in incarcerated hernia.



298. *Muscles of posterior thoracic and abdominal wall*; inner aspect ($\frac{2}{5}$).



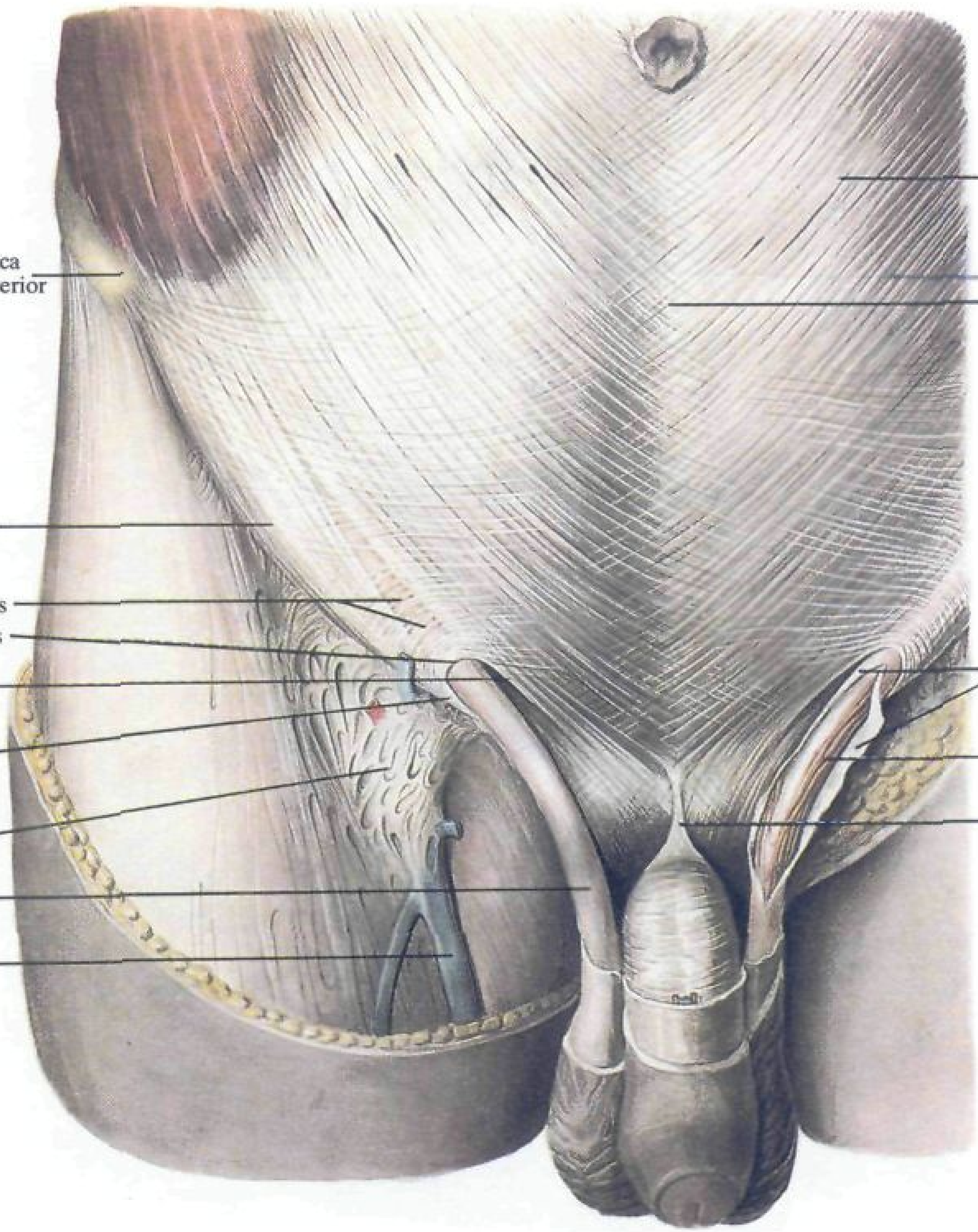
299. *Muscles of the back and abdomen* (½).
(Horizontal section through second lumbar vertebra.)



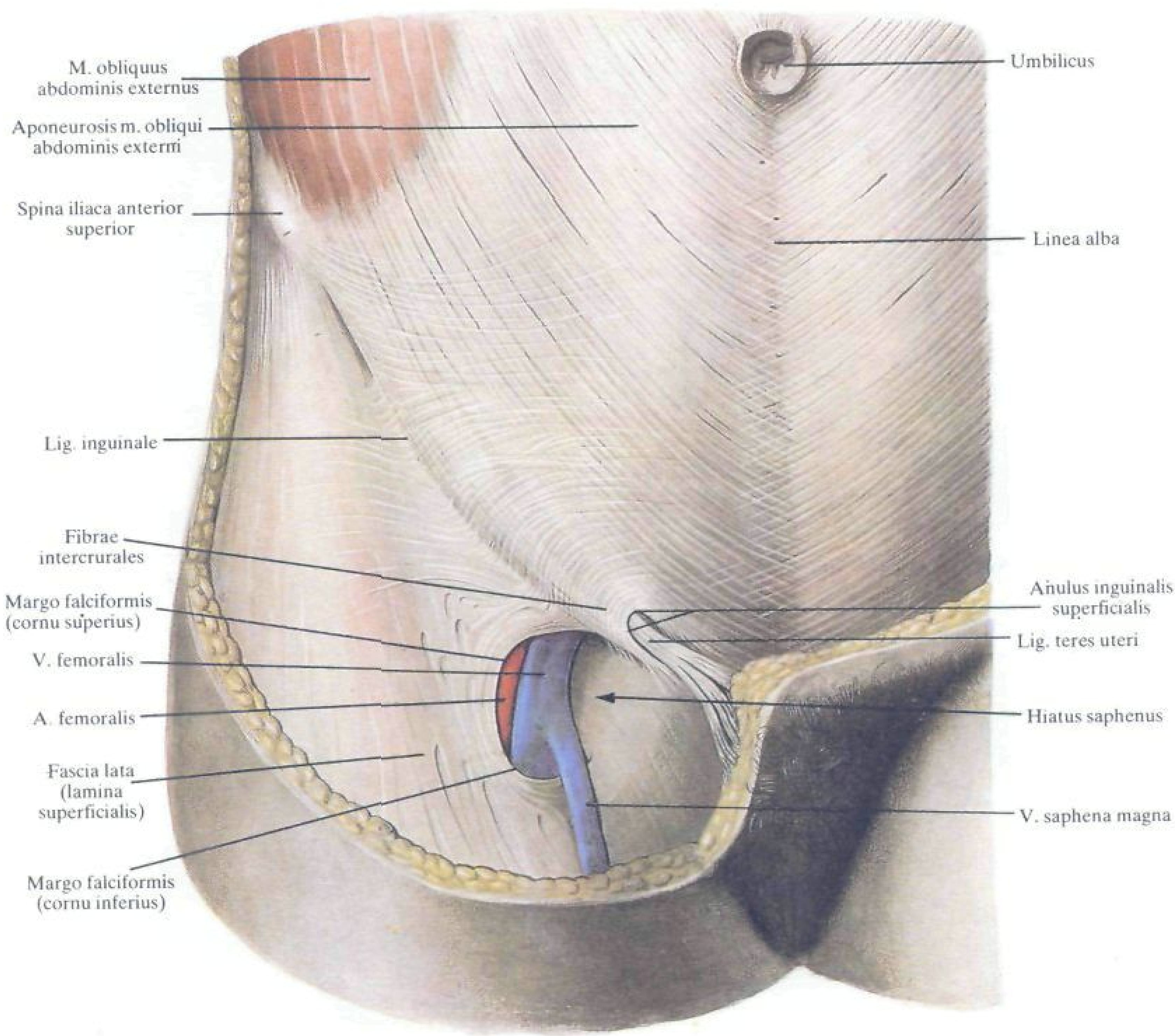
300. *Sheaths of rectus abdominis muscles at different levels.*

(Horizontal sections through anterior abdominal wall.)

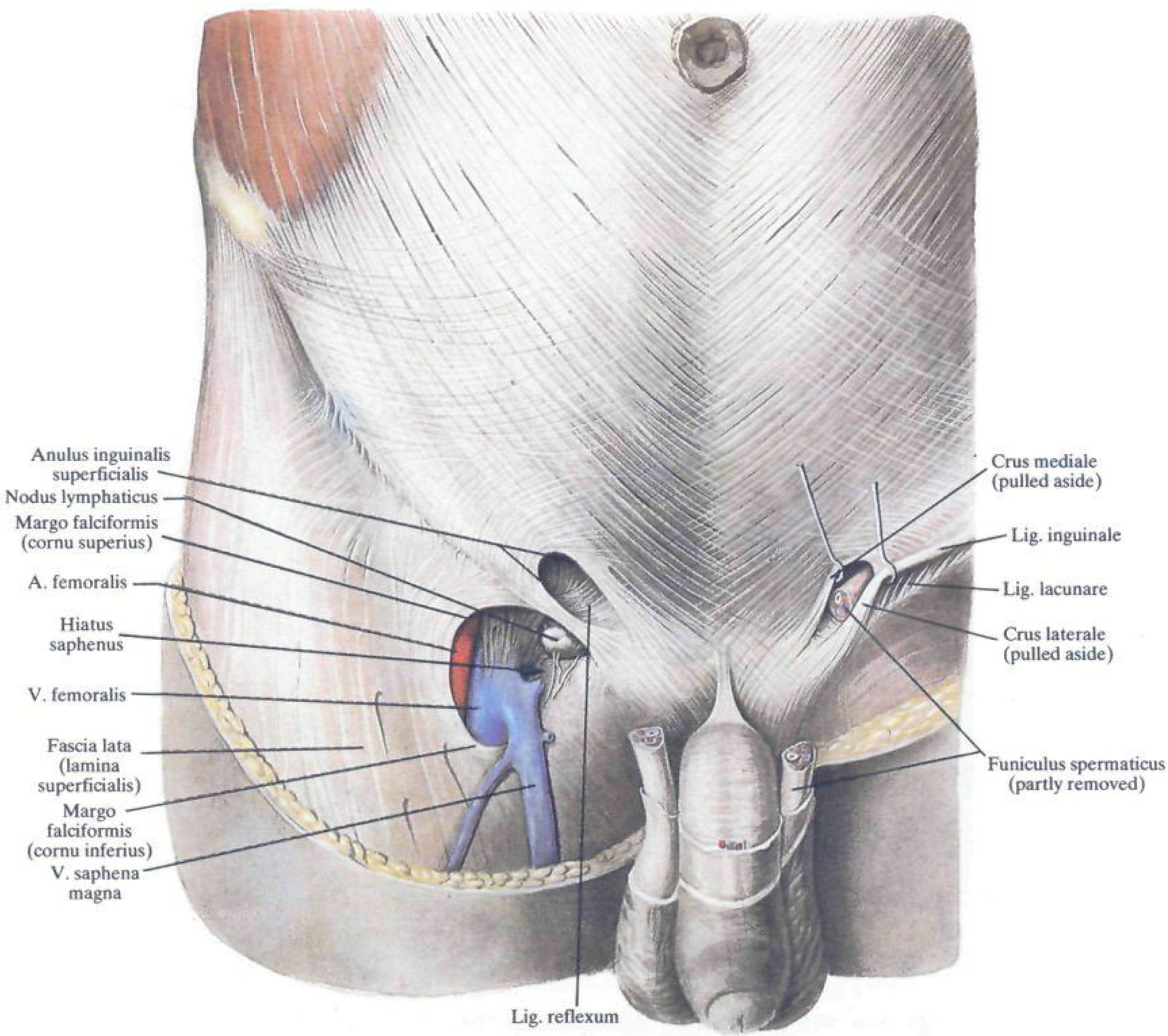
A — on the level of the xiphoid process
B — above the arcuate line
C — below the arcuate line
D — above the pubic symphysis



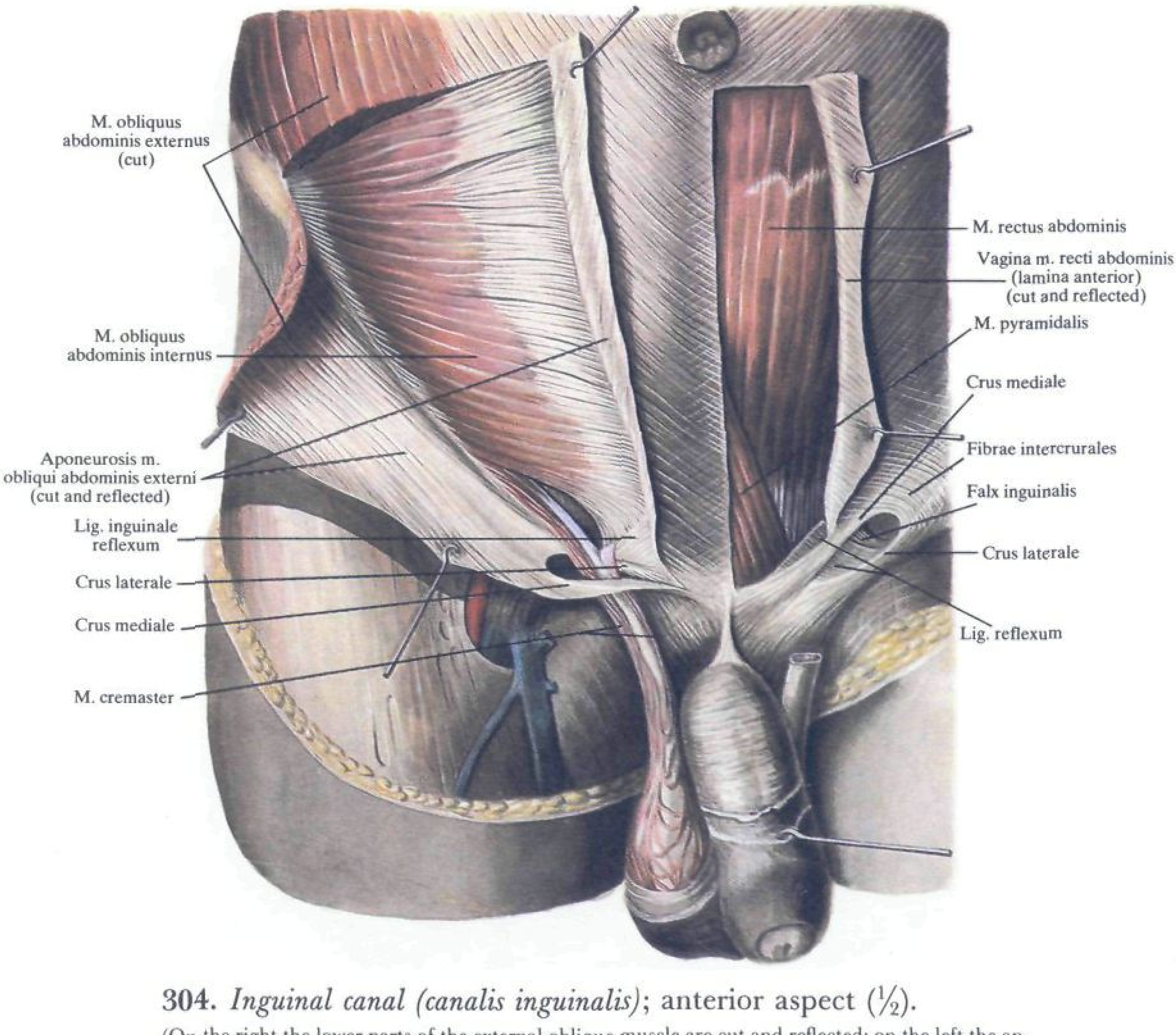
301. *Inguinal canal (canalis inguinalis) of a male*; anterior aspect (½).



302. *Inguinal canal (canalis inguinalis) of a female*; anterior aspect (½).

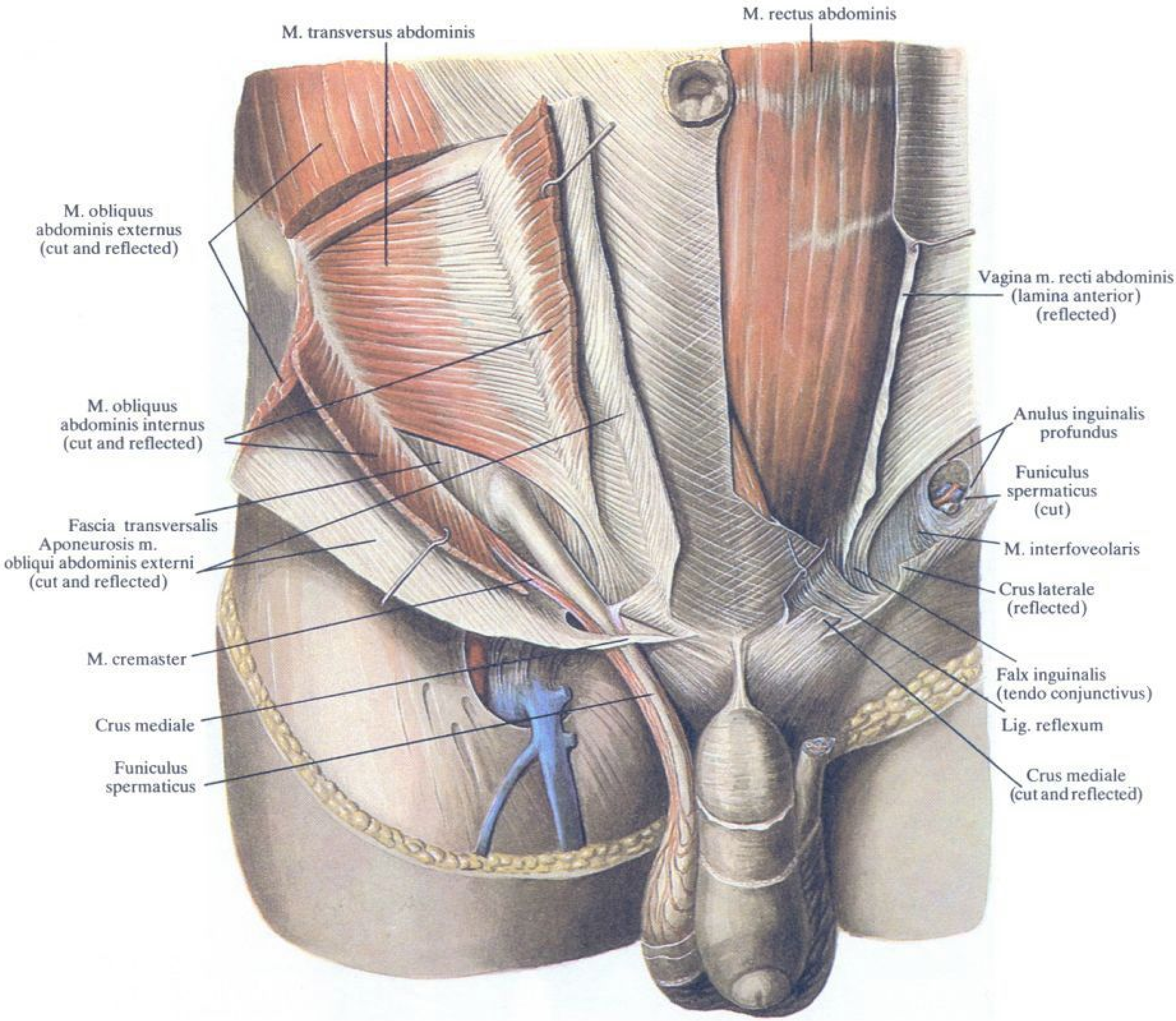


303. *Superficial inguinal ring (anulus inguinalis superficialis)*; anterior aspect (½).



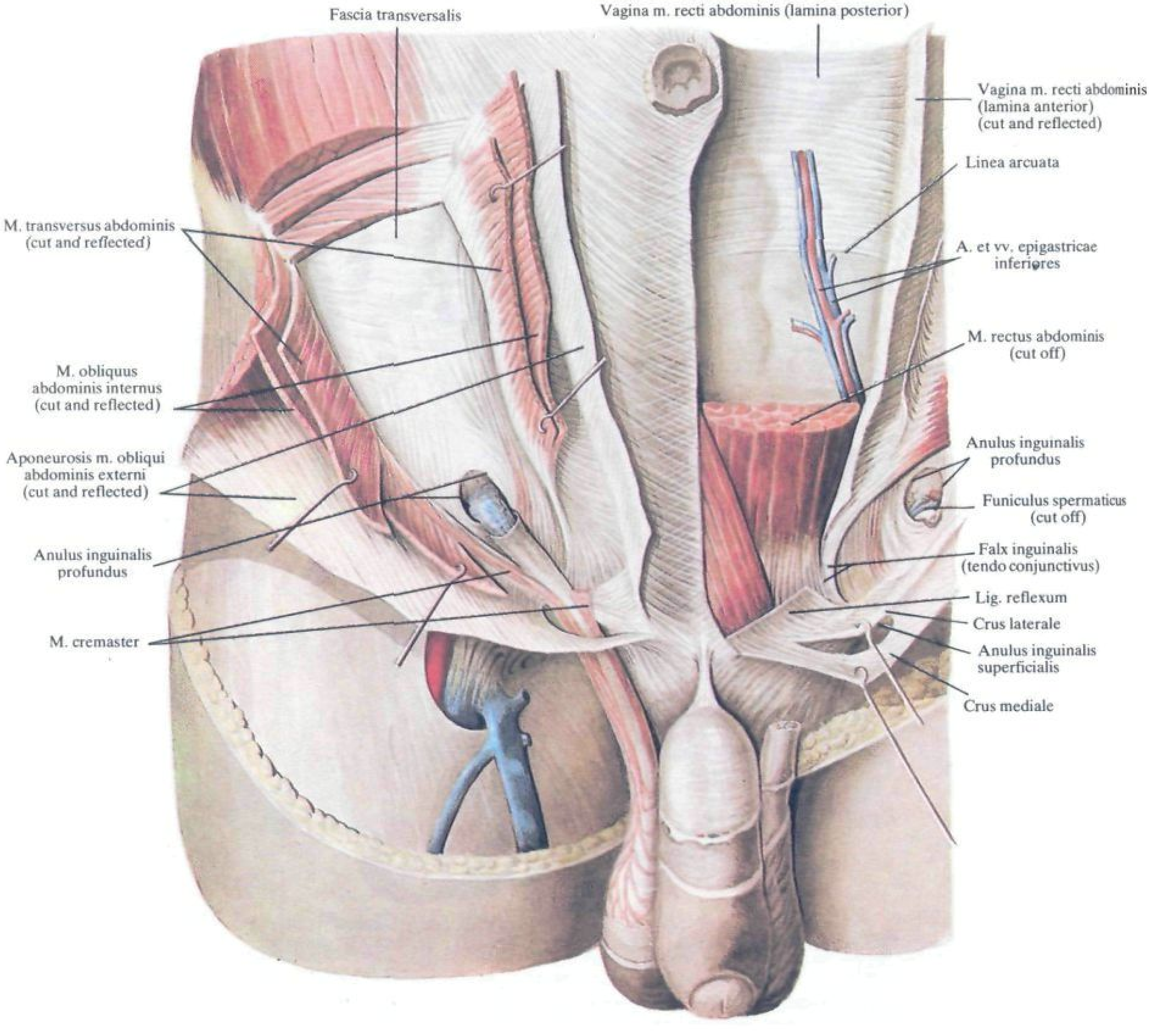
304. *Inguinal canal (canalis inguinalis)*; anterior aspect ($\frac{1}{2}$).

(On the right the lower parts of the external oblique muscle are cut and reflected; on the left the anterior wall of the rectus abdominis sheath is opened and drawn aside.)



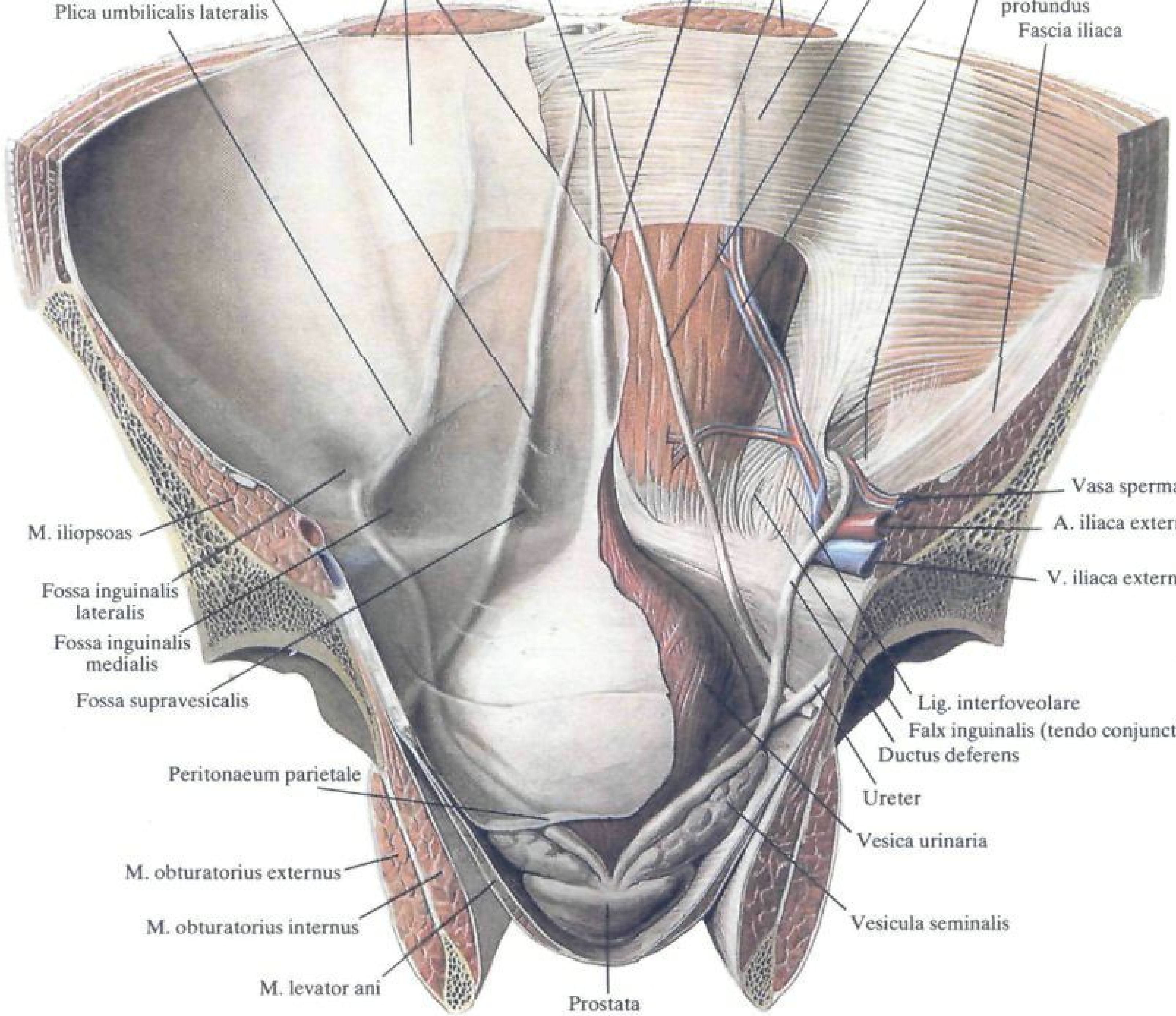
305. *Inguinal canal (canalis inguinalis)*; anterior aspect (½).

(On the right the external and internal oblique muscles are cut and reflected; the walls of the deep inguinal ring are exposed. On the left the spermatic cord is removed; the superficial inguinal ring is exposed.)



306. *Inguinal canal (canalis inguinalis)*; anterior aspect (½).

(The transversalis fascia and the deep inguinal ring are exposed on the right.)



307. *Anterior abdominal and pelvic wall*; inner aspect (½).

(The fossae and folds of the inner surface of the anterior abdominal wall are seen on the right. On the left the peritoneum and fascia transversalis are removed, the deep inguinal ring is exposed.)

MUSCLES OF THE UPPER LIMB

Musculi membri superioris

REGIONS OF THE UPPER LIMB

The following **regions of the upper limb** *(regiones membri superioris)* (Figs 309, 310, 319) are distinguished.

1. The **deltoid region** *(regio deltoidea)* corresponds to the position of the deltoid muscle.

2. The **upper arm** *(brachium)* has an **anterior brachial region** *(regio brachii anterior)* corresponding to the outlines of the biceps brachii muscle and a **posterior brachial region** *(regio brachii posterior)* corresponding to the outlines of the triceps brachii muscle (Figs 330, 331, 340).

3. The **elbow** *(cubitus)* in which are distinguished an **anterior cubital region** *(regio cubiti anterior)* with the **cubital fossa** *(fossa cubitalis)* and a **posterior cubital region** *(regio cubiti posterior)*.

4. The **forearm** *(antebrachium)* with an **anterior** *(regio antebrachii anterior)* and a **posterior antebrachial region** *(regio antebrachii posterior)*.

5. The **wrist** *(carpus)* in which an **anterior carpal region** *(regio carpalis anterior)* and a **posterior carpal region** *(regio carpalis posterior)* are distinguished.

6. The **hand** *(manus)* which has a **palm** *(palma manus)*, on whose medial side is the **thenar eminence** *(thenar)* and on the lateral side the **hypothenar eminence** *(hypothenar)*, and a **back** *(dorsum manus* s. *regio dorsi manus)* which corresponds to the dorsal surface of the carpus and metacarpus.

7. The **fingers** *(digiti manus)* in which are distinguished **palmar surfaces** *(facies digitales ventrales palmares)* and **dorsal surfaces** *(facies digitales dorsales)*.

MUSCLES OF THE UPPER LIMB

The **muscles of the upper limb** *(musculi membri superioris)* are divided into two groups according to their topographic and anatomic features. One group consists of the **muscles of the shoulder girdle** *(musculi cinguli membri superioris)* and the other is made up of the **muscles of the free upper limb** *(musculi partis liberae membri superioris)*. The muscles of the last-named group are divided in turn into the **muscles of the upper arm** *(musculi brachii)*, the **muscles of the forearm** *(musculi antebrachii)*, and the **muscles of the hand** *(musculi manus)*.

MUSCLES OF THE SHOULDER GIRDLE

The following are the muscles of the shoulder girdle (see also *Muscles of the Back* and *Muscles of the Chest*):

(1) the deltoid muscle *(musculus deltoideus)*;

(2) the supraspinatus muscle *(musculus supraspinatus)*;

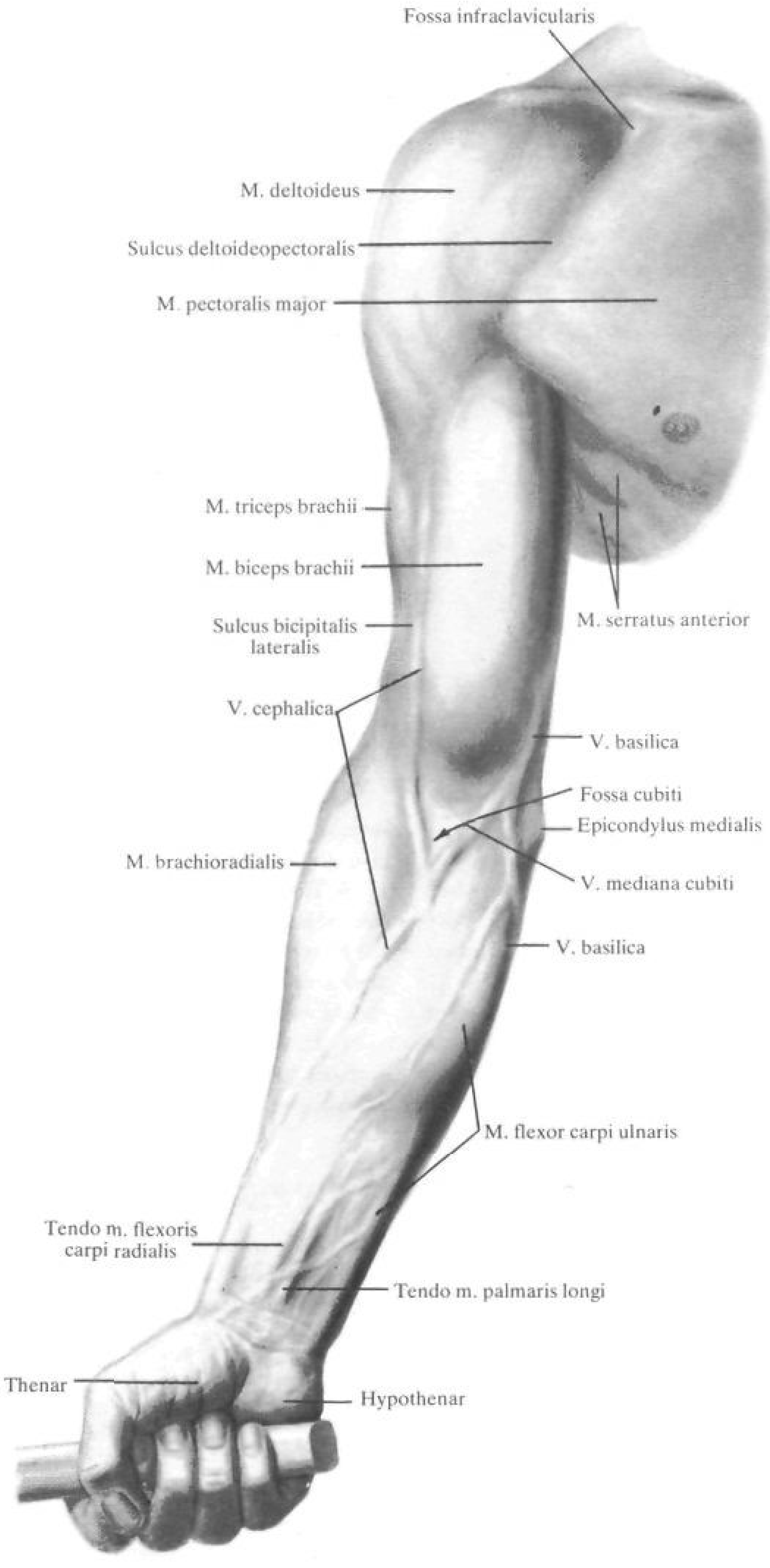
(3) the infraspinatus muscle *(musculus infraspinatus)*;

(4) the teres minor muscle *(musculus teres minor)*;

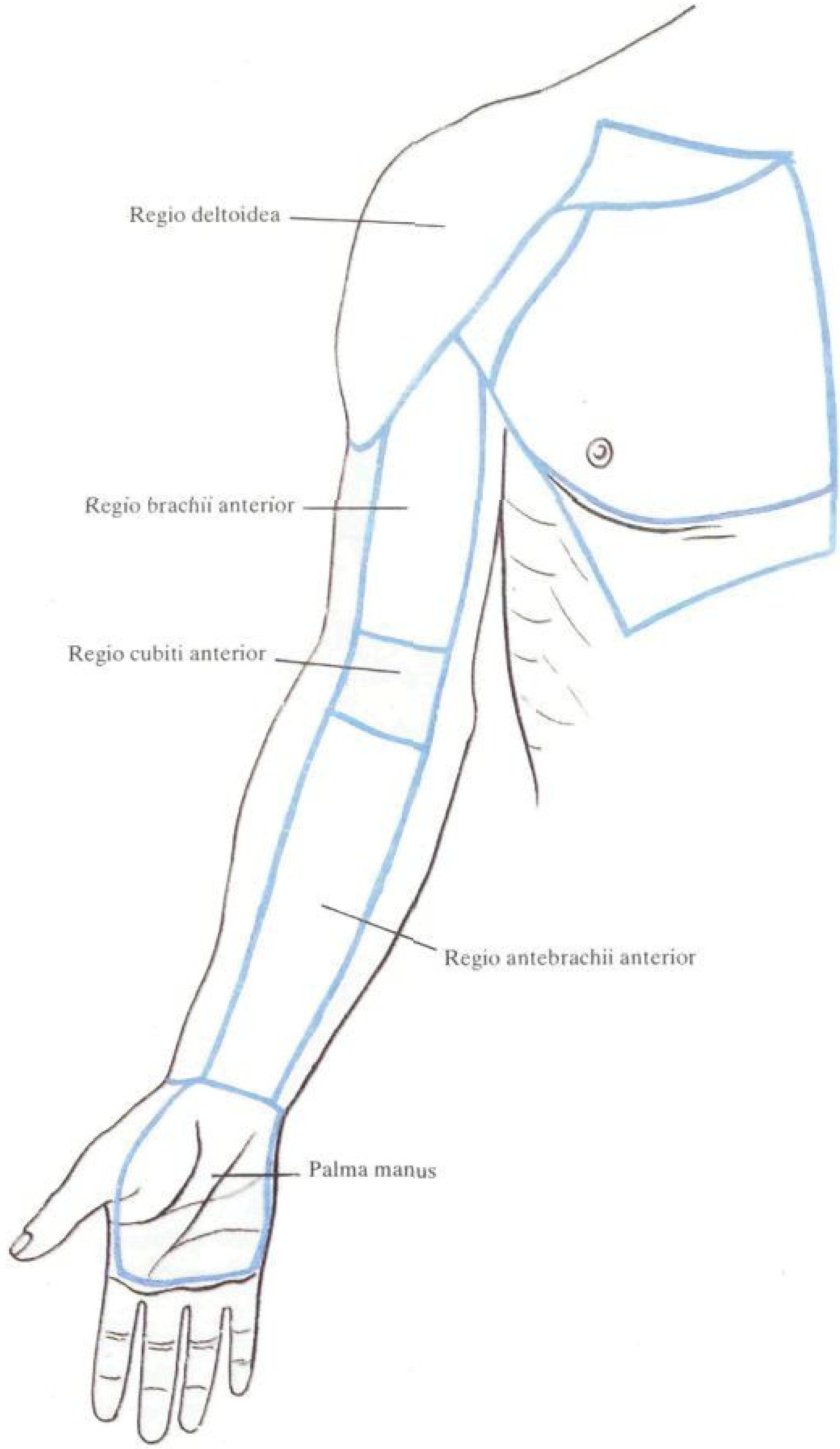
(5) the teres major muscle *(musculus teres major)*;

(6) the subscapularis muscle *(musculus subscapularis)*.

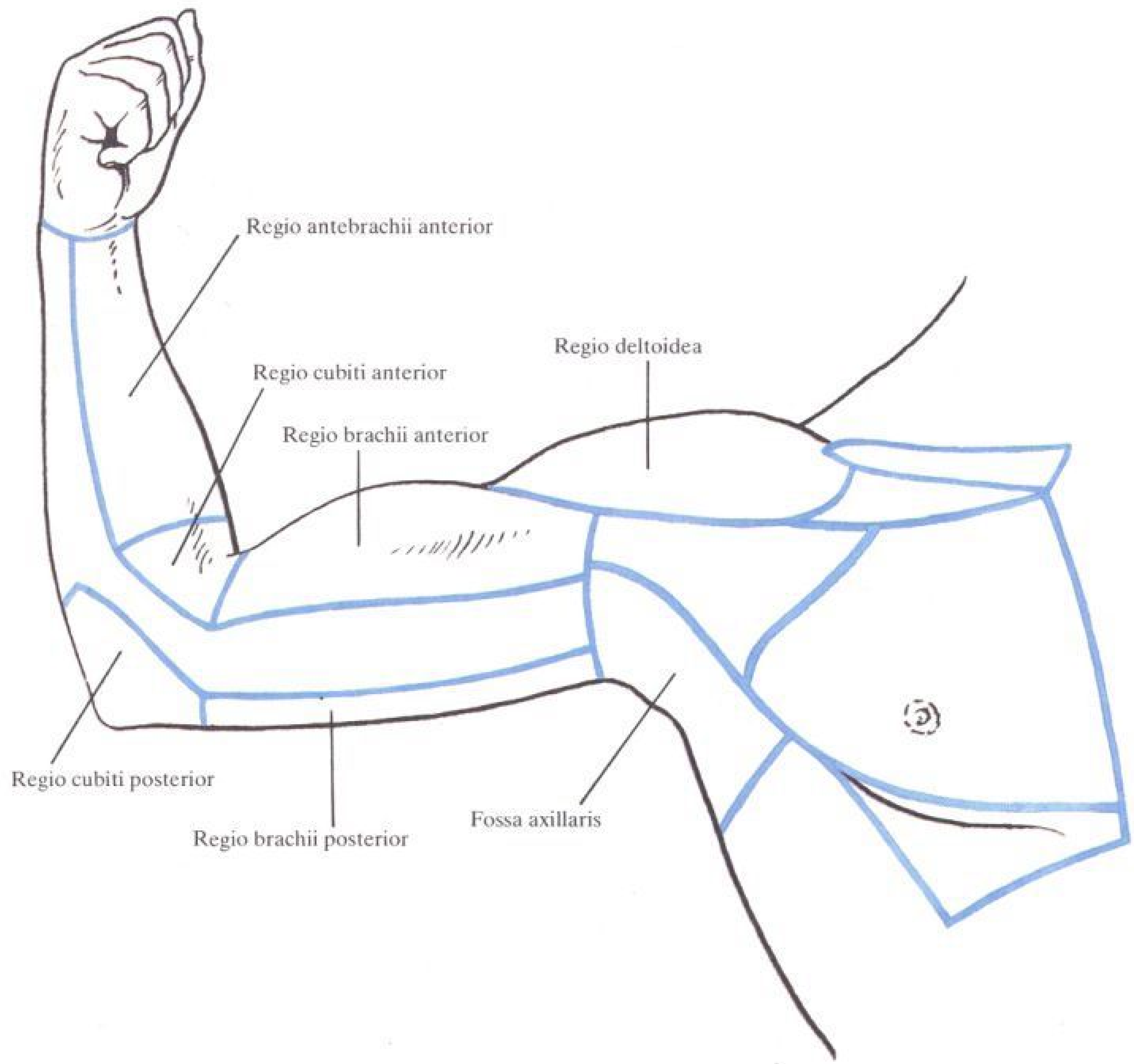
1. The **deltoid muscle** *(musculus deltoideus)* (Fig. 313) covers the shoulder joint. It is thick and triangular with the base facing upwards and the apex downwards. The muscle is made up of large muscle fibres converging fan-wise at the apex. It arises from the



308. *Outlines of the muscles on the anterior surface of right upper limb.*



309. *Regions of upper limb*; anterior aspect.



310. *Regions of upper limb.*

clavicle and scapula and is inserted into the deltoid tuberosity of the humerus. A large **subdeltoid bursa** *(bursa subdeltoidea)* is lodged between the inferior surface of the muscle and the greater tuberosity of the humerus.

Action: pulls the upper arm forwards and pronates it slightly, abducts the arm to the horizontal level, pulls the limb back, supinating it slightly.

Blood supply: the posterior circumflex humeral, acromiothoracic, and profunda brachii arteries.

Innervation: the circumflex nerve (C_5-C_6).

2. The **supraspinatus muscle** *(musculus supraspinatus)* (see Fig. 322) is trihedral and occupies the whole supraspinous fossa from whose walls it arises. The muscular fibres converge to form a narrower part of the muscle, stretch laterally, pass under the acromion, and are inserted into the facet on top of the greater tuberosity of the humerus. The end tendon of the muscle is fused with the posterior surface of the shoulder joint capsule and on contraction of the muscle pulls the capsule away thus preventing its incarceration.

Action: abducts the arm.

Blood supply: the suprascapular and circumflex scapular arteries.

Innervation: the suprascapular nerve (C_5-C_6).

3. The **infraspinatus muscle** *(musculus infraspinatus)* (see Fig. 322) is triangular, flat, and fills the infraspinatus fossa completely. Its lateral part is covered by the deltoid muscle, medial part by the trapezius muscle, and inferior parts by the latissimus dorsi and the teres major muscles. In the middle it is covered by its own fascia. The infraspinatus muscle arises from the entire surface of the infraspinatus fossa and the posterior surface of the scapula, leaving the external border and inferior angle free.

The muscle is directed laterally and its fibres converge to form a small short tendon which is inserted into the middle facet of the greater tuberosity of the humerus. At the insertion is the **bursa of the infraspinatus muscle** *(bursa subtendinea musculi infraspinati).*

Action: pulls the raised limb to the back and rotates the arm laterally.

311. *Lines of skin incisions on upper limb* (most suitable for exposure of muscles during dissection).

Blood supply: the circumflex scapular and suprascapular arteries.

Innervation: the suprascapular nerve (C_5–C_6).

4. The **teres minor muscle** *(musculus teres minor)* (see Fig. 322) is elongated, slightly rounded (on cross section) and its fibres are arranged parallel to one another.

The superior border of the muscle is in contact with the infraspinatus muscle; the posterior part is covered by the teres major and the anterior by the deltoid muscles. The teres minor muscle arises from the lateral border of the scapula and occupies a narrow area on it extending from below the infraglenoid tubercle to the inferior angle of the scapula. Passing laterally, the muscle is continuous with a short and rather strong tendon which is fused with the posterior surface of the shoulder joint capsule and inserted into the inferior facet of the greater tuberosity of the humerus.

Action: supinates the upper arm and pulls it slightly to the back; draws out the capsule of the shoulder joint.

Blood supply: the circumflex scapular artery.

Innervation: the circumflex nerve (C_5).

5. The **teres major muscle** *(musculus teres major)* (see Fig. 322) is flat and elongated with the fibres running first downwards and then parallel to its length. Its posterior part is covered by the latissimus dorsi muscle, the lateral part by the long head of the triceps brachii muscle and the deltoid muscle, and the middle part by a fine fascia connected to the fascia of the latissimus dorsi muscle.

The teres major muscle arises from the lateral border of the inferior angle of the scapula and fascia of the infraspinatus muscle and runs laterally to be inserted into the crest of the lesser tuberosity of the humerus. The **bursa of the teres major muscle** *(bursa subtendinea musculi teretis majoris)* is lodged at the insertion.

Action: pronates and pulls the upper arm back thus drawing it to the trunk.

Blood supply: the subscapular artery.

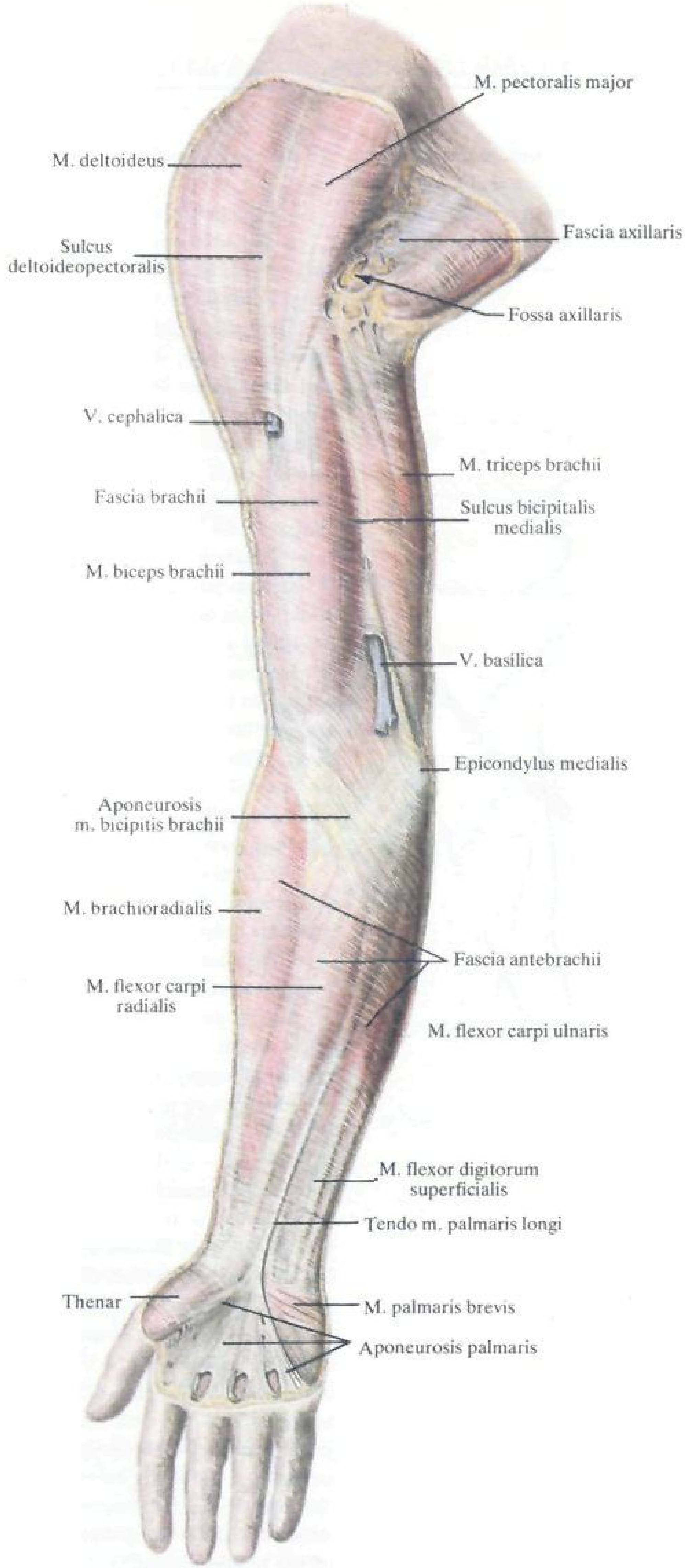
Innervation: the subscapular nerve (C_5–C_7).

6. The **subscapularis muscle** *(musculus subscapularis)* (Fig. 314) fills the subscapular fossa completely. It is flat, triangular and made up of muscle fibres which are separated by fascial layers. The base of the triangle is parallel to the medial scapular border, while the apex is formed by the converging muscle fibres and faces laterally towards the humerus. Two layers are distinguished in the muscle, superficial and deep. The superficial fibres arise from the costal surface of the scapula, the deep fibres originate from the subscapular fascia which is attached to the borders of the subscapular fossa. Running laterally the muscle is continuous with a small tendon which is fused with the anterior surface of the shoulder joint capsule (which the contracting muscle draws out) and is inserted into the lesser tuberosity of the humerus and its crest. At the insertion of the tendon is a small **subscapular bursa** *(bursa subtendinea musculi subscapularis)* which communicates with the cavity of the shoulder joint.

Action: pronates the arm and helps in its adduction to the trunk.

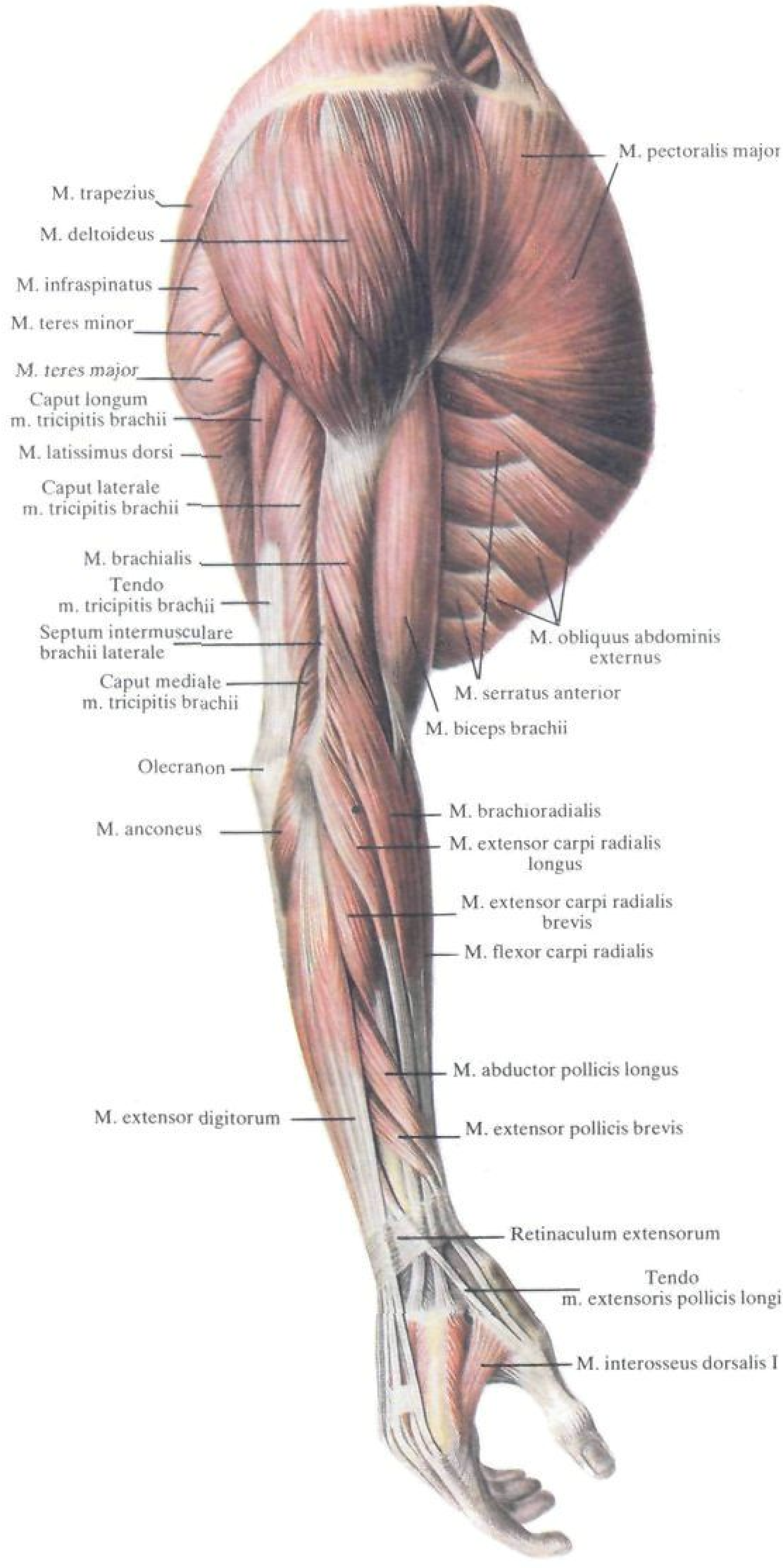
Blood supply: the subscapular artery.

Innervation: the subscapular nerve (C_5–C_7).

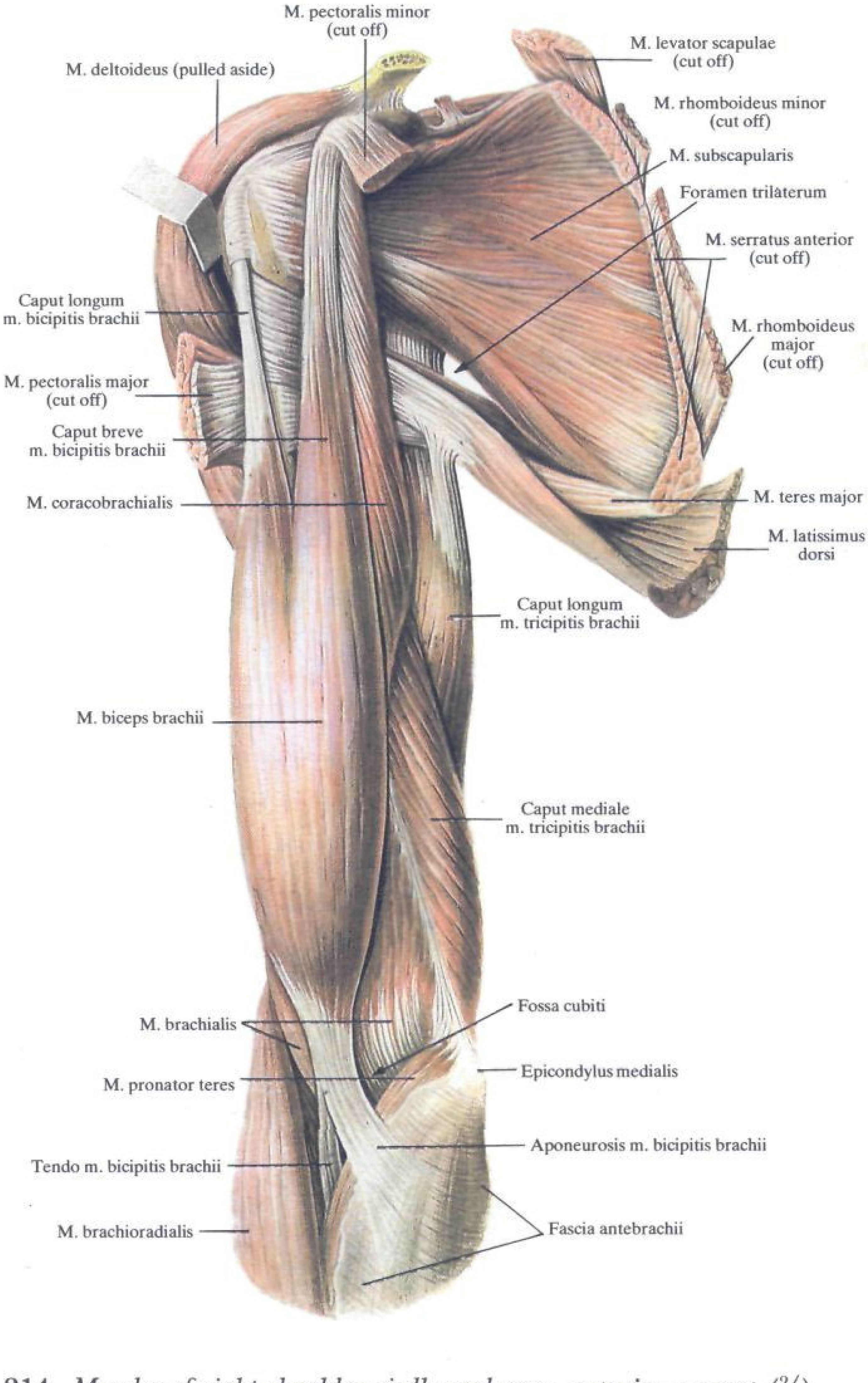


312. *Muscles and fasciae of right upper limb*; anterior aspect (¼).

(The skin and subcutaneous fat are removed.)



313. *Muscles of right upper limb*; lateral aspect (¼).



314. *Muscles of right shoulder girdle and arm*; anterior aspect ($\frac{2}{5}$).

MUSCLES OF THE FREE UPPER LIMB

MUSCLES OF THE UPPER ARM

The muscles of the upper arm are separated into the anterior and posterior groups. Flexors (the biceps brachii, coracobrachialis, and brachialis muscles) are mainly related to the first group, and extensors (the triceps brachii and anconeus muscle) to the second group.

THE ANTERIOR GROUP OF MUSCLES OF THE UPPER ARM

1. The **biceps brachii muscle** *(musculus biceps brachii)* (Figs 312-314) has two heads and is rounded and spindle-shaped. It occupies the anterior region of the upper arm and the bend of the elbow and lies directly under the skin.

The **long head** *(caput longum)* is located lateraly. It arises by a long tendon from the supraglenoid tubercle of the scapula, runs over the head of the humerus through the cavity of the shoulder joint, lies in the intertubercular groove where it is invested by the **intertubercular synovial sheath** *(vagina synovialis intertubercularis)* and is then continuous with a muscular belly.

The **short head** *(caput breve)* occupies a medial position. It takes origin by a wide tendon from the apex of the coracoid process of the scapula, passes downwards and is also continuous as a muscular belly.

The two heads are united to form a long fleshy belly which, on reaching the cubital fossa, becomes narrower and continues as a strong tendon which is inserted into the tuberosity on the radius.

Some of the fibres separate from the proximal end of the tendon as a thin sheet; this is the **bicipital aponeurosis** *(aponeurosis musculi bicipitis brachii* s. *lacertus fibrosus)*. To each side of the biceps brachii muscle on the upper arm run vertically and almost symmetrically two grooves called the **medial** and **lateral bicipital grooves** *(sulcus bicipitalis medialis* et *sulcus bicipitalis lateralis)*.

Action: flexes the limb at the elbow joint and supinates the forearm; the long head helps in abduction and the short head in adduction of the limb.

Blood supply: muscular branches of the axillary artery and brachial artery.

Innervation: the musculocutaneous nerve (C_5-C_6).

2. The **coracobrachialis muscle** *(musculus coracobrachialis)* (Fig. 315) is flat and covered entirely by the short head of the biceps brachii muscle. It takes origin from the apex of the coracoid process and is inserted below the middle of the medial surface of the humerus on the medial lip of the bicipital groove. Some of its fibres are also inserted into the medial intermuscular septum of the arm. At the origin of the muscle lies the **bursa of the coracobrachialis muscle** *(bursa musculi coracobrachialis)*.

Action: raises and adducts the arm.

Blood supply: anterior and posterior circumflex humeral arteries.

Innervation: the musculocutaneous nerve (C_6-C_7).

3. The **brachialis muscle** *(musculus brachialis)* (Fig. 315) is quite broad, fleshy, and spindle-shaped and lies under the biceps brachii muscle on the anterior surface of the lower half of the upper arm. It arises from the lateral and anterior surfaces of the distal half of the humerus, embracing in a horseshoe manner the insertion of the deltoid muscle, and also from the lateral and medial intermuscular septa of the arm. It then bridges the elbow joint, fuses with its capsule, and is inserted into the tuberosity of the ulna.

Action: flexes the forearm and stretches the capsule of the elbow joint.

Blood supply: the ulnar collateral arteries and the muscular branches of the brachial and radial recurrent arteries.

Innervation: the musculocutaneous nerve (C_5-C_6).

THE POSTERIOR GROUP OF MUSCLES OF THE UPPER ARM

1. The **triceps brachii muscle** *(musculus triceps brachii)* (Fig. 322) is large and long and stretches for the whole distance of the posterior surface of the arm from the scapula to the olecranon. It has three heads, a long, a lateral, and a medial head. At the origin they are covered by the deltoid muscle.

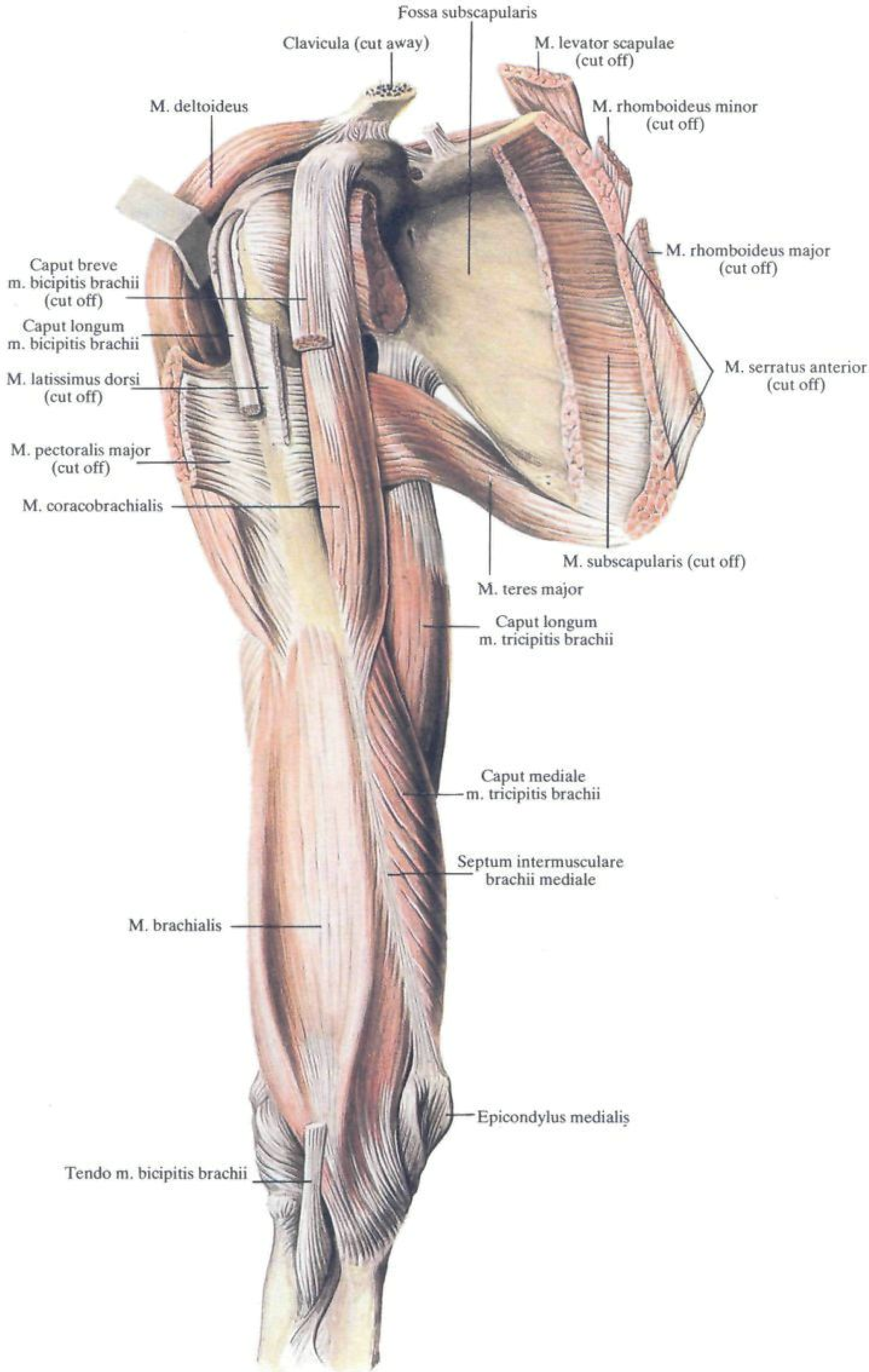
The **long head** *(caput longum)* arises by a wide tendon from the infraglenoid tubercle of the scapula, passes downwards in the space between the teres minor and major muscles, and is next and medial to the lateral head.

The **lateral head** *(caput laterale)* takes origin from the posterior surface of the humerus above the spiral groove and from the medial and lateral intermuscular septa and is directed medially and downwards.

The **medial head** *(caput mediale)* is covered by the lateral and partly by the long heads. It arises from the posterior surface of the humerus below the spiral groove and from the medial and lateral intermuscular septa.

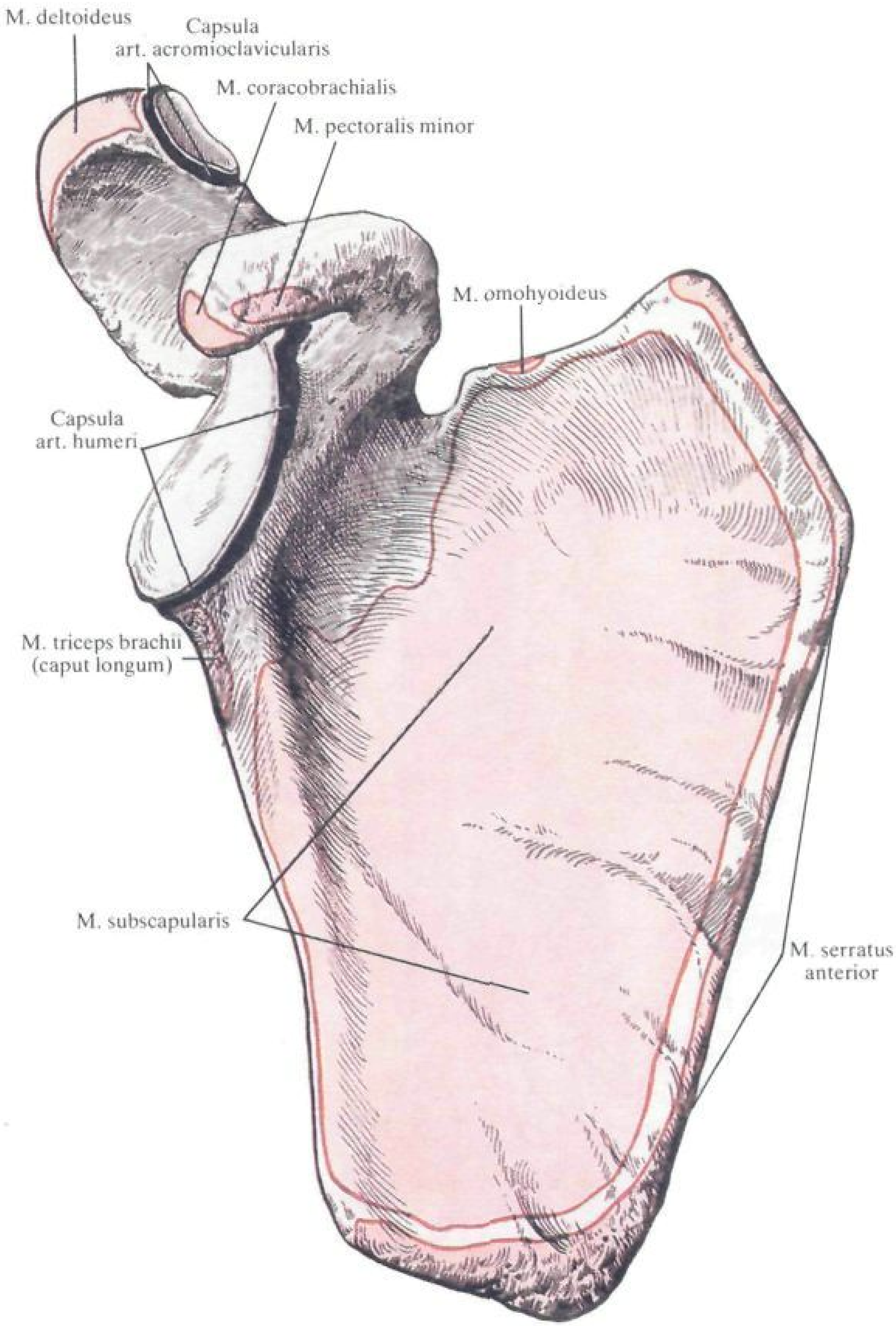
The three heads meet to form a strong spindle-shaped belly which is continuous downwards with a strong tendon inserted into the olecranon. Some of the deep fibres of the medial head intertwine with the capsule of the elbow joint.

Action: contraction of the long head moves the arm backwards

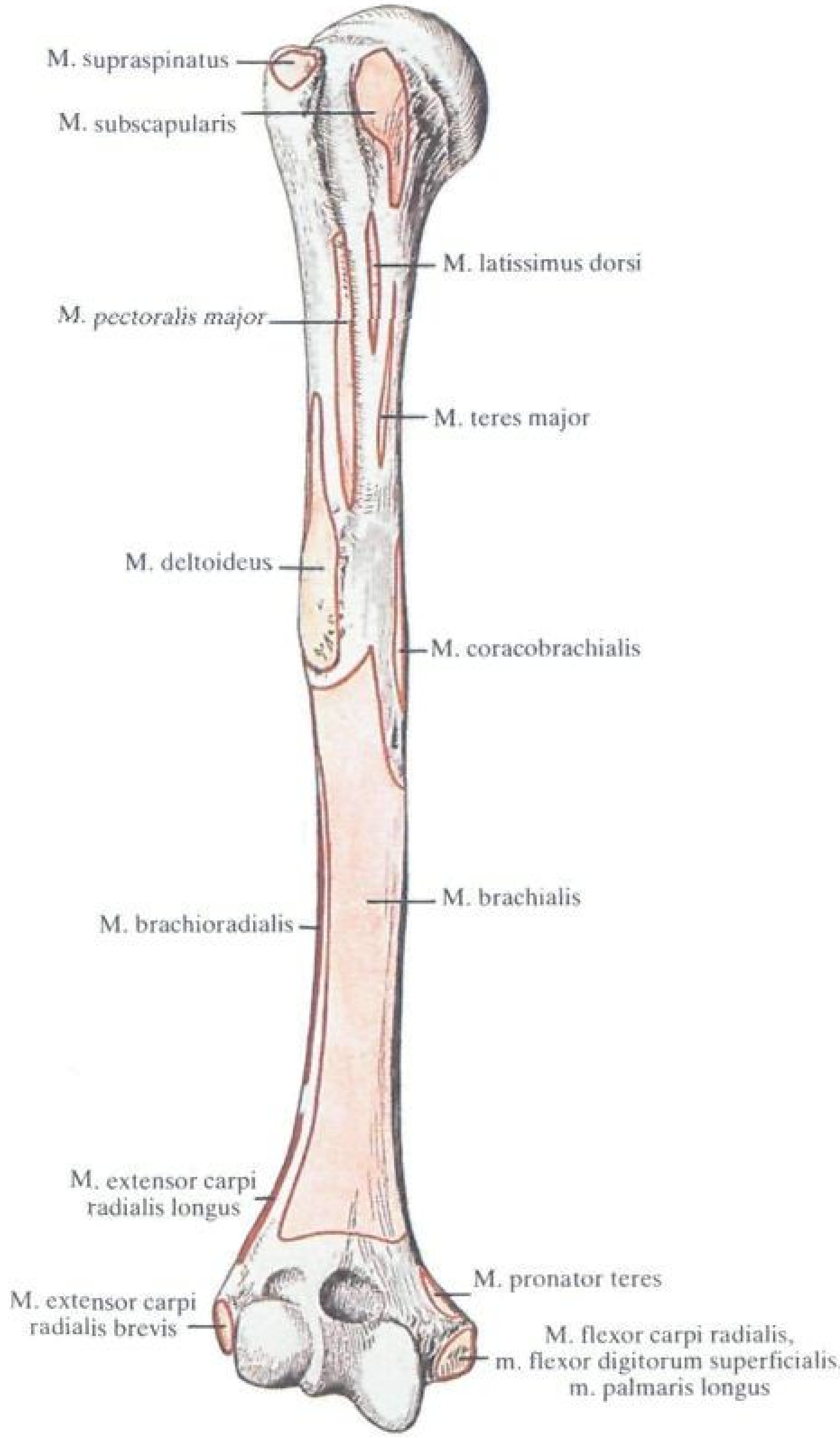


315. *Muscles of right shoulder girdle and arm*; anterior aspect (2/5).

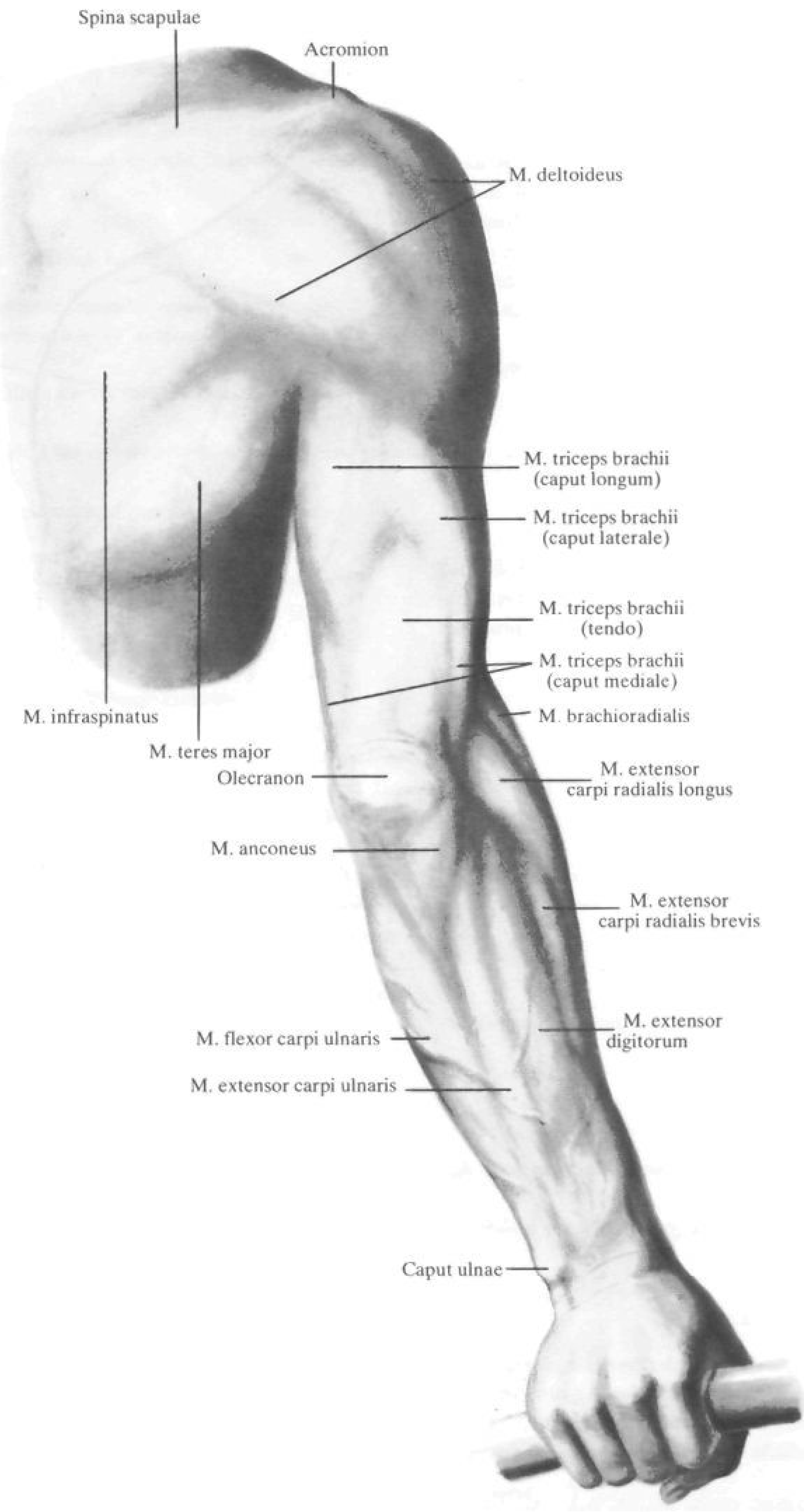
(The subscapularis and biceps brachii muscles are partly removed.)



316. *Sites of origin and insertion of muscles on right scapula*; anterior aspect (schematical representation).



317. *Sites of origin and insertion of muscles on right humerus*; anterior aspect (schematical representation).



318. *Outlines of muscles of right upper limb*; posterior aspect.

and adducts it; the whole muscle helps in extension of the forearm at the elbow.

Blood supply: the posterior circumflex humeral, profunda brachii, and ulnar collateral arteries.

Innervation: radial nerve (C_7–C_8).

2. The **anconeus muscle** *(musculus anconeus)* (Fig. 321) is small and pyramidal in shape. It is as if a continuation of the medial head of the triceps brachii muscle. Its apex takes origin from the lateral epicondyle of the humerus and the lateral ligament of the elbow, while the base, which consists of fibres radiating fan-wise from the apex, is inserted into the posterior surface of the olecranon and fuses with the capsule of the elbow joint.

Action: extends the forearm at the elbow joint and at the same time draws away its capsule.

Blood supply: the interosseous recurrent artery.

Innervation: the radial nerve (C_7–C_8).

MUSCLES OF THE FOREARM

The **muscles of the forearm** *(musculi antebrachii)* are divided into three groups according to their position: anterior, lateral (radial), and posterior. The muscles of the anterior and posterior groups are arranged in layers.

There are four layers in the anterior group.

First (Superficial) Layer

1. The **pronator teres muscle** *(musculus pronator teres)*.
2. The **flexor carpi radialis muscle** *(musculus flexor carpi radialis)*.
3. The **palmaris longus muscle** *(musculus palmaris longus)*.
4. The **flexor carpi ulnaris muscle** *(musculus flexor carpi ulnaris)*.

Second Layer

The **flexor digitorum superficialis muscle** *(musculus flexor digitorum superficialis)*.

Third Layer

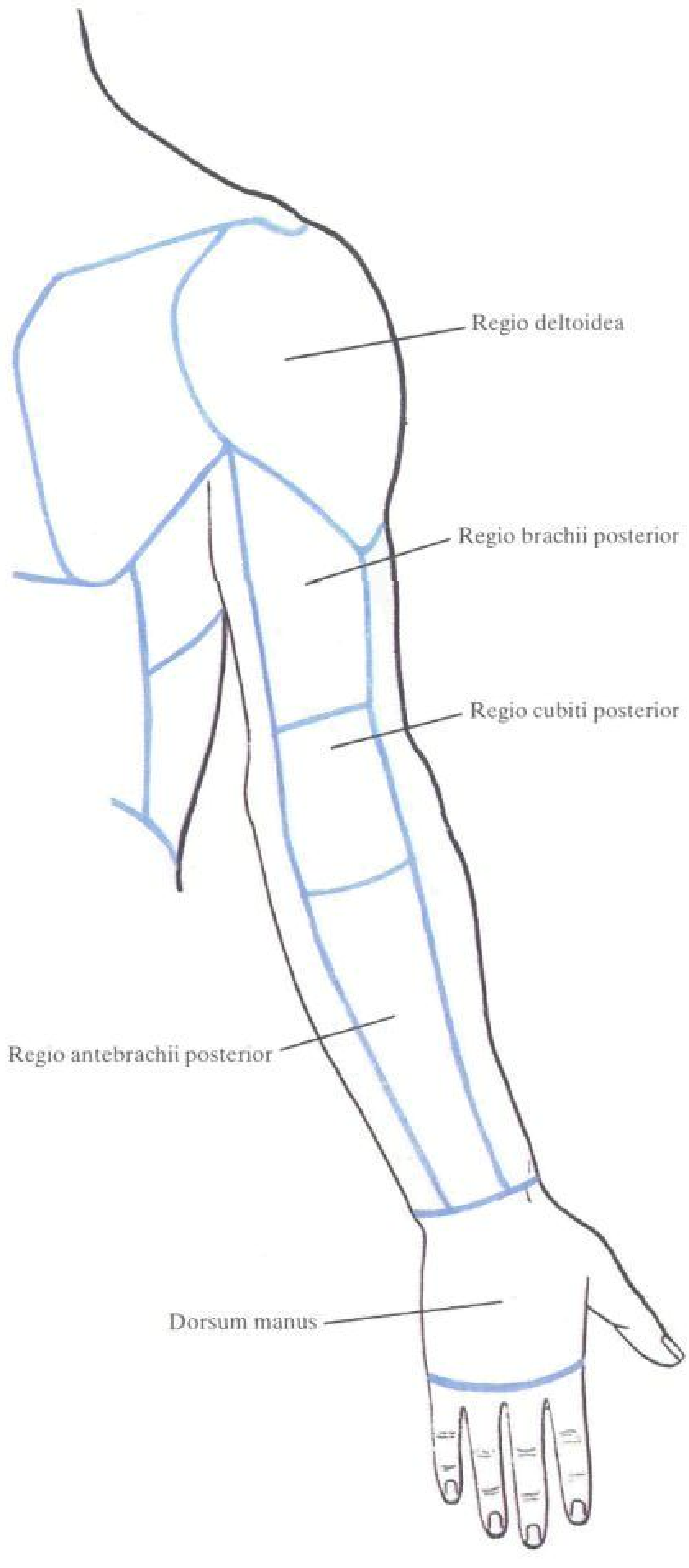
1. The **flexor digitorum profundus muscle** *(musculus flexor digitorum profundus)*.
2. The **flexor pollicis longus muscle** *(musculus flexor pollicis longus)*.

Fourth Layer

The **pronator quadratus muscle** *(musculus pronator quadratus)*.

The lateral (radial) group includes the following muscles.

1. The **brachioradialis muscle** *(musculus brachioradialis)*.
2. The **extensor carpi radialis longus muscle** *(musculus extensor carpi radialis longus)*.
3. The **extensor carpi radialis brevis muscle** *(musculus extensor carpi radialis brevis)*. The muscles of the posterior group lie in two layers.



319. *Regions of upper limb*; posterior aspect.

Superficial Layer

1. The **extensor carpi ulnaris muscle** *(musculus extensor carpi ulnaris)*.
2. The **extensor digitorum muscle** *(musculus extensor digitorum)*.
3. The **extensor digiti minimi muscle** *(musculus extensor digiti minimi)*.

Deep Layer

1. The **supinator muscle** *(musculus supinator)*.
2. The **abductor pollicis longus muscle** *(musculus abductor pollicis longus)*.
3. The **extensor pollicis brevis muscle** *(musculus extensor pollicis brevis)*.
4. The **extensor pollicis longus muscle** *(musculus extensor pollicis longus)*.
5. The **extensor indicis muscle** *(musculus extensor indicis)*.

THE ANTERIOR GROUP OF MUSCLES OF THE FOREARM

First (Superficial) Layer

1. The **pronator teres muscle** *(musculus pronator teres)* (Fig. 333) is thick and the shortest in this layer. It arises by two heads. The larger, **humeral head** *(caput humerale)* arises from the medial epicondyle of the humerus, medial intermuscular septum, and antebrachial fascia; the smaller, **ulnar head** *(caput ulnare)* takes origin from the medial edge of the tuberosity of the ulna. The two heads form a belly which is slightly flattened from front to back and is continuous with a narrow tendon. The muscle stretches obliquely and laterally to be inserted into the middle third of the lateral surface of the radius.

Action: pronates the forearm and helps in its flexion at the elbow joint.

Blood supply: muscular branches of the brachial, ulnar and radial arteries.

Innervation: the median nerve (C_6-C_7).

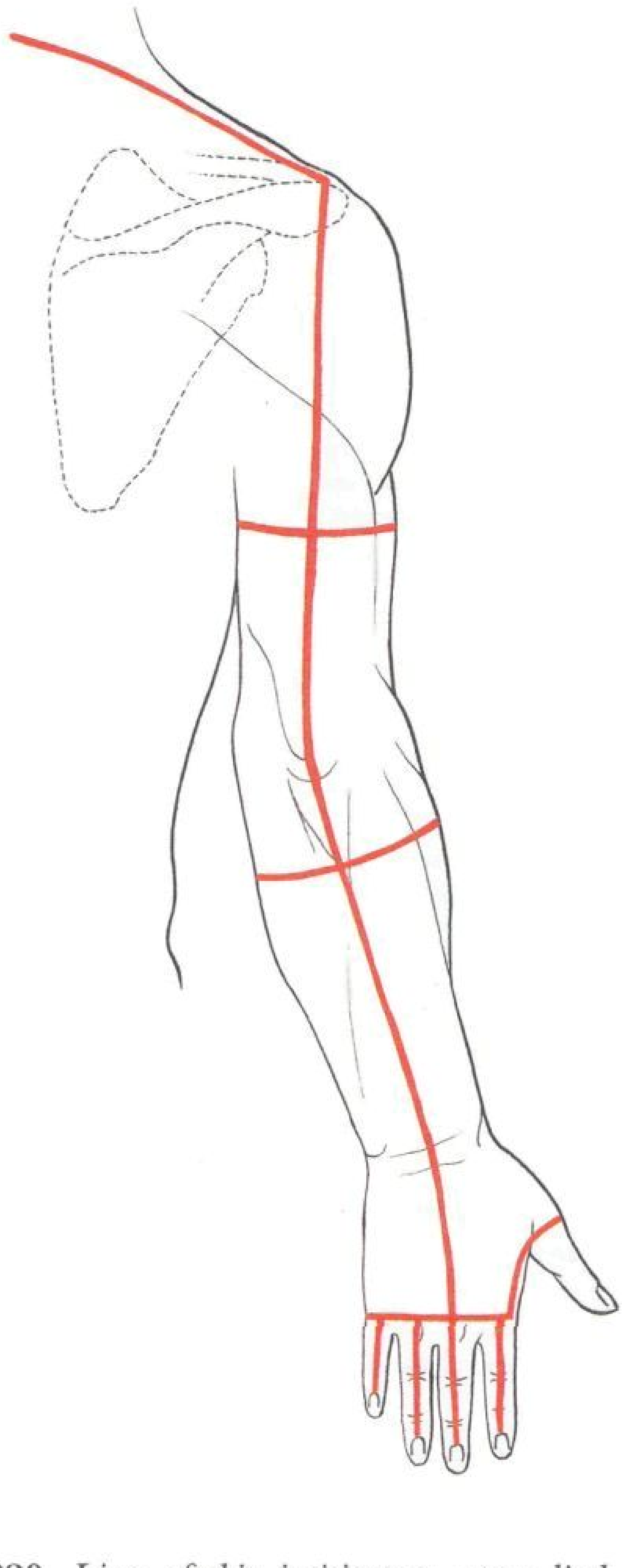
2. The **flexor carpi radialis muscle** *(musculus flexor carpi radialis)* is bipennate, flat, and long. It lies laterally to all the forearm flexors. Proximally it is covered by the aponeurosis of the biceps brachii muscle and the palmaris longus muscle; the remaining, larger, part is covered only by fascia and skin. The muscle arises from the medial humeral epicondyle, the intermuscular septa, and the antebrachial fascia, runs downwards, passes under the flexor retinaculum, and is inserted into the base of the palmar surface of the second (third) metacarpal bone.

Action: flexes the hand at the wrist and pronates it.

Blood supply: muscular branches of the radial artery.

Innervation: the median nerve [C_6-C_7 (C_8)].

3. The **palmar longus muscle** *(musculus palmaris longus)* (Fig. 330) has a short spindle-shaped belly and a very long tendon. It lies directly under the skin medial to the flexor carpi radialis muscle. It takes origin from the medial humeral epicondyle, the in-



320. *Lines of skin incisions on upper limb* (most suitable for exposure of muscles in dissection).

termuscular septum, and the antebrachial fascia, passes to the palm and continues as the wide palmar aponeurosis.

Action: tenses the palmar aponeurosis and helps in flexion of the hand.

Blood supply: muscular branches of the radial artery.

Innervation: the median nerve [(C_7) C_8].

4. The **flexor carpi ulnaris muscle** *(musculus flexor carpi ulnaris)* (Fig. 331) occupies the medial border of the forearm. It has a long fleshy belly and a rather thick tendon. It arises by two heads, by the **humeral head** *(caput humerale)* from the medial epicondyle of the humerus and the intermuscular septum, and by the **ulnar head** *(caput ulnare)* from the olecranon, the two upper thirds of the dorsal surface and fascia of the forearm. Running downwards, the tendon passes under the flexor retinaculum to be inserted into the pisiform bone. Some of the fibres are continuous with the pisometacarpal and pisohamate ligaments which are inserted into the hamate and fifth metacarpal bones.

Action: flexes the hand and helps to adduct it.

Blood supply: the superior ulnar collateral, supratrochlear brachial, and ulnar arteries.

Innervation: the ulnar nerve (C_8, Th_1).

Second Layer

1. The **flexor digitorum sublimis muscle** *(musculus flexor digitorum superficialis)* (Fig. 331) is covered in front by the palmaris longus and flexor carpi radialis muscles which leave grooves on it. The muscle itself takes origin by two heads. One is called the **humero-ulnar head** *(caput humeroulnare)*; it is long and narrow and arises from the medial epicondyle of the humerus and the coronoid process of the ulna. The other is the **radial head** *(caput radiale)* which is wide and short and arises from the proximal palmar surface of the radius. The two heads join to form a common belly which separates into four long tendons. These tendons pass over to the hand and run in the carpal tunnel to be inserted into the bases of the middle phalanges of the fingers. At the level of the proximal phalanges each tendon splits into two and therefore has two points of insertion on the edges of the base of the middle phalanges.

Action: flexes the middle phalanges of the index, middle, ring, and little fingers.

Blood supply: the radial and ulnar arteries.

Innervation: the median nerve (C_7–C_8, Th_1).

Third Layer

1. The **flexor digitorum profundus muscle** *(musculus flexor digitorum profundus)* (Fig. 332) is a strongly developed flat and wide belly which springs from the proximal half of the anterior ulnar surface and the interosseous membrane. It passes downwards and gives place to four tendons which run under the flexor retinaculum and into the carpal tunnel with the tendons of the flexor digitorum profundus muscle lying above them. Then each tendon of the flexor digitorum profundus muscle passes between the slips of the flexor digitorum sublimis tendons to be inserted into the bases of the distal phalanges of all fingers except for the thumb. The tendons of the flexor digitorum sublimis and profundus are enclosed in a **common synovial sheath** *(vagina synovialis communis musculi flexorum digitorum manus)*. The sheaths for the tendons of the index, middle, and ring fingers originate at the level of the metacarpal heads and pass to the distal phalanges separately from the common sheath. Only the sheath for the tendon of the little finger is connected with the common sheath.

Action: flexes the distal phalanges of all fingers except for the thumb.

Blood supply: muscular branches of the ulnar artery.

Innervation: ulnar and median nerves (C_6–C_8, Th_1).

2. The **flexor pollicis longus muscle** *(musculus flexor pollicis longus)* (Fig. 332) is long, unipennate, and lies on the lateral border of the forearm. It arises from the upper two thirds of the anterior radial surface and the interosseous membrane and from the medial epicondyle of the humerus. The muscle is continuous with a long tendon which, passing downwards, lies in the carpal tunnel; it is then invested by the **synovial sheath of the flexor pollicis longus tendon** *(vagina tendinis musculi flexoris pollicis longi)* and is inserted into the base of the distal phalanx of the thumb.

Action: flexes the distal phalanx of the thumb.

Blood supply: muscular branches of the radial, ulnar, and anterior interosseous arteries.

Innervation: the median nerve (C_6–C_8).

Fourth Layer

The **pronator quadratus muscle** *(musculus pronator quadratus)* (Fig. 333) is a thin quadrangular plate formed of transverse muscle fibres stretching directly on the interosseous membrane. It takes origin from the distal part of the palmar surface of the ulna and is inserted into the palmar surface of the radius on the same level.

Action: pronates the forearm.

Blood supply: the anterior interosseous artery.

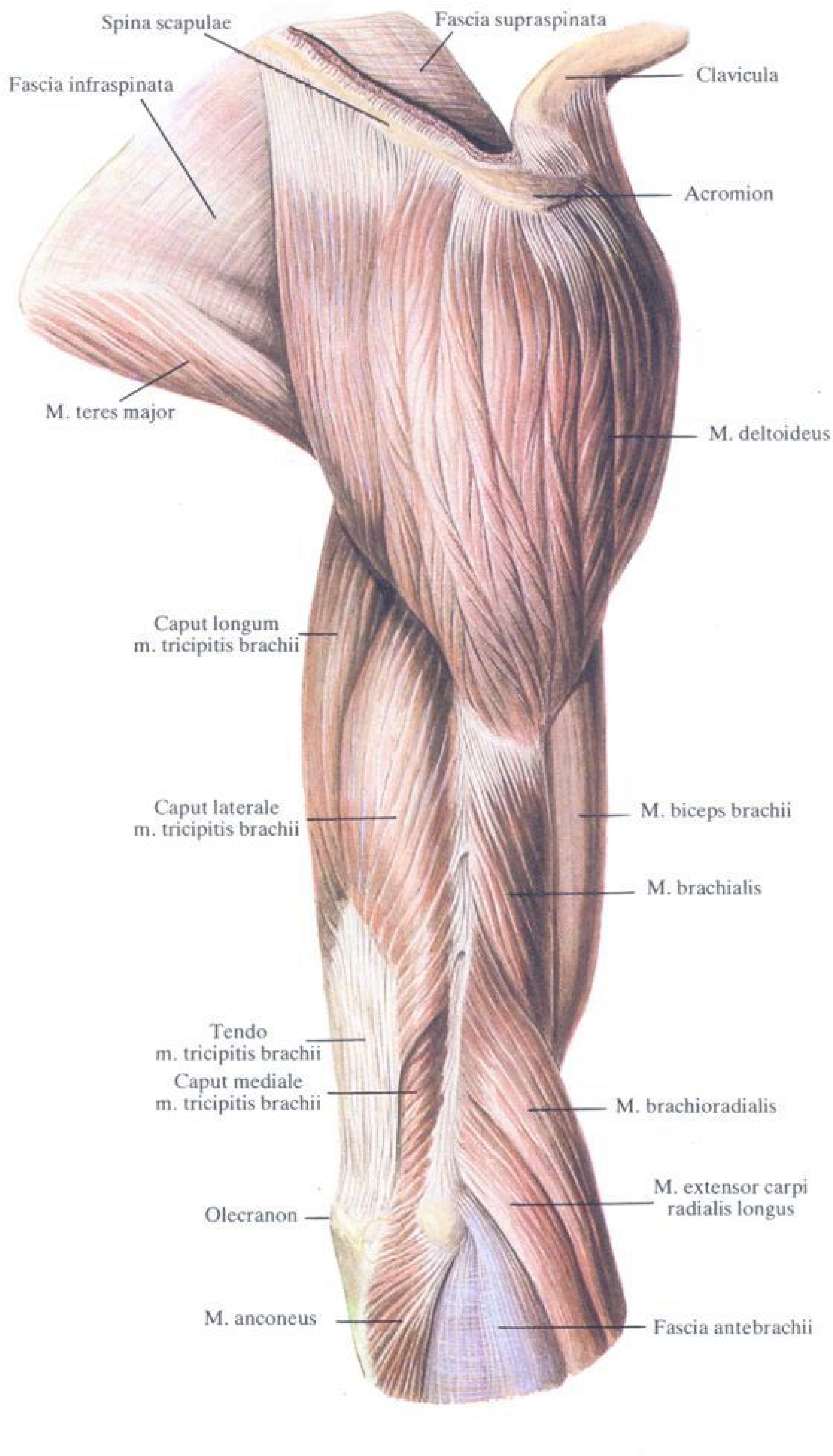
Innervation: the median nerve (C_6–C_8).

THE LATERAL (RADIAL) GROUP OF MUSCLES OF THE FOREARM

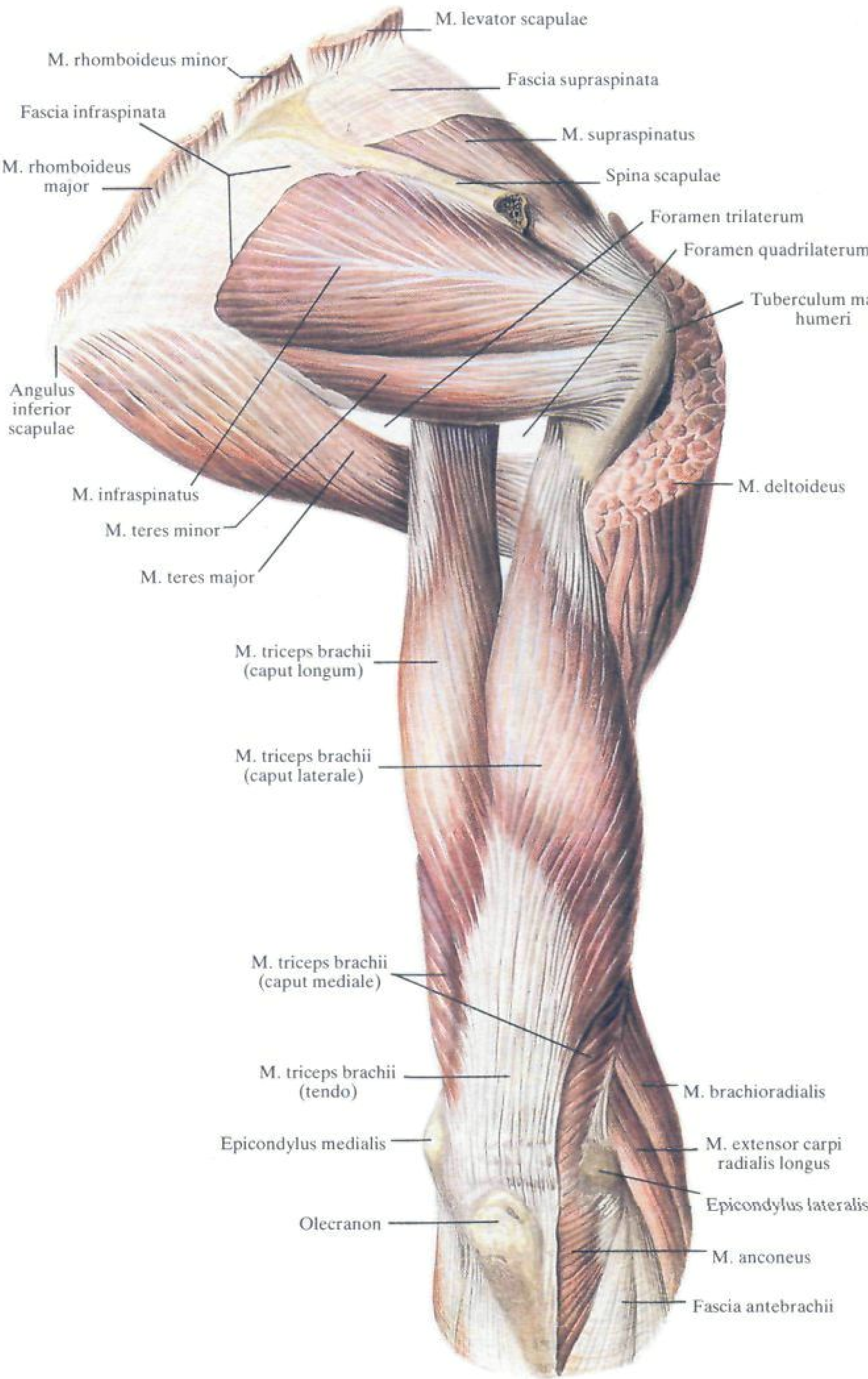
1. The **brachioradialis muscle** *(musculus brachioradialis)* (Fig. 336) is spindle-shaped and occupies the extreme lateral position. Slightly below its middle the muscle gives place to a long tendon. The muscle arises from the lateral border of the humerus slightly above the lateral epicondyle and from the lateral intermuscular septum of the upper arm and runs downwards to be inserted into the lateral surface of the radius proximal to the styloid process.

Action: flexes the limb at the elbow joint and helps both to pronate and to supinate the radius.

Blood supply: the anterior descending branch of the profunda brachii artery and radial recurrent arteries.

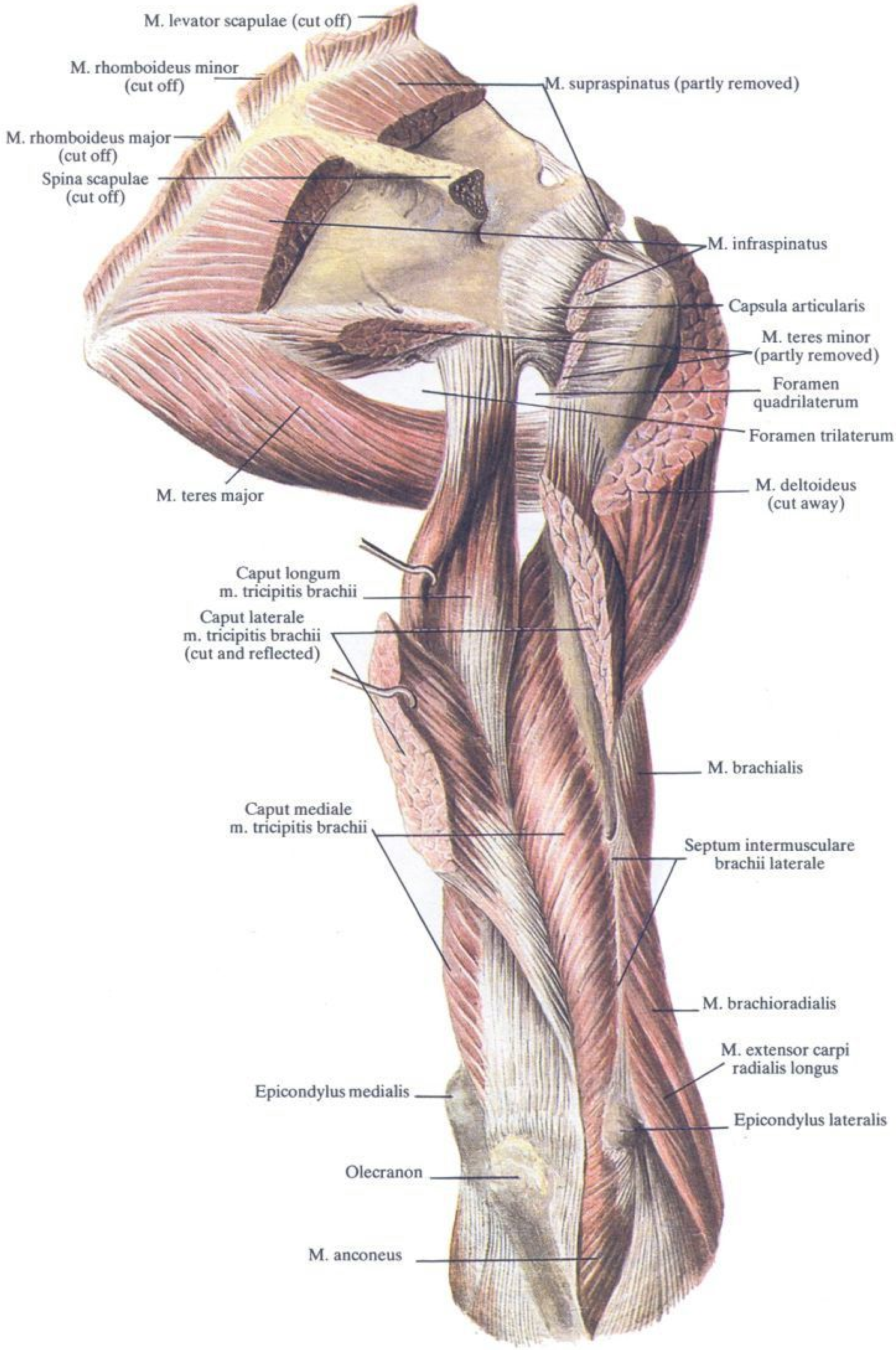


321. *Muscles of right shoulder girdle and arm*; lateral view.

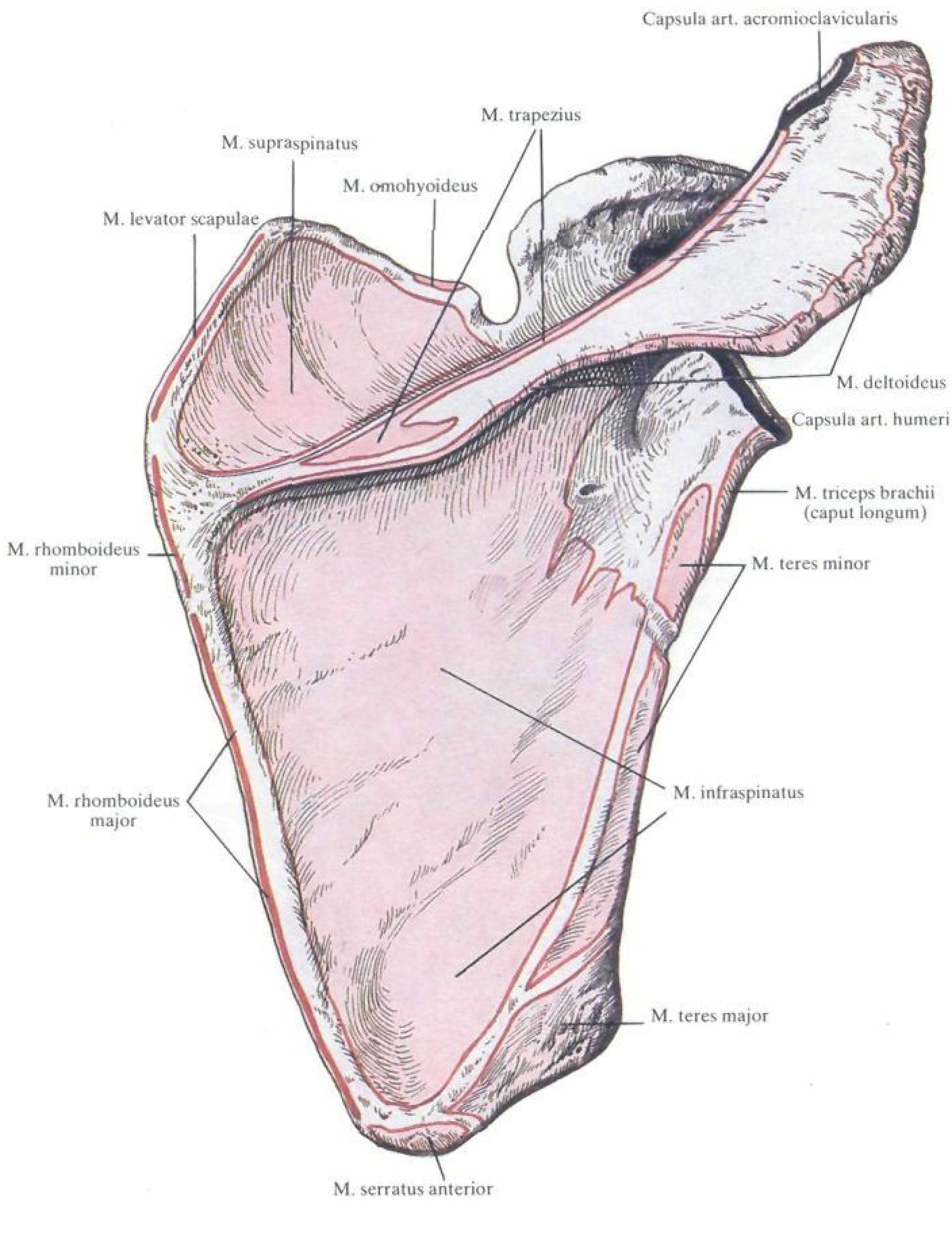


322. *Muscles of right shoulder girdle and arm*; posterior aspect (2/5).

(The deltoid muscle is partly removed.)



323. *Muscles of right shoulder girdle and arm*; posterior aspect (2/5).



324. *Sites of origin and attachment of muscles and joint capsules on the right scapula*; posterior aspect (schematical representation).

Innervation: the radial nerve [C_5-C_6 (C_7)].

2. The **extensor carpi radialis longus muscle** *(musculus extensor carpi radialis longus)* (Fig. 336) is spindle-shaped with a narrow tendon which is much longer than its belly. A small portion of the upper part of the muscle is covered by the brachioradialis muscle; in the distal part its tendon is crossed by the abductor pollicis longus and extensor pollicis brevis muscles which run downwards and obliquely. The muscle takes origin from the lateral epicondyle and the lateral intermuscular septum of the upper arm, passes downwards and gives place to a tendon which runs under the extensor retinaculum and is inserted into the base of the dorsal surface of the second metacarpal bone.

Action: flexes the limb at the elbow joint, extends the hand at the wrist joint and helps in its abduction.

Blood supply: the radial collateral (profunda brachii) and recurrent arteries.

Innervation: the radial nerve (C_5-C_7).

3. The **extensor carpi radialis brevis muscle** *(musculus extensor carpi radialis brevis)* (Fig. 337) is slightly covered by the extensor carpi radialis longus muscle proximally; distally it is crossed by the abductor pollicis longus and extensor pollicis brevis muscles. The extensor carpi radialis brevis muscle arises from the lateral humeral epicondyle and the collateral and annular radial ligaments. It runs downwards and is continuous with a tendon which passes next to the extensor carpi radialis longus tendon in the **synovial sheath of the tendons of the radial extensors of the wrist** *(vagina tendinum musculorum extensorum carpi radialium)* and is inserted into the base of the third metacarpal bone.

Action: extends the hand at the wrist joint and abducts it a little.

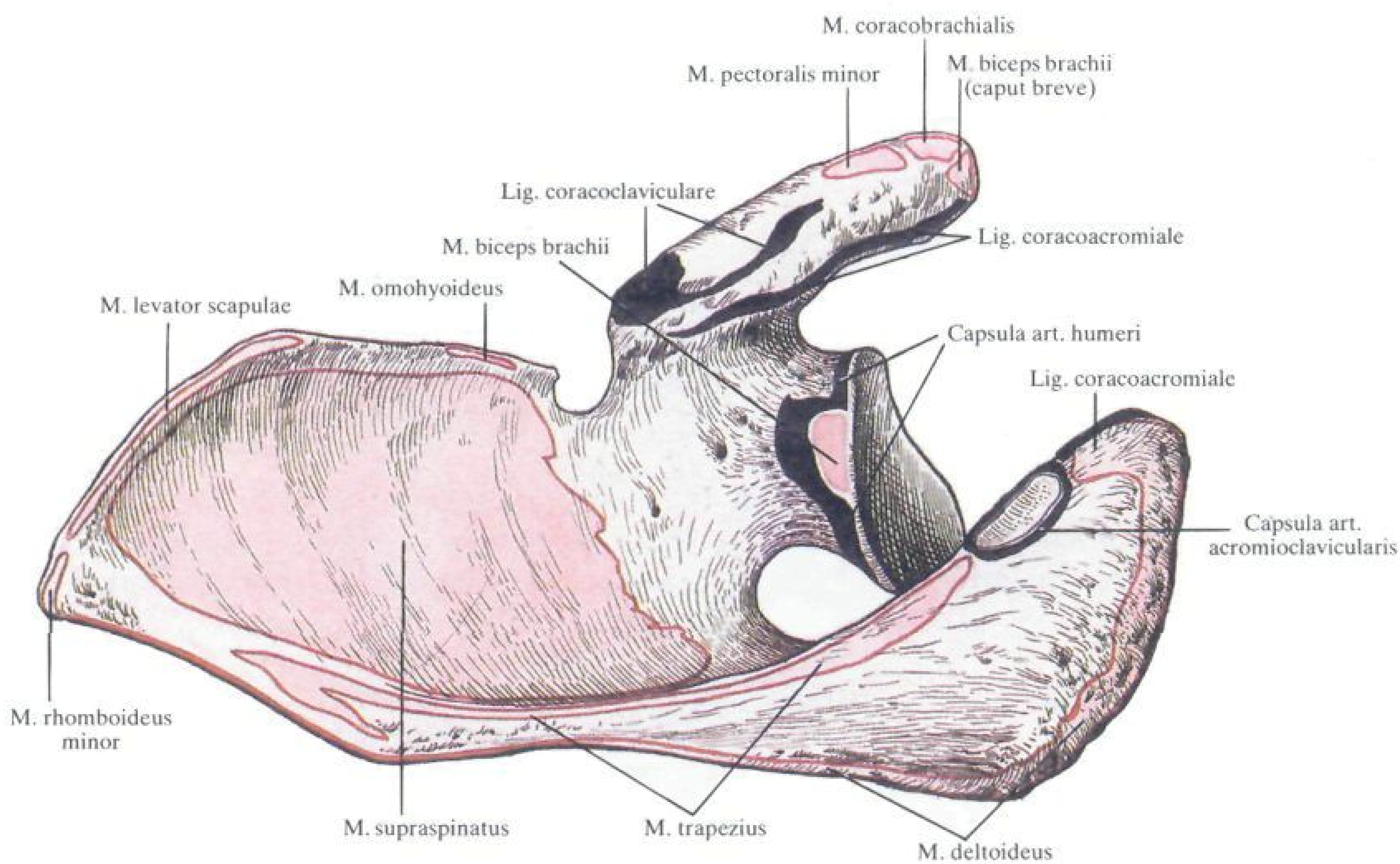
Blood supply: the branches of the profunda brachii artery and the recurrent radial artery.

Innervation: the radial nerve [(C_5) C_6-C_7].

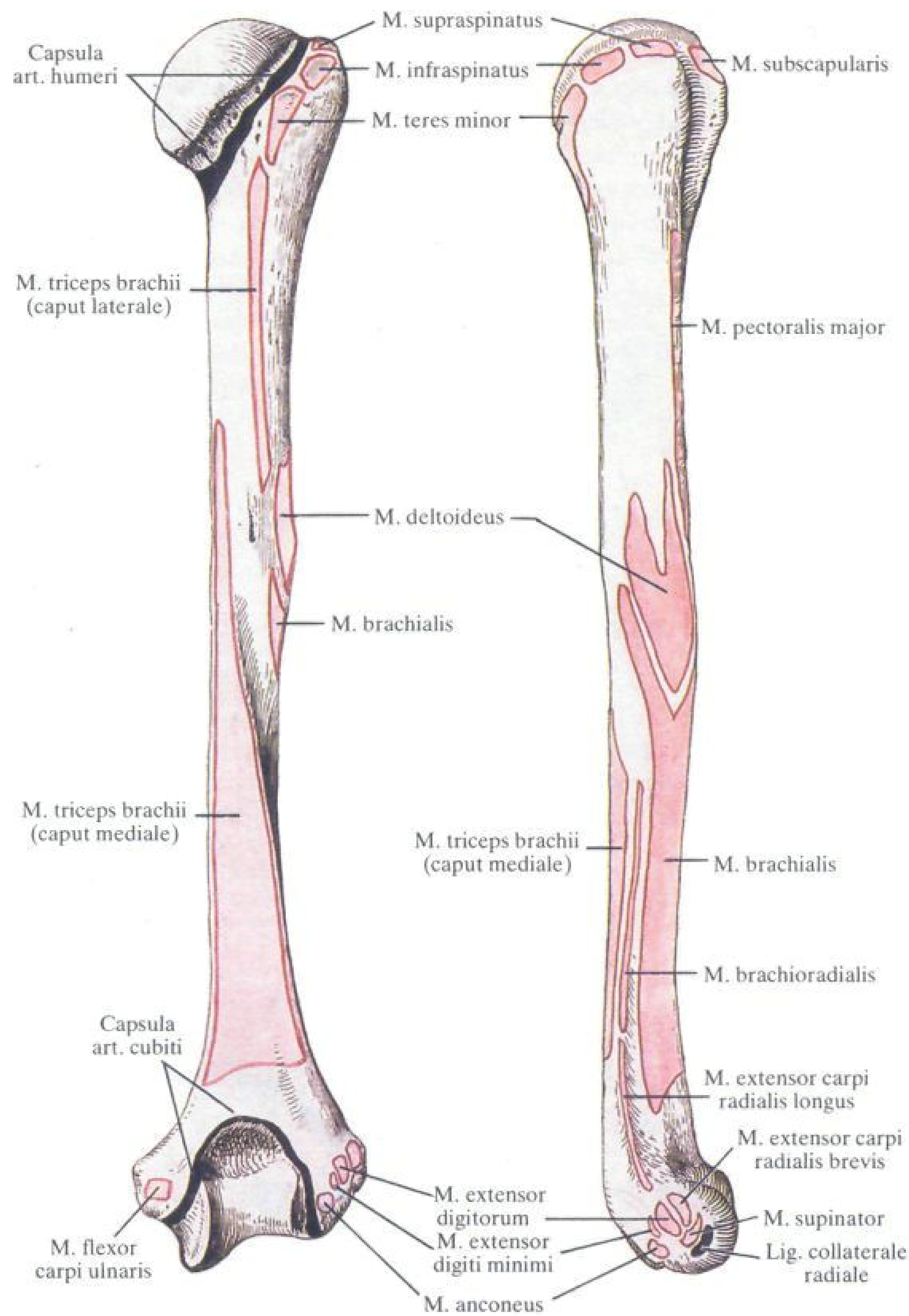
THE POSTERIOR GROUP OF MUSCLES OF THE FOREARM

The Superficial Layer

1. The **extensor carpi ulnaris muscle** *(musculus extensor carpi ulnaris)* (Fig. 337) has a long spindle-shaped belly and lies on the medial border of the dorsal surface of the forearm. It arises from the lateral epicondyle of the humerus, posterior border of the ulna, and the capsule of the elbow joint and is inserted into the base of the dorsal surface of the fifth metacarpal bone by a short but strong tendon which is invested by a **synovial sheath of the exten-**



325. *Sites of origin and attachment of muscles, ligaments, and joint capsules on right scapula*; superior aspect (schematical representation).



326. *Sites of origin and attachment of muscles, ligaments, and joint capsules on right humerus*; posterior and lateral aspects (schematical representation).

sor carpi ulnaris tendon *(vagina tendinis musculi extensoris carpi ulnaris).*

Action: abducts the hand to the ulnar side and extends it at the wrist joint.

Blood supply: the posterior interosseous artery.

Innervation: the radial nerve [(C_6) C_7-C_8].

2. The **extensor digitorum muscle** *(musculus extensor digitorum)* (Fig. 337) has a spindle-shaped belly and, according to the direction of the muscular bundles, it is bipennate. It is directly under the skin nearer to the lateral border of the dorsal surface of the forearm and borders upon the extensor carpi ulnaris and the extensor digiti minimi muscles on the ulnar side and upon the extensor carpi radialis longus and brevis muscles on the radial side.

The muscle takes origin from the lateral epicondyle of the humerus, the capsule of the elbow joint, and the antebrachial fascia. At the middle of its length the belly separates into four tendons which, after passing under the extensor retinaculum, are enclosed together with the extensor indicis tendon into a common

synovial sheath of the extensor digitorum and **extensor indicis tendons** *(vagina tendinum musculorum extensoris digitorum* et *extensoris indicis)* stretching approximately to the middle of the metacarpal bones.

On the hand the tendons are joined together by fine inconstant **intertendinous connections** *(connexus intertendinei)*; at the base of the proximal phalanges of the index, middle, ring, and little fingers each tendon ends in a tendinous expansion which fuses with the capsule of the metacarpophalangeal joint. The tendinous expansions separate into three slips, the lateral two are inserted into the base of the distal phalanx and the middle one into the base of the middle phalanx.

Action: extends the fingers and assists in extension of the hand at the wrist.

Blood supply: the posterior interosseous artery.

Innervation: the radial nerve (C_6–C_8).

3. The **extensor digiti minimi muscle** *(musculus extensor digiti minimi)* (Fig. 337) is a small spindle-shaped belly lying directly under the skin in the lower half of the dorsal surface of the forearm between the extensor carpi ulnaris and extensor digitorum muscles. It takes origin from the lateral epicondyle of the humerus, antebrachial fascia, and the lateral ligament of the elbow, runs downwards, and gives place to a tendon which is lodged in the **synovial sheath of the extensor digiti minimi tendon** *(vagina tendinis musculi extensoris digiti minimi)*. On leaving the sheath the tendon joins the extensor digitorum tendon passing to the little finger and both are inserted into the base of the distal phalanx.

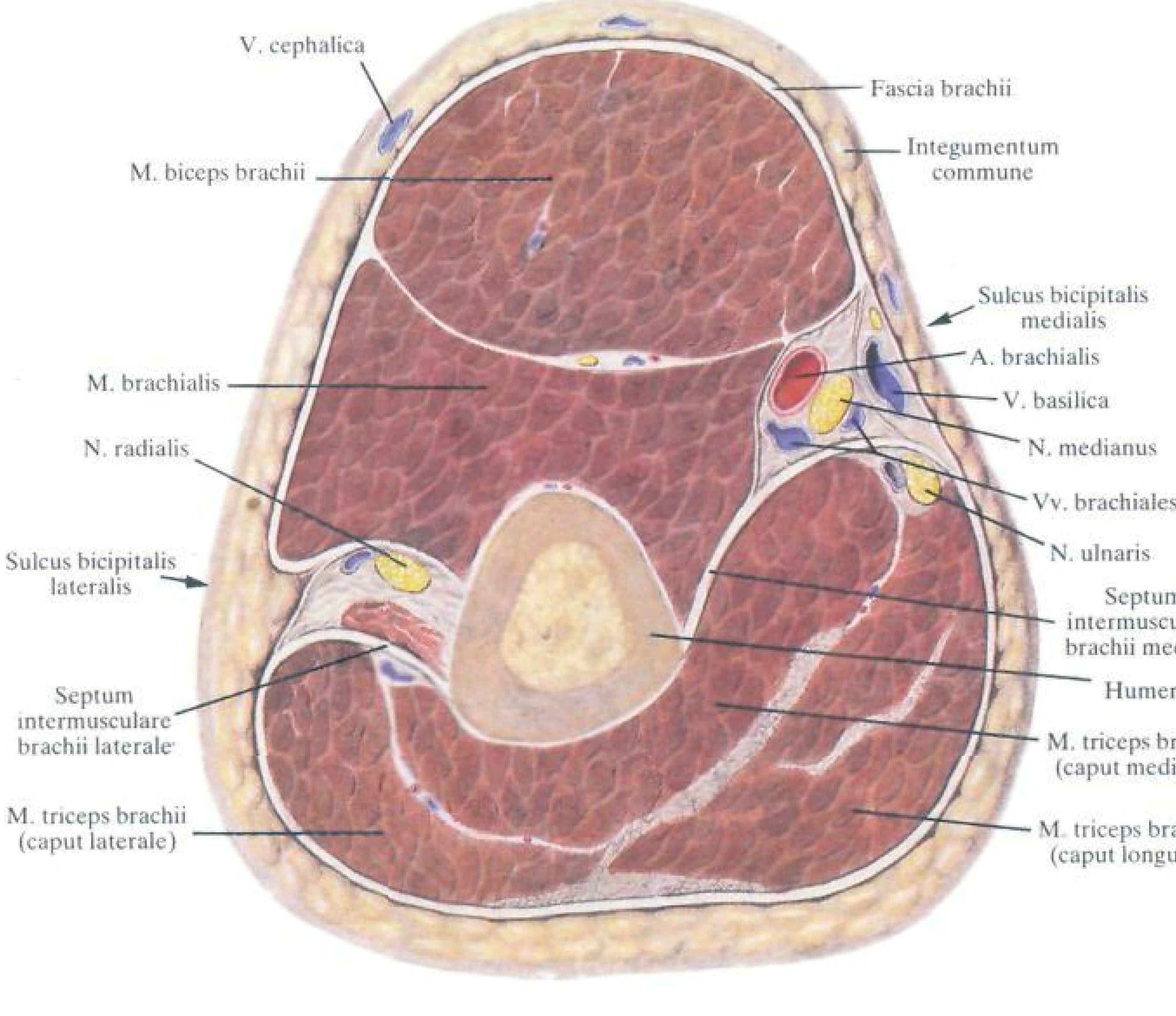
Action: extends the little finger.

Blood supply: the posterior interosseous artery.

Innervation: the radial nerve (C_6–C_8).

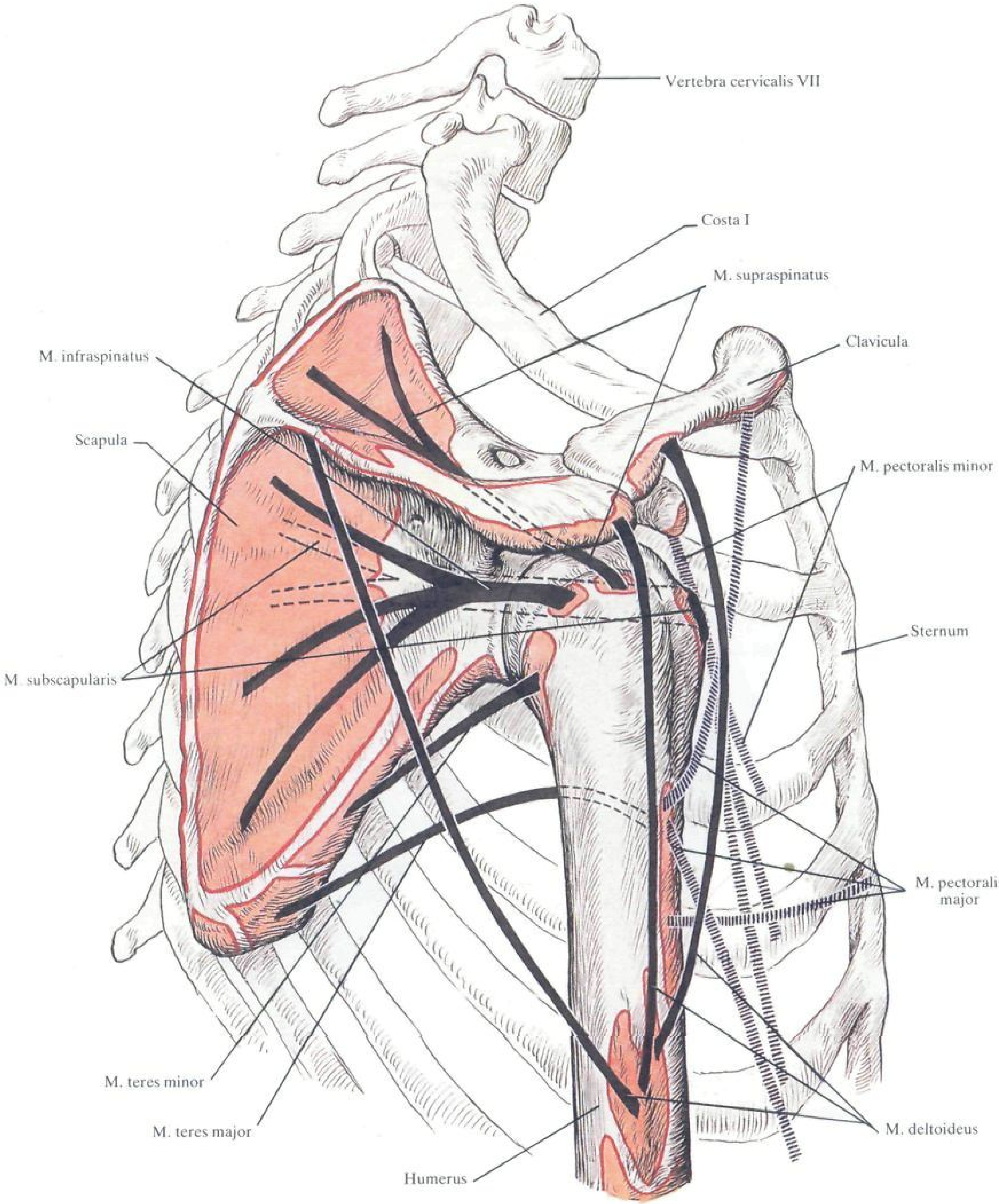
The Deep Layer

1. The **supinator muscle** *(musculus supinator)* (Fig. 338) is a thin rhomboid sheet lying on the lateroposterior surface of the proximal end of the forearm. It arises from the lateral epicondyle of the humerus, the supinator crest of the ulna, and the capsule of the elbow joint, extends obliquely downwards and laterally embracing the upper end of the radius, and is inserted into it for a distance from the tuberosity of the radius to the insertion of the pronator teres muscle.

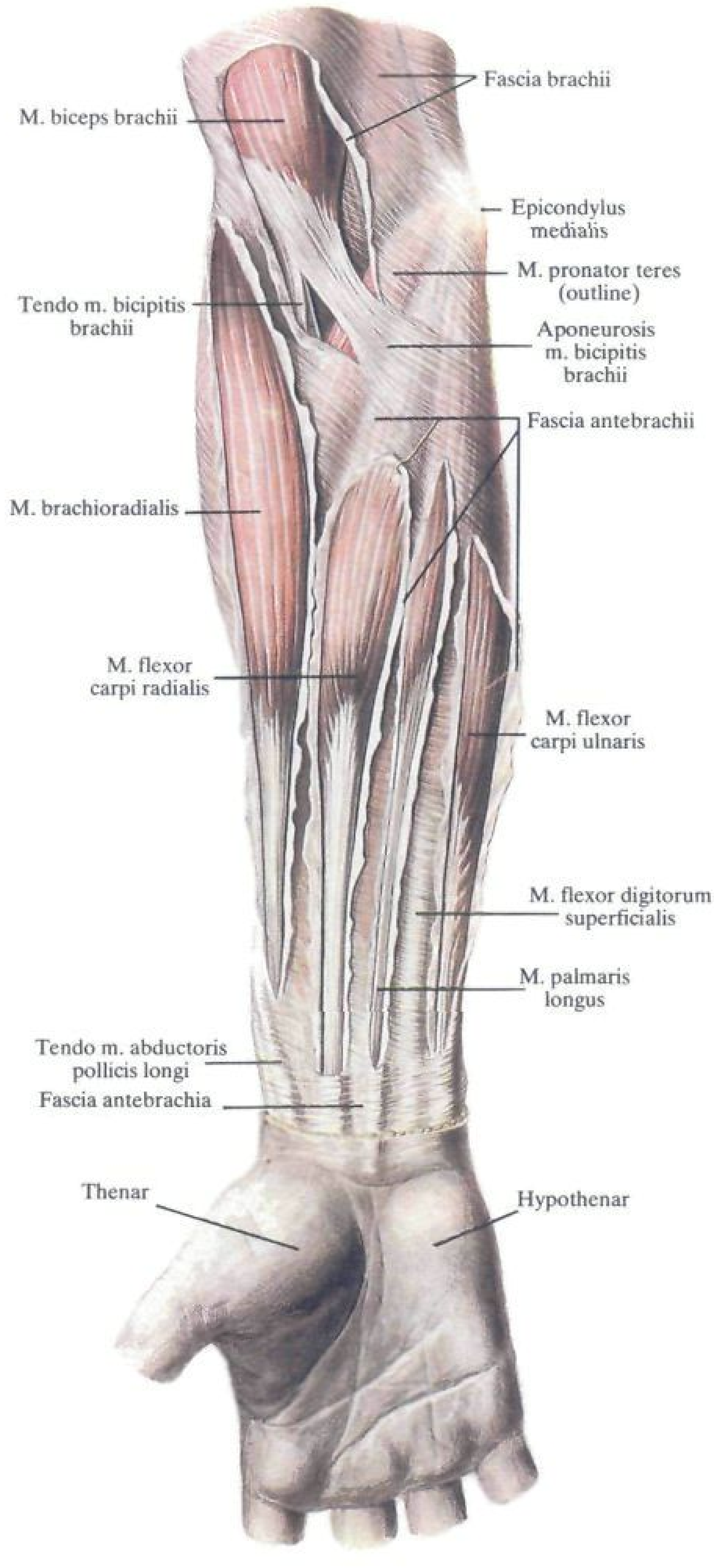


327. *Muscles and fasciae of right upper arm* ($^9/_{10}$).

(Transverse section through middle of upper arm.)

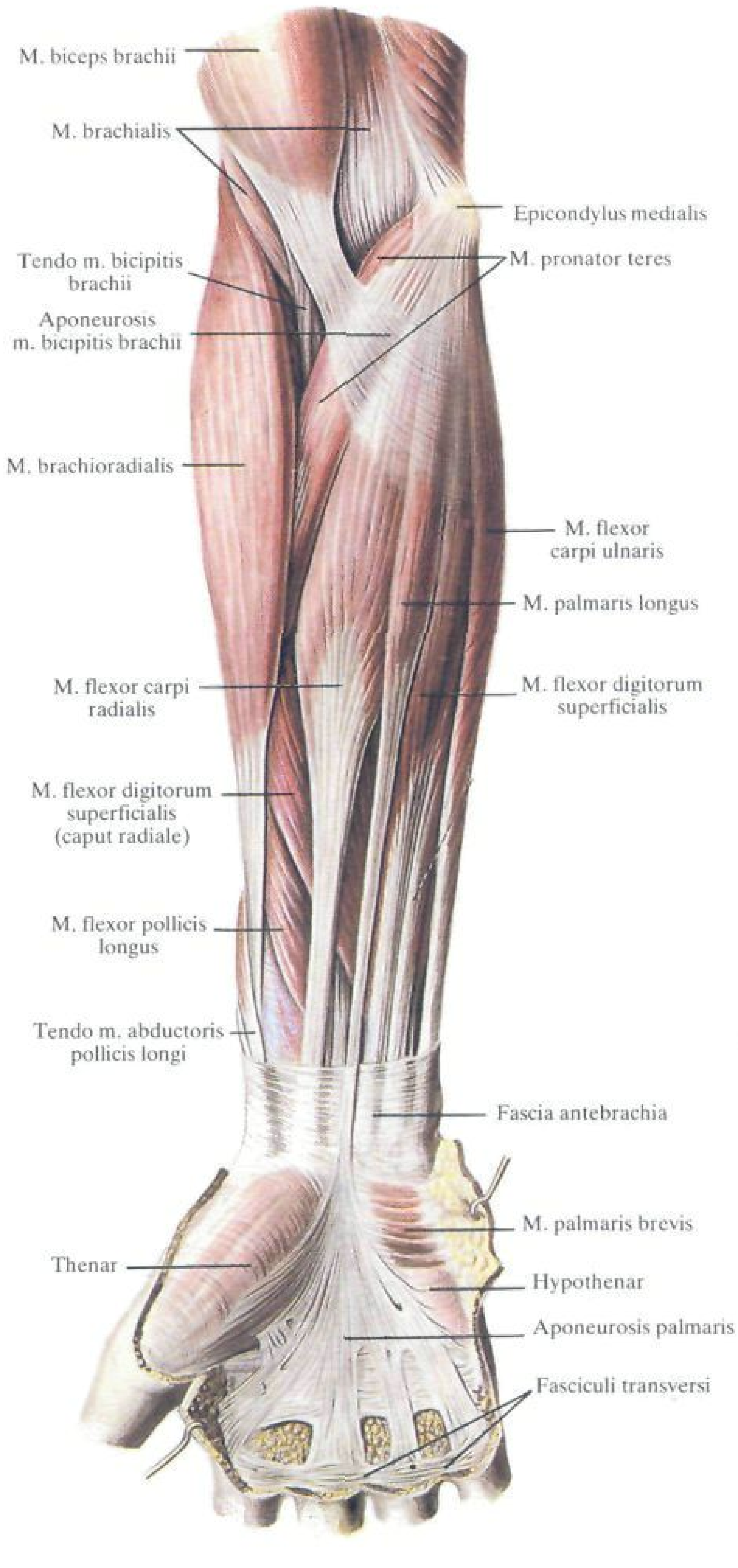


328. *Sites of origin and insertion of muscles on the bones of right shoulder girdle and upper arm*; lateral aspect (schematical representation).



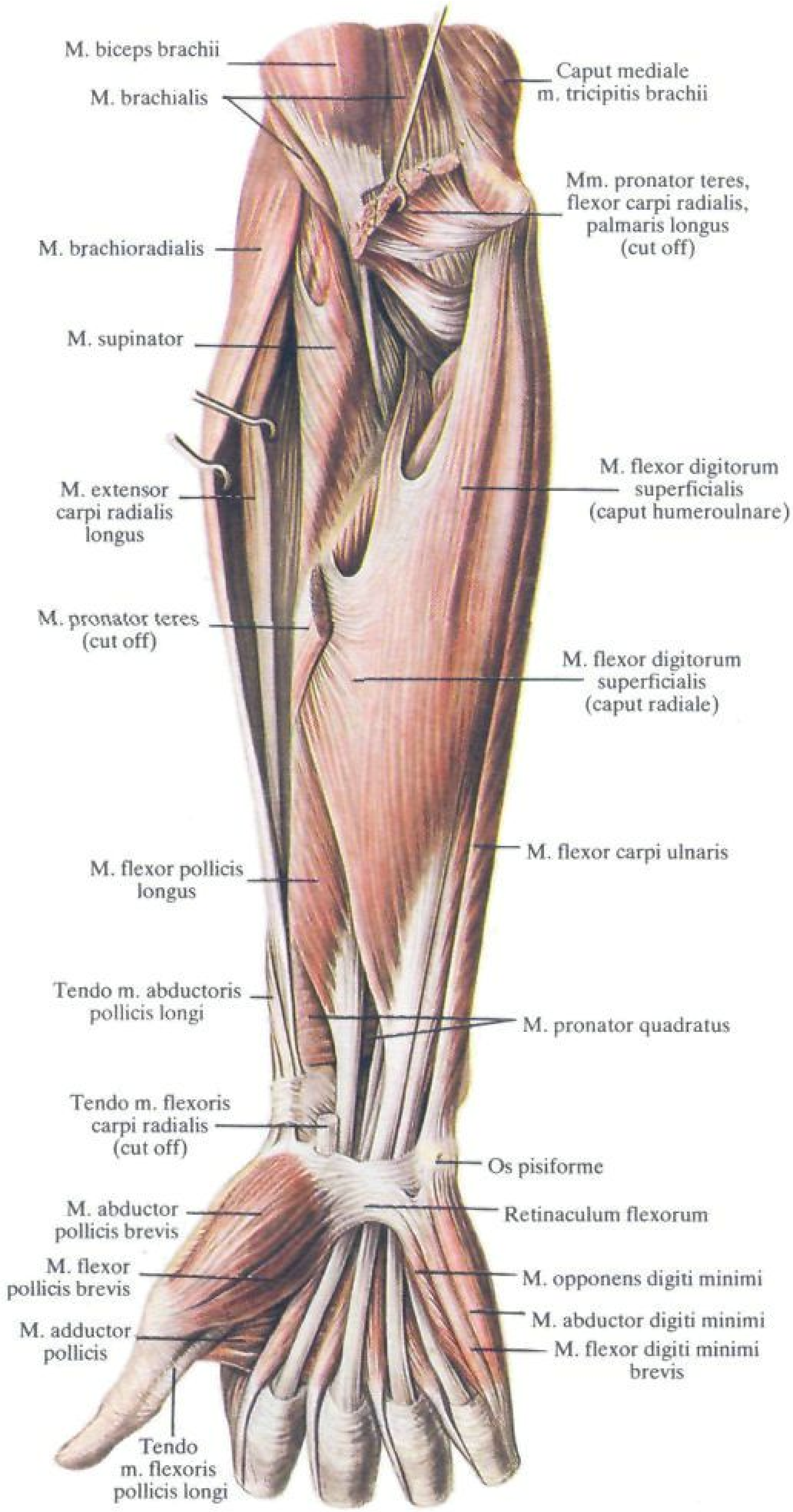
329. *Muscles and fasciae of the right forearm*; anterior aspect ($\frac{2}{5}$).

(Fascial sheaths of muscles are opened.)



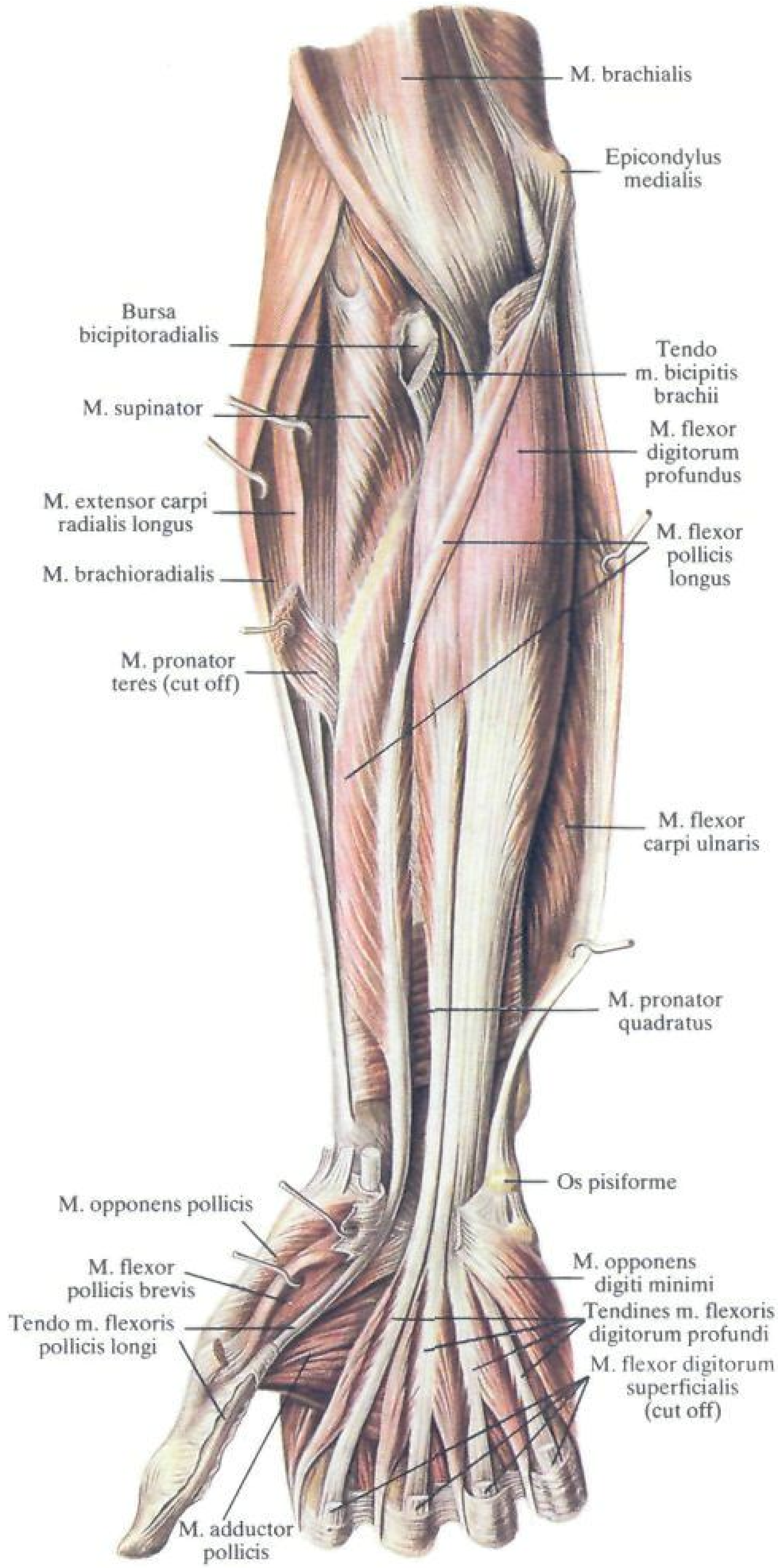
330. *Muscles of right forearm*; anterior aspect ($^2/_5$).

(First [superficial] layer.)



331. *Muscles of right forearm*; anterior aspect (2/5).

(Second layer.)



332. *Muscles of right forearm*; anterior aspect (2/5).

(Third layer.)

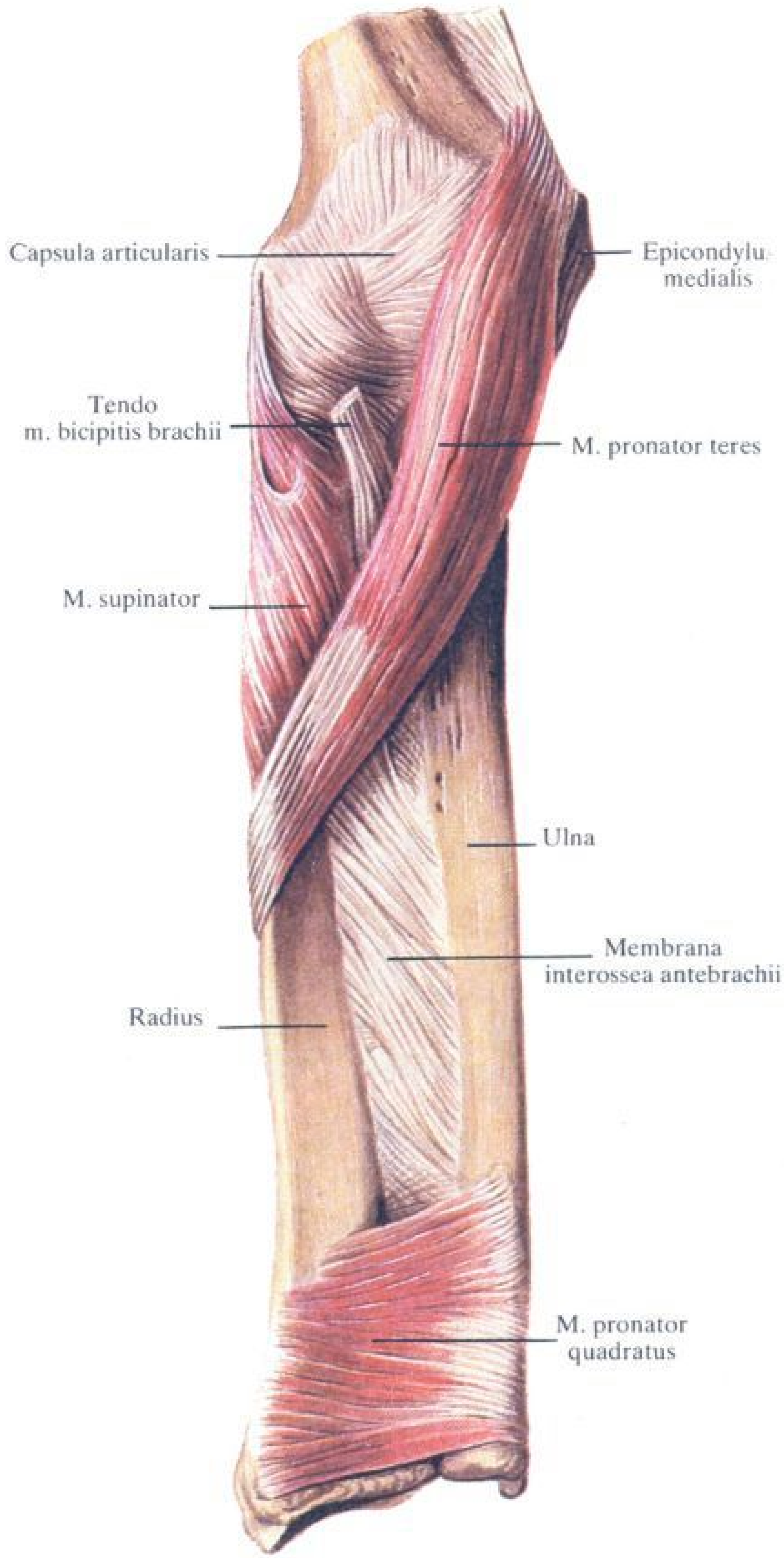
Action: causes lateral rotation (supination) of the forearm and helps in extension of the limb at the elbow joint.

Blood supply: the radial recurrent and interosseous recurrent arteries.

Innervation: the radial nerve [(C_5) C_6-C_7 (C_8)].

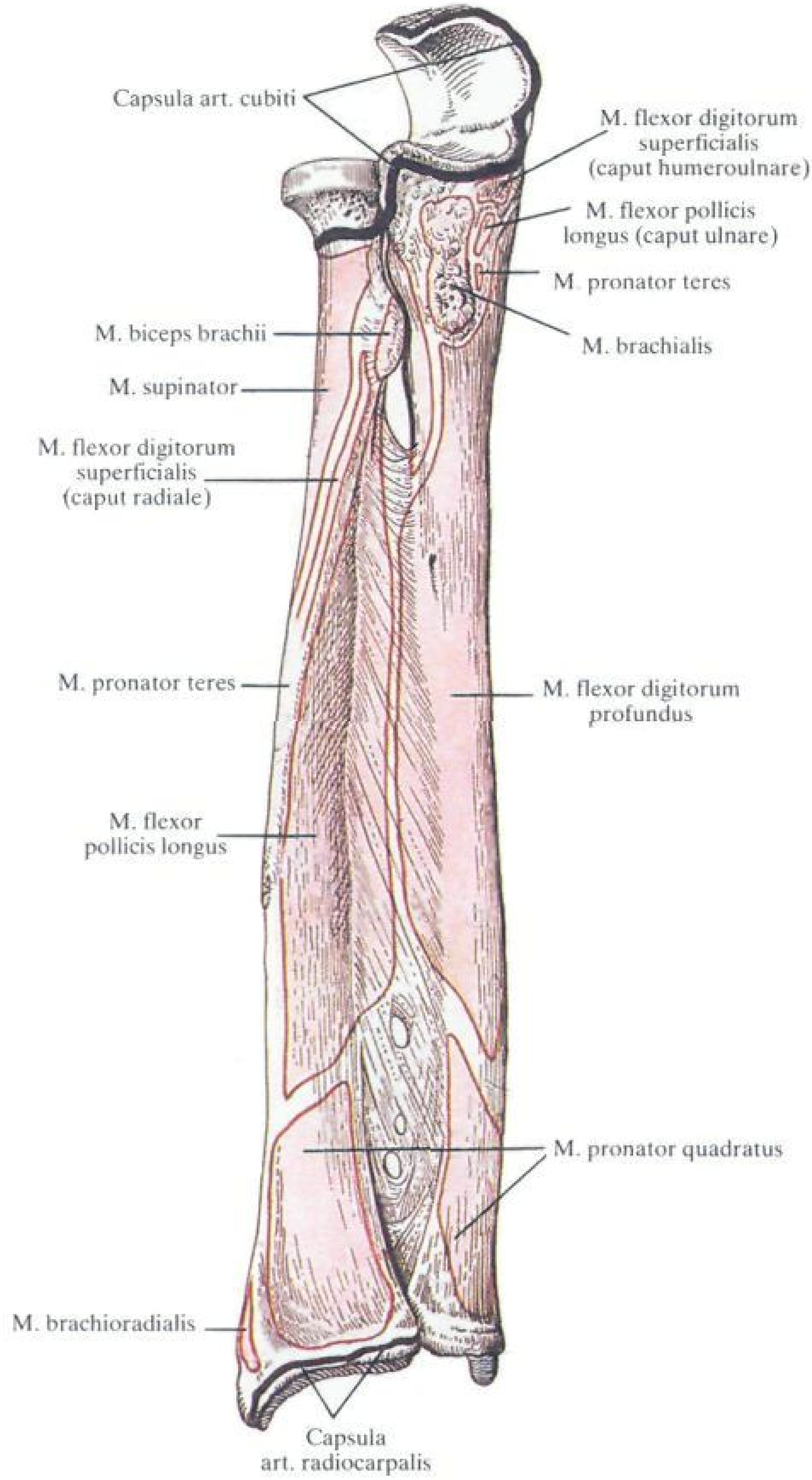
2. The **abductor pollicis longus muscle** *(musculus abductor pollicis longus)* (Fig. 338) has a flattened bipennate belly which is continuous with a thin long tendon. It lies in the distal half of the dorsolateral surface of the forearm and is covered at its origin by the extensor carpi radialis brevis and extensor digitorum muscles, while its lower part is directly under the antebrachial fascia and skin.

The muscle takes origin from the posterior surface of the radius and ulna and from the interosseous membrane, runs obliquely downwards, with the tendon curving around the radius, and after passing under the extensor retinaculum it is inserted into the base of the first metacarpal bone.



333. *Muscles of right forearm*; anterior aspect ($\frac{1}{2}$).

(Fourth layer consisting of the pronator quadratus muscle.)



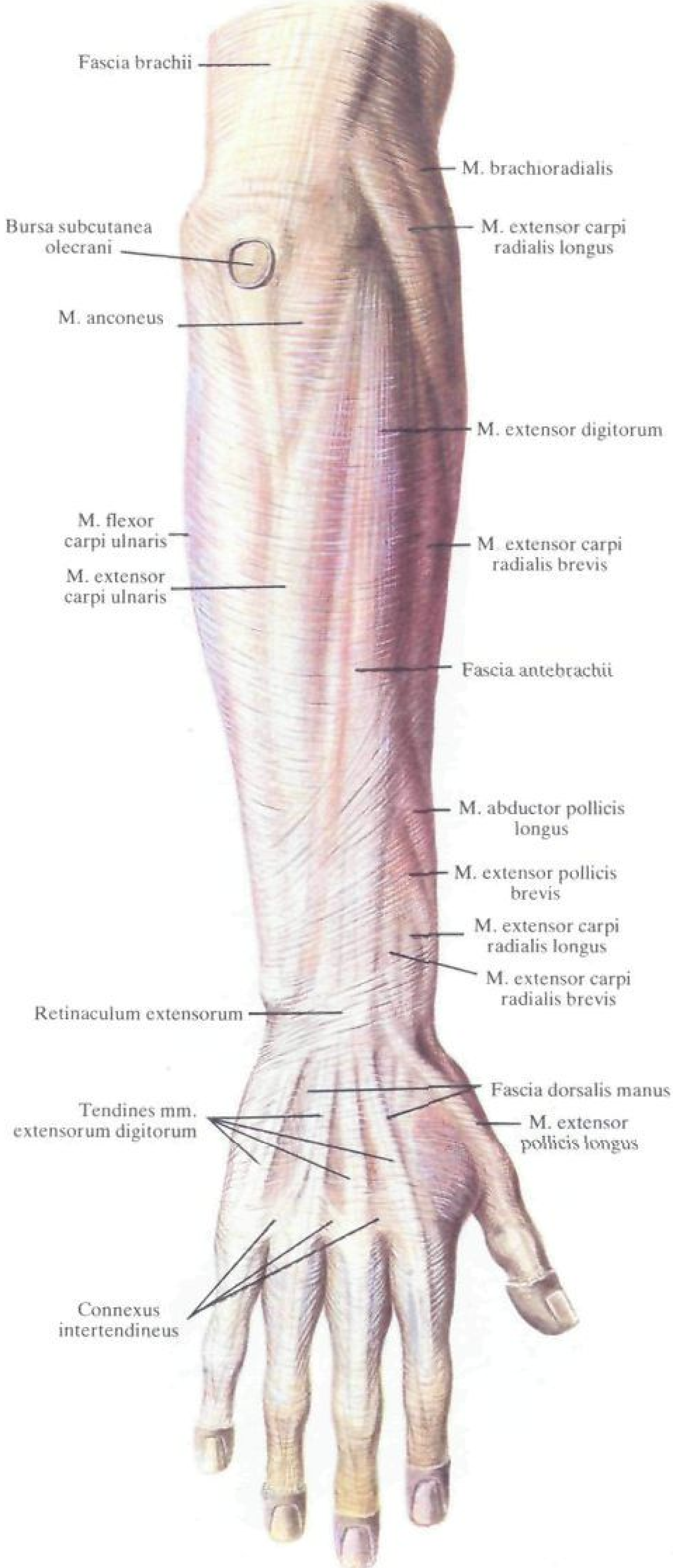
334. *Sites of origin and attachment of muscles and joint capsules on the bones of the right forearm*; anterior aspect (schematical representation).

(The interosseous membrane is intact.)

Action: abducts the thumb and assists in abducting the hand. Blood supply: the posterior and anterior interosseous arteries. Innervation: the radial nerve [C_6–C_7 (C_8)].

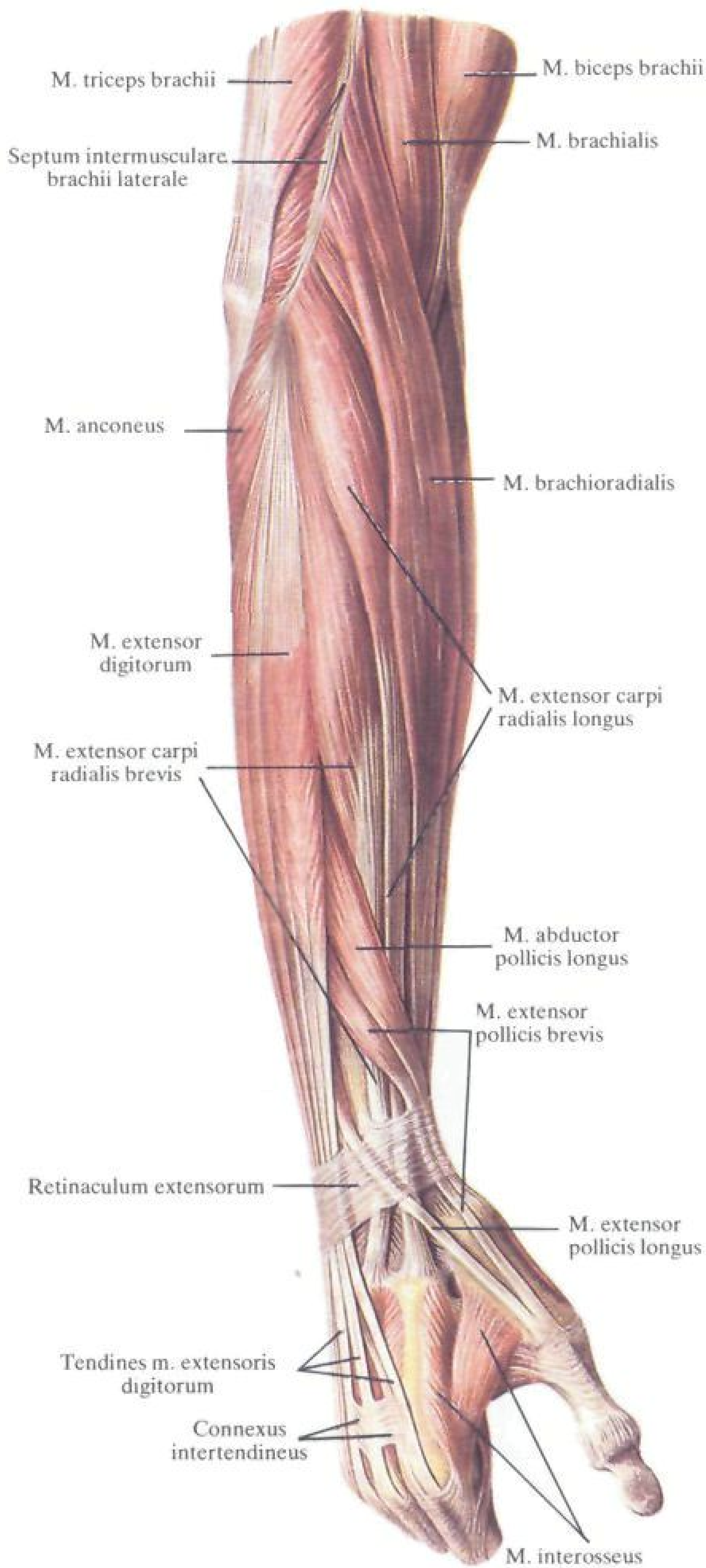
3. The **extensor pollicis brevis muscle** *(musculus extensor pollicis brevis)* (Fig. 338) is on the lateral border of the lower dorsal surface of the forearm. It arises from the interosseous membrane, the dorsal surface of the radius, and the ulnar crest (interosseous border) and runs obliquely downwards next to the abductor pollicis longus tendon.

The tendons of the two muscles are invested in the **synovial sheath of the tendons of the abductor pollicis longus and extensor pollicis brevis muscles** *(vagina tendinum musculorum abductoris longi*

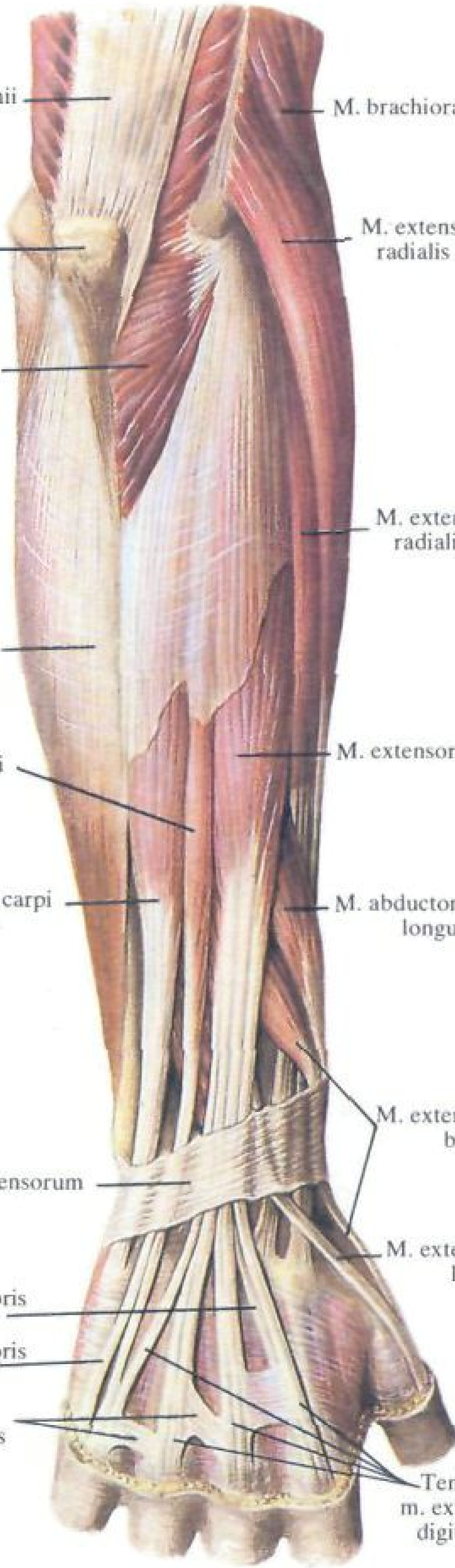


335. *Muscles and fasciae of right forearm*; posterior aspect (1/3).

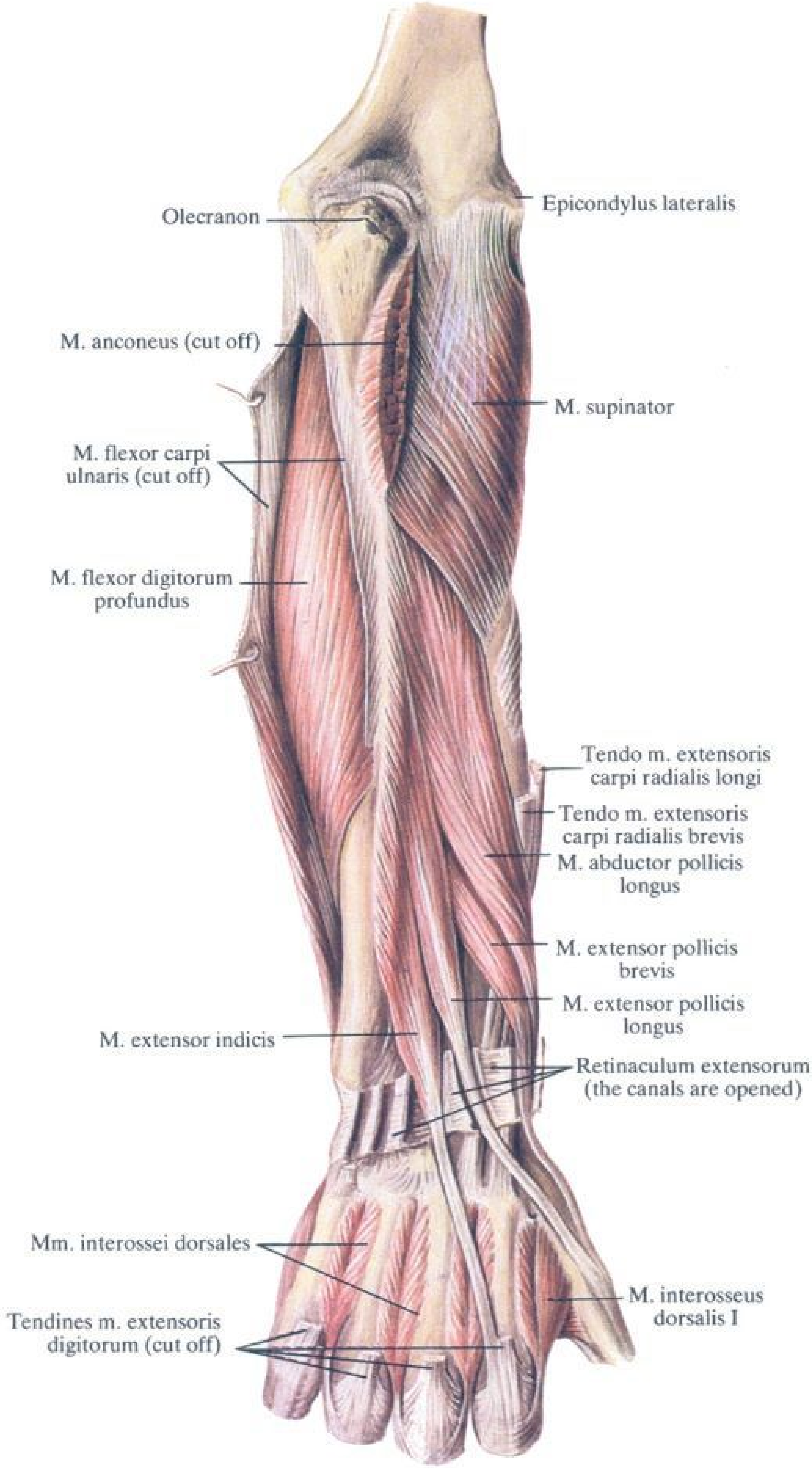
(The skin and subcutaneous fat are removed.)



336. *Muscles of right forearm*; lateral aspect (2/5).



337. *Muscles of right forearm*; posterior aspect (2/5).
(Superficial layer.)



338. *Muscles of right forearm*; posterior aspect (2/5).
(Deep layer.)

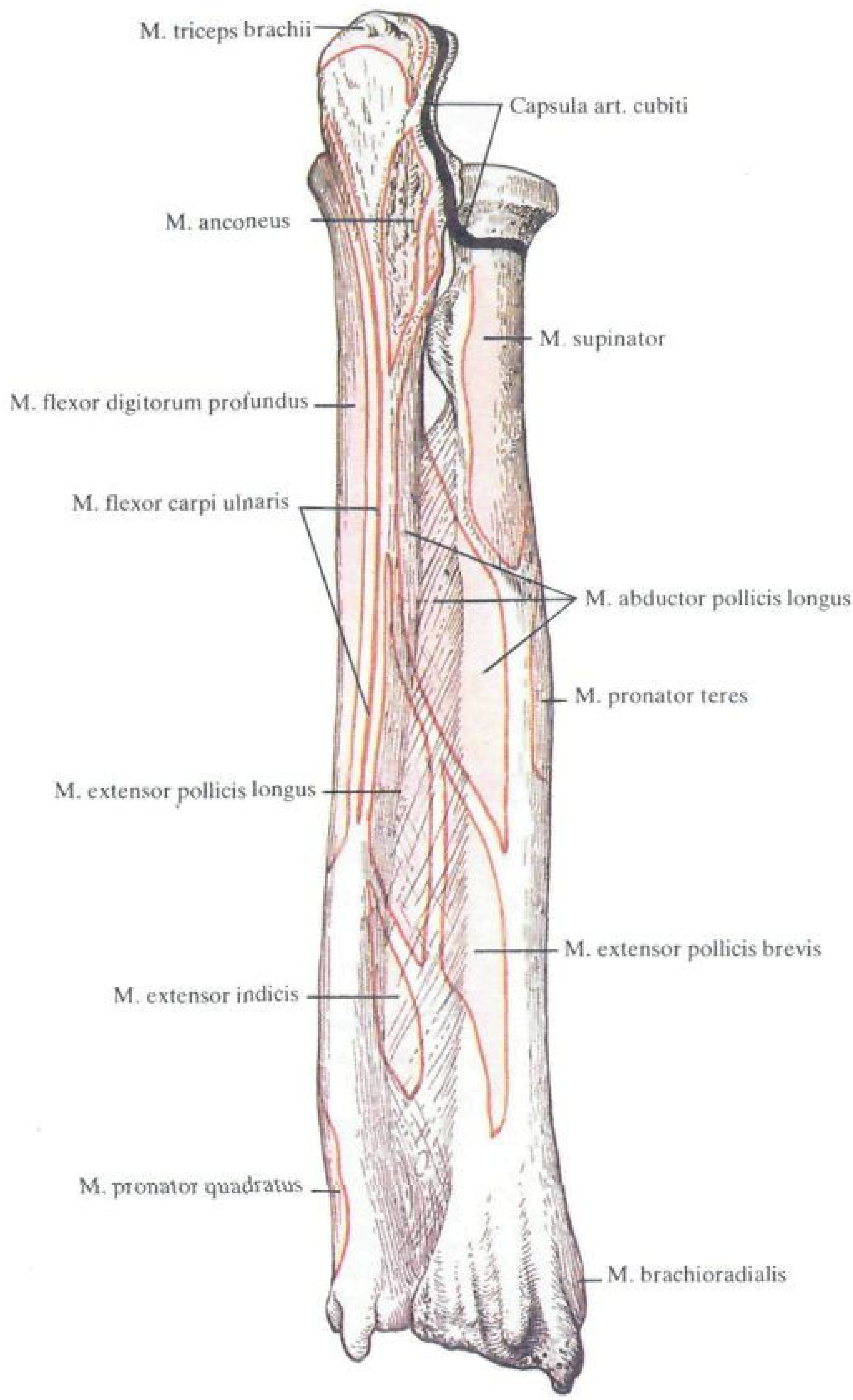
et *extensoris brevis pollicis)*. After passing under the extensor retinaculum the muscle is inserted into the base of the dorsal surface of the proximal phalanx of the thumb.

Action: extends and slightly abducts the proximal phalanx of the thumb.

Blood supply: the posterior and anterior interosseous arteries.

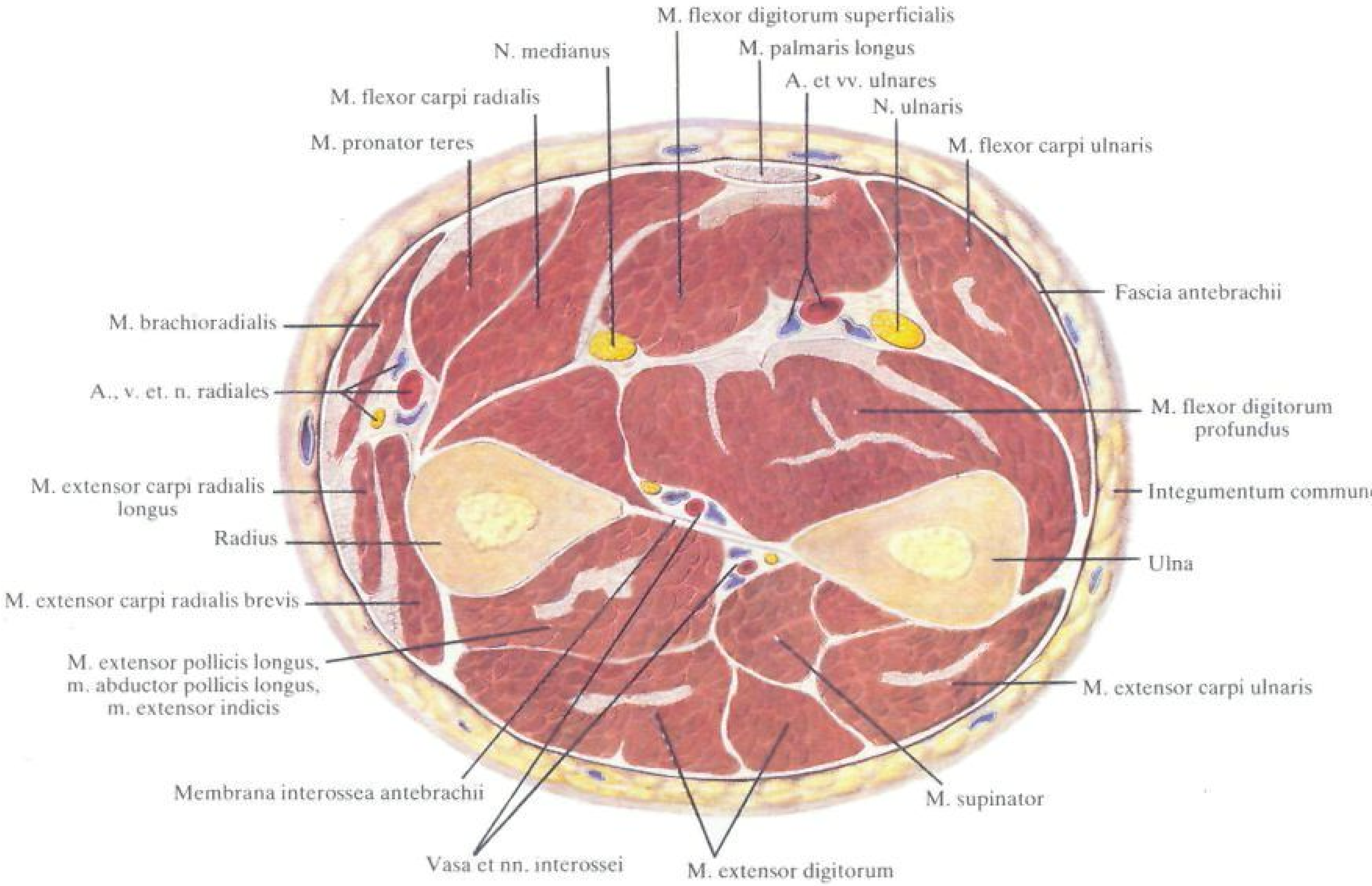
Innervation: the radial nerve [C_6-C_7 (C_8)].

4. The **extensor pollicis longus muscle** *(musculus extensor pollicis longus)* (Fig. 338) has a spindle-shaped belly and a long tendon. It lies next to the extensor pollicis brevis muscle and arises from the interosseous membrane and the interosseous border and posterior surface of the ulna, runs downwards, and gives place to a tendon which is invested in the **synovial sheath of the extensor pollicis longus tendon** *(vagina tendinis musculi extensoris pollicis longi)*. The



339. *Sites of origin and attachment of muscles and joint capsules on bones of right forearm*; posterior aspect (schematical representation).

(The interosseous membrane is intact.)



340. *Muscles and fasciae of right forearm* ($^9/_{10}$).
(Transverse section through middle of forearm.)

tendon curves around the first metacarpal bone, emerges onto its dorsal surface, and extends to the base of the distal phalanx to be inserted into it.

Action: extends the thumb and abducts it partly.

Blood supply: the posterior and anterior interosseous arteries.

Innervation: the radial nerve [(C_6) C_7-C_8].

5. The **extensor indicis muscle** *(musculus extensor indicis)* (Fig. 338) has a narrow, long, and spindle-shaped belly lying on the lower dorsal surface of the forearm and is covered by the extensor digitorum muscle. Sometimes it is absent. The muscle arises from the lower third of the dorsal surface of the ulna, and ends as a tendon which passes under the extensor retinaculum and together with the extensor digitorum tendon runs through the synovial sheath and extends to the dorsal surface of the index finger to be inserted into its tendinous expansion.

Action: extends the index finger.

Blood supply: the posterior and anterior interosseous arteries.

Innervation: the radial nerve [(C_6) C_7-C_8].

MUSCLES OF THE HAND

The **muscles of the hand** are subdivided according to their location into two groups, one formed of the muscles of the palmar surface and the other consisting of muscles of the dorsal surface. The muscles of the thenar eminence, muscles of the hypothenar eminence, and muscles of the middle group are distinguished in the group on the palmar surface.

Muscles of the Thenar

1. The **abductor pollicis brevis muscle** *(musculus abductor pollicis brevis)*.
2. The **flexor pollicis brevis muscle** *(musculus flexor pollicis brevis)*.
3. The **opponens pollicis muscle** *(musculus opponens pollicis)*.
4. The **adductor pollicis muscle** *(musculus adductor pollicis)*.

Muscles of the Hypothenar

1. The **palmaris brevis muscle** *(musculus palmaris brevis)*.
2. The **abductor digiti minimi muscle** *(musculus abductor digiti minimi)*.
3. The **flexor digiti minimi brevis muscle** *(musculus flexor digiti minimi brevis)*.
4. The **opponens digiti minimi muscle** *(musculus opponens digiti minimi)*.

Muscles of the Middle Group

1. The **lumbrical muscles** *(musculi lumbricales)*.
2. The **palmar interossei muscles** *(musculi interossei palmares)*.

MUSCLES OF THE PALMAR SURFACE

Muscles of the Thenar

1. The **abductor pollicis brevis muscle** *(musculus abductor pollicis brevis)* (Fig. 341) is on the radial (lateral) surface of the thenar directly under the skin. It arises from the tendon of the abductor pollicis longus muscle, antebrachial fascia, tubercle of the scaphoid, and flexor retinaculum and is inserted into the radial surface of the base of the proximal phalanx of the thumb. Its tendon usually lodges a sesamoid bone.

Action: abducts the thumb and sets it in mild opposition, helps in flexion of the proximal phalanx.

Blood supply: superficial palmar branch of radial artery.

Innervation: the median nerve (C_6–C_7).

2. The **flexor pollicis brevis muscle** *(musculus flexor pollicis brevis)* (Fig. 341) lies medially of the abductor pollicis brevis muscle and also directly under the skin. It arises from the flexor retinaculum, the trapezium, trapezoid, and capitate bones, and the base of the first metacarpal bone. The muscle fibres run distally and are inserted radially: the superficial fibres *(caput superficiale)* are inserted into the radial sesamoid bone, the deep fibres *(caput profundum)* are inserted into both sesamoid bones of the metacarpophalangeal joint of the thumb.

Action: flexes the proximal phalanx of the thumb.

Blood supply: superficial palmar branch of radial artery, deep palmar arch.

Innervation: the superficial fibres—the median nerve (C_6–C_7), deep—the ulnar nerve (C_8–Th_1).

3. The **opponens pollicis muscle** *(musculus opponens pollicis)* (Fig. 342) is shaped like a thin triangular sheet and lies under the abductor pollicis brevis muscle. It arises from the crest of the trapezium and the flexor retinaculum and is inserted into the radial border of the first metacarpal bone.

Action: opposes the thumb in relation to the little finger.

Blood supply: superficial palmar branch of radial artery, deep palmar arch.

Innervation: the median nerve (C_6–C_7).

4. The **adductor pollicis muscle** *(musculus adductor pollicis)* (Fig. 343) is the deepest in the thenar group. It arises by two heads whose fibres are directed one towards the other at an angle. The **oblique head** *(caput obliquum)* takes origin from the radiate carpal ligament, the capitate bone, and the palmar surface of the second and third metacarpal bones; the **transverse head** *(caput transversum)* arises from the palmar surface of the third metacarpal and the heads of the second and third metacarpal bones. The muscle bundles converge at an angle to be inserted into the base of the proximal phalanx of the thumb, the ulnar sesamoid bone, and the capsule of the metacarpophalangeal joint.

Action: adducts the thumb and assists in flexing the proximal phalanx.

Blood supply: superficial and deep palmar arches.

Innervation: the ulnar nerve (C_8).

Muscles of the Hypothenar

1. The **palmaris brevis muscle** *(musculus palmaris brevis)* (see Fig. 330) is a thin plate of parallel fibres. It takes origin from the ulnar border of the palmar aponeurosis and the flexor retinaculum and is inserted into the skin of the hypothenar.

Action: tenses the palmar aponeurosis thus forming folds on the skin of the hypothenar.

Blood supply: the ulnar artery.

Innervation: the ulnar nerve [(C_7), C_8, Th_1].

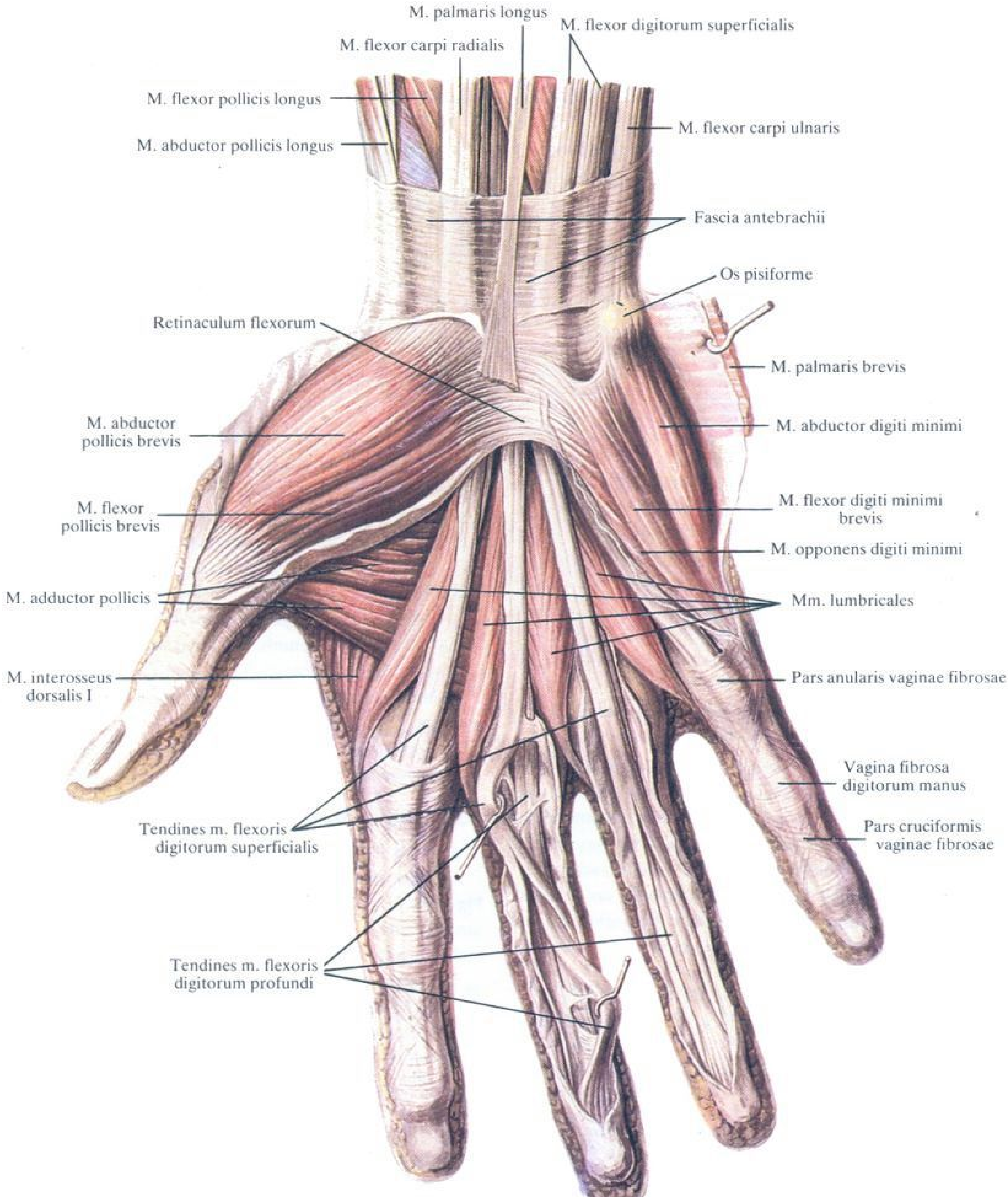
2. The **abductor digiti minimi muscle** *(musculus abductor digiti minimi)* (Fig. 341) occupies the extreme medial position in this group of muscles and lies directly under the skin and partly under the palmaris brevis muscle. It arises from the pisiform bone, the tendon of the flexor carpi ulnaris muscle, and the flexor retinaculum and is inserted into the ulnar side of the base of the proximal phalanx of the little finger.

Action: abducts the little finger and assists in flexion of its proximal phalanx.

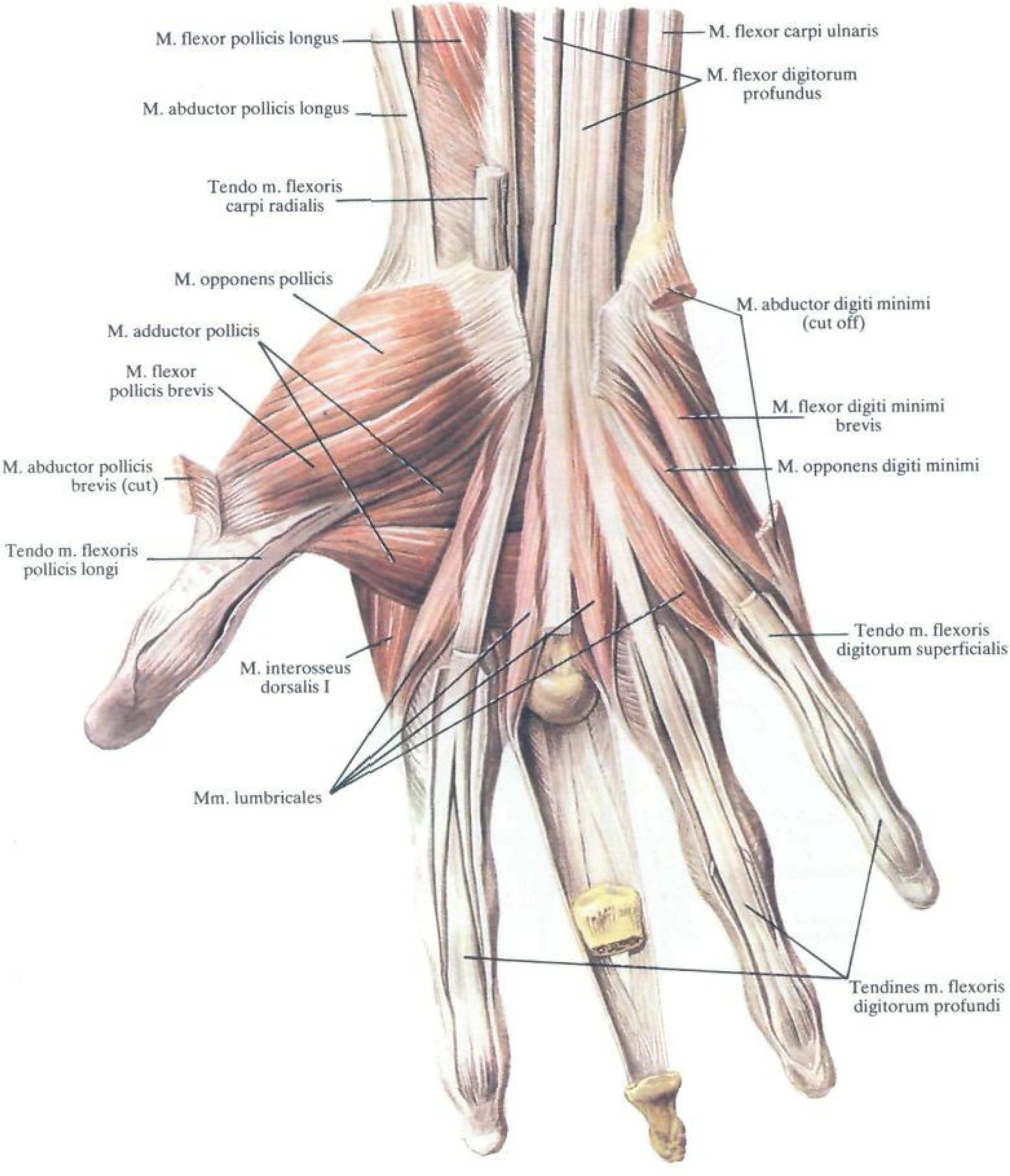
Blood supply; deep branch of the ulnar artery.

Innervation: the ulnar nerve [(C_7), C_8, Th_1].

3. The **flexor digiti minimi brevis muscle** *(musculus flexor digiti*

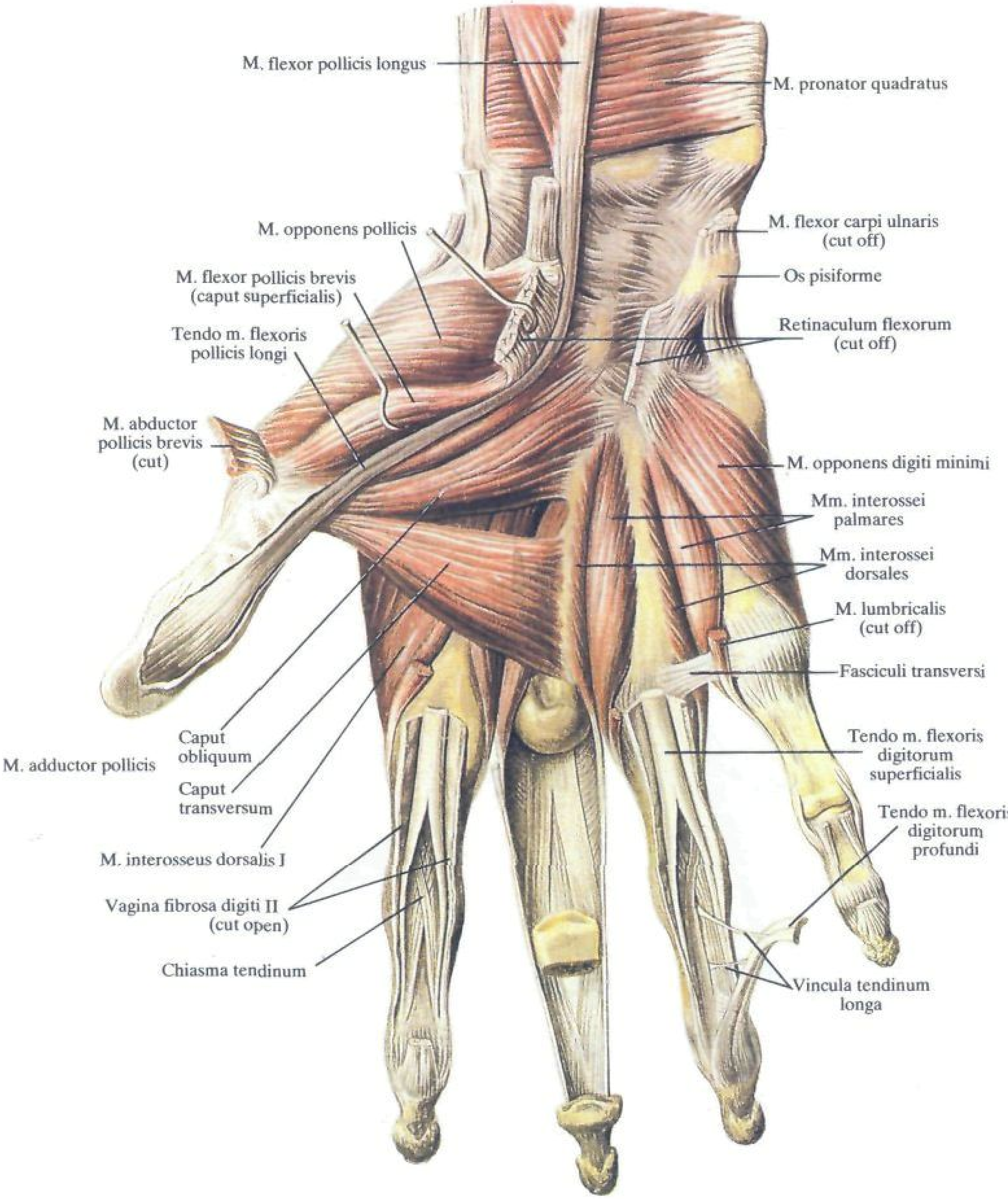


341. *Muscles of right hand*; palmar surface (3/4).
(Fasciae are partly removed.)



342. *Muscles of right hand*; palmar surface ($^4/_5$).

(The proximal and part of the middle phalanx of the middle finger are removed; the extensor digitorum tendon is exposed.)



343. *Muscles of right hand*; palmar surface (2/3).

minimi brevis) (see Fig. 341) is small and flattened; it lies lateral to the abductor digiti minimi muscle and its upper part is covered by the palmaris brevis muscle and skin. The muscle arises from the hook of the hamate bone and the flexor retinaculum, runs distally, and is inserted into the base of the proximal phalanx of the little finger.

Action: flexes the proximal phalanx of the little finger and helps in its adduction.

Blood supply: deep branch of the ulnar artery.

Innervation: the ulnar nerve (C_7-C_8).

4. The **opponens digiti minimi muscle** *(musculus opponens digiti minimi)* (Fig. 341) is medial to the flexor digiti minimi brevis muscle which covers its lateral border. The muscle takes origin from the hook of the hamate bone and the flexor retinaculum and is inserted into the ulnar side of the fifth metacarpal bone.

Action: draws the little finger to oppose the thumb (opposition).

Blood supply: deep branch of the ulnar artery.

Innervation: the ulnar nerve (C_7-C_8).

The Middle Group

1. The **lumbrical muscles** *(musculi lumbricales)* (Fig. 341), four in number, are small and spindle-shaped. Each arises from the radial border of the corresponding flexor digitorum profundus tendon and is inserted into the dorsal surface of the base of the proximal phalanx of the index, middle, ring, and little fingers to intertwine with the dorsal aponeurosis on the radial side of these fingers.

Action: flex the proximal phalanx and extend the middle and distal phalanges of the four fingers.

Blood supply: superficial palmar arch.

Innervation: first and second muscles—the median nerve, third and fourth muscles—the ulnar nerve (C_8, Th_1).

2. The **palmar interossei muscles** *(musculi interossei palmares)* (Fig. 344) are three spindle-shaped muscle fibres lodged in the interosseous spaces between the metacarpal bones. The first muscle lies on the radial part of the palm; it arises from the ulnar side of the second metacarpal bone and is inserted into the ulnar side of the metacarpophalangeal joint of the index finger and into its dorsal aponeurosis. The second and third interossei muscles are on the ulnar half of the palm; arising on the radial side of the fourth and fifth metacarpal bones they are inserted into the radial side of the capsules of the metacarpophalangeal joints of the ring and little fingers.

Action: flex the proximal and extend the middle and distal phalanges of the index, ring, and little fingers; adduct these fingers to the middle finger.

Blood supply: deep palmar arch.

Innervation: the ulnar nerve (C_8, Th_1).

MUSCLES OF THE DORSAL SURFACE

The **dorsal interossei muscles** *(musculi interossei dorsales)* (Fig. 349), four in number, are spindle-shaped and bipennate and lie in the interosseous spaces on the dorsal surface of the hand. Each arises by two heads from the adjacent sides of the bases of two adjacent metacarpal bones; the first and second muscles are inserted into the radial side of the index and middle fingers, while the third and fourth muscles are inserted into the ulnar side of the middle and ring fingers.

Action: the two muscles on the radial side pull the proximal phalanges of the index and middle fingers towards the thumb; the two muscles on the ulnar side pull the middle and ring fingers towards the little finger. In addition, all four muscles assist in flexing the proximal and extending the middle and distal phalanges of the index, middle, ring, and little fingers.

Blood supply: deep palmar arch.

Innervation: the ulnar nerve (C_8, Th_1).

FASCIAE OF THE UPPER LIMB

The fasciae covering the upper limb differ characteristically in thickness along their distance. In some places the fascial layers form clearly defined sheaths and line fossa, canals, and other structures of various size.

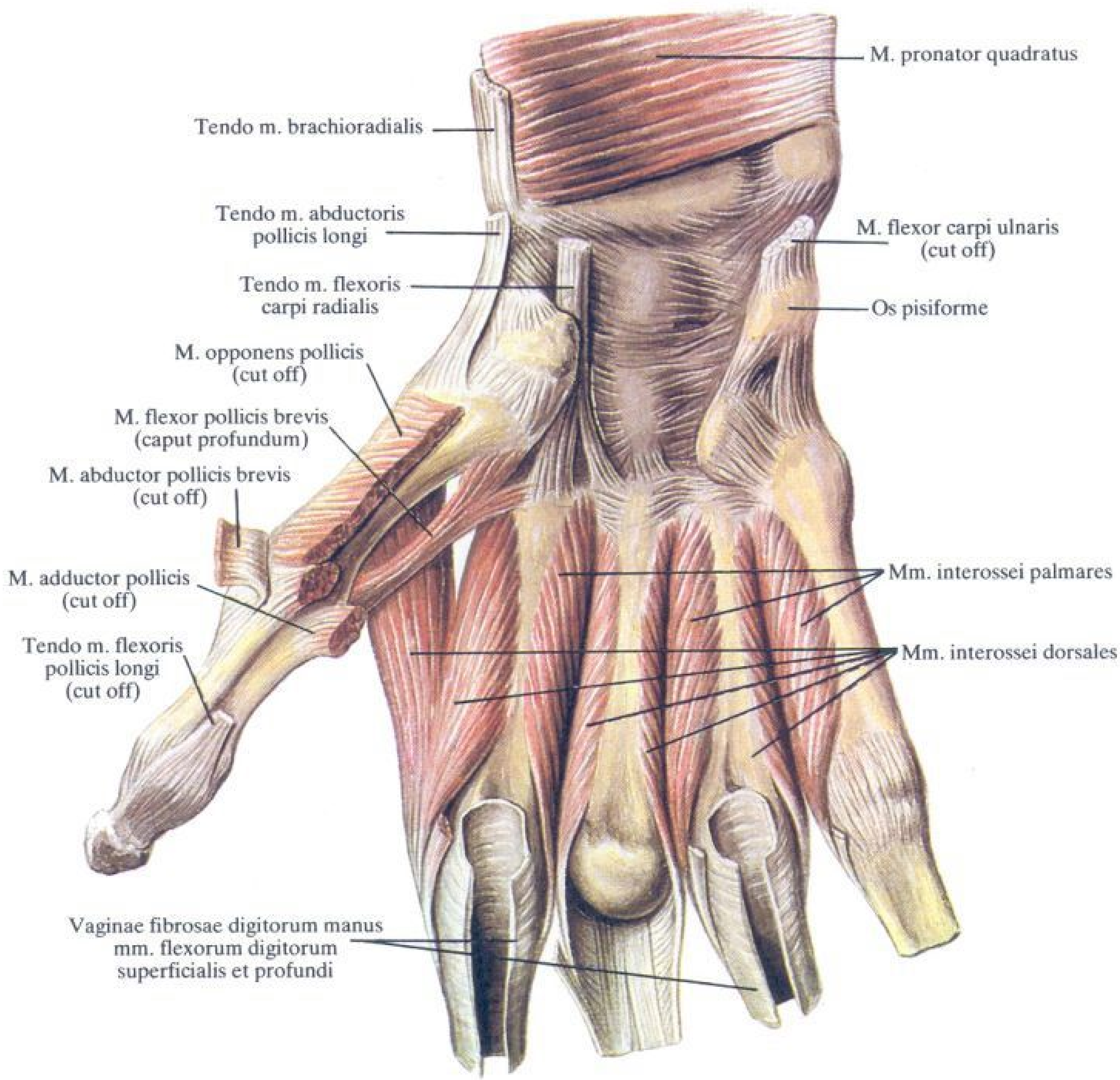
FASCIAE OF THE SHOULDER GIRDLE

The following fasciae are distinguished in the region of the shoulder girdle (see Figs 285, 312, 321, 327): (a) the deltoid fascia consisting of a weaker superficial layer and a stronger deep layer. The superficial layer covers the outer surface of the deltoid muscle and at the anterior border of the muscle is continuous with the pectoral fascia. The deep layer invests the deltoid muscle, which it separates from the muscles of the shoulder girdle (the infraspinatus and teres minor) and the capsule of the shoulder joint, and is continuous with the fascia covering the triceps brachii muscle; (b) the supraspinous fascia which is rather thick and stretches on the edges of the supraspinous fossa to cover the supraspinatus muscle; (c) the infraspinous fascia which is attached to the edges of the infraspinous fossa and blends with the deep layer of the deltoid muscle fascia to form a sheath for the infraspinatus and teres minor muscles; (d) the subscapular fascia which is thin and hardly detectable and is attached to the edges of the subscapular fossa to cover the subscapularis muscle.

The **axillary fascia** *(fascia axillaris)* is a relatively thick sheet covering the axillary fossa inferiorly; it has a series of openings transmitting the nerves and blood and lymph vessels. It is unnoticeably continuous superiorly with the fascia of the deltoid muscle, inferiorly with the brachial fascia and posteriorly with the fascia covering the latissimus dorsi and teres major muscles.

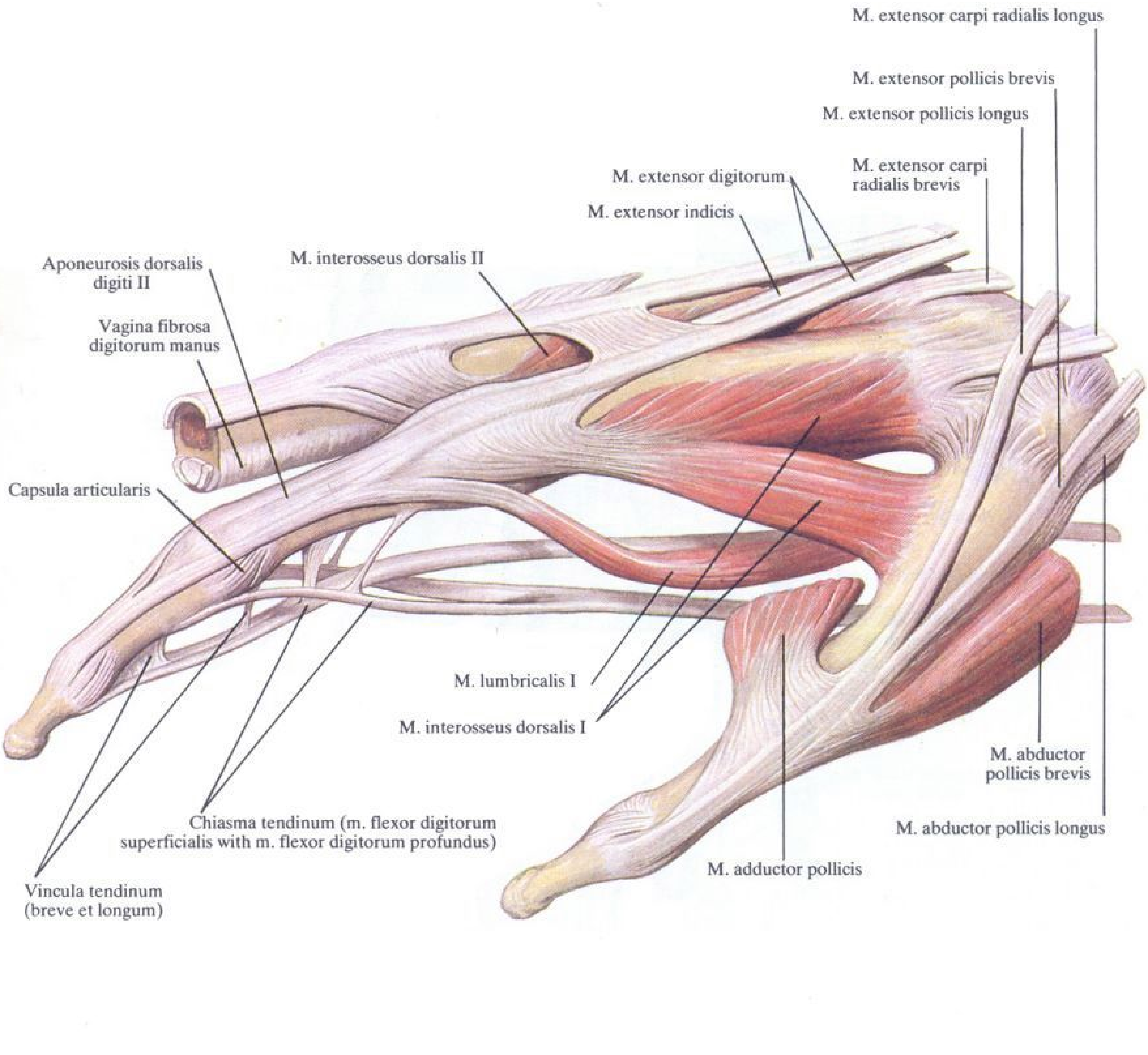
FASCIAE OF THE ARM

The **brachial fascia** *(fascia brachii)* is clearly defined and is thickest in the middle third of the upper arm and below the deltoid muscle. Two frontally arranged intermuscular septa, lateral and medial, are present between the flexors and extensors in the lower half of the arm; they form fascial sheaths for these groups of muscles and serve for insertion of some parts of the arm and fore-

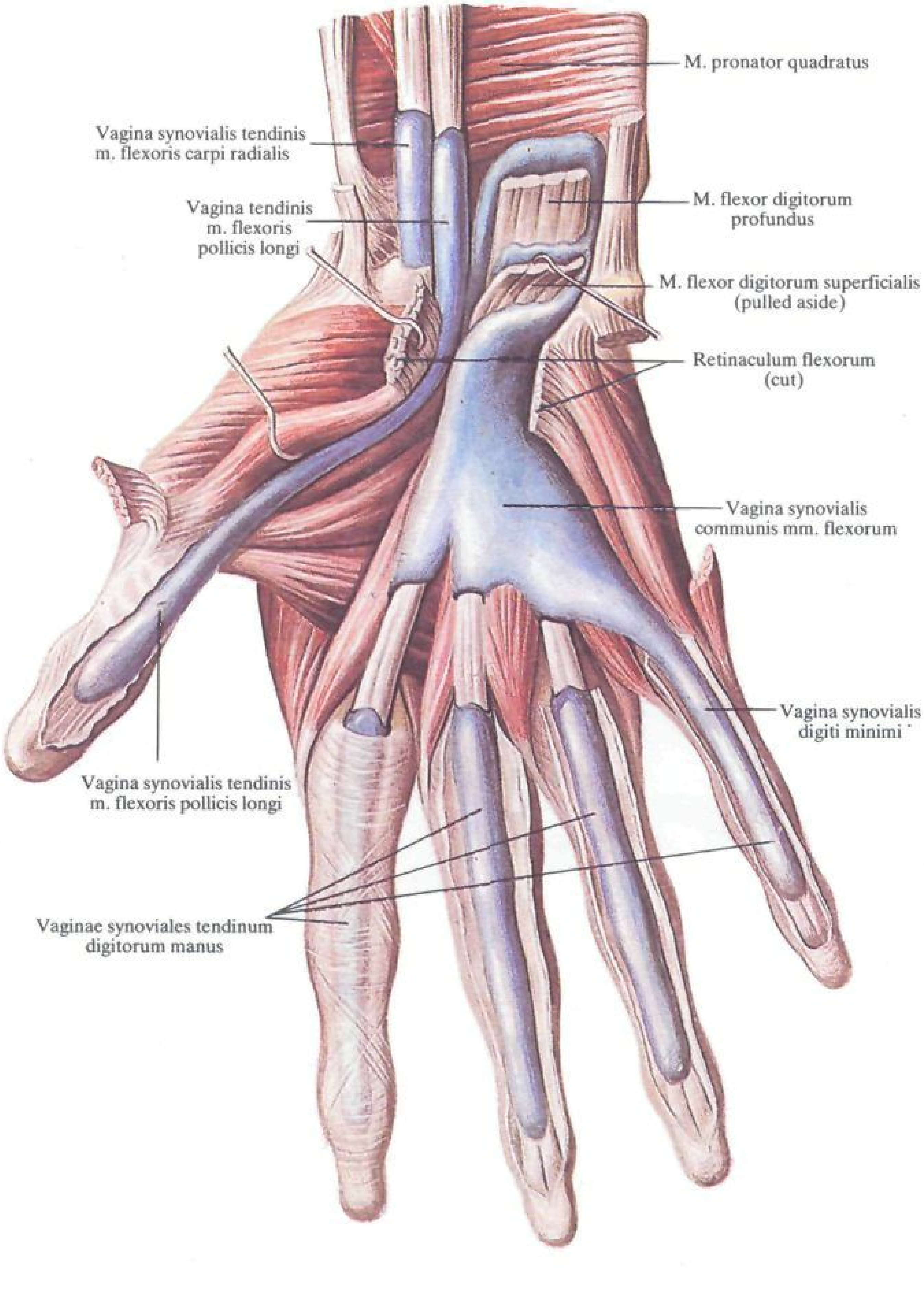


344. *Muscles of right hand*; palmar surface (3/5).
(Interossei muscles.)

arm muscles. The **lateral intermuscular septum of the upper arm** *(septum intermusculare brachii laterale)* arises from the brachial fascia covering the lateral surface of the upper arm and passes deeper to be attached to the lateral border of the humerus for a distance from the deltoid tuberosity to the lateral epicondyle; it separates the lateral and medial heads of the triceps muscle from the brachialis and brachioradialis muscles. The **medial intermuscular septum of the upper arm** *(septum intermusculare brachii mediale)* is stronger; it arises from the brachial fascia and is on the medial surface of the upper arm where it is attached to the medial border of the humerus for the distance between the distal end of the coracobrachialis muscle and the medial epicondyle. The medial septum separates the medial head of the triceps muscle from the brachialis and pronator teres muscles. In some parts the brachial fascia is pierced by nerves and blood vessels.



345. *Tendons of flexors and extensor of index finger.*



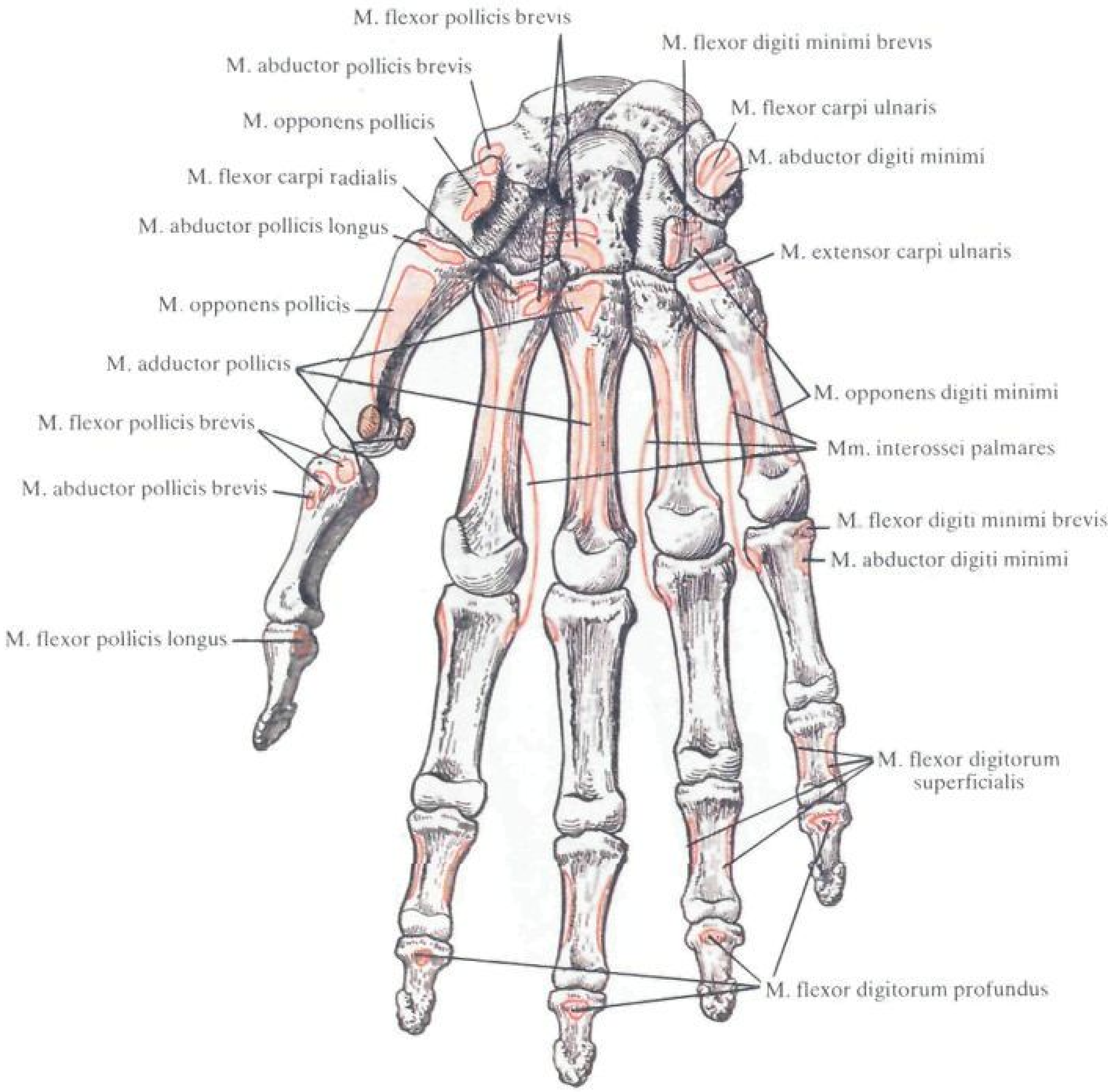
346. *Synovial sheaths of tendons (vaginae synoviales tendinum) of right hand;* palmar surface ($\frac{2}{3}$).

(Staining material is injected into the sheath.)

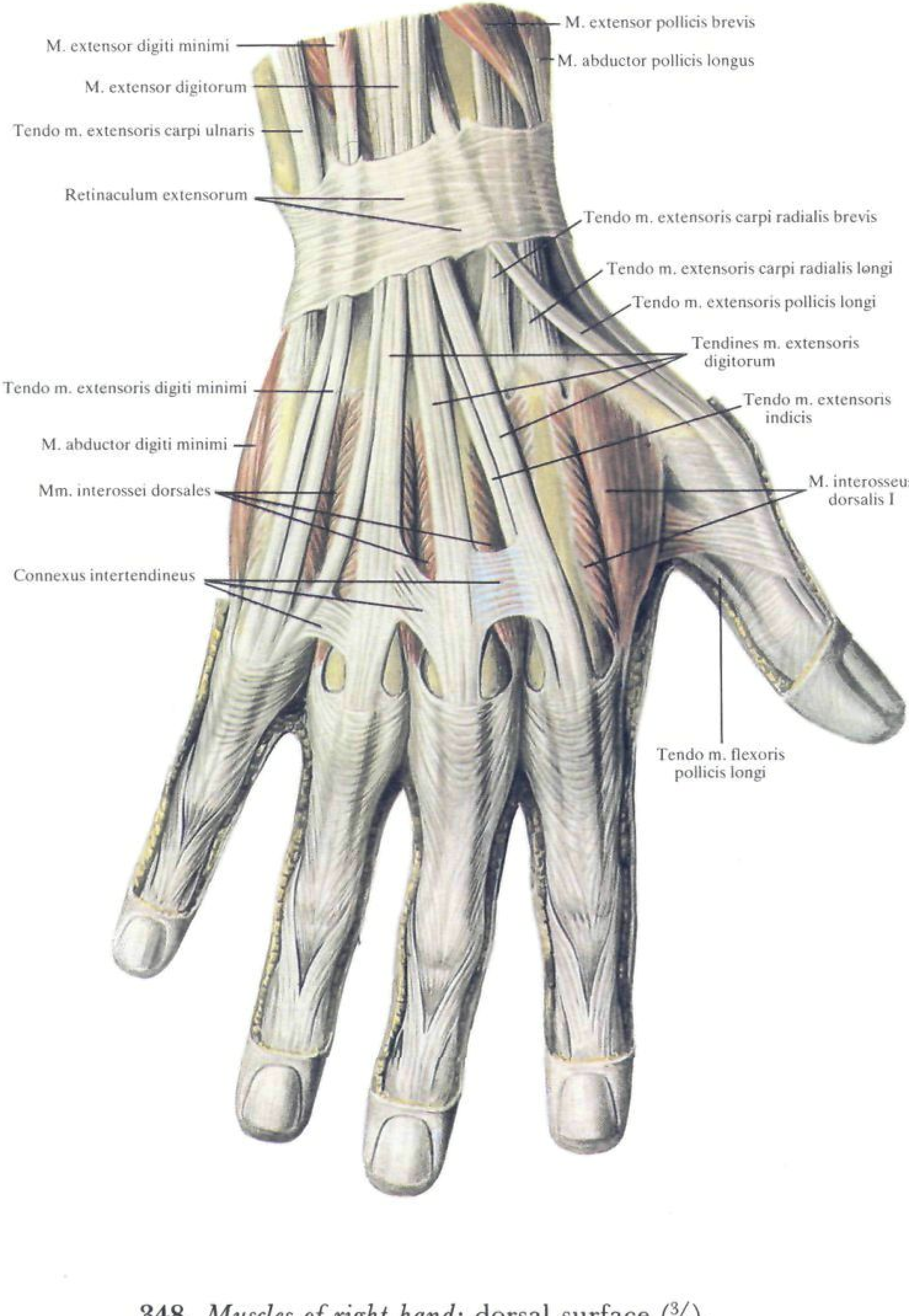
FASCIAE OF THE FOREARM

The **antebrachial fascia** *(fascia antebrachii)* (see Figs 329, 335) is a continuation of the brachial fascia. It is thickest in the region of the elbow joint from where arise some of the muscles of the forearm. For its whole distance the fascia gives off many septa penetrating between separate groups of muscles and forming fascial sheaths for them. Over the whole circumference of the forearm the antebrachial fascia is closely fused with the superficial muscles. Superiorly it blends with a fibrous sheet, the bicipital aponeurosis; inferiorly it forms well defined transversely running bands embracing the wrist joint (Fig. 341).

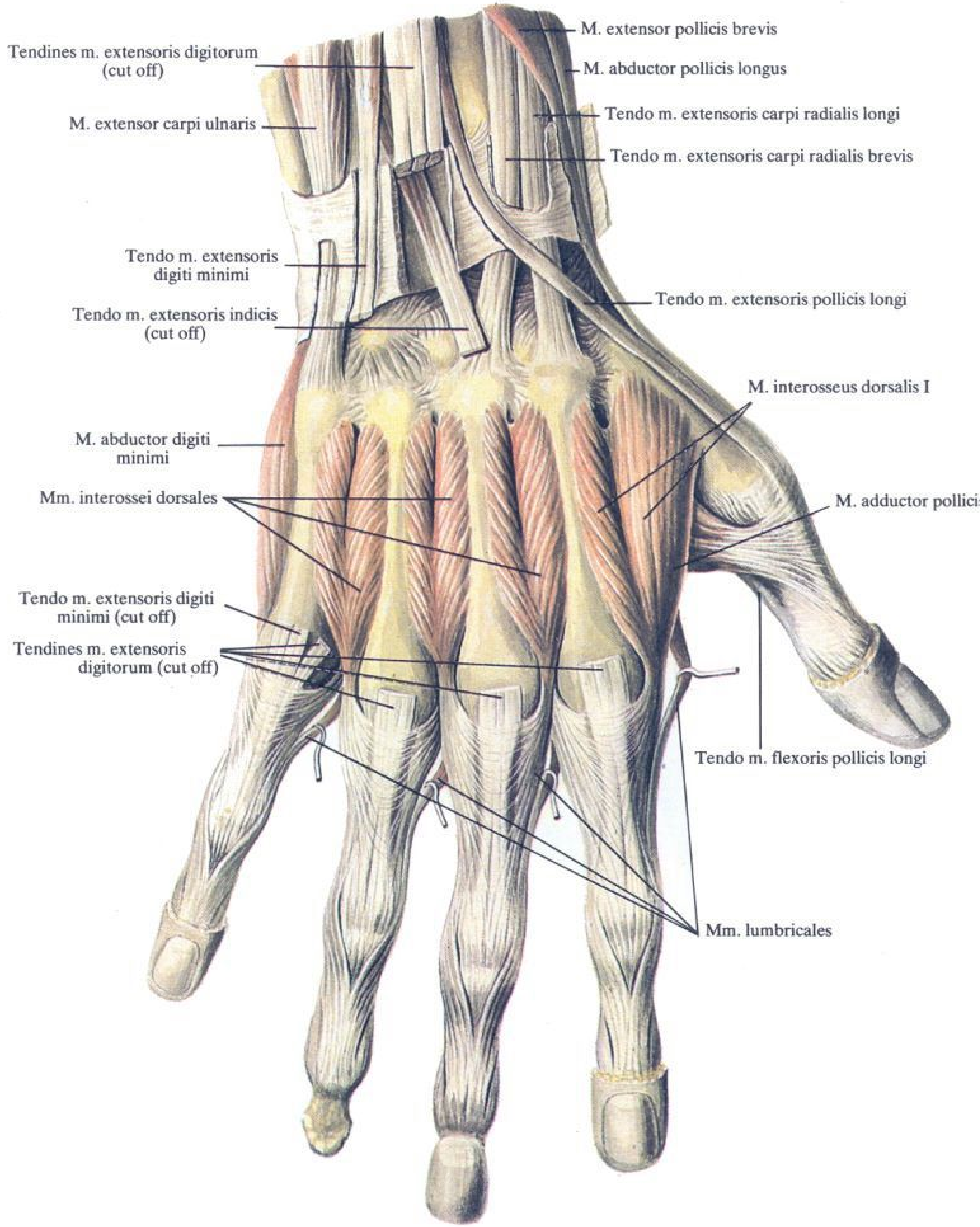
The fascial septa and bones of the forearm and the interosseous membrane form three seats for muscles in the upper half of the forearm: lateral, posterior, and anterior. The lateral seat lodges the brachioradialis and extensor carpi radialis muscles; the posterior (extensor) seat is occupied by the extensor digitorum, extensor digiti minimi, extensor carpi ulnaris, anconeus, and supinator muscles. The anterior seat, which is separated into a superficial and deep parts by a fascial sheet, lodges the group of the anterior forearm muscles with the flexor digitorum profundus and flexor pollicis longus muscles lying in the deep part and the pronator teres, flexor carpi radialis, flexor digitorum superficialis, palmaris longus, and flexor carpi ulnaris muscles in the superficial part. In the lower half of the forearm the fascial seats are the same in number but are smaller because they surround tendons extending from the muscles and not the muscles themselves.



347. *Sites of origin and insertion of muscles on bones of right hand*; palmar surface (schematical representation).

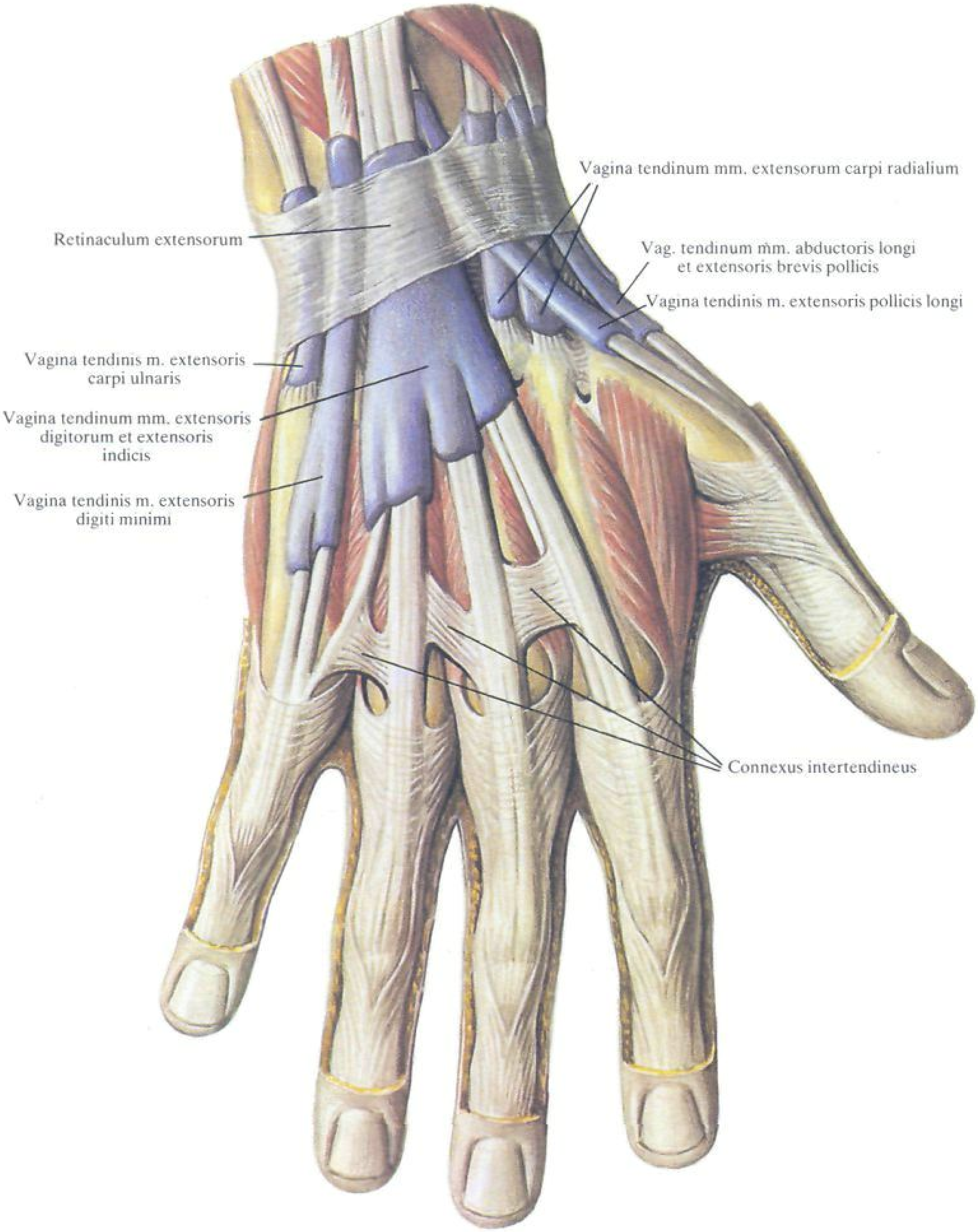


348. *Muscles of right hand*; dorsal surface (3/4).



349. *Muscles of right hand*; dorsal surface ($\frac{3}{4}$).

[The extensor tendons of digits (except for the thumb) are removed, the canals are opened.]



350. *Synovial sheaths of tendons (vaginae synoviales tendinum) on right hand*; dorsal surface (2/5).

FASCIAE OF THE HAND

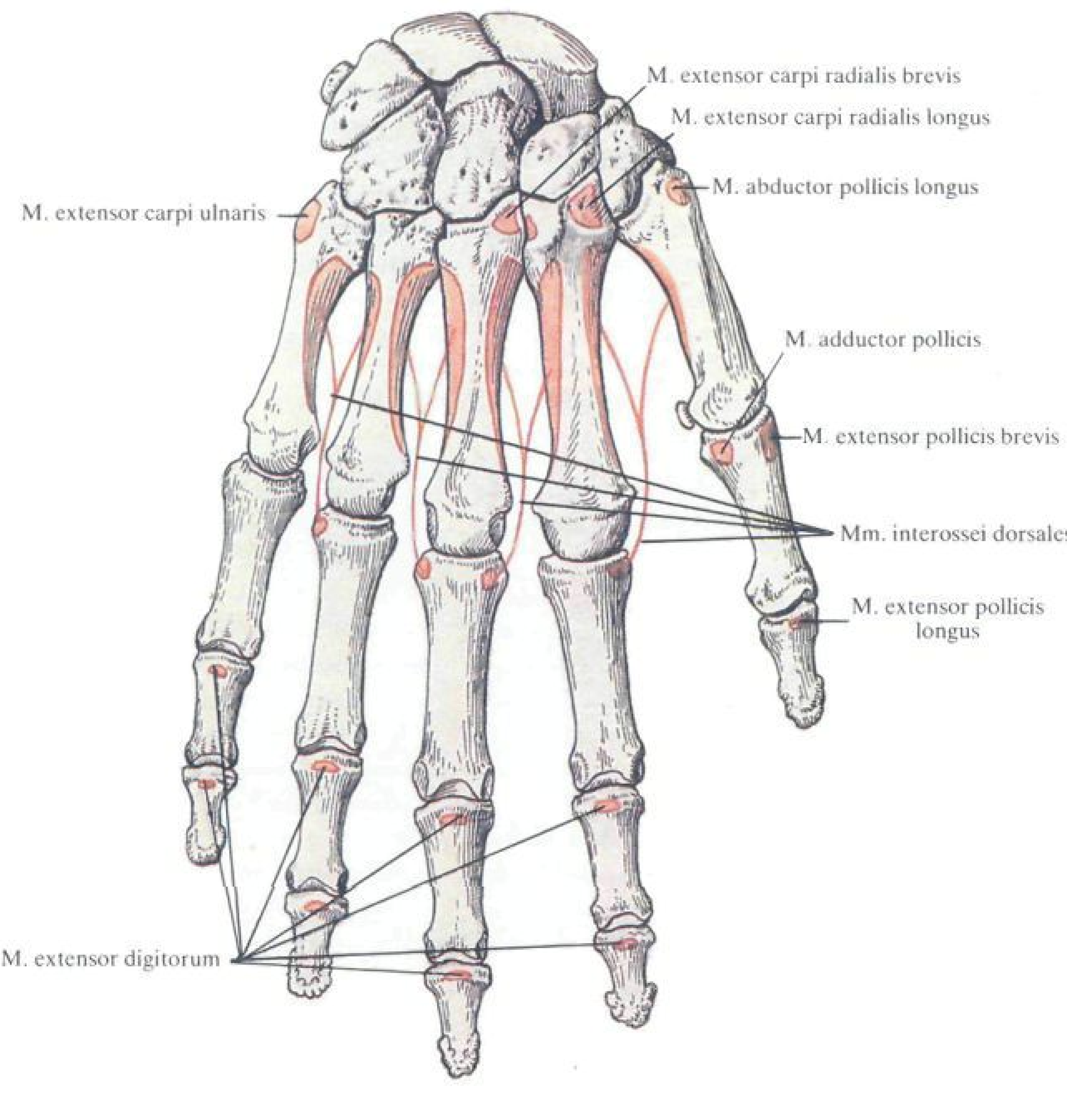
The **fasciae of the hand** *(fasciae manus)* (see Figs 330, 335) are direct continuations of the antebrachial fascia.

Two fasciae, superficial and deep, are distinguished on the palmar surface of the hand. The superficial fascia is a thin sheet covering the muscles of the thenar and hypothenar. In the central parts of the palm it thickens markedly and is continuous with the **palmar aponeurosis** *(aponeurosis palmaris)*. The aponeurosis is triangular, its base faces the fingers and the apex faces the forearm and blends with the flexor retinaculum. In the region of the apex the tendon of the palmaris longus muscle is inserted into the aponeurosis in which its fibres diverge fan-wise to reach the bases of the fingers where they are grouped into larger bands.

The palmar aponeurosis contains besides the longitudinal bands also superficial transverse ligaments *(fasciculi transversi)*, particularly clearly defined at the base of the interdigital spaces (Fig. 343).

The deep fascia of the hand, which is called the palmar interosseous fascia, is a relatively thin sheet of loose alveolar tissue covering the palmar interossei muscles. The tendons of the flexor digitorum muscles, vessels, and nerves lie between the deep fascia and the palmar aponeurosis.

The superficial and the deep fascia blend on the sides to form a space in which the flexor tendons and the lumbrical muscles pass.



351. *Sites of origin and insertion of muscles on bones of right hand*; dorsal aspect (schematical representation).

The palmar fascia of the fingers forms **fibrous flexor sheaths of the fingers** *(vaginae fibrosae digitorum manus)* in which the digitorum flexor tendons stretch. These sheaths are lined with a synovial membrane and their walls are strengthened by ligaments. The best developed among these sheaths is the **annular part of the fibrous flexor sheath** *(pars anularis vaginae fibrosae)*. **Collateral ligaments** *(ligamenta collateralia)* are also present here.

SYNOVIAL SHEATHS OF MUSCLE TENDONS OF THE HAND

On the palmar surface are five **synovial sheaths of the flexor tendons of fingers** *(vaginae synoviales digitorum manus)* (Figs 346, 350) which are isolated from one another. The largest, the **common synovial sheath of the flexor tendons** *(vagina synovialis communis musculorum flexorum digitorum manus)* is lodged in the carpal tunnel and contains the tendons of the flexor digitorum sublimis and profundus muscles emerging onto the hand. This sheath is also connected with the sheath of the little finger which contains the flexor tendons extending to this finger.

Three sheaths of an identical type are on the palmar surface of the index, middle, and ring fingers. They arise on the level of the metacarpophalangeal joints and reach the base of the distal phalanges.

The sheaths contain the tendons of the flexor digitorum sublimis and flexor digitorum profundus muscles.

There is a separate **synovial sheath of the flexor pollicis longus tendon** *(vagina tendinis musculi flexoris pollicis longi)*. It is lodged in the carpal tunnel lateral to the common synovial sheath of the flexor tendons and runs to the thumb to be inserted into base of the distal phalanx.

On the dorsal surface of the hand the **dorsal fascia of the hand** *(fascia dorsalis manus)* covering the dorsal interossei muscles contributes to the formation of the synovial sheaths.

Six synovial sheaths are located on the dorsal surface of the hand (Fig. 350). Each contains tendons of certain muscles stretching on the dorsal surface of the forearm. The sheaths are located under the extensor retinaculum where the tendons pass from the forearm to the hand. Counting from the radial side, the first sheath contains the tendons of the abductor pollicis longus and the extensor pollicis brevis muscles; the second sheath lodges the tendons of the extensor carpi radialis muscles; the third invests the tendon of the extensor pollicis longus muscle; the fourth contains the tendon of the extensor digitorum and extensor incidis muscles; the fifth lodges the tendon of the extensor digiti minimi muscle, and the sixth sheath contains the tendon of the extensor carpi ulnaris muscle.

THE AXILLARY FOSSA

The **axillary fossa**, or **armpit** *(fossa axillaris)* (see Fig. 312) is a depression between the lateral surface of the thoracic wall and the medial surface of the upper arm. It is clearly defined in maximum abduction of the upper arm.

With removal of the skin covering the fossa, the underlying fascia and the loose fatty tissue, a large **axillary cavity** *(cavum axillare)* is exposed which rather resembles in shape a four-sided pyramid whose apex faces upwards and the base downwards. The base of the pyramid is also the lower aperture of the axillary cavity. The upper aperture of the axillary cavity forms in the region of the apex.

Four walls limiting the axillary fossa are distinguished: medial, lateral, anterior, and posterior. The medial wall is formed by the serratus anterior muscle; the lateral by the coracobrachialis muscle and the short head of the biceps brachii muscle; the anterior wall is formed by the pectoralis major and minor muscles, and the posterior wall is formed by the subscapularis, teres major, and latissimus dorsi muscles.

When the arm is abducted another two openings are seen in the axillary fossa which are formed by the passage of the long head of the triceps brachii muscle between the teres major and teres minor muscles. A three-sided opening *(foramen trilaterum)* is bounded by the medial border of the long head laterally, by the teres minor muscle superiorly, and by the teres major muscle inferiorly. Laterally of the long head of the triceps brachii muscle is a four-sided opening *(foramen quadrilaterum)* whose medial side is the lateral surface of the long head of the triceps brachii muscle, the upper side is the teres minor muscle (from the posterior aspect) or the subscapularis muscle (from the anterior aspect), the lower side is the teres major muscle, and the lateral side is the humerus. The axillary fossa is filled with loose fatty tissue containing many vessels, lymph nodes, and nerves.

THE CUBITAL FOSSA

The **cubital fossa** *(fossa cubitalis)* (see Fig. 314) is in the anterior cubital region *(regio cubiti anterior)*. The fossa proper is seen only when the skin and the fatty tissue filling the fossa are removed.

The cubital fossa is bounded by the brachialis muscle superiorly, by the pronator teres muscle medially, and by the brachioradialis muscle laterally. Superficial and deep vessels and nerves pass in it.

MUSCLES OF THE LOWER LIMB

Musculi membri inferioris

REGIONS OF THE LOWER LIMB

The following are the **regions of the lower limb** *(regiones membri inferioris)* (Figs 353, 365).

1. The **gluteal region** *(regio glutea)* is continuous with the posterior femoral region. Its upper boundary is formed by the iliac crest, the lower boundary is the **fold of the buttock** *(sulcus gluteus* s. *plica glutea)*.

2. The femoral regions:

(a) the **anterior femoral region** *(regio femoris anterior)* corresponds to the location of the quadriceps femoris and sartorius muscles. The lower boundary line passes 4 cm above the patella;

(b) the **posterior femoral region** *(regio femoris posterior)* corresponds to the space bounded superiorly by the fold of the buttock and inferiorly by a transverse line drawn 3-4 cm above the base of the patella.

3. The regions of the knee:

(a) the **anterior region of the knee** *(regio genus anterior)* is on the anterior, lateral, and medial surfaces of the knee. It includes the patellar region which corresponds to the contours of the patella and the femoral condyles;

(b) the **posterior region of the knee** *(regio genus posterior)* is on the posterior surface of the knee. It includes the **popliteal fossa** *(fossa poplitea)*.

4. The crural regions:

(a) the **anterior crural region** *(regio crurus anterior)* extends from the tibial tuberosity to the level of the base of the malleoli and occupies the anterior surface of the leg;

(b) the **posterior crural region** *(regio cruris posterior)* including the calf which is the most protruding upper part of this region.

5. The regions of the foot:

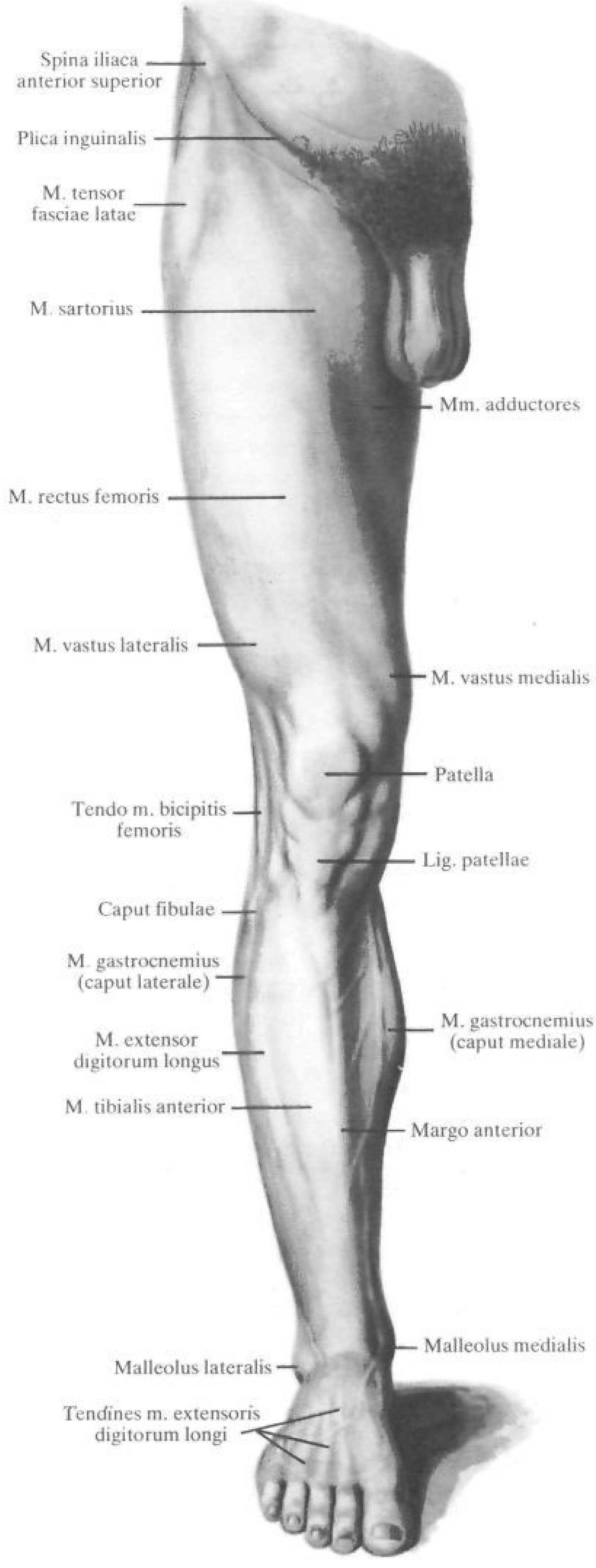
(a) the **dorsum of the foot** *(dorsum pedis)* is on the dorsal and lateral and medial surfaces of the foot and extends from the bend of the ankle joint to the proximal phalanges of the toes;

(b) the **region of the sole of the foot** *(planta pedis)* is on the plantar surface of the foot and stretches from the distal areas of the posterior surface of the calcaneum to the proximal phalanges of the toes;

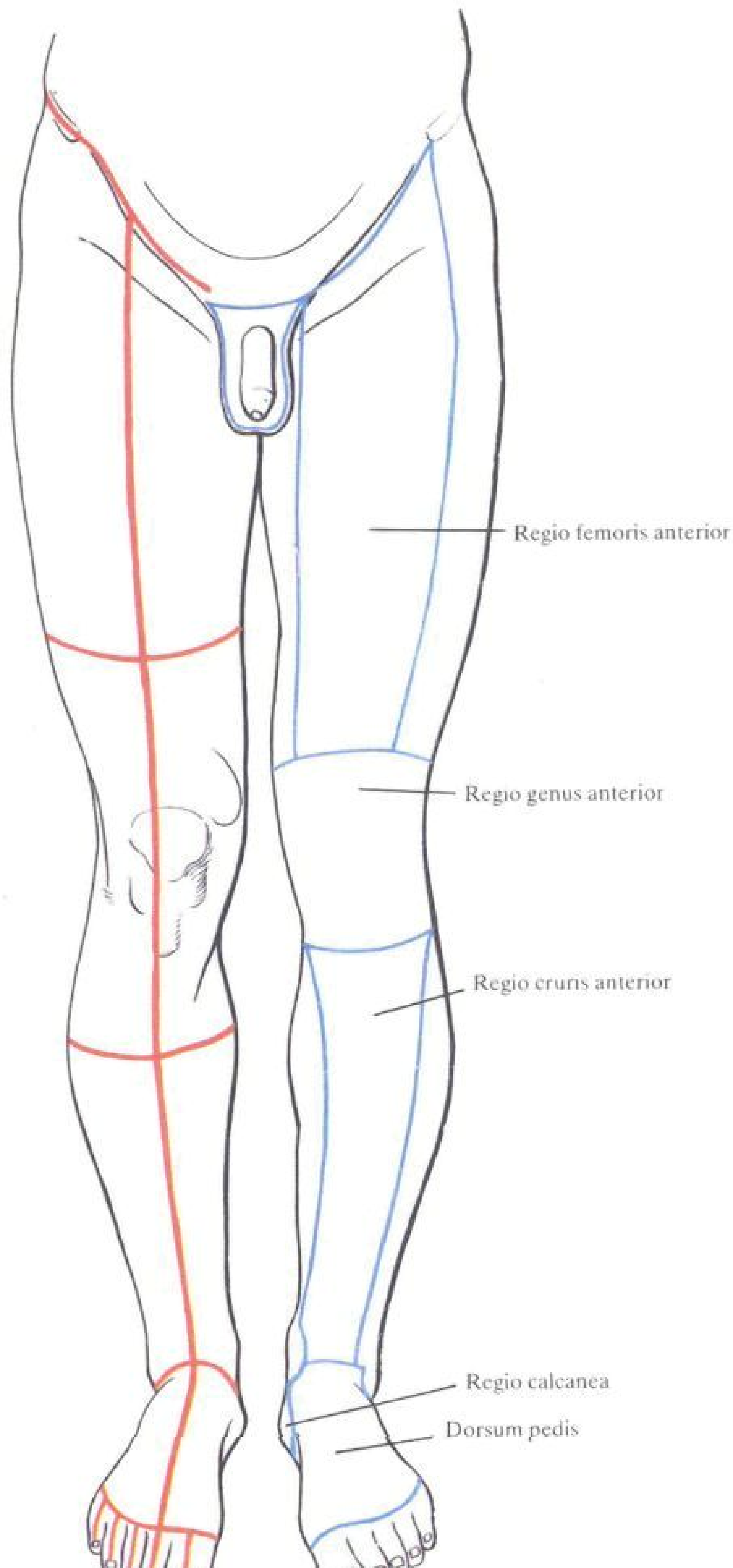
(c) the **calcanean region** *(regio calcanea)* corresponds to the posterior surface of the calcaneum.

MUSCLES OF THE LOWER LIMB

The **muscles of the lower limbs** *(musculi membri inferioris)* are divided into two groups according to their topographo-anatomical features, namely the muscles of the hip joint and the muscles of the free lower limb. The muscles of the last-named group are in turn subdivided into the muscles of the thigh, the muscles of the leg, and the muscles of the foot (Figs 352-401).



352. *Outlines of muscles of right lower limb*; anterior aspect.



353. *Regions and lines of skin incisions on lower limb.*
(Blue line—area boundaries; red line—skin incisions most suitable for exposure of muscles in dissection.)

MUSCLES OF THE HIP JOINT

The muscles of the hip joint are grouped into internal and external muscles.

The Internal Group of Muscles of the Hip Joint

1. The **psoas major muscle** *(musculus psoas major).*
2. The **psoas minor muscle** *(musculus psoas minor).*
3. The **iliacus muscle** *(musculus iliacus)*
4. The **iliopsoas muscle** *(musculus iliopsoas).*
5. The **obturator internus muscle** *(musculus obturatorius interna).*
6. The **piriformis muscle** *(musculus piriformis).*
7. The **coccygeus muscle** *(musculus coccygeus).*

The External Group of Muscles of the Hip Joint

1. The **gluteus maximus muscle** *(musculus gluteus maximus).*
2. The **gluteus medius muscle** *(musculus gluteus medius).*
3. The **gluteus minimus muscle** *(musculus gluteus minimus).*
4. The **quadratus femoris muscle** *(musculus guadratus femoris).*
5. The **gemellus superior muscle** *(musculus gemellus superior).*
6. The **gemellus inferior muscle** *(musculus gemellus inferior).*
7. The **obturator externus muscle** *(musculus obturatorius externus).*
8. The **tensor fasciae latae muscle** *(musculus tensor fasciae latae).*

THE INTERNAL GROUP OF MUSCLES OF THE HIP JOINT

1. The **psoas major muscle** *(musculus psoas major)* (see Fig. 297) is long and spindle-shaped. It takes origin by five slips from the lateral surface of the bodies of the twelfth thoracic and upper four lumbar vertebrae and the respective intervertebral cartilages. Slips which are located deeper arise from the transverse processes of all lumbar vertebrae. Becoming slightly narrower, the muscle runs downwards and a little laterally and fuses with the fibres of the iliacus muscle to form a common iliopsoas muscle.

2. The **psoas minor muscle** *(musculus psoas minor)* (see Fig. 297) is inconstant, thin, and spindle-shaped. It lies on the anterior surface of the psoas major muscle. It arises from the lateral surface of the bodies of the twelfth thoracic and first lumbar vertebrae and stretches downwards; its tendon is continuous with the fascia iliaca and is inserted together with it into the pectineal line and the iliopubic eminence.

Action: tenses the fascia iliaca.

Blood supply: the lumbar arteries.

Innervation: muscular branches of the lumbar plexus (L_1-L_2).

3. The **iliacus muscle** *(musculus iliacus)* (see Fig. 297) fills the iliac fossa completely and arises from its walls. It resembles a triangle in shape with the apex facing downwards.

The fibres forming the muscle converge fan-wise towards the arcuate line and blend with those of the psoas major to form the iliopsoas muscle.

4. The **iliopsoas muscle** *(musculus iliopsoas)* (see Fig. 297) forms from fusion of the distal muscle fibres of the iliacus muscle and the psoas major muscle. It emerges from the pelvic cavity through the lacuna musculorum and runs downwards on the anterior surface of the hip joint to be inserted by a thin short tendon into the lesser trochanter of the femur; the **bursa of the psoas major tendon** *(bursa ileopectinea)* is lodged between the capsule of the hip joint and the tendon and often communicates with the cavity of the hip joint.

Action: flexes the hip joint and rotates the thigh medially. When the thigh is fixed the muscle flexes the trunk forwards.

Blood supply: the iliolumbar and the deep circumflex iliac arteries.

Innervation: the muscular branches of the lumbar plexus (L_1-L_2).

5. The **obturator internus muscle** *(musculus obturatorius internus)* (Fig. 360) is flattened and its muscular fibres are directed slightly fan-wise. It takes origin by a wide part from the inner surface of the hip bone around the obturator membrane and from its inner surface. A small cleft between the bands of the muscle and the obturator groove of the pubic bone is transformed into the **obturator canal** *(canalis obturatorius)* transmitting vessels and nerves. Converging, the muscle fibres are directed laterally, pass over the lesser sciatic notch almost at a right angle, leave the pelvic cavity through the lesser sciatic foramen, and are inserted by a short strong tendon into the trochanteric fossa. Where the bands pass over the lesser sciatic notch lies the **bursa of the obturator internus muscle** *(bursa ischiadica musculi obturatorii interni).*

The obturator internus muscle is divided topographically into two parts, one larger, extending to the exit from the pelvic cavity and called the intrapelvic part, and the other, smaller, tendinous part stretching under the gluteus maximus muscle and called the extrapelvic part.

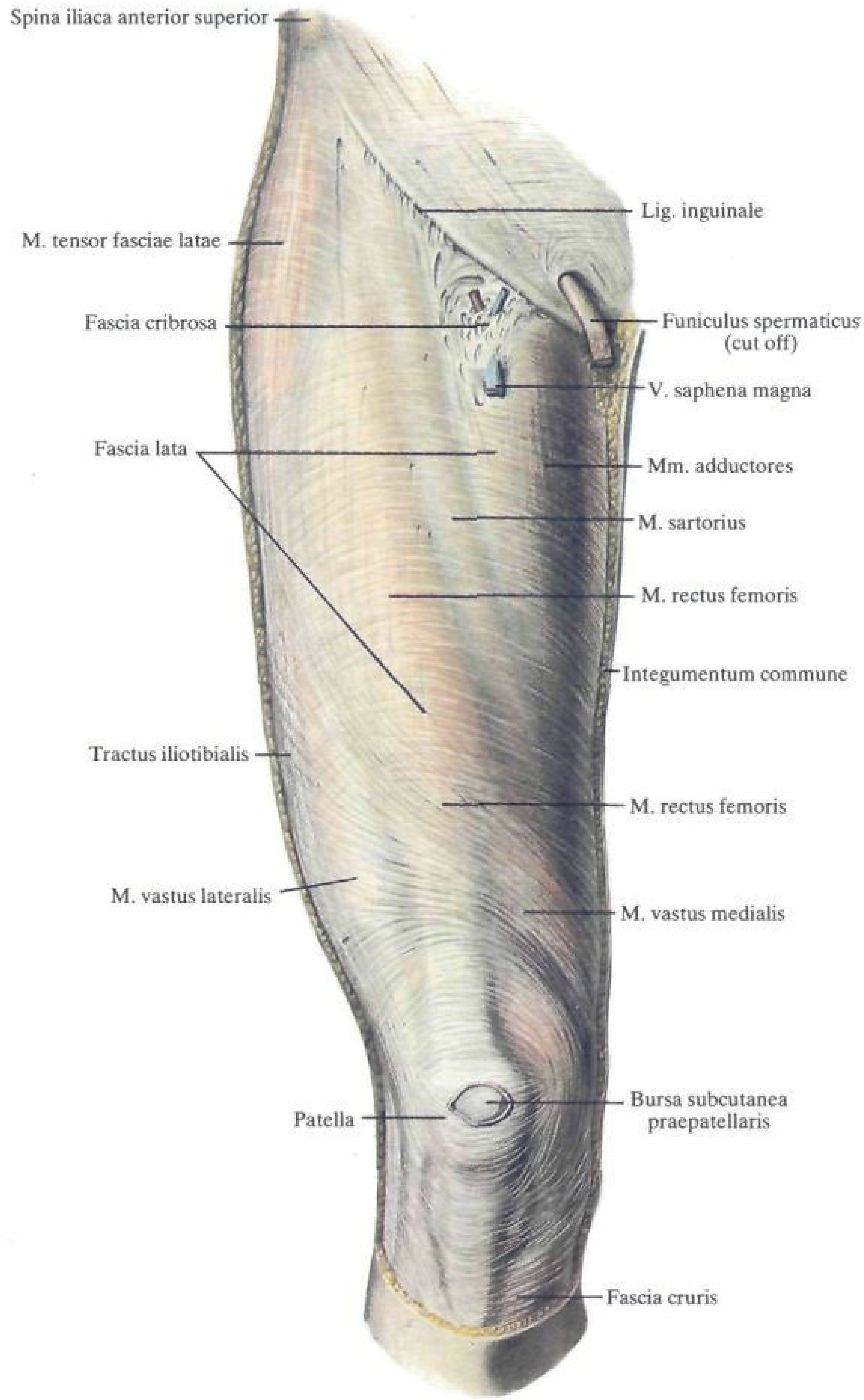
Action: supinates the thigh.

Blood supply: the inferior gluteal, obturator, and internal pudendal arteries.

Innervation: muscular branches of the sacral plexus [L_4-L_5; S_1-S_2(S_3)].

6. The **piriformis muscle** *(musculus piriformis)* (Fig. 357) is shaped like a flat isosceles triangle whose base arises from the anterior surface of the sacrum lateral to the anterior sacral foramina, between the second and fourth foramina. Converging, the muscle fibres are directed laterally and emerge from the cavity of the true pelvis through the greater sciatic foramen; the muscle then gives place to a narrow and short tendon which is inserted into the apex of the greater trochanter. At the place of the insertion is the synovial **bursa of the piriformis muscle** *(bursa musculi piriformis).* When passing through the greater sciatic foramen the muscle fails to fill it completely but leaves small slits along the upper and lower borders which transmit vessels and nerves. The slit formed along the upper border of the piriformis muscle is called the suprapiriformis foramen and that formed along the lower border is the infrapiriformis foramen.

Action: supinates the thigh and assists in its abduction.



354. *Muscles and fasciae of right thigh*; anterior aspect (1/4).
(Skin and subcutaneous layer are removed.)

Blood supply: the superior and inferior gluteal arteries.

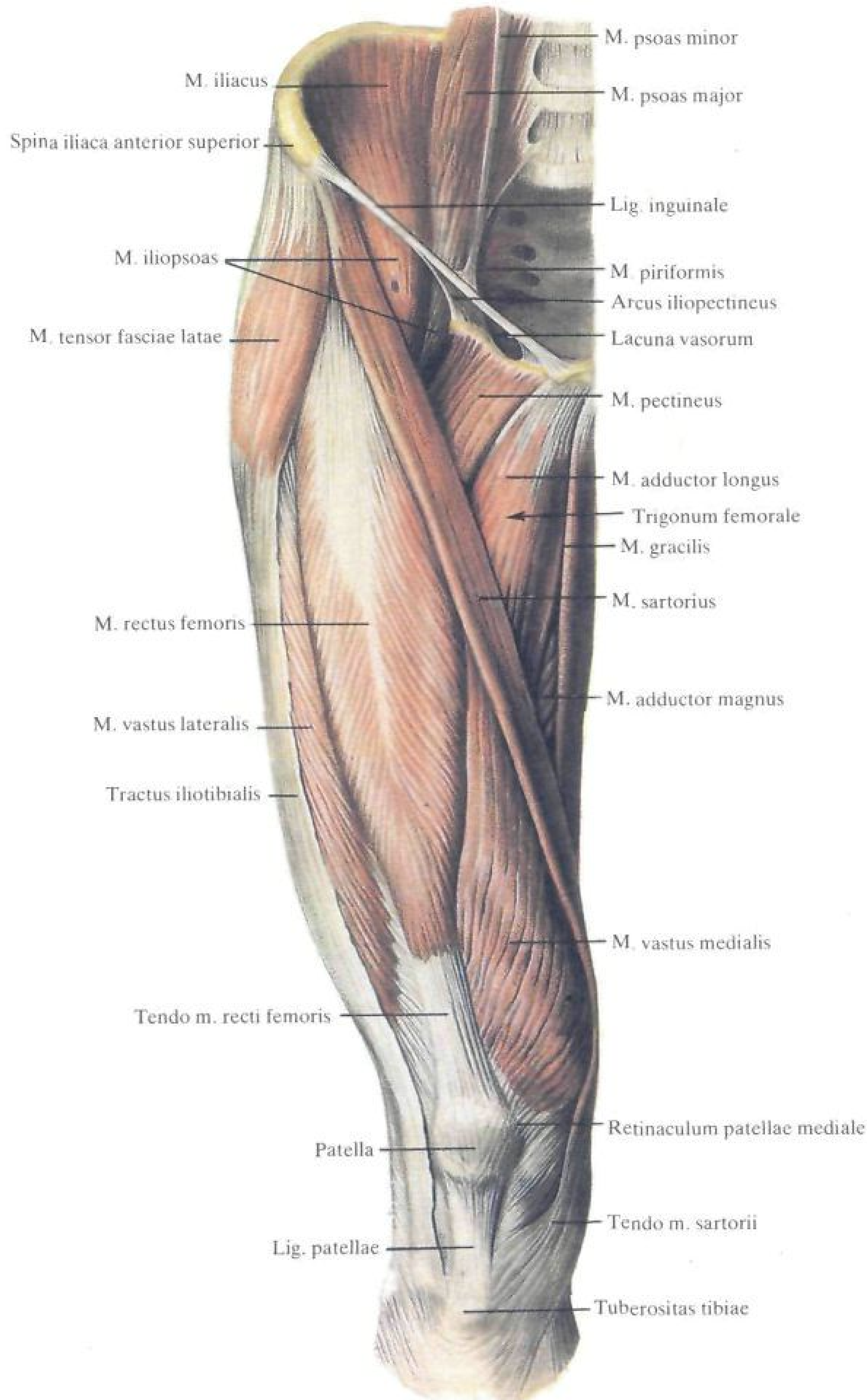
Innervation: muscular branches of the sacral plexus [S_1–S_2(S_3)].

7. The **coccygeus muscle** *(musculus coccygeus)* (Figs 360, 361) is a thin sheet with a relatively small number of muscle fibres. Arising from the ischial spine, it passes on the medial side of the sacrospinous ligament and is inserted into the lateral surface of the lower two sacral and upper two or three coccygeal vertebrae.

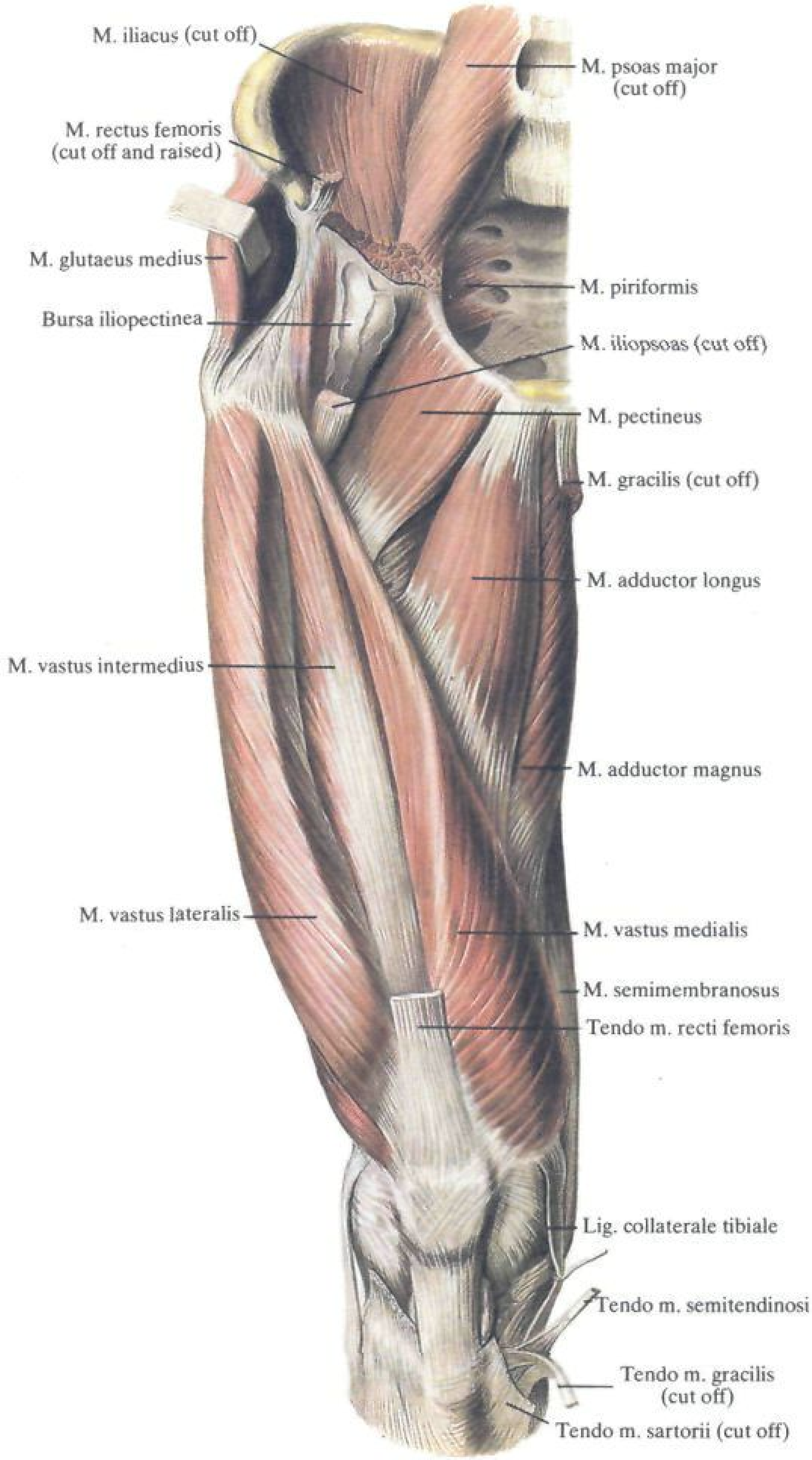
Action: in man the muscle is rudimentary; on contraction it contributes to strengthening the pelvic walls.

Blood supply: muscular branches of the internal pudendal artery.

Innervation: muscular branches of the pudendal nerve.

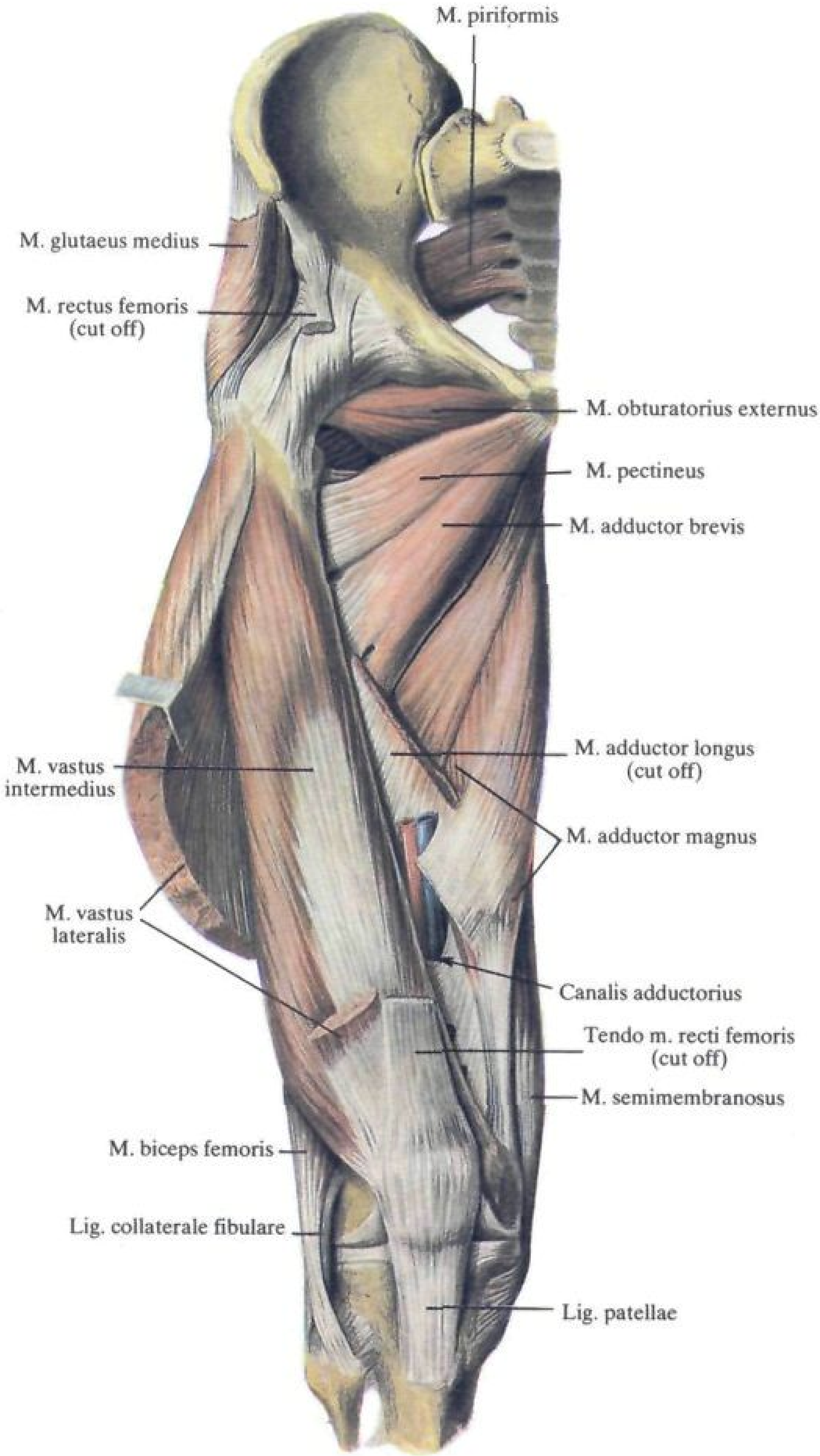


355. *Muscles of right hip joint and thigh*; anterior aspect ($\frac{1}{4}$).

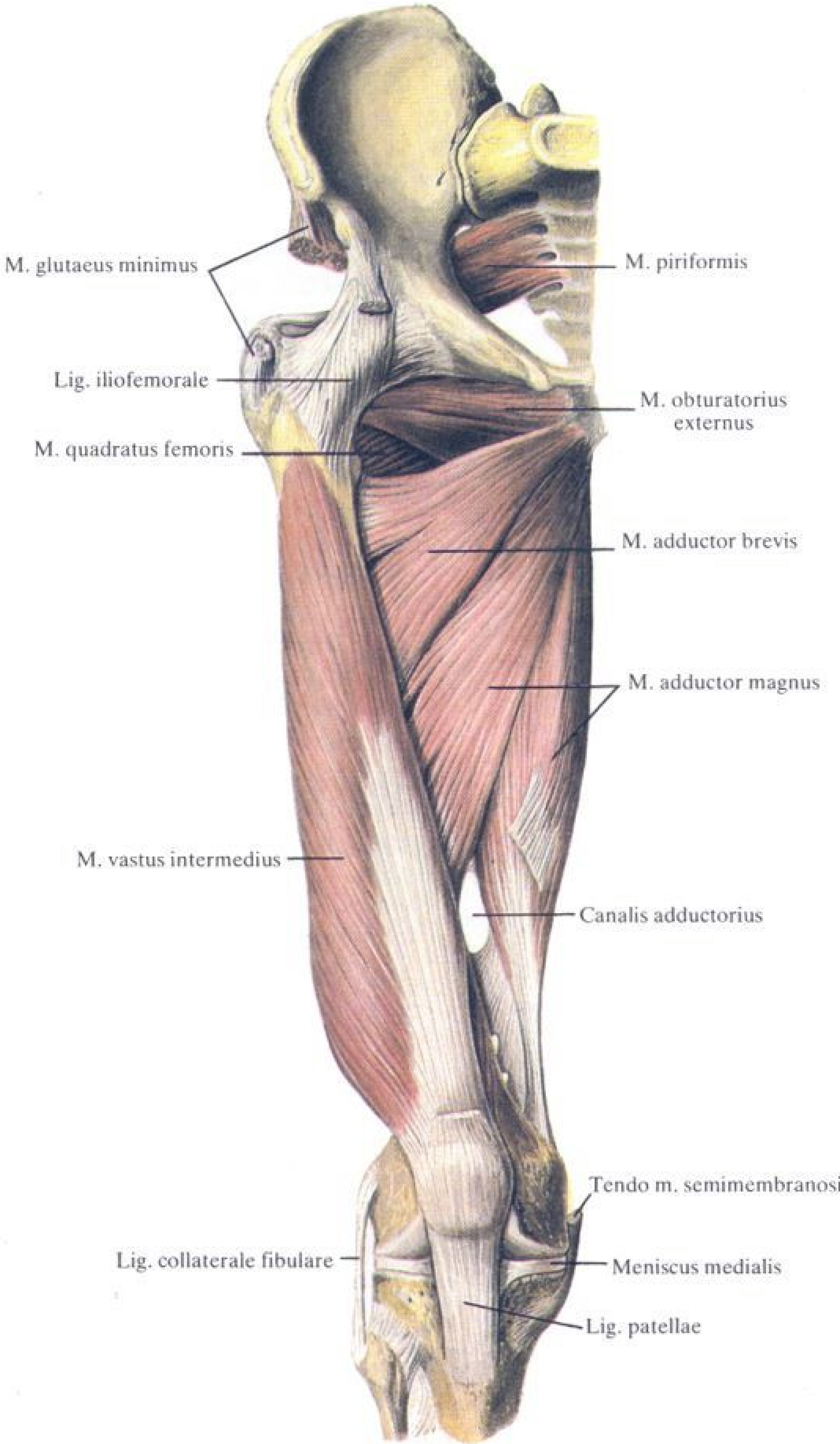


356. *Muscles of right hip joint and thigh*; anterior aspect (1/4).

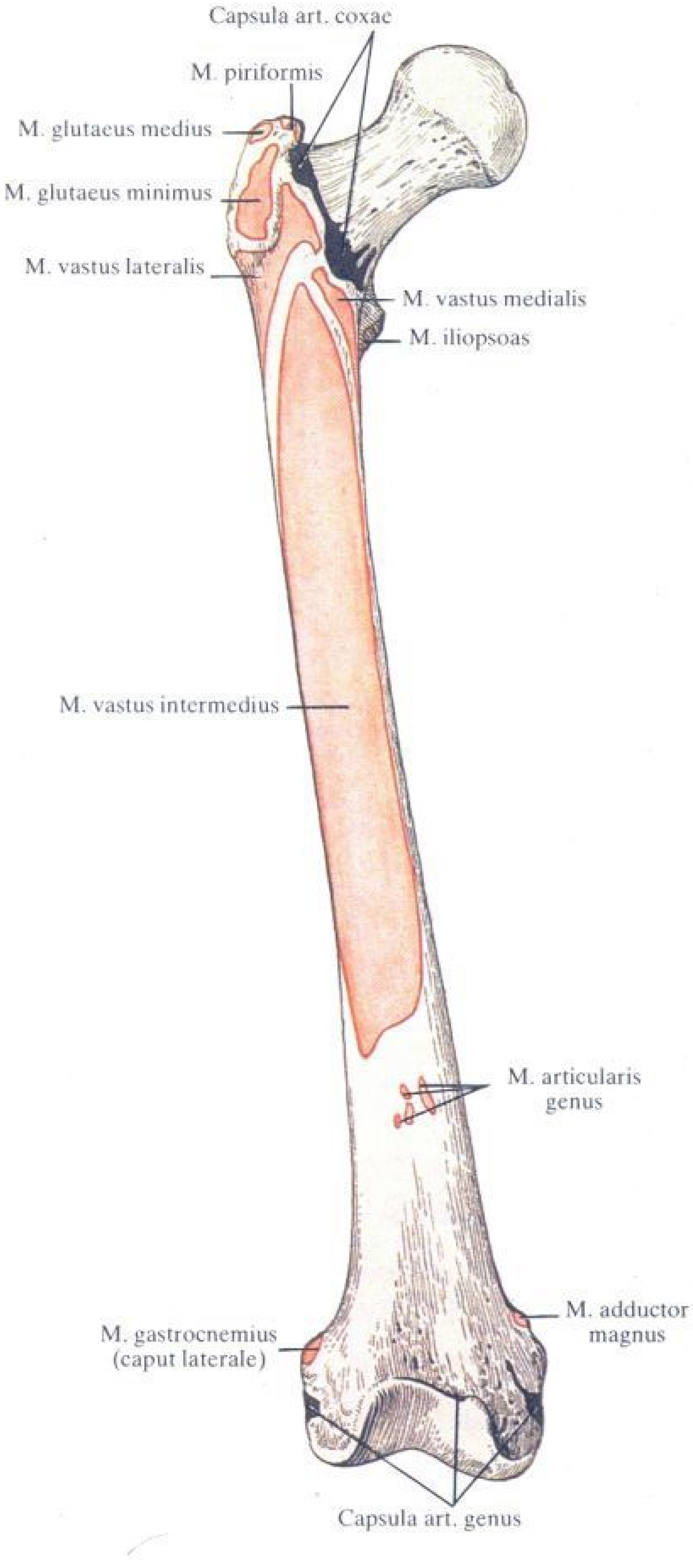
(The rectus femoris and sartorius muscles and part of the iliopsoas muscle are removed.)



357. *Muscles of right hip joint and thigh*; anterior aspect ($\frac{1}{4}$).



358. *Muscles of right hip joint and thigh*; anterior aspect ($^1/_4$).



359. *Sites of origin and attachment of muscles and articular capsules on right thigh*; anterior aspect (schematical representation).

THE EXTERNAL GROUP OF MUSCLES OF THE HIP JOINT

1. The **gluteus maximus muscle** *(musculus gluteus maximus)* resembles a rhombus in shape. It is formed of large fibres and is strong, flat, and 2-3 cm thick. It covers the greater trochanter and the other muscles of this group. The muscle arises from the posterior part of the external surface of the iliac bone to the back of the posterior gluteal line, from the lateral borders of the sacrum and coccyx, and from the sacrotuberous ligament. The muscle fibres stretch obliquely downwards and laterally and the upper ones are inserted into the fascia lata which is continuous with the iliotibial tract, while the lower fibres are inserted into the gluteal tuberosity of the femur. The **trochanteric bursa of the gluteus maximus muscle** *(bursa trochanterica musculi glutei maximi)* is lodged here between the greater trochanter and the muscle.

Action: brings the trunk to an erect position when it is bent forwards, extends the thigh, and tenses the fascia lata of the thigh.

Blood supply: the superior and inferior gluteal, medial circumflex, and profunda femoris (perforating artery prima) arteries.

Innervation: inferior gluteal nerve (plexus sacralis) (L_5, S_1-S_2).

2. The **gluteus medius muscle** *(musculus gluteus medius)* (Fig. 369) is under the gluteus maximus. It resembles a triangle in shape. The muscle is thick and consists of two layers, superficial and deep. The muscle fibres run fan-wise; they arise widely from the external surface of the ala of the ilium between the anterior gluteal line in front, the iliac crest above, and the posterior gluteal line below. Then all the muscle fibres converge to form a strong common tendon which is inserted into the apex of the greater trochanter; the **trochanteric bursa of the gluteus medius muscle** *(bursa trochanterica musculi glutei medii)* is lodged here.

Action: abducts the thigh, with the anterior fibres rotating it medially and the posterior fibres rotating it laterally; assists in bringing erect the trunk when it is bent forwards.

Blood supply: the superior gluteal and lateral circumflex arteries.

Innervation: the superior gluteal nerve (sacral plexus) (L_1-L_5, S_1).

3. The **gluteus minimus muscle** *(musculus gluteus minimus)* (Fig. 369) resembles the gluteus medius in shape but is much thinner across, and is completely covered by it. The muscle arises from the external surface of the ilium between the anterior and inferior gluteal lines. The muscle fibres then converge to be continuous with a tendon which is inserted into the anterior border of the greater trochanter. The **trochanteric bursa of the gluteus minimus muscle** *(bursa trochanterica musculi glutei minimi)* lies here.

Action: similar to that of the gluteus medius muscle, it abducts the limb and contributes to bringing the trunk to an erect position when it is bent.

Blood supply: the superior gluteal and lateral circumflex arteries.

Innervation: the superior gluteal nerve (plexus sacralis) (L_1-L_5, S_1).

4. The **quadratus femoris muscle** *(musculus quadratus femoris)* (Fig. 370) has the appearance of a relatively thick rectangle which

is covered by the gluteus maximus muscle posteriorly. It takes origin from the lateral surface of the ischial tuberosity and is inserted into the trochanteric crest and reaches the greater trochanter.

Action: rotates the thigh laterally.

Blood supply: the inferior gluteal, medial circumflex, and obturator arteries.

Innervation: the sciatic nerve (sacral plexus) (L_4-L_5, S_1).

5. The **gemellus superior muscle** *(musculus gemellus superior)* (Fig. 371) is a small slip arising from the ischial spine; it is inserted into the trochanteric fossa. The muscle adjoins the superior border of the obturator internus tendon after it emerges from the pelvic cavity.

Action: rotates the thigh laterally.

Blood supply: the inferior gluteal and internal pudendal arteries.

Innervation: branches of the sacral plexus (L_4-L_5, S_1).

6. The **gemellus inferior muscle** *(musculus gemellus inferior)* (Fig. 371) resembles the gemellus superior muscle in shape and lies below the tendon of the obturator internus muscle. It arises from the ischial tuberosity and is inserted into the trochanteric fossa.

Action: rotates the thigh laterally.

Blood supply and innervation are the same as in the case of the gemellus superior muscle.

7. The **obturator externus muscle** *(musculus obturatorius externus)* (see Fig. 297) is shaped like an irregular triangle. It arises by its widest part from the obturator membrane and the bony edge of the obturator foramen, after which the muscle fibres converge fan-wise and are continuous with a tendon lying on the posterior surface of the capsule of the hip joint. The muscle is inserted into the trochanteric fossa next to the obturator internus muscle.

Action: rotates the thigh laterally.

Blood supply: the obturator and lateral circumflex arteries.

Innervation: the obturator nerve (lumbar plexus) [(L_2), L_3-L_4)]:

8. The **tensor fasciae latae muscle** *(musculus tensor fasciae latae)* (Fig. 355) is flat and slightly elongated. It lies on the anterolateral surface of the pelvis and its distal end blends with the fascia lata femoris. The muscle arises from the outer lip of the iliac crest closer to the anterior superior iliac spine. The muscle fibres are directed vertically downwards to be continuous with the iliotibial tract.

Action: tenses the fascia lata and helps in flexion of the thigh.

Blood supply: the superior gluteal and lateral circumflex arteries.

Innervation: the superior gluteal nerve (sacral plexus) (L_4-L_5, S_1).

MUSCLES OF THE FREE LOWER LIMB

The muscles of the free lower limb are divided into the muscles of the thigh, the muscles of the leg, and the muscles of the foot.

MUSCLES OF THE THIGH

The **muscles of the thigh** *(musculi femoris)* form an anterior, medial, and lateral groups. Extensors are predominantly related to the first, adductors to the second, and flexors to the third group.

The Anterior Group

1. The **sartorius muscle** *(musculus sartorius)*.
2. The **quadriceps femoris muscle** *(musculus quadriceps femoris)*.
3. The **articularis genus muscle** *(musculus articularis genus)*.

The Medial Group

1. The **gracilis muscle** *(musculus gracilis)*.
2. The **adductor longus muscle** *(musculus adductor longus)*.
3. The **adductor brevis muscle** *(musculus adductor brevis)*.
4. The **adductor magnus muscle** *(musculus adductor magnus)*.
5. The **pectineus muscle** *(musculus pectineus)*.

The Posterior Group

1. The **semitendinosus muscle** *(musculus semitendinosus)*.
2. The **semimembranosus muscle** *(musculus semimembranosus)*.
3. The **biceps femoris muscle** *(musculus biceps femoris)*.

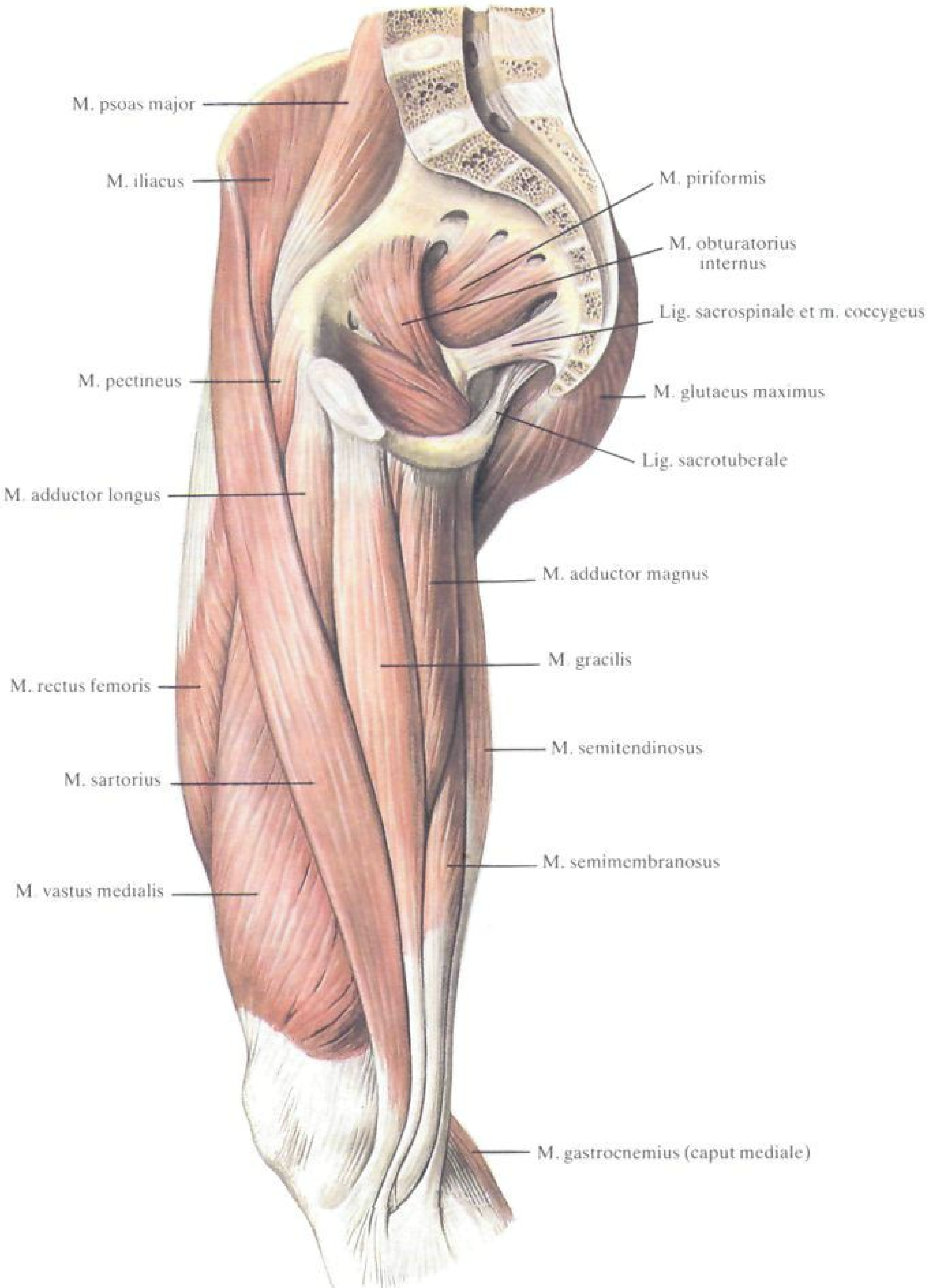
THE ANTERIOR GROUP OF MUSCLES OF THE THIGH

1. The **sartorius muscle** *(musculus sartorius)* (Fig. 355) is a strap-like and longest muscle in the human body. Lying on the anterior surface of the thigh, it descends spirally, passing to the medial surface, and then curving around the back of the medial epicondyle passes over to the anteromedial surface of the leg. The muscle arises from the anterior superior iliac spine, passes obliquely downwards, and ends as a flat tendon which is inserted into the tubercle of the tibia; some fibres blend with the fascia of the upper part of the leg.

Action: flexes the thigh and leg, rotating the thigh laterally and the leg medially thus assisting in crossing the legs.

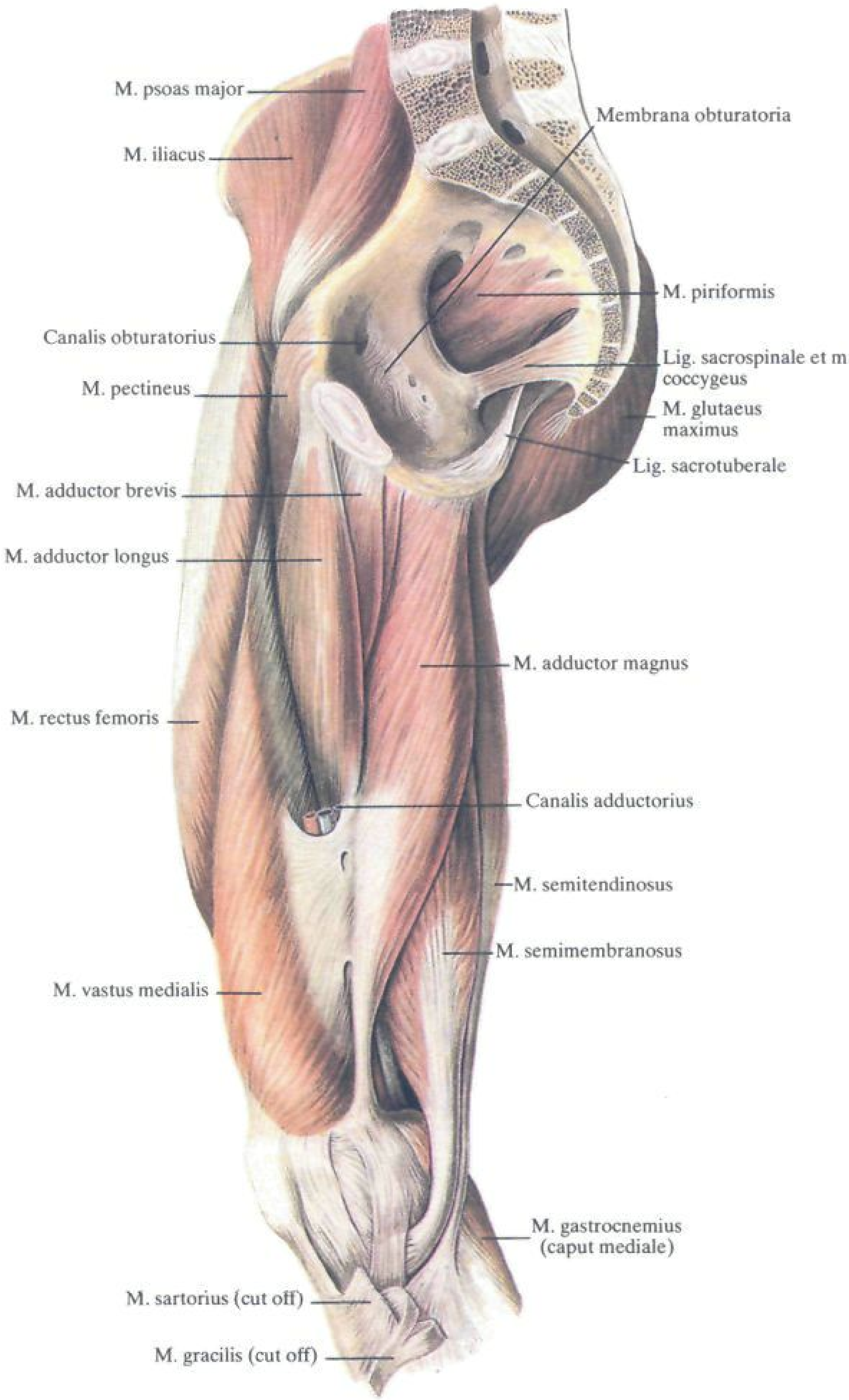
Blood supply: the lateral circumflex and superior genicular arteries and muscular branches of the femoral artery.

Innervation: the femoral nerve (lumbar plexus) (L_2-L_3).



360. *Muscles of right hip joint and thigh* (1/4).

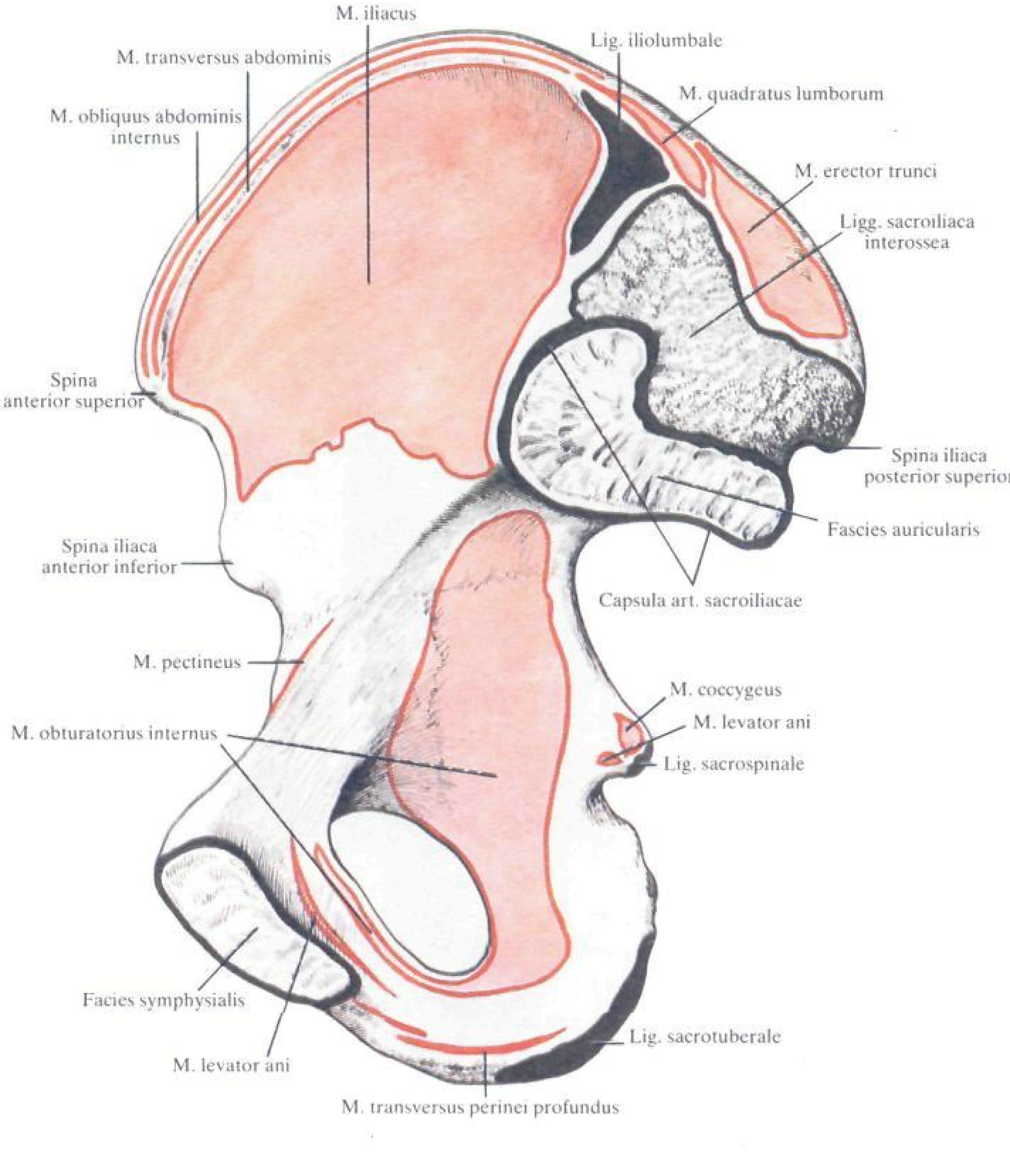
(The internal muscles of the hip joint, the anterior and medial groups of thigh muscles.)



361. *Muscles of right hip joint and thigh*; medial aspect (¼).

2. The **quadriceps femoris muscle** *(musculus quadriceps femoris)* (Figs 355-359) occupies the anterolateral surface of the thigh and its lower parts extend to the lateral surface. Each of its four heads arises independently, but on reaching the knee they form a common tendon which passes on the anterior surface of the patella and is inserted into the tubercle of the tibia.

A. The **rectus femoris muscle** *(musculus rectus femoris)* is the longest head and occupies the anterior surface of the thigh. It takes origin by a fine tendon from the anterior inferior iliac spine and superior border of the acetabulum and then passes downwards to be continuous with a narrow tendon which fuses with the base and anterior surface of the patella. On reaching the tibia the ten-

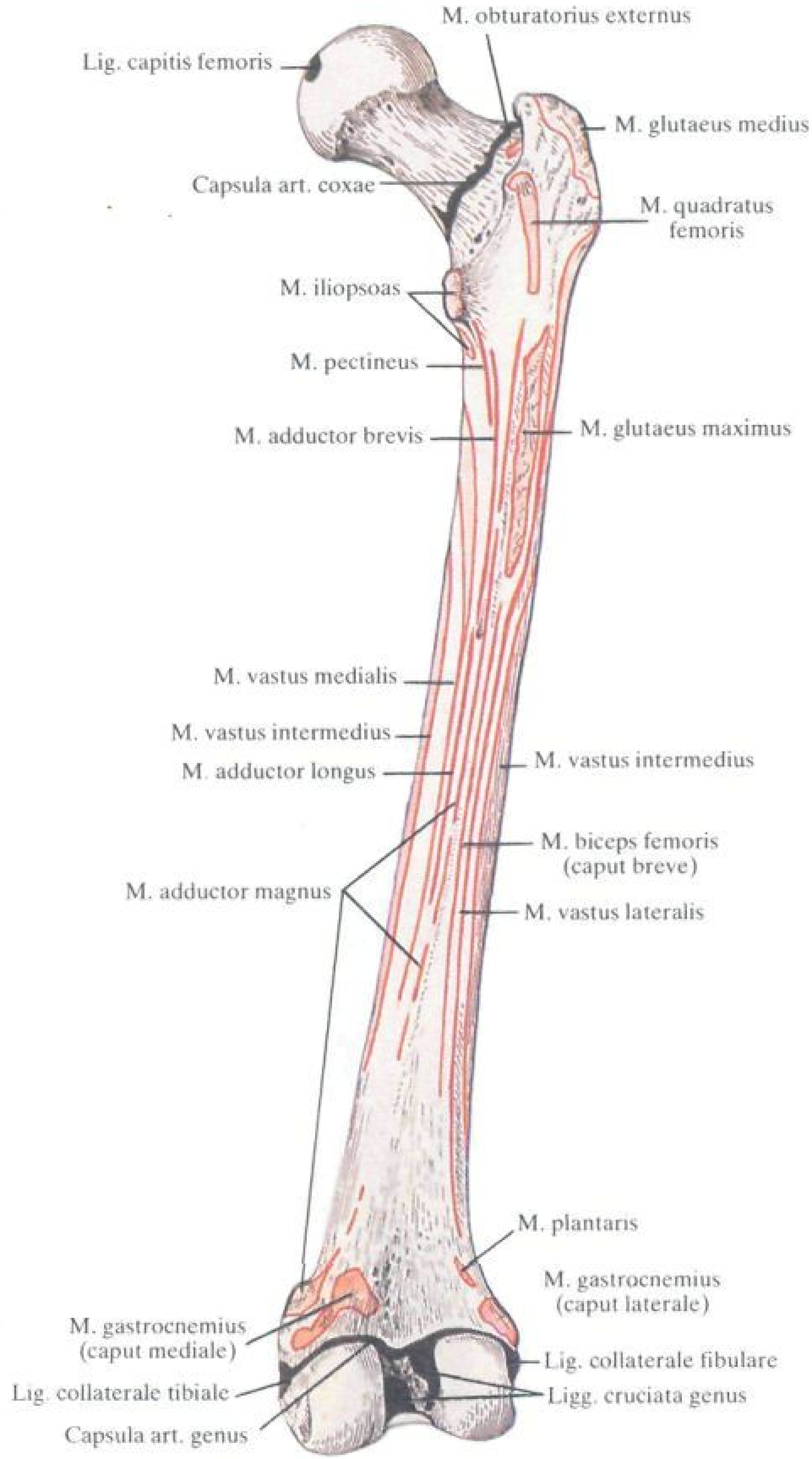


362. *Sites of origin and attachment of muscles and articular capsule on right hip bone*; inner aspect (schematical representation).

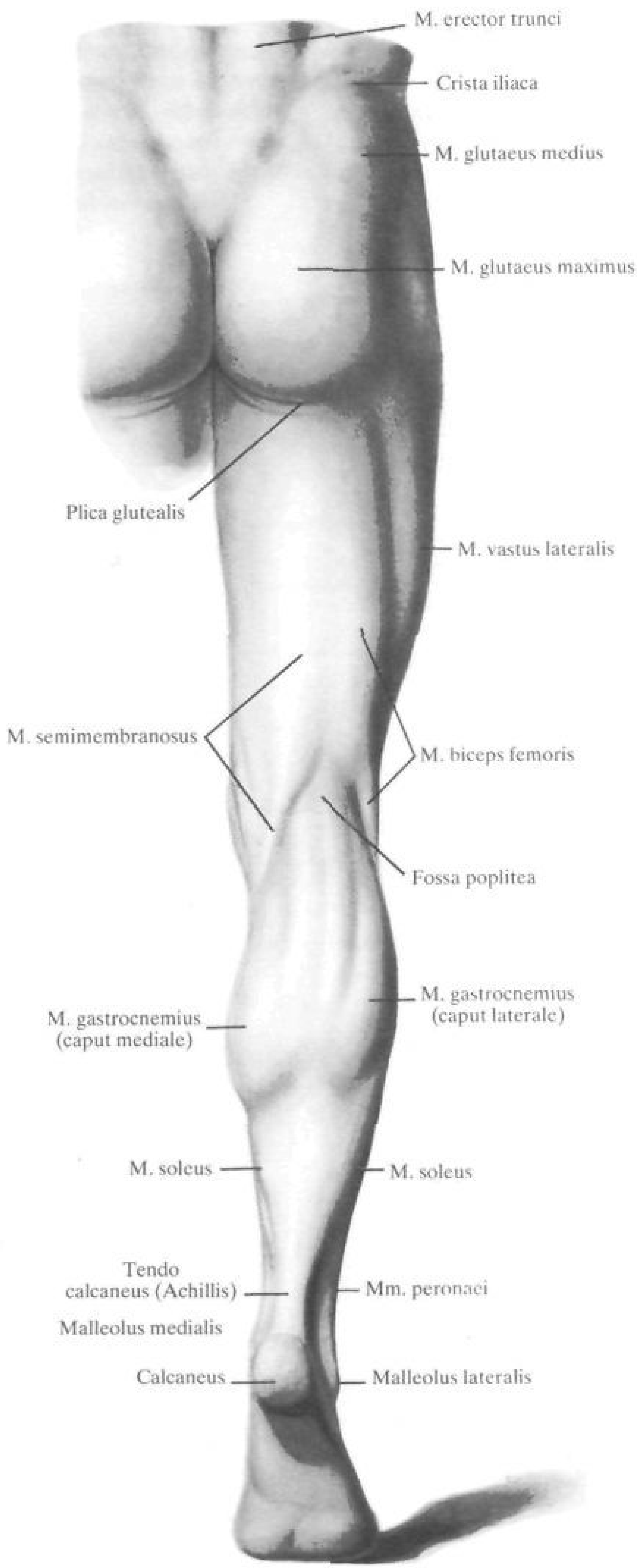
don of the muscle is inserted into the tibial tubercle. Below the patella the tendon is called the ligamentum patellae.

B. The **vastus medialis muscle** *(musculus vastus medialis)* occupies the anteromedial surface of the lower half of the thigh. The muscle fibres forming it are directed obliquely downwards and anteriorly. In front it is partly covered by the rectus muscle. The vastus medialis muscle arises from the medial lip of the linea aspera and runs downwards to be continuous with a wide tendon which partly blends with the common tendon together with the rectus femoris muscle and is partly inserted into the medial border of the patella to form the medial retinaculum of the patella.

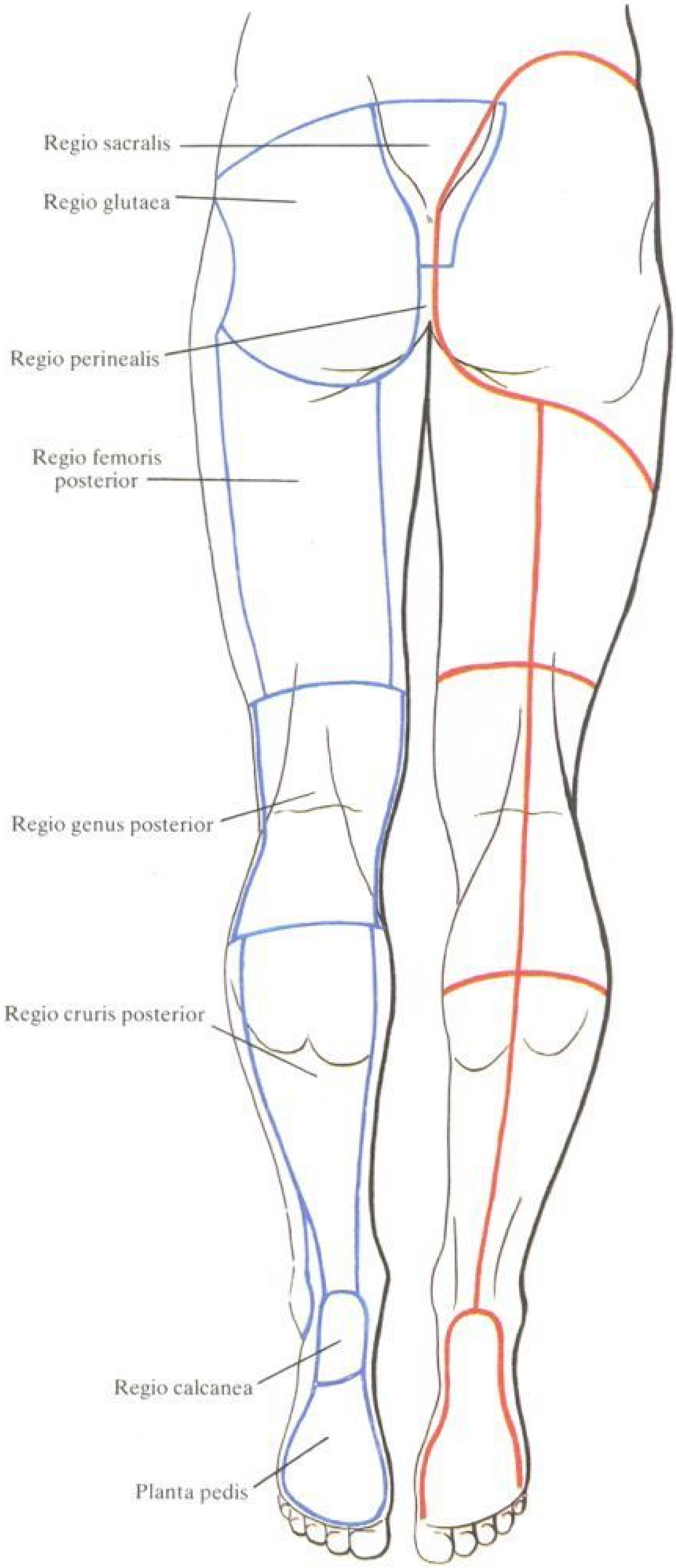
C. The **vastus lateralis muscle** *(musculus vastus lateralis)* occu-



363. *Sites of origin and attachment of muscles, ligaments, and articular capsules on right femur*; posterior aspect (schematical representation).

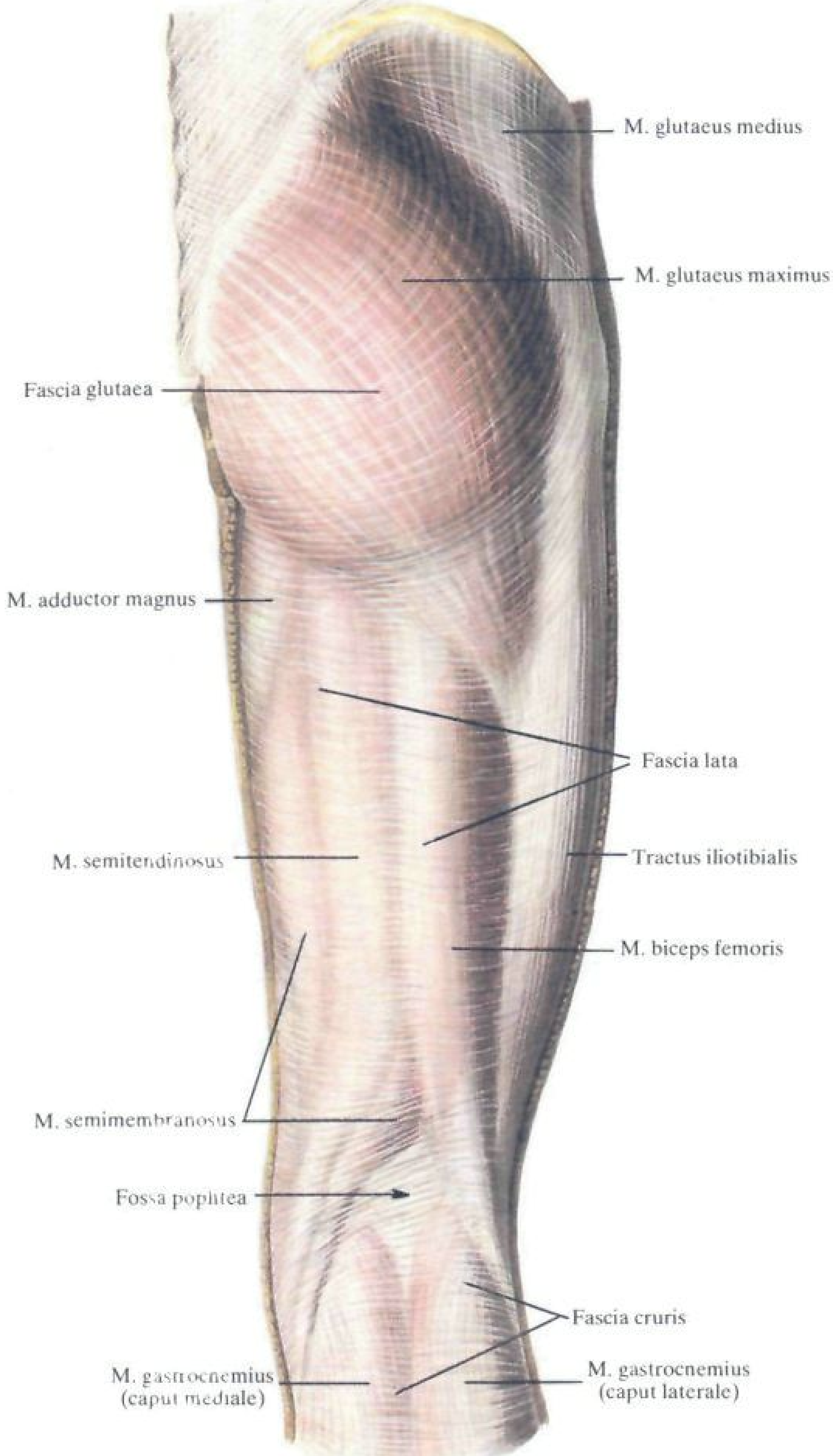


364. *Outlines of muscles of right lower limb*; posterior aspect.

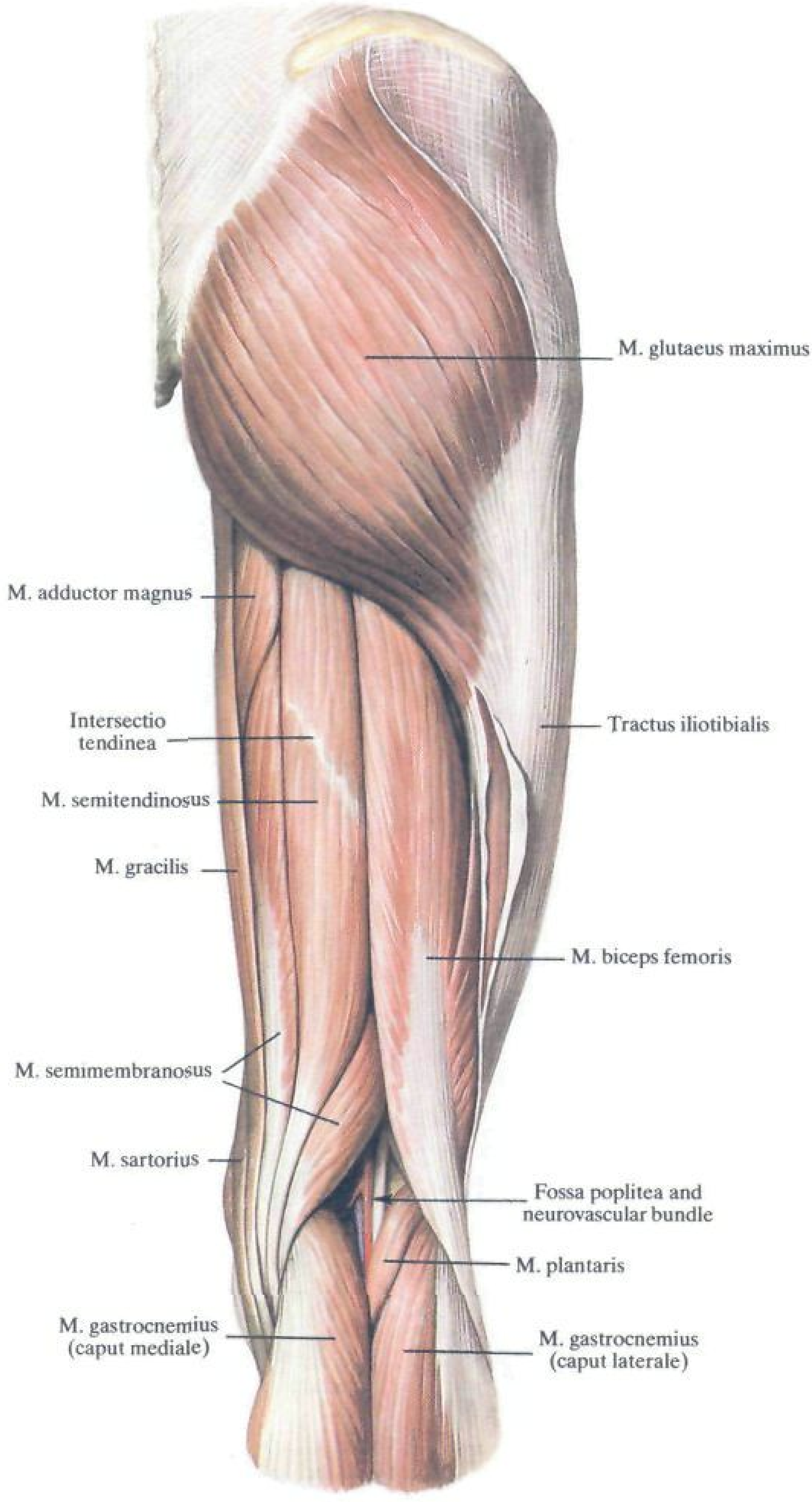


365. *Regions and skin incisions on lower limb.*

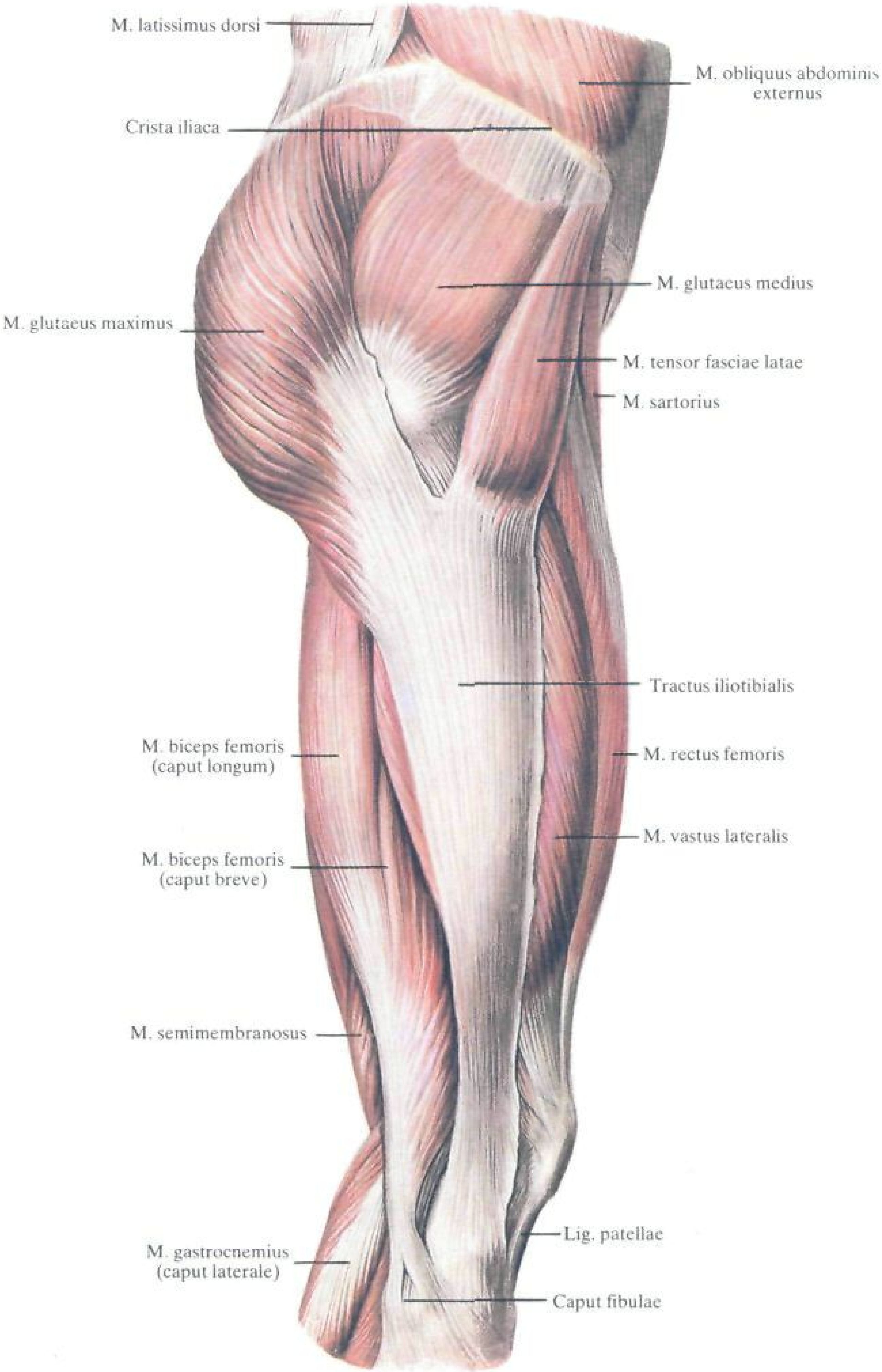
(Blue line—area boundaries; red line—skin incisions most suitable for exposure of muscles in dissection.)



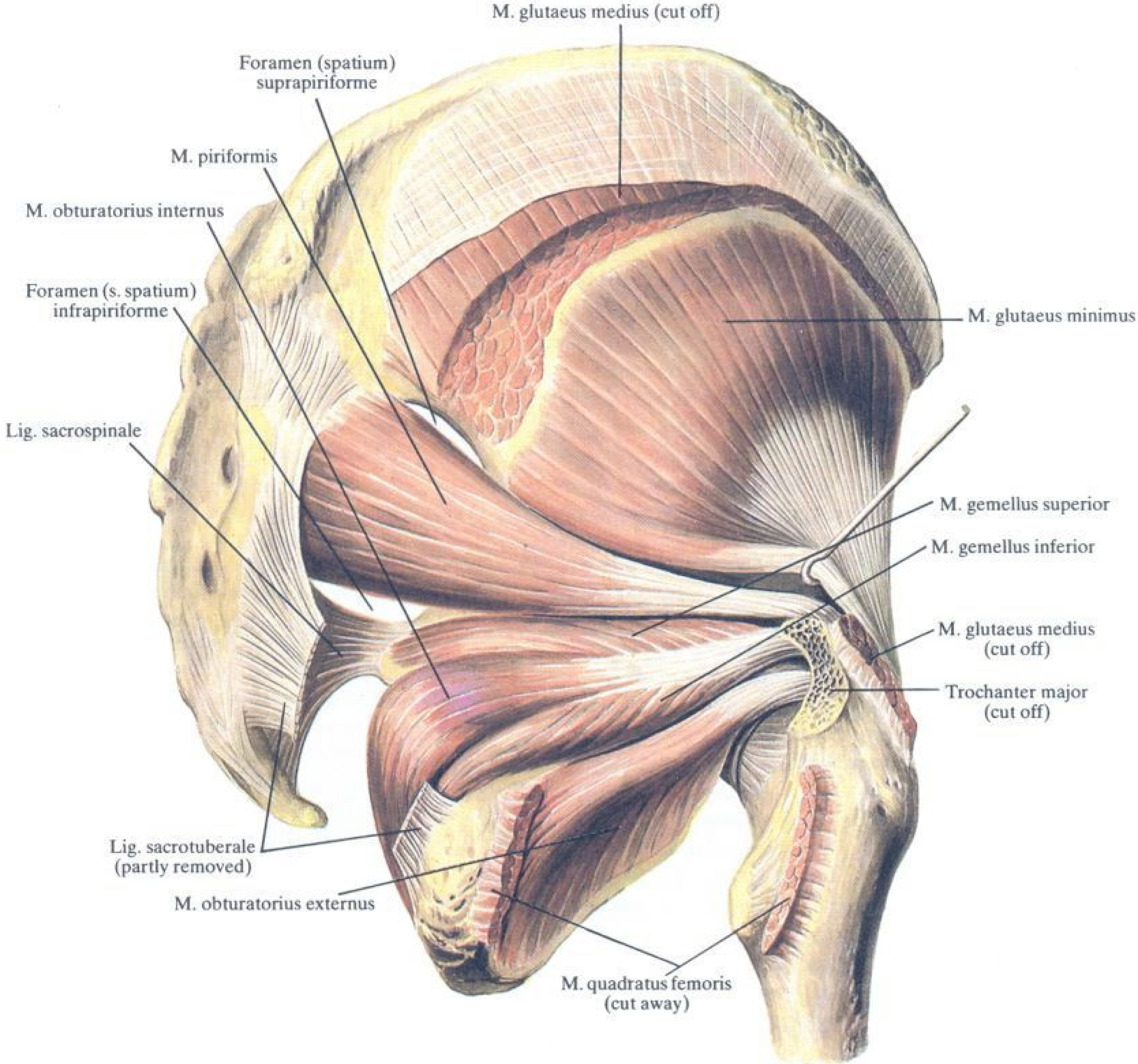
366. *Muscles and fasciae of right hip joint and thigh*; posterior aspect (1/4).



367. *Muscles and fasciae of right hip joint and thigh;* posterior aspect (1/4).



368. *Muscles and fasciae of right hip joint and thigh*; lateral aspect ($^1/_4$).



369. *Muscles of hip joint*; posterior aspect ($\frac{1}{2}$).

pies almost the entire anterolateral surface of the thigh. It is partly covered by the tensor fasciae latae muscle in the upper part and by the rectus femoris muscle in front. The muscle fibres forming it are directed downwards and forwards.

The muscle arises from the greater trochanter, the intertrochanteric line, and the lateral lip of the linea aspera. It runs downwards and ends as a wide tendon part of which fuses with the rectus femoris tendon to form a common tendon and the other part is inserted into the lateral border of the patella to form the lateral retinaculum of the patella.

D. The **vastus intermedius muscle** *(musculus vastus intermedius)* is on the anterior surface of the thigh between the vastus medialis and vastus lateralis muscles and directly under the rectus femoris muscle. It is the weakest among all the other heads. The vastus intermedius muscle takes origin from the anterior surface of the femur, starting from the intertrochanteric line, runs downwards and gives place (almost in the middle of its length) to a wide tendon which fuses distally with the tendon of the rectus femoris muscle to form the common tendon of the quadriceps muscle.

The four heads forming the quadriceps femoris muscle are inserted into various areas of the patella and the following bursae are found at the sites of insertion (see Fig. 227): (a) the **subcutaneous prepatellar bursa** *(bursa subcutanea prepatellaris)* lying in the subcutaneous fat in front of the patella; (b) the **suprapatellar bursa** *(bursa suprapatellaris)* lodged under the quadriceps femoris tendon above the patella; (c) the **subcutaneous infrapatellar bursa** *(bursa subcutanea infrapatellaris)* lying in front of the ligamentum patellae; (d) the **deep infrapatellar bursa** *(bursa infrapatellaris profunda)* lodged at the insertion of the ligamentum patellae into the tubercle of the tibia, and some other bursae.

Some of these bursae may communicate with the cavity of the knee joint.

Action: contraction of all the heads of the quadriceps femoris muscle extends the leg at the knee joint; the rectus femoris muscle flexes the hip joint.

Blood supply: lateral circumflex and profunda femoris arteries.

Innervation: femoral nerve (lumbar plexus) (L_2-L_4).

3. The **articularis genus muscle** *(musculus articularis genus)* (see Figs 225, 359) is a flat sheet of several clearly defined muscle fibres. It is on the anterior surface of the thigh under the vastus intermedius muscle. It takes origin from the anterior surface of the lower third of the femur and runs downwards to be inserted into the anterior surface and sides of the capsule of the knee joint.

Action: tenses the capsule of the knee joint.

Blood supply: lateral circumflex artery and perforating branches of the profunda femoris artery.

Innervation: the femoral nerve.

THE MEDIAL GROUP OF MUSCLES OF THE THIGH

1. The **gracilis muscle** *(musculus gracilis)* (Fig. 360) is long and slightly flattened. It lies under the skin and occupies the extreme medial position in this group of muscles. It arises from the anterior surface of the pubic bone, passes downwards, and gives place to a thin tendon which curves behind the medial epicondyle of the femur and is inserted into the tubercle of the tibia. Before reaching the site of its insertion the gracilis tendon blends with the tendons of the sartorius and semitendinosus muscles and the crural fascia to form a superficial 'goose's foot' *(pes anserinus superficialis)*. Here is also the **anserine bursa** *(bursa anserina cruris)*.

Action: adducts the thigh and also helps in flexing the leg at the knee joint while rotating the limb laterally.

Blood supply: external pudendal, obturator, and profunda femoris arteries.

Innervation: anterior branch of the obturator nerve (L_2-L_4).

2. The **adductor longus muscle** *(musculus adductor longus)* (Fig. 356) is flat and resembles a triangle in shape. It lies on the anteromedial surface of the thigh.

The muscle arises by a short strong tendon from the pubic bone below the pubic tubercle lateral of the gracilis muscle. Then gradually expanding it runs downwards and is inserted into the middle third of the medial lip of the linea aspera.

Action: adducts the thigh, assists in its flexion at the hip joint and lateral rotation.

Blood supply: external pudendal, obturator, and profunda femoris arteries.

Innervation: anterior branch of obturator nerve (L_2-L_3).

3. The **adductor brevis muscle** *(musculus adductor brevis)* (Fig. 357) is triangular and lies under the adductor longus muscle. It arises on the anterior surface of the inferior ramus of the pubis lateral of the gracilis muscle. Running downwards and laterally, it expands slightly and is inserted into the upper third of the medial lip of the linea aspera.

Action: adducts the thigh and assists in its flexion at the hip joint and lateral rotation.

Blood supply: the obturator and perforating arteries.

Innervation: anterior branch of the obturator nerve (L_2-L_4).

4. The **adductor magnus muscle** *(musculus adductor magnus)* (Fig. 358) is broad, thick, and the largest in this group. It lies under the adductor longus and adductor brevis muscles lateral of the gracilis muscle. The adductor magnus arises by a strong short tendon from the inferior ramus of the pubis and the ramus of the ischium for a distance to the ischial tuberosity; the muscle fibres then diverge fan-wise downwards and laterally and are inserted by a broad tendon into the medial lip of the linea aspera on the femur for its whole length. Some of the distal muscle fibres end in a thin tendon which is inserted into the medial epicondyle of the femur.

Action: adducts the thigh, rotating it slightly laterally.

Blood supply: the obturator and perforating arteries.

Innervation: posterior branch of the obturator nerve (L_2-L_3) and branches of the sciatic nerve (L_4-L_5).

5. The **adductor minimus muscle** *(musculus adductor minimus)* (Figs 370, 371) is as if part of the upper fibres of the adductor magnus muscle. It takes origin from the anterior surface of the inferior ramus of the pubis and the ramus of the ischium and is inserted into the medial lip of the linea aspera on the femur. It is triangular and lies to the front of the adductor brevis muscle; it borders upon the obturatorius externus and quadratus femoris muscles above and the adductor magnus muscle below.

Action: flexes the thigh at the hip joint, adducts and rotates it laterally.

Blood supply: obturator and perforating arteries.

Innervation: posterior branch of the obturator nerve (L_3-L_4).

6. The **pectineus muscle** *(musculus pectineus)* (Fig. 356) is flat and almost quadrangular. It borders upon the iliopsoas muscle laterally and the adductor longus muscle medially. A small depression forms between the iliopsoas and the pectineus.

The muscle arises from the superior ramus and pecten of the pubis, extends downwards and slightly laterally, and is inserted into the spiral line.

Action: flexes and adducts the thigh, rotating it slightly laterally.

Blood supply: the obturator, external pudendal, and profunda femoris arteries.

Innervation: branches of the femoral nerves and inconstantly branches of the obturator nerve (L_2-L_3).

THE POSTERIOR GROUP OF MUSCLES OF THE THIGH

1. The **semitendinosus muscle** *(musculus semitendinosus)* (Fig. 367) is long and thin and lies closer to the medial border of the posterior surface of the thigh. Its lateral margin borders upon the biceps femoris muscle, the medial upon the semimembranosus muscle. The proximal end is covered by the gluteus maximus muscle. Often the muscle is interrupted in the middle by a **tendinous intersection** *(intersectio tendinea)*. The muscle arises from the ischial tuberosity, runs downwards, and is continuous with a long tendon which bends around the medial femoral epicondyle and stretches on the anteromedial surface of the tibia to be inserted into its tubercle. Some of the end fibres of the tendon blend with the fascia of the leg and thus contribute to the formation of the superficial 'goose's foot' (Fig. 360).

Action: extends the thigh at the hip joint, flexes the leg at the knee joint and slightly rotates it medially, assists in bringing the trunk to an erect position.

Blood supply: the perforating arteries.

Innervation: branches of the tibial nerve [L_4-L_5; S_1 (S_2)].

2. The **semimembranosus muscle** *(musculus semimembranosus)* (Fig. 367) lies on the medial border of the posterior surface of the thigh. Its lateral margin is covered by the semitendinosus muscle which leaves a mark here in the form of a wide longitudinal groove. The medial margin of the muscle is free. The muscle arises by a flat strong tendon from the ischial tuberosity. It passes downwards and is continuous with a flat tendon which gradually narrows, becomes rounded and after curving around the medial epicondyle runs to the anteromedial surface of the tibia. Here the tendon becomes wider, separating into three bands to form the deep 'goose's foot' *(pes anserinus profundus)* (Fig. 382). The medial band lies horizontally and ends on the medial condyle of the tibia; the middle band also stretches to the medial condyle and is continuous with the fascia covering the popliteus muscle; the lateral band reaches the capsule of the knee joint and is continuous with the oblique posterior ligament of the knee.

The **bursa of the semimembranosus tendon** *(bursa musculi semimembranosus)* forms where the tendon separates into bands.

Action: extends the thigh at the hip joint, flexes the leg at the knee joint and rotates it medially.

Blood supply: medial circumflex, perforating, and popliteal arteries.

Innervation: the tibial nerve (L_4-L_5; S_1).

3. The **biceps femoris muscle** *(musculus biceps femoris)* (Fig. 368) stretches on the lateral border of the posterior surface of the thigh. It has two heads, long and short, which fuse to form a single common belly. The **long head** *(caput longum)* arises from the ischial tuberosity by a small flat tendon; the **short head** *(caput breve)* takes origin from the lateral lip of the linea aspera for the length of the distal half of the femur. At the origin of the long head is the **upper bursa of the biceps femoris muscle** *(bursa musculi bicipitis femoris superior)*. On fusion, both heads form a strong belly which passes downwards and gives place to a long narrow tendon: after curving around the back of the lateral epicondyle the tendon is inserted into the head of the fibula. Some bands pass horizontally to be inserted into the edge of the superior articular surface of the tibia, others run downwards and blend with the crural fascia. Between the tendon of the muscle and the lateral ligament of the knee is lodged the **lower bursa of the biceps femoris muscle** *(bursa subtendinea musculi bicipitis femoris inferior)*.

Action: extends the thigh at the hip joint, flexes the leg at the knee joint rotating it laterally.

Blood supply: medial circumflex, perforating, and popliteal arteries.

Innervation: the long head—tibial and sciatic nerves (S_1-S_2), the short head—common peroneal nerve (L_4-L_5; S_1).

MUSCLES OF THE LEG

The **muscles of the leg** *(musculi cruris)* form three groups: lateral, anterior, and posterior; the posterior group has two layers, superficial and deep. The lateral group is composed predominantly of flexors and pronators of the foot and the anterior group—of extensors of the foot; the posterior group is mostly formed of flexors and supinators of the foot.

The Lateral Group

1. The **peroneus longus muscle** *(musculus peroneus [fibularis] longus)*.

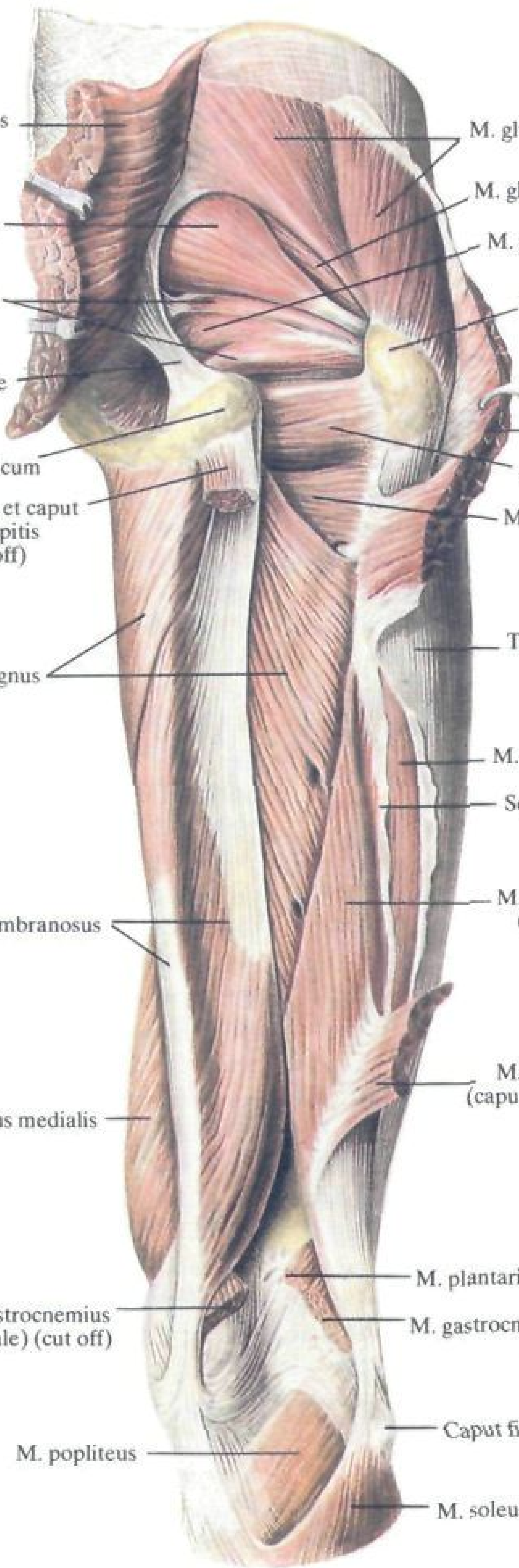
2. The **peroneus brevis muscle** *(musculus peroneus [fibularis] brevis)*.

The Anterior Group

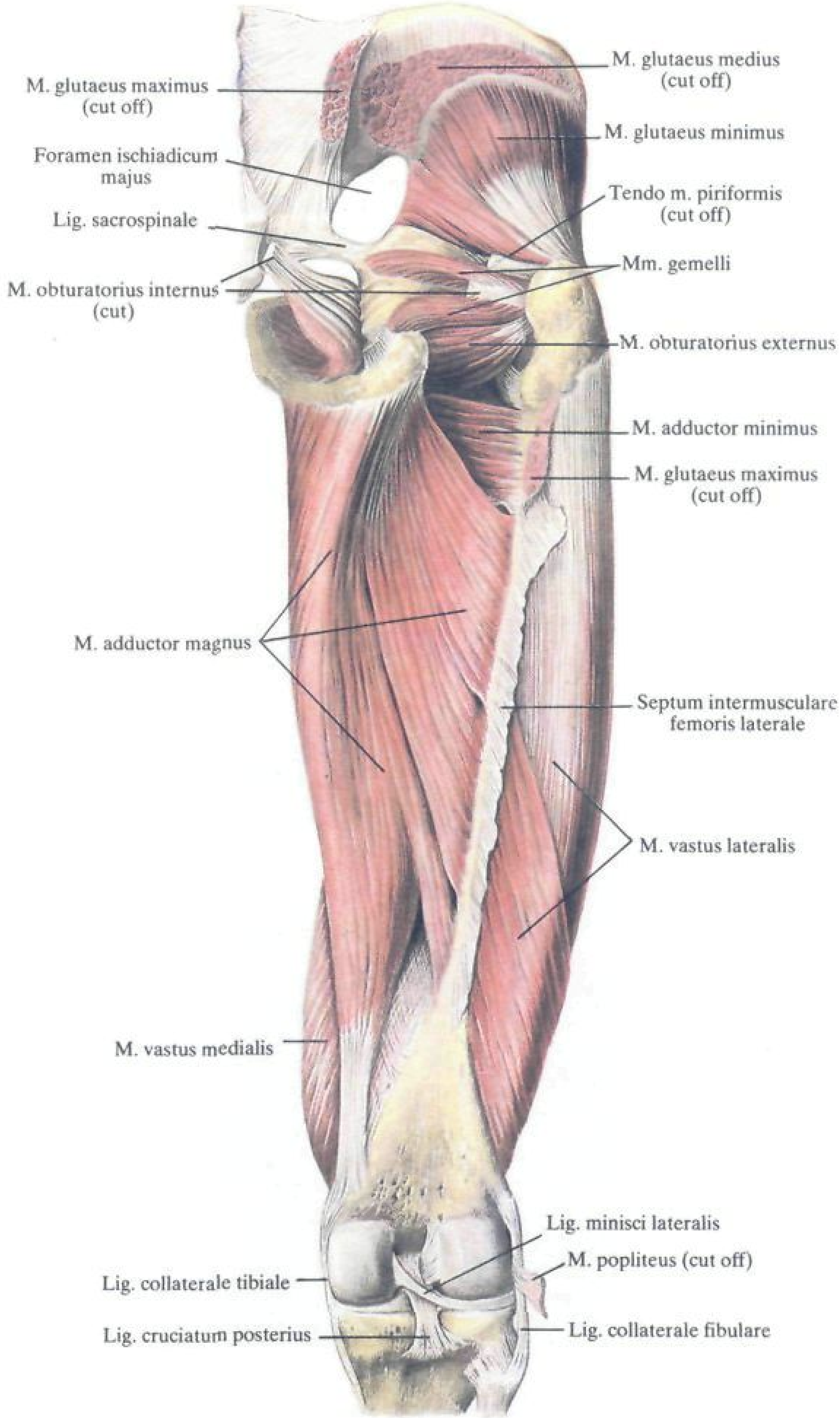
1. The **tibialis anterior muscle** *(musculus tibialis anterior)*.

2. The **extensor digitorum longus muscle** *(musculus extensor digitorum longus)*.

3. The **extensor hallucis longus muscle** *(musculus extensor hallucis longus)*.



370. *Muscles of right hip joint and thigh*; posterior aspect ($\frac{1}{4}$).



371. *Muscles of right hip joint and thigh*; posterior aspect (1/4).

The Posterior Group

Superficial Layer

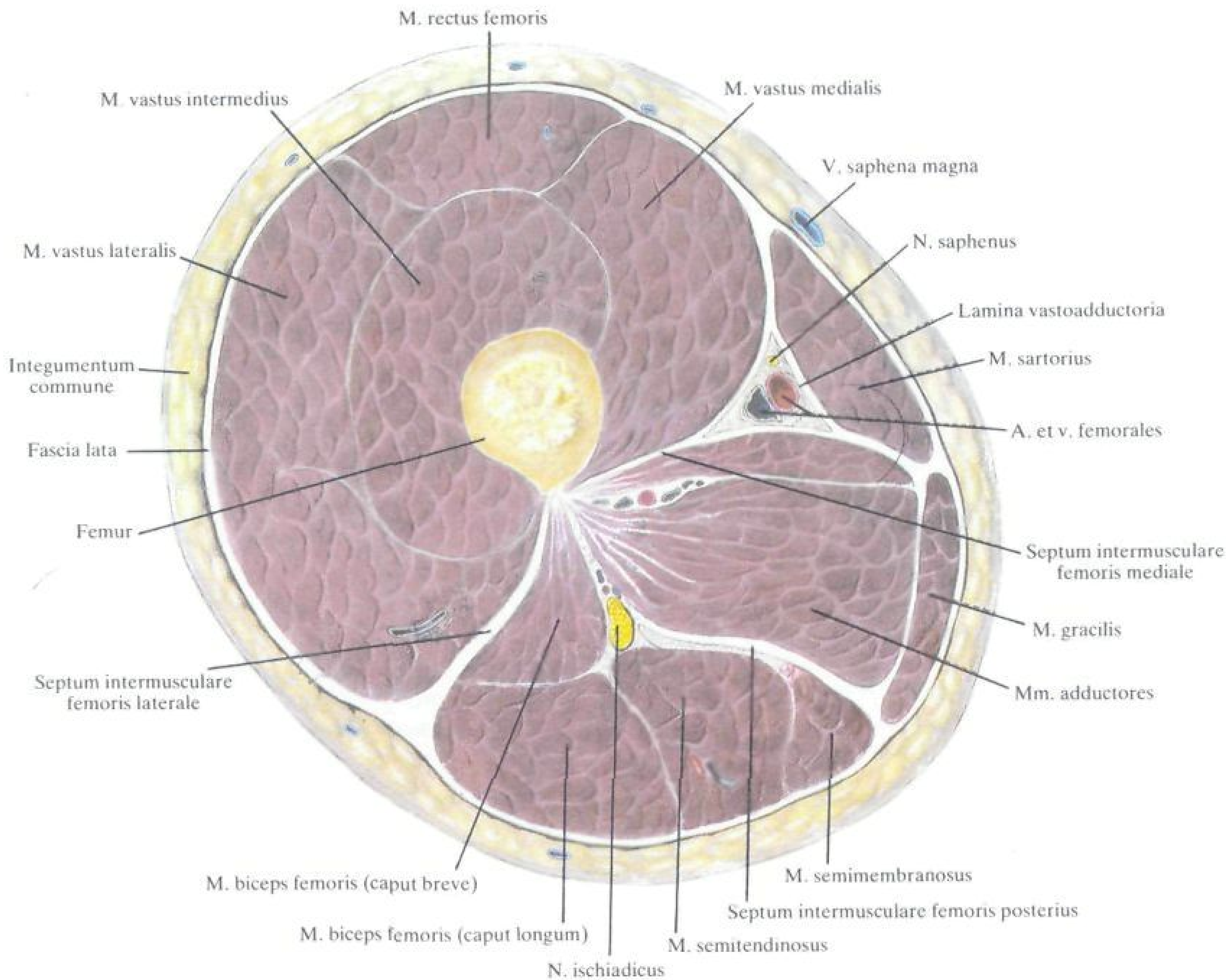
1. The **triceps surae muscle** *(musculus triceps surae).*
2. The **plantaris muscle** *(musculus plantaris).*

Deep Layer

1. The **popliteus muscle** *(musculus popliteus).*
2. The **flexor digitorum longus muscle** *(musculus flexor digitorum longus).*
3. The **flexor hallucis longus muscle** *(musculus flexor hallucis longus).*
4. The **tibialis posterior muscle** *(musculus tibialis posterior).*

THE LATERAL GROUP OF MUSCLES OF THE LEG

1. The **peroneus longus muscle** *(musculus peroneus [fibularis] longus)* (Fig. 379) is on the lateral surface of the leg. Its upper part lies directly on the fibula, while the lower part covers the peroneus brevis muscle. The peroneus longus muscle arises by two heads: an anterior head arising from the head of the fibula, the lateral condyle of the tibia, and the fascia cruris, and a posterior head arising from the upper parts of the lateral surface of the fibula. Between the two heads is the superior musculo-fibular canal. Stretching downwards, the muscle is continuous with a long tendon which curves around the lateral malleolus posteriorly, passes on the la-



372. *Muscles and fasciae of right thigh* (1/3).
(Transverse section through the middle of the thigh.)

teral surface of the calcaneum, over to the sole under the peroneal tubercle, fits into the groove for the tendons of the peroneus muscles, and crosses the sole obliquely to be inserted into the tubercle of the first metatarsal bone, the base of the second metatarsal bone and the medial cuneiform bone.

Action: accomplishes plantar flexion of the foot and lowers its medial border.

Blood supply: the lateral inferior genicular, peroneal, and anterior tibial arteries.

Innervation: superficial peroneal nerve (musculocutaneous nerve of lower limb) [(L_4) L_5; S_1].

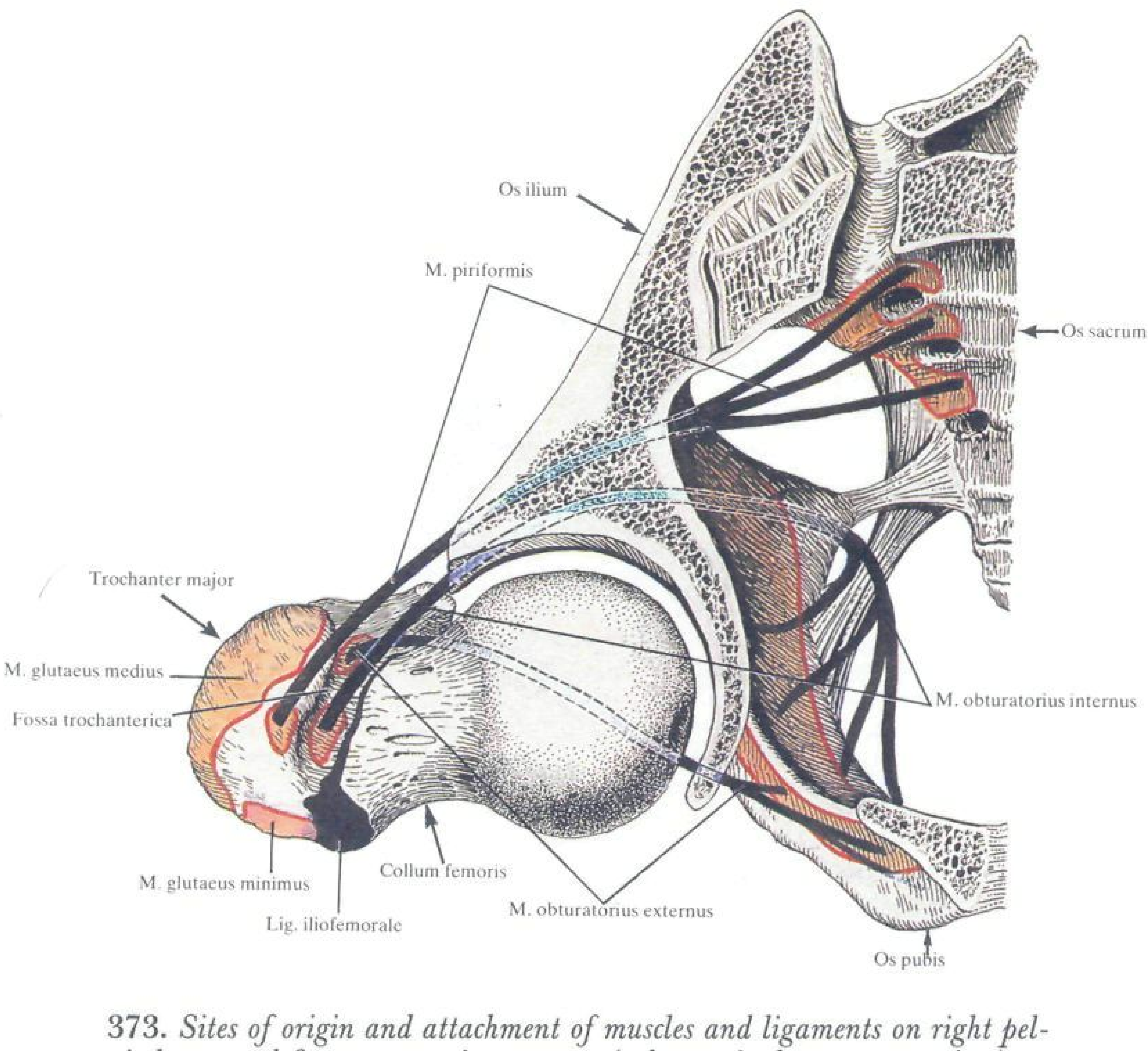
2. The **peroneus brevis muscle** *(musculus peroneus [fibularis] brevis)* (Fig. 379) is long, thin, and lies directly on the lateral surface of the fibula under the peroneus longus muscle. It arises from the lower half of the lateral surface of the fibula and the intermuscular septa of the leg and extends downwards next to the peroneus longus tendon. After curving around the lateral malleolus posteriorly it passes forwards on the lateral surface of the calcaneum and is inserted into the tubercle of the fifth metatarsal bone.

Action: causes plantar flexion of the foot and raises its lateral border.

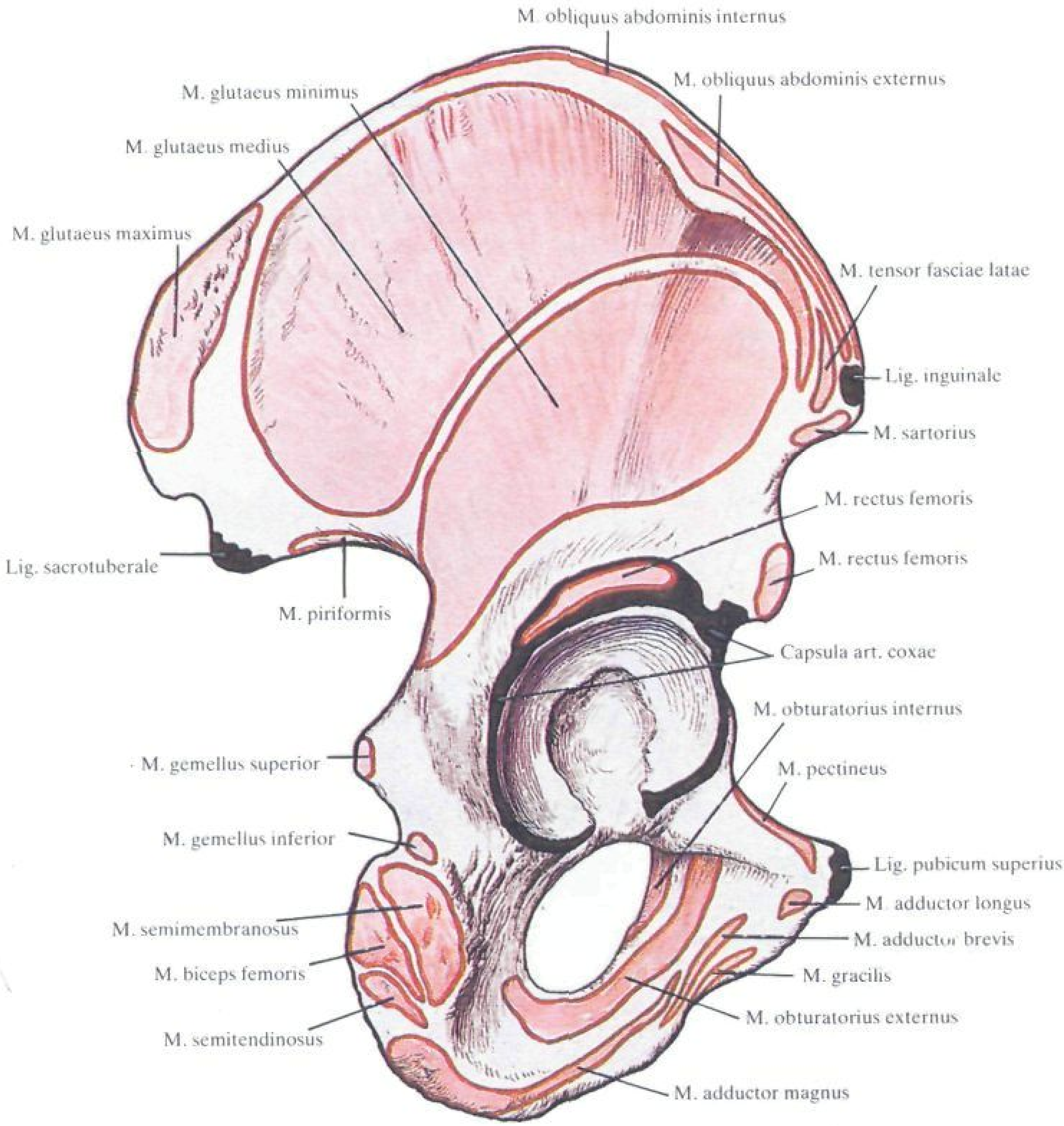
Blood supply: peroneal and anterior tibial arteries.

Innervation: superficial peroneal nerve (musculocutaneous nerve of lower limb) [(L_4) L_5; S_1].

On passing behind the lateral malleolus, the tendons of both peroneal muscles are invested in a **common synovial sheath of the peroneal tendons** *(vagina synovialis musculorum peroneorum [fibularium] communis)*. Distally this sheath separates to form a separate sheath for each tendon.



373. *Sites of origin and attachment of muscles and ligaments on right pelvic bones and femur*; superior aspect (schematical representation).



374. *Sites of origin and attachment of muscles, ligaments, and articular capsules on right hip bone*; outer aspect (schematical representation).

THE ANTERIOR GROUP OF MUSCLES OF THE LEG

1. The **tibialis anterior muscle** *(musculus tibialis anterior)* (Figs 376, 379) is long and narrow and lies superficially occupying the extreme medial position in relation to the other muscles of this group. Its medial border adjoins the anterior border of the tibia, while its lateral border adjoins the extensor digitorum longus muscle proximally and the extensor hallucis longus muscle distally. The tibialis anterior muscle arises by its broadest part from the lateral tibial surface (beginning from the lateral condyle) and the interosseous membrane. In the lower third of the leg it is continuous with a long flat tendon which is lodged in a canal under the inferior extensor retinaculum and extends first to the medial border of the foot and then to the plantar surface on which it is inserted into the medial cuneiform bone and the base of the first metatarsal bone. The small **bursa of the tibialis anterior tendon** *(bursa subtendinea musculi tibialis anterioris)* can be found at the site of the insertion.

Action: accomplishes dorsal flexion of the foot and raises its medial border.

Blood supply: anterior tibial artery.

Innervation: deep peroneal (anterior tibial) nerve (L_4-L_5; S_1).

2. The **extensor digitorum longus muscle** *(musculus extensor digitorum longus)* (Fig. 376) lies lateral of the tibialis anterior muscle. The extensor hallucis longus tendon passes between these two muscles in the lower third of the leg. The extensor digitorum muscle arises from the upper third of the tibia, the head and anterior border of the fibula, the interosseous membrane, the anterior intermuscular septum, and the crural fascia. It is then directed downwards, narrows gradually, and gives place to a narrow and long tendon which passes in the lateral canal under the inferior extensor retinaculum. Before entering the canal it separates into five thin tendons which pass to the dorsal surface of the foot; four of them are inserted into the phalanges of the lateral four toes. At the site of insertion each tendon separates into three slips, the middle one terminating on the base of the middle phalanx and the two collateral slips are inserted into the base of the distal phalanx. The fifth small tendon is inserted into the base of the fifth metatarsal bone. This tendon is often fused with an inconstant **peroneus tertius muscle** *(musculus peroneus tertius, s. fibularis tertius)* which arises from the lower third of the fibula and the interosseous membrane and is also inserted into the base of the fifth metatarsal bone.

Action: extends the lateral four toes, accomplishes dorsal flexion of the foot, and together with the peroneus tertius muscle raises (pronates) its lateral border.

Blood supply: anterior tibial artery.

Innervation: deep peroneal (anterior tibial) nerve.

3. The **extensor hallucis longus muscle** *(musculus extensor hallucis longus)* (Fig. 377) lies between the tibialis anterior and the extensor digitorum longus muscles which cover its upper two thirds. The muscle arises from the medial surface of the middle and lower thirds of the fibula and the interosseous membrane and passes downwards to be continuous with a narrow long tendon which fits into the middle canal and passes under the inferior extensor retinaculum to the great toe to be inserted into its distal phalanx. Some of the fibres fuse with the base of the proximal phalanx.

Action: extends the great toe, assists in dorsal flexion of the foot, raising (supinating) its medial border.

Blood supply: the anterior tibial artery.

Innervation: the deep peroneal (anterior tibial) nerve.

THE POSTERIOR GROUP OF MUSCLES OF THE LEG

Superficial Layer

1. The **triceps surae muscle** *(musculus triceps surae)* (Figs 380, 381) is made up of the gastrocnemius muscle lying superficially and the soleus muscle located in front of it closer to the leg bones.

A. The **gastrocnemius muscle** *(musculus gastrocnemius)* (Fig. 380) consists of two strong fleshy **heads, medial** *(caput mediale)* and **lateral** *(caput laterale)*.

The stronger medial head arises from the popliteal surface of the femur above the medial condyle, the lateral head arises symmetrically but at a slightly lower level above the lateral condyle. Both heads at their origin form the inferior border of the popliteal fossa. Extending downwards, they unite approximately in the middle of the leg and are then continuous with a tendon.

B. The **soleus muscle** *(musculus soleus)* (Fig. 381) is flat and covered by the gastrocnemius muscle. It arises from the head and upper third of the shaft of the fibula as well as from the soleal line and middle third of the shaft of the tibia. Some of the muscle fibres arise from the tendinous arch of the soleus muscle (stretched between the leg bones). Passing downwards, the muscle is continuous with a tendon which fuses with the gastrocnemius tendon to form a strong *tendo calcaneus (Achillis)* in the lower third of the leg; the tendon is inserted into the posterior surface of the calcaneum. The **bursa of the tendo calcaneus** *(bursa tendinis calcanei s. Achillis)* is found at the insertion.

Action: the triceps surae muscle flexes the leg at the knee joint, accomplishes plantar flexion of the foot, raises the heel. When the foot is steadied the muscle pulls the leg and thigh to the back.

Blood supply: the posterior tibial and peroneal arteries.

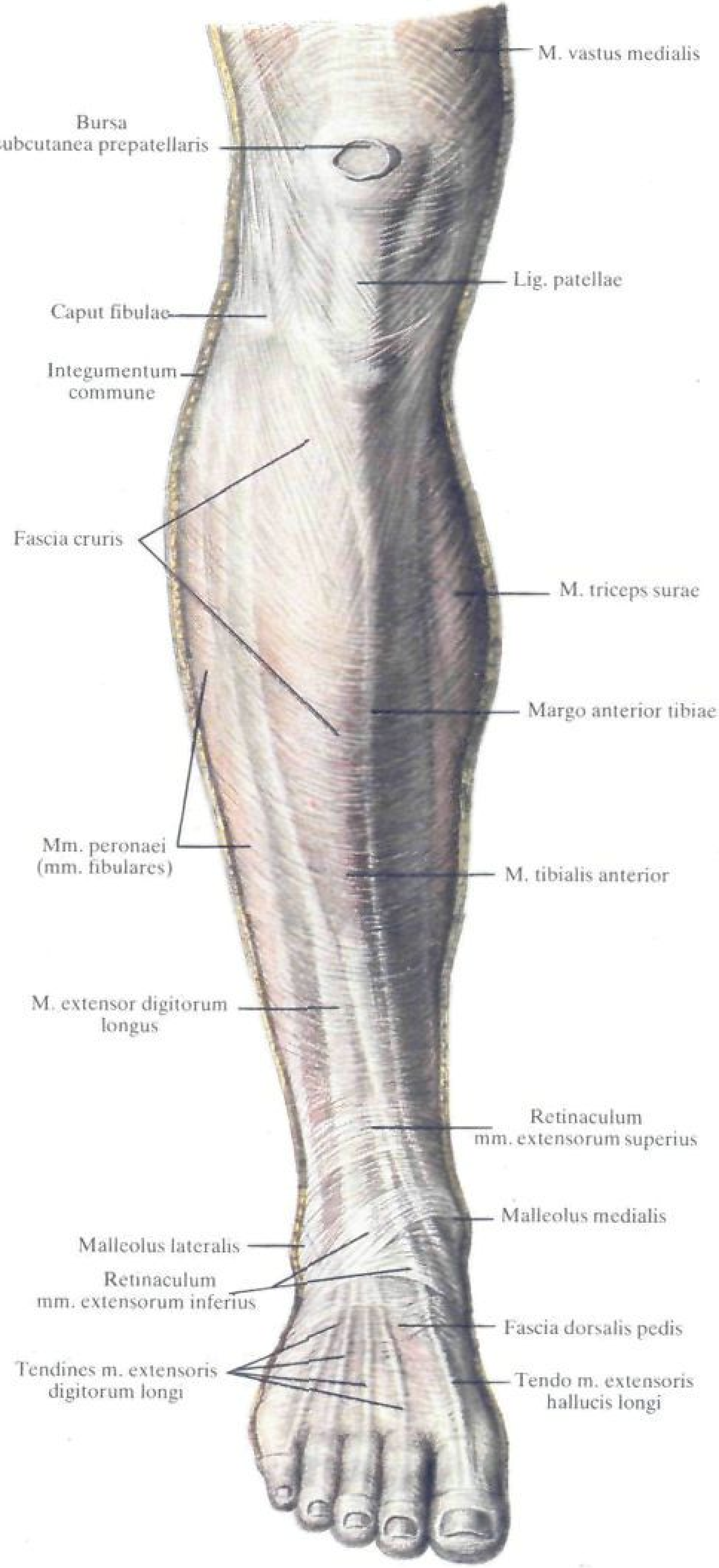
Innervation: the tibial (medial popliteal) nerve (L_4-L_5; S_1-S_2).

2. The **plantaris muscle** *(musculus plantaris)* (Fig. 381) is rudimentary and often absent. Its muscular belly is spindle-shaped, short, and arises from the lateral femoral condyle and the posterior wall of the knee joint capsule. It extends downwards and slightly medially and ends in a long, narrow tendon lying between the gastrocnemius and soleus muscles. In the lower third of the leg it usually fuses with the tendo calcaneus, but in some cases it is inserted into the calcaneum independently and its fibres intertwine with those of the plantar aponeurosis.

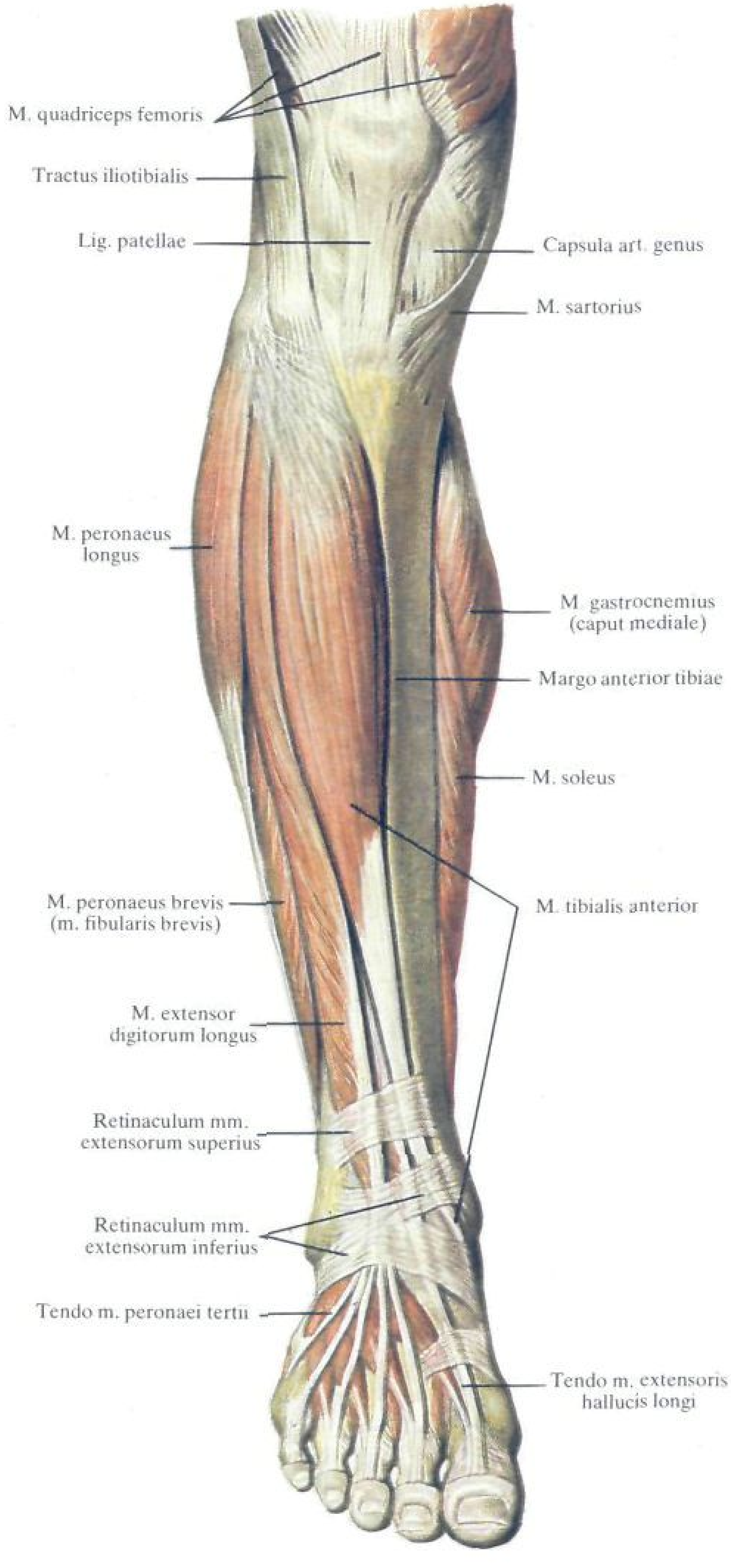
Action: tenses the capsule of the knee joint.

Blood supply: the popliteal artery.

Innervation: the tibial (medial popliteal) nerve (L_4-L_5; S_1).



375. *Muscles and fasciae of right leg and foot*; anterior aspect (1/4).



376. *Muscles of right leg and foot*; anterior aspect (¼).

Deep Layer

1. The **popliteus muscle** *(musculus popliteus)* (Fig. 383) is flat, short, and lies directly on the posterior surface of the capsule of the knee joint. It arises from the lateral femoral condyle and the arcuate ligament of the knee. It is directed downwards, becomes slightly wider, and is inserted into the posterior surface of the tibia above the soleal line.

Action: flexes the knee and rotates the leg medially at the same time, pulling at the capsule of the knee joint.

Blood supply: the popliteal artery.

Innervation: the tibial (medial popliteal) nerve (L_5; S_1–S_2).

2. The **flexor digitorum longus muscle** *(musculus flexor digitorum longus)* (Fig. 382) occupies the extreme medial position in this group of muscles; it lies on the posterior surface of the tibia. The muscle arises from the middle third of the posterior surface of the tibia and from the deep layer of the crural fascia. It stretches downwards and ends in a long tendon which curves around the back of the medial malleolus under the flexor retinaculum. It then passes to the sole in which it is directed obliquely and laterally and separates into four tendons passing to the lateral four toes to be inserted into the bases of the distal phalanges. Before insertion each tendon perforates the tendon of the flexor digitorum brevis muscle.

Action: flexes the distal phalanges of the lateral four toes, assists in plantar flexion of the foot by raising (supinating) its medial border.

Blood supply: the posterior tibial artery.

Innervation: the tibial (medial popliteal) nerve (L_5; S_1–S_2).

3. The **flexor hallucis longus muscle** *(musculus flexor hallucis longus)* (Fig. 382) occupies the extreme lateral position on the posterior surface and covers partly the tibialis posterior muscle.

It arises from the lower two thirds of the fibula, the interosseous membrane, and the posterior intermuscular septum of the leg. The muscle is directed downwards to be continuous with a long tendon which passes under the flexor retinaculum and onto the sole in the groove between the talus and calcaneum.

Here the tendon stretches under the flexor digitorum longus tendon and sends it some of the fibrous bands. After that it runs forwards and is inserted into the base of the distal phalanx of the great toe.

Action: flexes the great toe and also assists in flexion of the latter four toes through the fibrous bands added to the flexor digitorum longus tendon; accomplishes plantar flexion and lateral rotation of the foot.

Blood supply: the peroneal artery.

Innervation: the tibial (medial popliteal) nerve (L_5; S_1–S_2).

4. The **tibialis posterior muscle** *(musculus tibialis posterior)* (Fig. 383) lies between the flexor digitorum longus and flexor hallucis longus muscles directly on the interosseous membrane.

It arises from the interosseous membrane and from the adjoining borders of the tibia and fibula. The muscle runs downwards and ends in a long tendon which, on passing in a separate canal under the flexor retinaculum, curves around the back of the medial malleolus and passes over to the sole to be inserted into the tuberosity of the navicular and into the medial, intermediate, and lateral cuneiform bones.

Action: accomplishes plantar flexion of the foot and rotates it laterally (supinates) at the same time.

Blood supply: the posterior tibial and peroneal arteries.

Innervation: the tibial (medial popliteal) nerve (L_5; S_1–S_2).

MUSCLES OF THE FOOT

The **muscles of the foot** *(musculi pedis)* are separated into the muscles of the dorsal surface of the foot and those of the plantar surface of the foot.

The muscles of the dorsum of the foot are mainly extensors, the muscles of the sole are mainly flexors.

Muscles of the Dorsal Surface

1. The **extensor digitorum brevis muscle** *(musculus extensor digitorum brevis).*
2. The **extensor hallucis brevis muscle** *(musculus extensor hallucis brevis).*

Muscles of the Plantar Surface

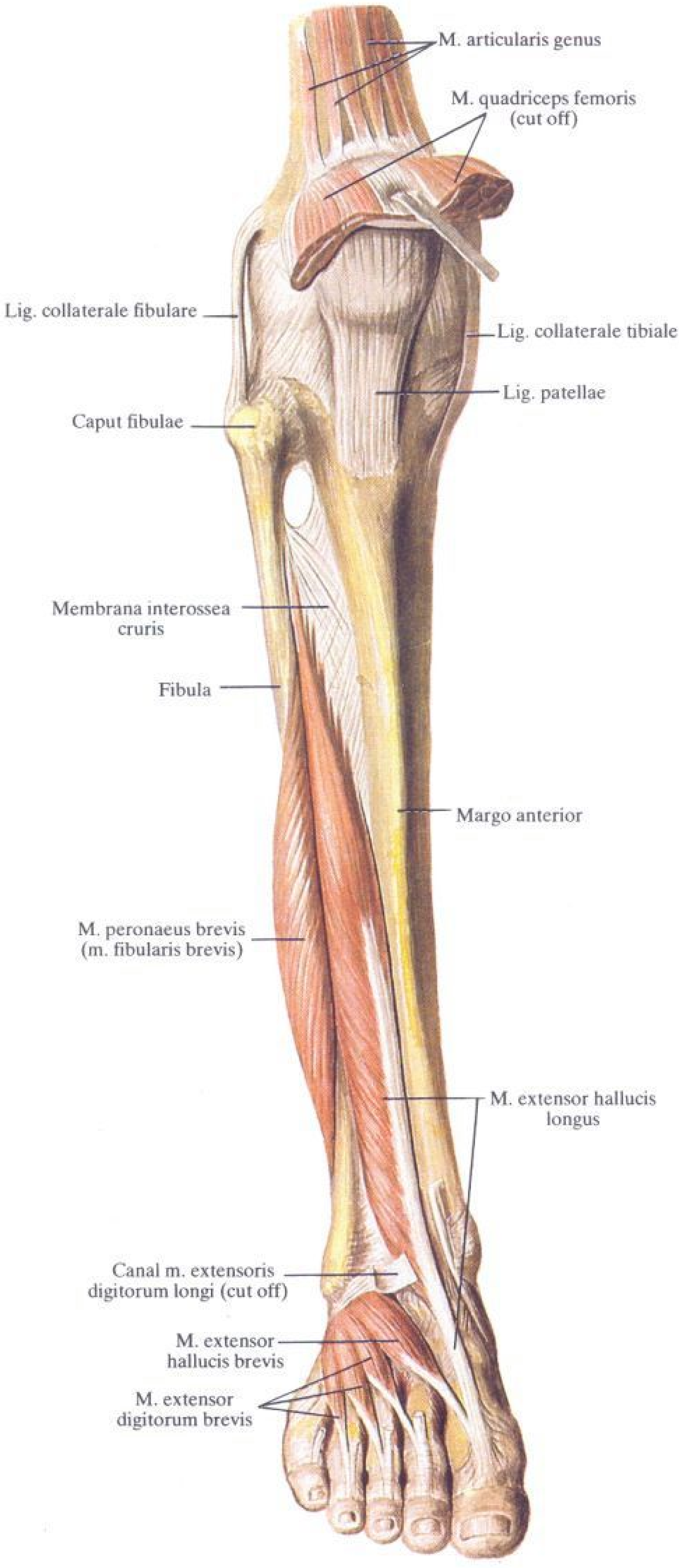
The muscles of the sole form the following three groups: (a) the muscles of the eminence of the great toe, or the muscles of the medial plantar eminence; (b) the muscles of the eminence of the little toe, or the muscles of the lateral plantar eminence; (c) the plantar muscles proper, or the muscles of the median plantar eminence.

Muscles of the Eminence of the Great Toe

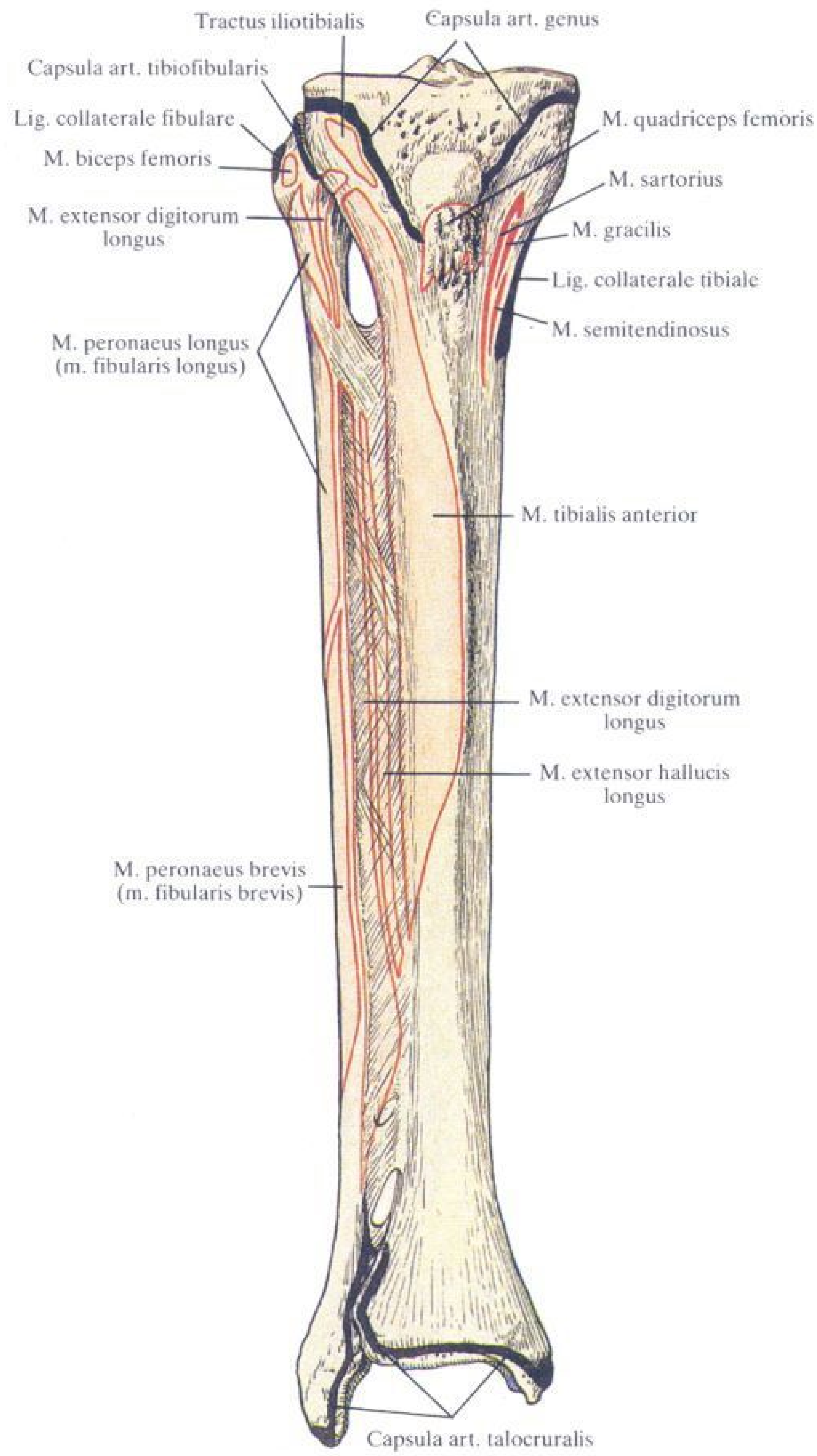
1. The **abductor hallucis muscle** *(musculus abductor hallucis).*
2. The **flexor hallucis brevis muscle** *(musculus flexor hallucis brevis).*
3. The **adductor hallucis muscle** *(musculus adductor hallucis).*

Muscles of the Eminence of the Little Toe

1. The **abductor digiti minimi muscle** *(musculus abductor digiti minimi).*
2. The **flexor digiti minimi brevis muscle** *(musculus flexor digiti minimi brevis).*
3. The **opponens digiti minimi muscle** *(musculus opponens digiti minimi).*

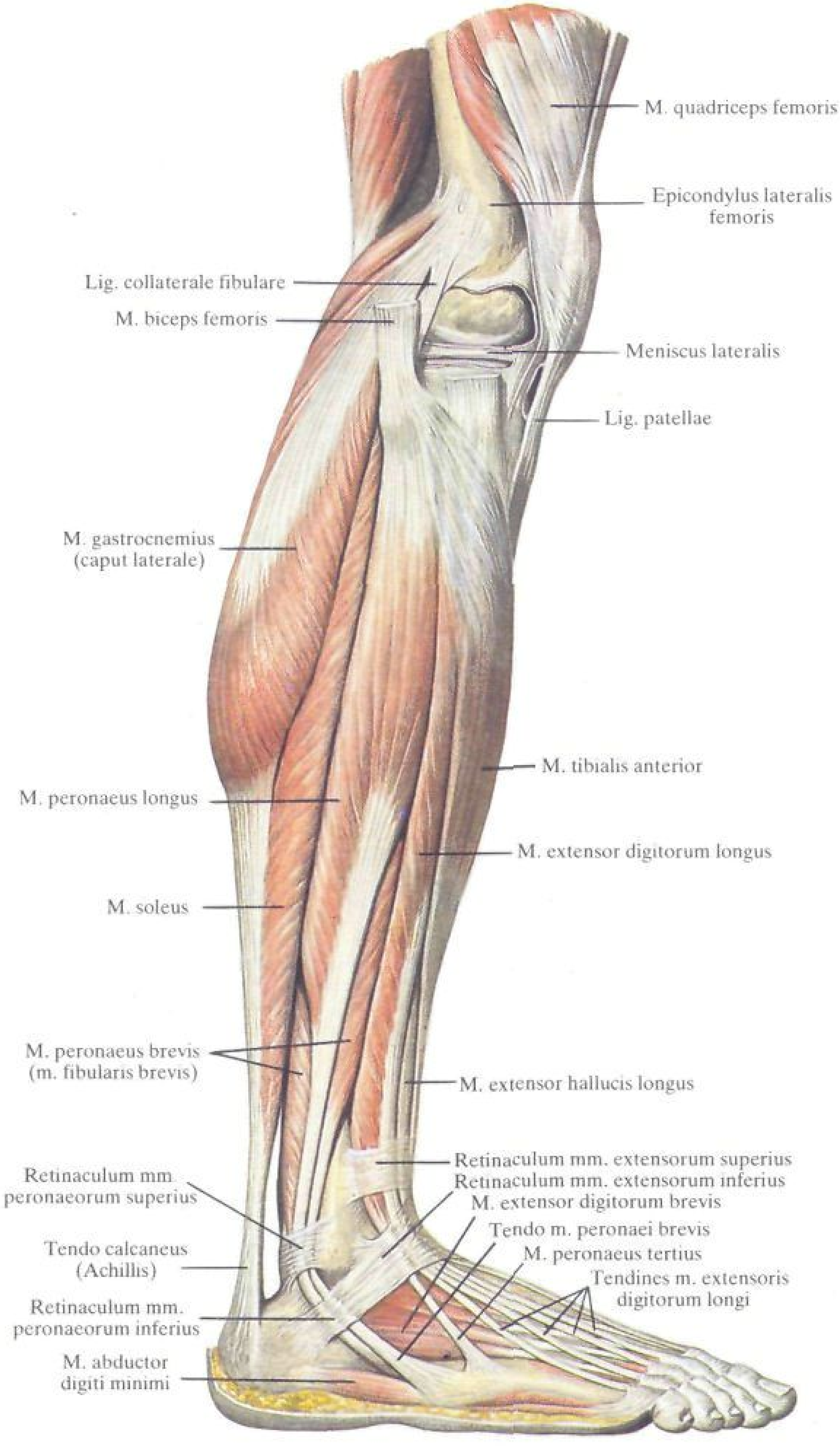


377. *Muscles of right leg and foot*; anterior aspect (1/4).

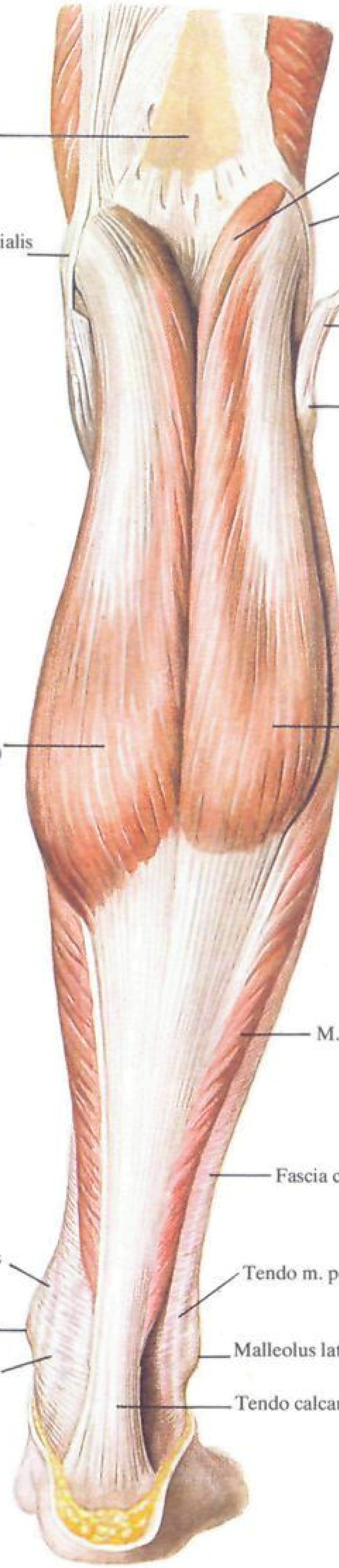


378. *Sites of origin and attachment of muscles, ligaments, and articular capsules on bones of right leg*; anterior aspect (schematical representation).

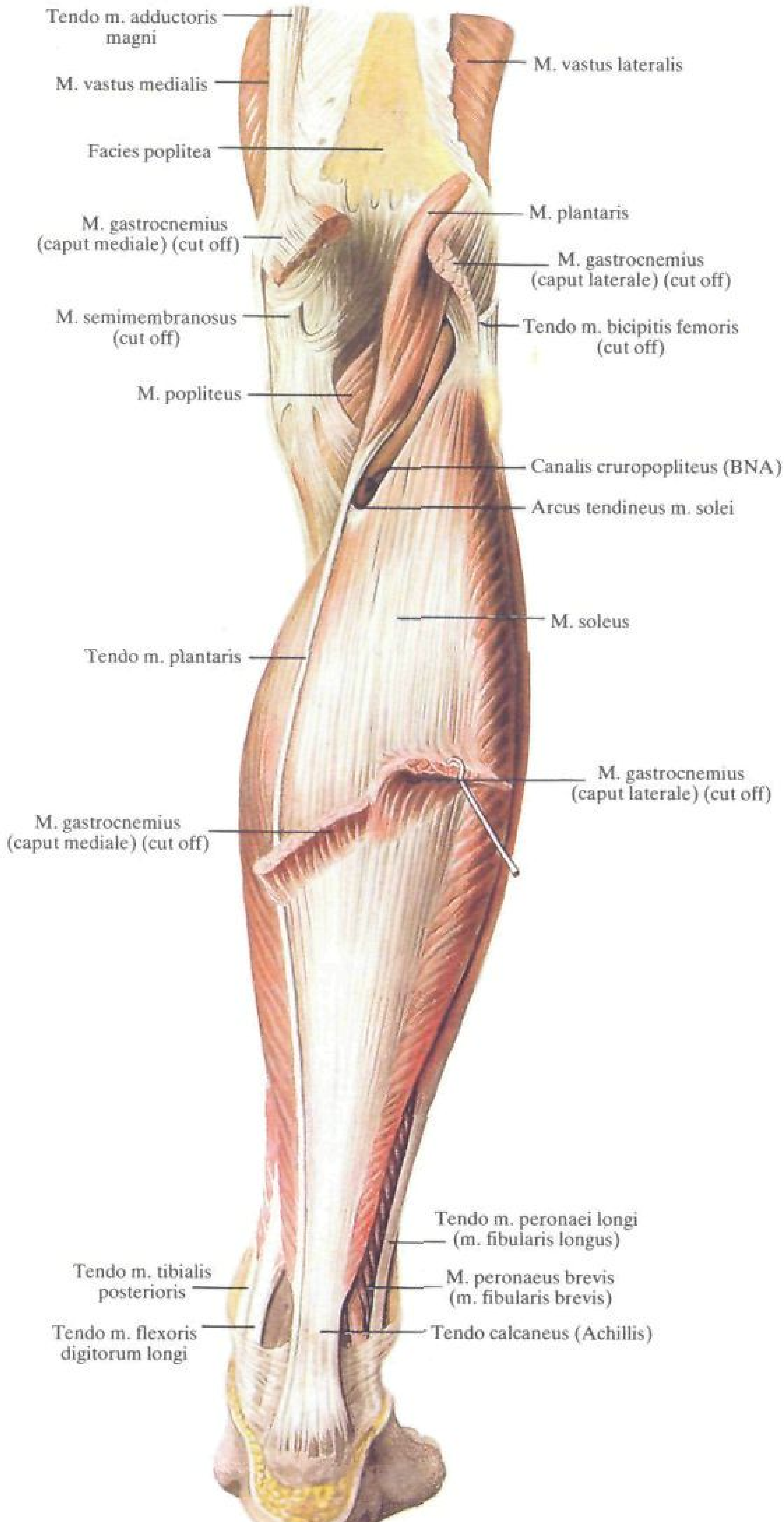
(The interosseous membrane is left intact.)



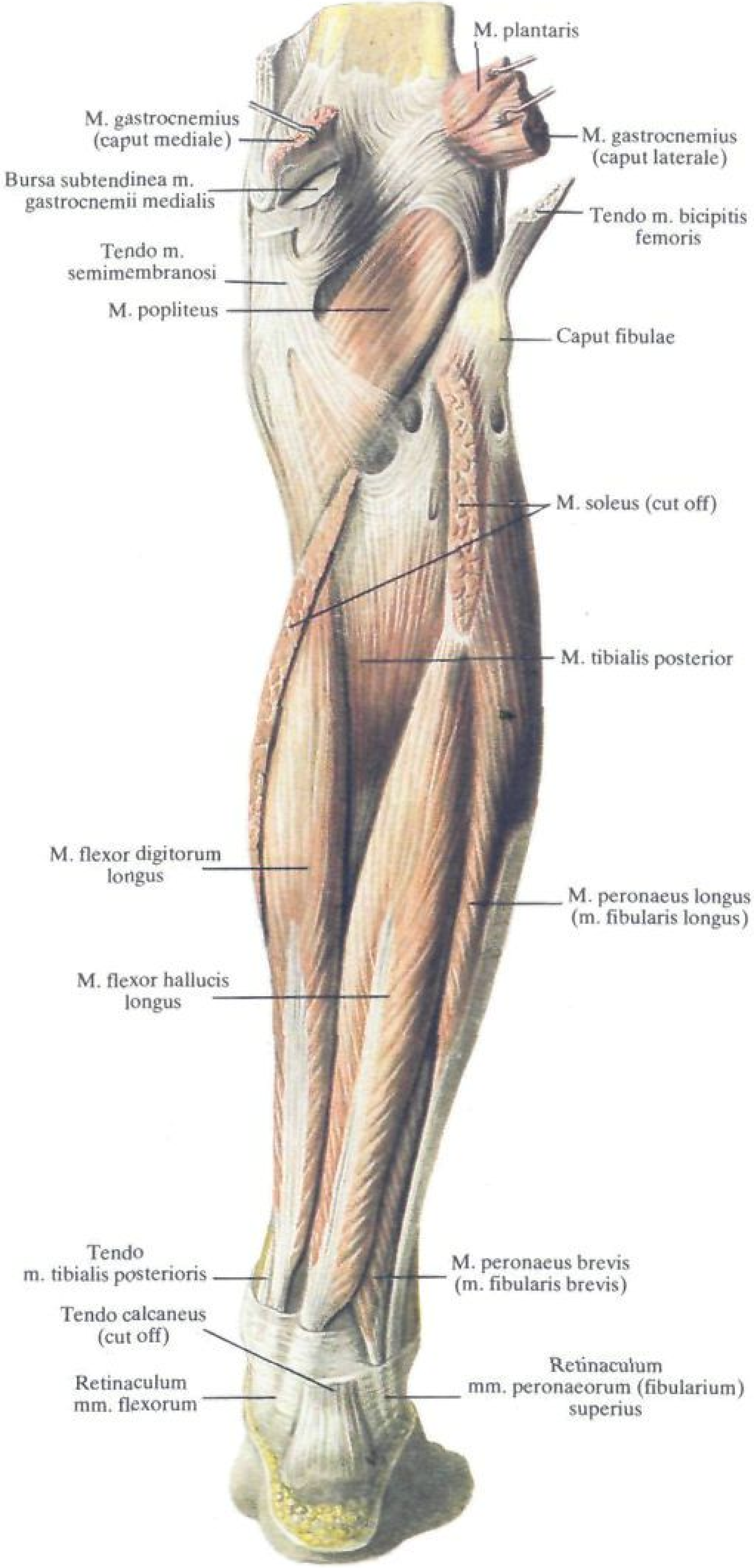
379. *Muscles of right leg and foot*; lateral aspect ($\frac{1}{4}$).



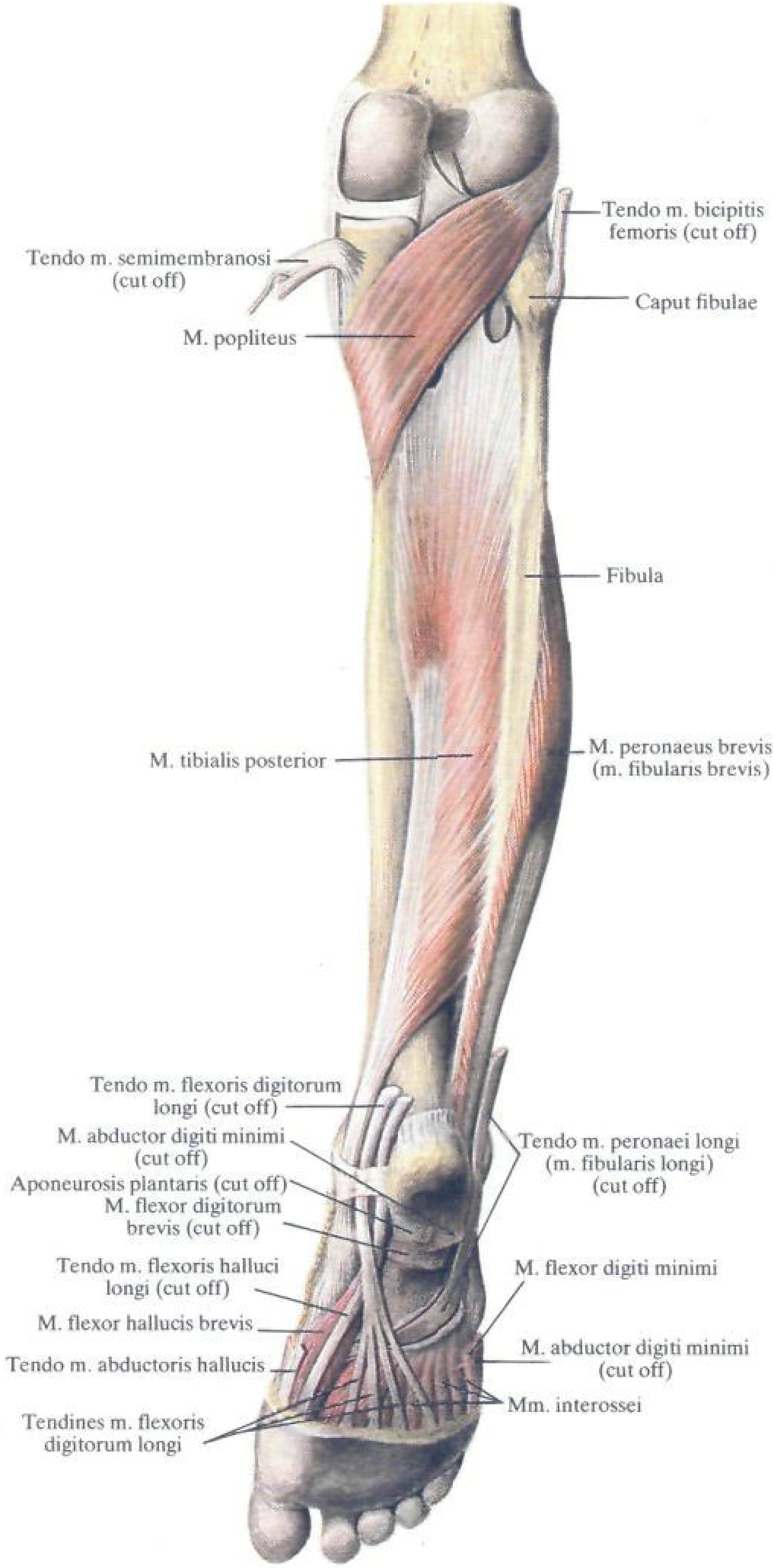
380. *Muscles of right leg*; posterior aspect (¼).
(Superficial layer.)



381. *Muscles of right leg*; posterior aspect (¼).
(Superficial layer.)



382. *Muscles of right leg*; posterior aspect (1/4).
(Deep layer.)



383. *Muscles of right leg and foot*; posterior aspect (¼).
(Deep layer.)

Muscles of the Median Eminence

1. The **flexor digitorum brevis muscle** *(musculus flexor digitorum brevis).*
2. The **quadratus plantae (flexor accessorius) muscle** *(musculus quadratus plantae [musculus flexor accessorius]).*
3. The **lumbrical muscles** *(musculi lumbricales).*
4. The **plantar interossei muscles** *(musculi interossei plantares).*
5. The **dorsal interossei muscles** *(musculi interossei dorsales).*

MUSCLES OF THE DORSAL SURFACE

1. The **extensor digitorum brevis muscle** *(musculus extensor digitorum brevis)* (Fig. 389) is flat and lies directly on the dorsal surface of the foot. It arises from the upper and lateral surfaces of the anterior part of the calcaneus and runs forwards to end in four narrow tendons. The distal ends of these tendons fuse with the extensor digitorum longus tendons and are inserted into the base of the proximal phalanges of the lateral four toes and take part in the formation of the dorsal tendinous expansion. A tendon to the little toe is sometimes absent.

Action: extends the lateral four toes and at the same time pulls them laterally.

Blood supply: the tarsal artery and the perforating branch of the peroneal artery.

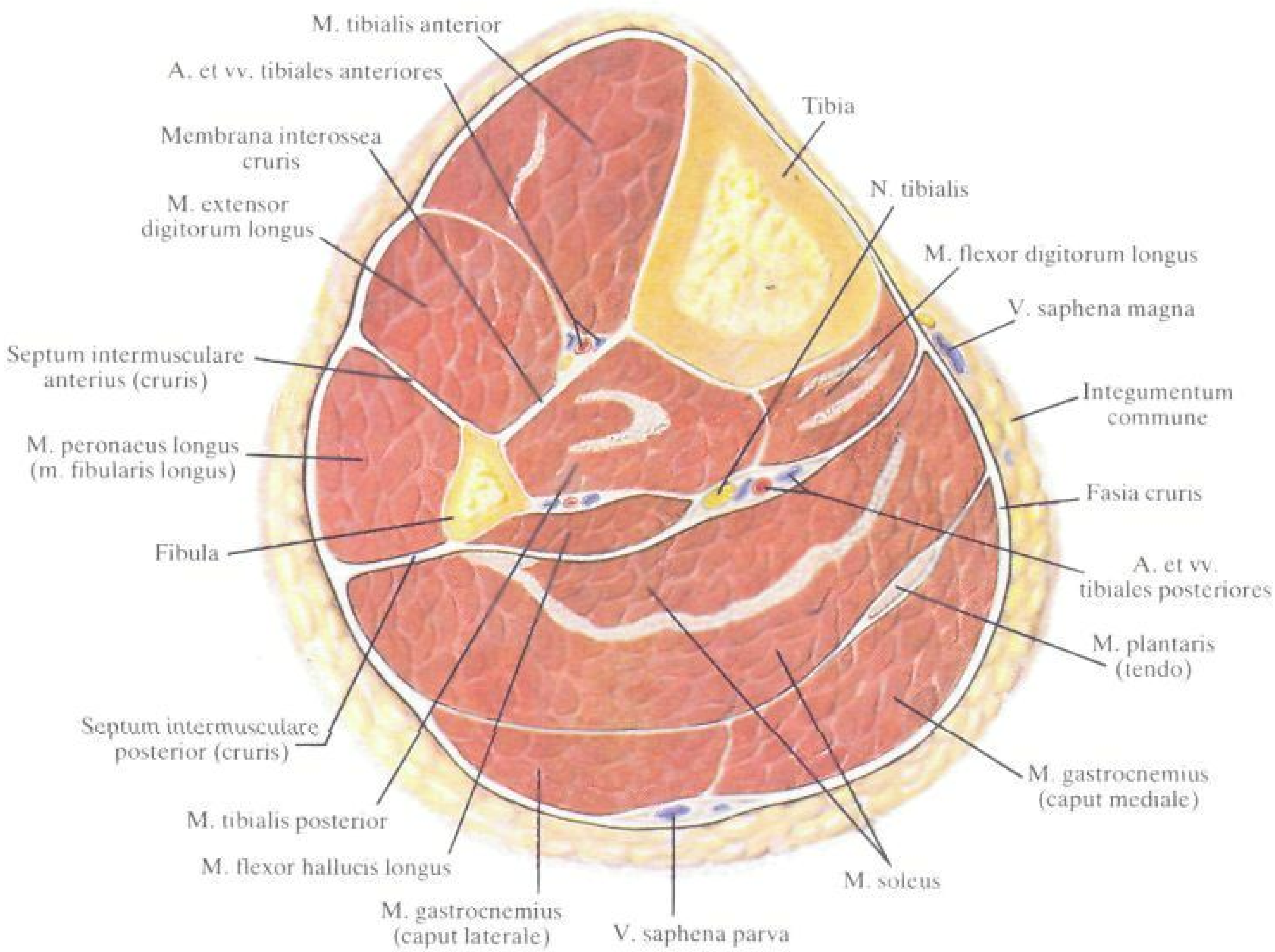
Innervation: the deep peroneal (anterior tibial) nerve (L_4–L_5; S_1).

2. The **extensor hallucis brevis muscle** *(musculus extensor hallucis brevis)* (Fig. 389) lies medially of the extensor digitorum brevis muscle. It arises from the upper surface of the anterior part of the calcaneus, runs forwards and medially, and ends in a tendon which is inserted into the base of the proximal phalanx of the great toe. The distal end of the tendon fuses with the extensor hallucis longus tendon and contributes to the formation of the dorsal tendinous expansion.

Action: extends the great toe.

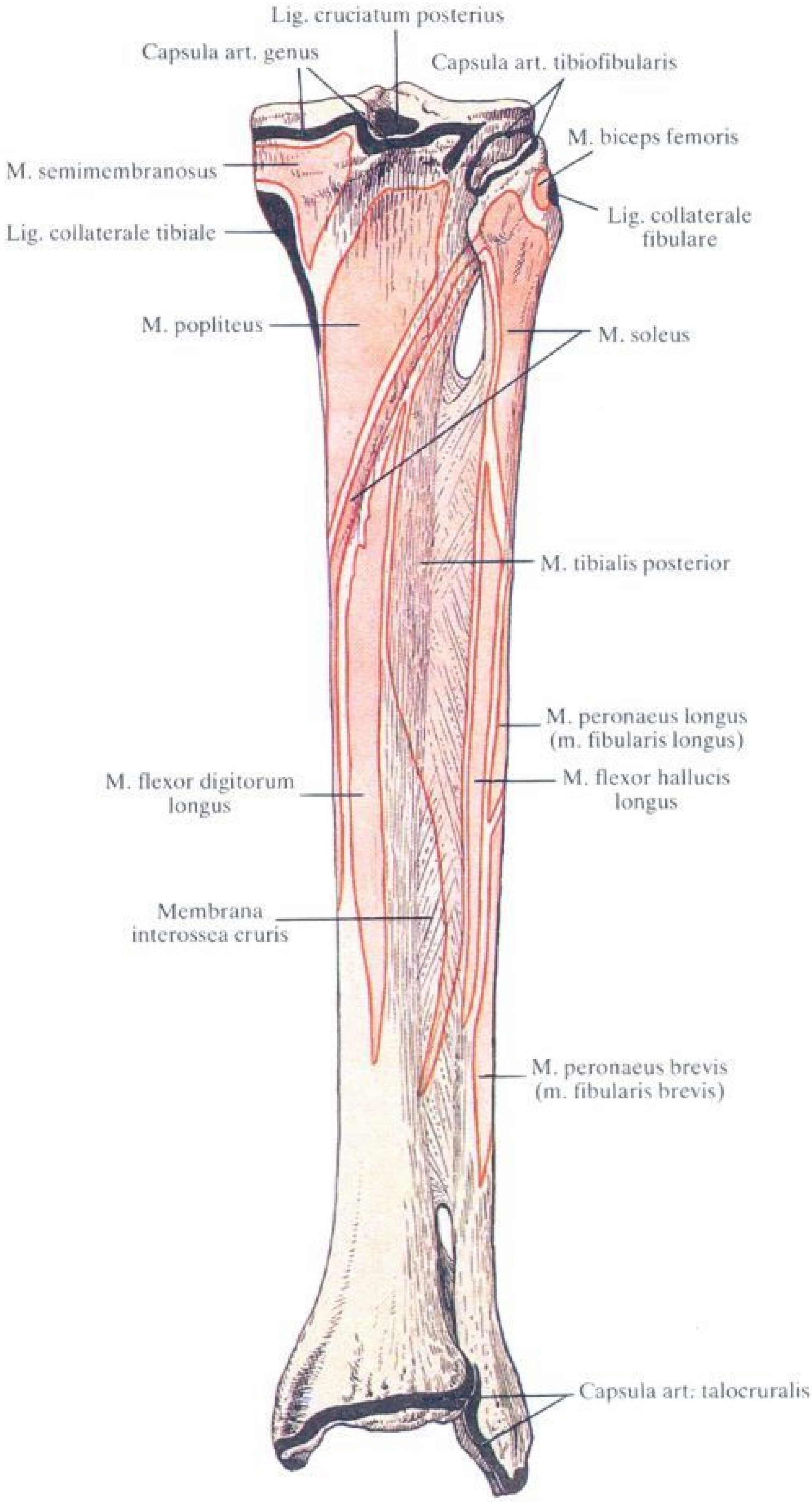
Blood supply: the tarsal artery and the perforating branch of the peroneal artery.

Innervation: the deep peroneal (anterior tibial) nerve (L_4–L_5; S_1).

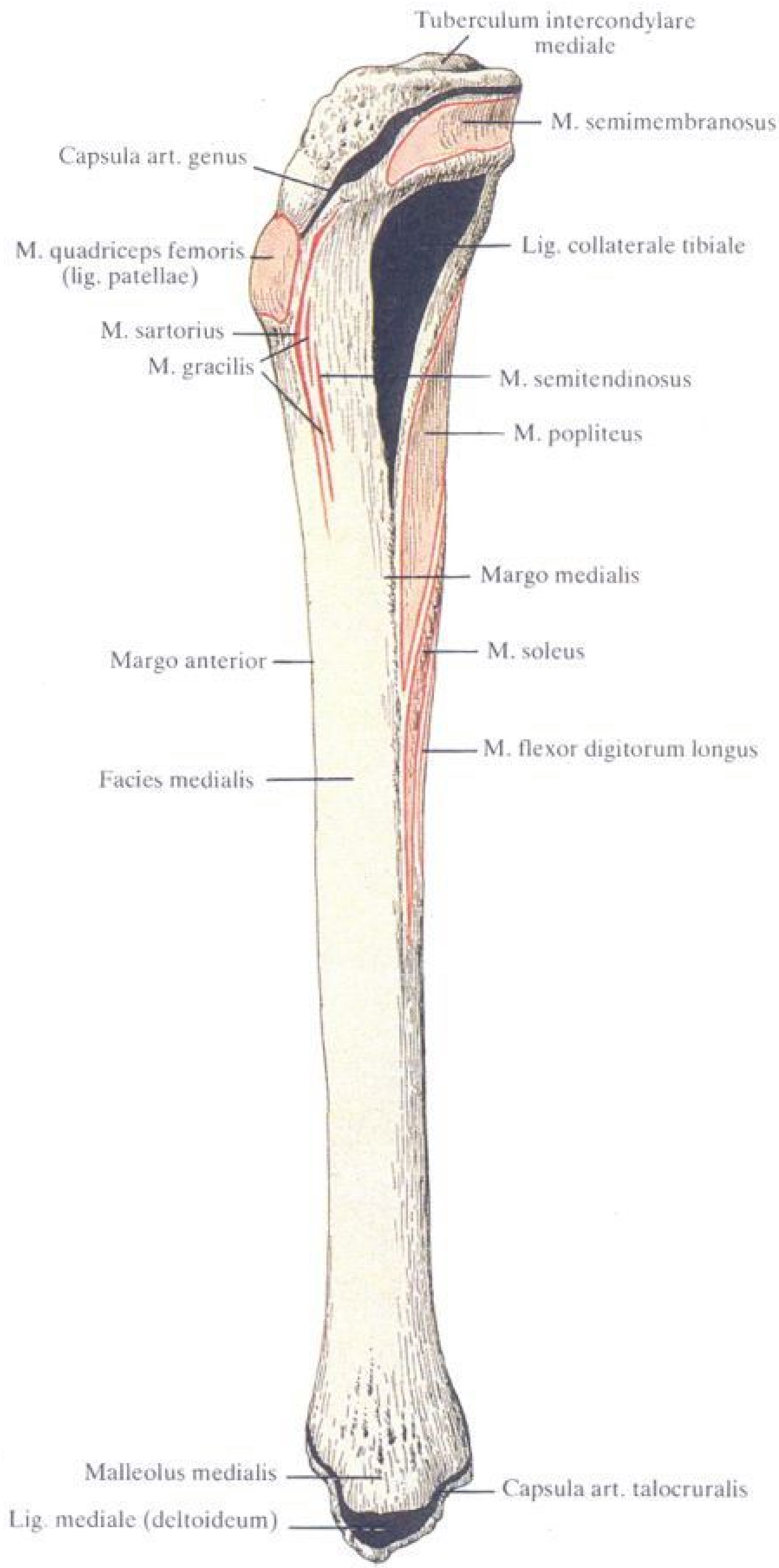


384. *Muscles and fasciae of right leg* (1/3).

(Transverse section through middle of leg.)



385. *Sites of origin and attachment of muscles, ligaments, and articular capsules on bones of right leg*; posterior aspect (schematical representation).
(The interosseous membrane is left intact.)



386. *Sites of origin and attachment of muscles, ligaments, and articular capsules on the right tibia*; medial surface (schematical representation).

MUSCLES OF THE PLANTAR SURFACE

Muscles of the Eminence of the Great Toe

1. The **abductor hallucis muscle** *(musculus abductor hallucis)* (Fig. 387) lies superficially and occupies the extreme medial position in this group of muscles. It arises from the flexor retinaculum, the medial tubercle of the calcaneum, and the plantar surface of the navicular bone. It is directed forwards and ends in a tendon which fuses with the flexor hallucis brevis tendon and is inserted into the medial sesamoid bone and base of the proximal phalanx of the great toe.

Action: flexes and abducts the great toe and strengthens the medial part of the arch of the foot.

Blood supply: the medial plantar artery.

Innervation: the medial plantar nerve (L_5; S_1).

2. The **flexor hallucis brevis muscle** *(musculus flexor hallucis brevis)* (Fig. 395) lies directly on the first metatarsal bone and is slightly shorter than the abductor hallucis muscle which covers it partly. It arises from the medial cuneiform bone, the plantar surface of the navicular bone, the tibialis posterior tendon, and the long plantar ligament. The tendon of the muscle together with the adductor hallucis tendon is inserted into the lateral and medial sesamoid bones and the base of the proximal phalanx of the great toe, separating thus into two distal tendons, each being related respectively to the lateral and medial heads of the muscle.

Action: flexes the great toe.

Blood supply: the medial plantar artery and the plantar arch.

Innervation: lateral head—the lateral plantar nerve (S_1-S_2), medial head—the medial plantar nerve (L_5-S_2).

3. The **adductor hallucis muscle** *(musculus adductor hallucis)* (Fig. 365) lies deeply, directly on the metatarsal bones, and is covered by the flexor digitorum longus and flexor digitorum brevis muscles. It arises by two heads, transverse and oblique.

The **transverse head** *(caput transversum)* arises from the plantar surface of the capsules of the third, fourth, and fifth metatarsophalangeal joints, the distal ends of the lateral four metatarsal bones, the plantar aponeurosis (septum laterale), and from the transverse ligaments of the heads of the metatarsal bones. The **oblique head** *(caput obliquum)* is stronger and arises from the plantar surface of the cuboid and lateral cuneiform bones, the base of the four lateral metatarsal bones, the long plantar ligament, and from the plantar sheath of the peroneus longus muscle. Both heads are continuous with a common tendon which is inserted into the lateral sesamoid bone and the base of the proximal phalanx of the great toe.

Action: adducts and flexes the great toe.

Blood supply: the plantar and dorsal metatarsal arteries; the perforating branch of the arcuate artery.

Innervation: the lateral plantar nerve (S_1-S_2).

Muscles of the Eminence of the Little Toe

1. The **abductor digiti minimi muscle** of the foot *(musculus abductor digiti minimi)* (see Fig. 393) lies laterally of all the muscles of this group directly under the plantar aponeurosis. It arises from the lateral and medial tubercles of the calcaneum and from the plantar aponeurosis. Extending forwards, it is continuous with a short tendon which is inserted into the lateral side of the base of the proximal phalanx of the little toe.

Action: abducts and flexes the proximal phalanx of the little toe.

Blood supply: the lateral plantar artery.

Innervation: the lateral plantar nerve (S_1-S_2).

2. The **flexor digiti minimi brevis muscle** *(musculus flexor digiti minimi brevis)* (see Fig. 395) is medial to the abductor digiti minimi muscle of the foot and partly covered by it. It arises from the fifth metatarsal bone, the long plantar ligament, and the plantar sheath of the peroneus longus muscle, runs forwards, and ends in a tendon which fuses with the tendon of the abductor digiti minimi muscle to be inserted into the base of the proximal phalanx of the little toe.

Action: flexes the proximal phalanx of the little toe.

Blood supply: the lateral plantar artery.

Innervation: the lateral plantar nerve (S_1-S_2).

3. The **opponens digiti minimi muscle** *(musculus opponens digiti minimi)* (Figs 395, 396) is very often absent. It arises together with the flexor digiti minimi brevis muscle from the long plantar ligament and from the sheath of the peroneus longus muscle and is inserted into the lateral border of the fifth metatarsal bone.

Action: adducts and opposes the fifth metatarsal bone; together with the flexor digiti minimi brevis muscle strengthens the lateral part of the arch of the foot.

Blood supply: the lateral plantar artery.

Innervation: the lateral plantar nerve (S_1-S_2).

Muscles of the Median Eminence

1. The **flexor digitorum brevis muscle** *(musculus flexor digitorum brevis)* (Fig. 393) occupies the medial position on the foot under the plantar aponeurosis. It arises by a short strong tendon from the medial tubercle of the calcaneum and the plantar aponeurosis. Running forwards, the muscular belly ends in four tendons which are lodged in the synovial canals with the flexor digitorum longus tendons. In the region of the proximal phalanges of the lateral four toes each of the four flexor digitorum brevis tendons separates into two slips to be inserted into the base of the middle phalanges of these toes. The flexor digitorum longus tendon passes between the slips.

Action: flexes the middle phalanges of the lateral four toes.

Blood supply: the posterior tibial and lateral and medial plantar arteries.

Innervation: the medial plantar nerve (L_5; S_1).

2. The **flexor digitorum accessorius muscle** *(musculus quadratus plantae s. musculus flexor accessorius)* (Fig. 394) is almost quadrangular and lies under the flexor digitorum brevis muscle. It arises from the inferior and medial surfaces of the posterior part of the calca-

neum by two separate heads which fuse to form a common belly. Running forwards, the muscle narrows slightly and is inserted into the lateral border of the flexor digitorum longus tendon at the point of its division into separate tendons.

Action: together with the flexor digitorum longus muscle flexes the distal phalanges and lends the traction of this muscle a straight direction.

Blood supply: the lateral plantar artery.

Innervation: the lateral plantar nerve (S_1-S_2).

3. The **lumbrical muscles** *(musculi lumbricales)* (Fig. 394) are thin, short, and four in number. They lie between the flexor digitorum longus tendons, are covered by the flexor digitorum brevis muscle, and come in contact with the interossei muscles in the depth of the sole. Each lumbrical muscle arises from the respective flexor digitorum longus tendon, the lateral three arising by two heads and the first muscle by a single head. They run forwards and in the region of the metatarsophalangeal joints curve around the medial surface of the lateral four toes, and pass over to their dorsal surface to be inserted into their dorsal tendinous expansion. In some cases the lumbrical muscles are inserted into the joint capsules and even stretch to the distal phalanges. Synovial bursae of the lumbrical muscles are lodged between these muscles and the deep transverse ligament of the sole.

Action: flex the proximal phalanges of the lateral four toes extending at the same time their middle and distal phalanges.

Blood supply: the lateral and medial plantar arteries.

Innervation: the medial and lateral plantar nerves (L_5; S_1-S_2).

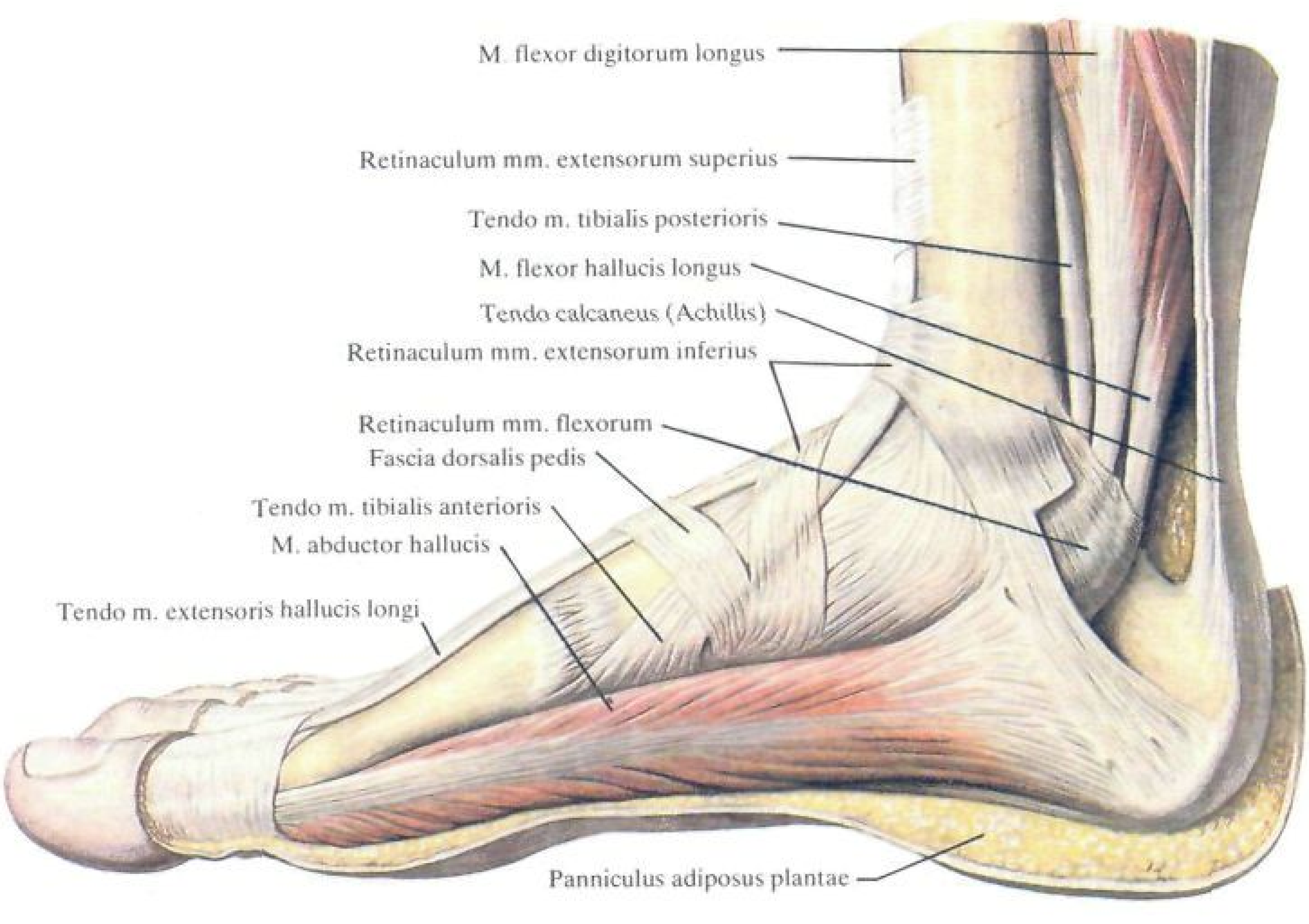
4. The **plantar interossei muscles** *(musculi interossei plantares)* (Fig. 396) are narrow, short, and three in number. They lie in the spaces between the second and third, the third and fourth, and the fourth and fifth toes. Each muscle arises from the medial surfaces of the third, fourth, and fifth metatarsal bones and are inserted into the base of the proximal phalanx and are partly continuous with the dorsal tendinous expansion.

Action: flex the proximal phalanges and extend the middle and distal phalanges of the third, fourth, and fifth toes and also adduct these toes towards the second toe.

Blood supply: the plantar arch and the plantar metatarsal arteries.

Innervation: the lateral plantar nerve (S_1-S_2).

5. The **dorsal interossei muscles** *(musculi interossei dorsales)* (Fig. 390) resemble the plantar muscles in shape. They are four in



387. *Muscles and fasciae of right foot*; medial aspect ($\frac{1}{2}$).

number and fill all the interosseous spaces on the dorsal surface. Each muscle arises from the opposing surfaces of two adjacent metatarsal bones. They pass forwards, and are inserted into the base of the proximal phalanges of the second, third, and fourth toes and into the dorsal tendinous expansion.

Action: the first interossei muscle pulls the second toes medially; the second, third, and fourth muscles displace the second, third, and fourth toes laterally. The four muscles also flex the proximal phalanges and extend the middle and distal phalanges of these toes.

Blood supply: the plantar arch and the plantar metatarsal arteries.

Innervation: the lateral plantar nerve (S_1-S_2).

THE SUBSARTORIAL CANAL

The adductor magnus muscle has openings which transmit blood vessels. The lowest and largest opening is called the **opening in the adductor magnus** *(hiatus tendineus [adductorius])*. A little higher is a thick intermuscular layer of fascia bridging the vastus medialis and the adductor magnus muscles, which is called the **lamina vastoadductoria**. Between these muscles and the fascial lamina is a space triangular in cross-section. It is called the **subsartorial canal** *(canalis adductorius)* and lodges the femoral artery and vein and the saphenous nerve. The vessels pass from the canal into the popliteal fossa, while the nerve pierces the fascial lamina to appear on the medial surface of the thigh.

THE POPLITEAL FOSSA

The **popliteal fossa** *(fossa poplitea)* (see Figs 364, 366, 367) is in the region of the posterior surface of the knee and is rhomboid. It is bounded by the biceps femoris muscle superiorly and laterally, by the semimembranosus muscle superiorly and medially, and by both heads of the gastrocnemius muscle and the plantaris muscle inferiorly; the floor of the fossa is formed by the popliteal surface of the femur and the posterior surface of the knee joint capsule.

THE CRUROPOPLITEAL CANAL

The **cruropopliteal canal** *(canalis cruropopliteus)* (it is described in detail in manuals of topographical anatomy) passes between the anterior surface of the soleus muscle and the deep muscles of the posterior group on the leg. The proximal end of the canal arises from the popliteal fossa. Its opening is bounded anteriorly by the popliteus muscle and posteriorly by the tendinous arch of the soleus muscle. The canal lodges nerves and vessels entering it from the popliteal fossa.

FASCIAE OF THE LOWER LIMB

FASCIAE OF THE PELVIS AND THIGH

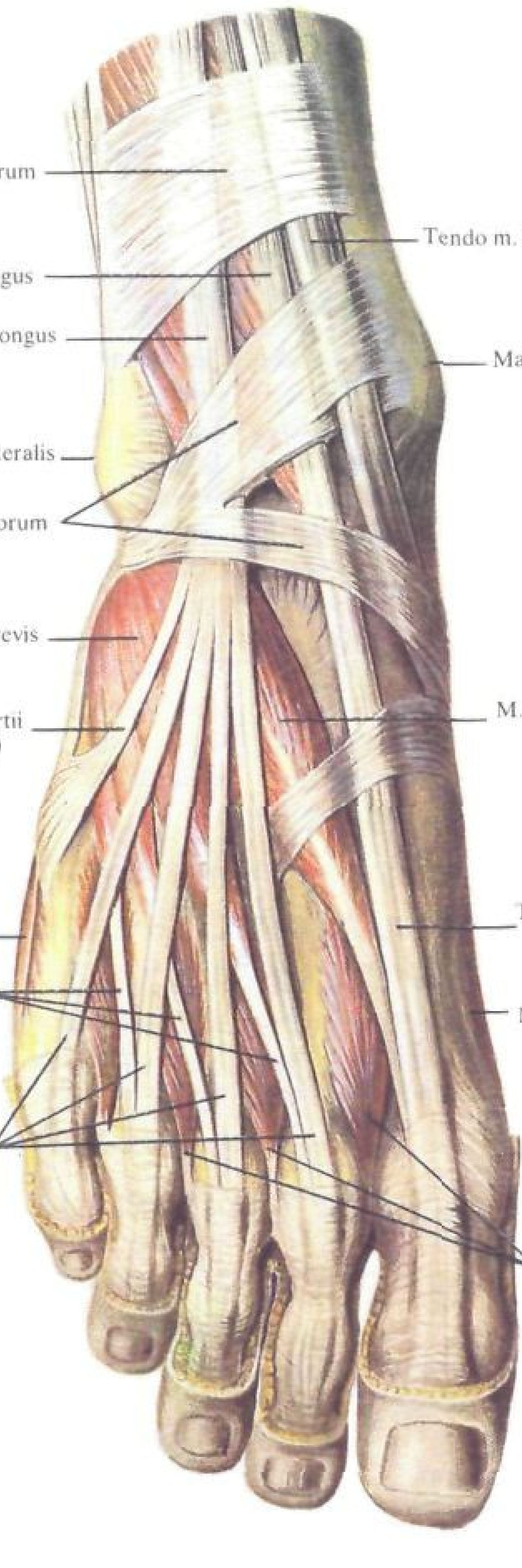
The external surface of the pelvis is covered by a fascia which is a continuation of the **lumbar fascia** *(fascia thoracolumbalis)* (see Fig. 253). Below the outer lip of the iliac crest and the dorsal sacral surface the fascia covers the group of gluteus muscles and is continuous downwards with the fascia lata of the thigh.

The fascia covering the gluteus maximus muscle thickens noticeably in the region of the femoro-gluteal fold (see Fig. 366). The layer of fascia lining the inner surface of the gluteus maximum muscle covers the gluteus medius, piriformis, obturatorius internus, and quadratus femoris muscles.

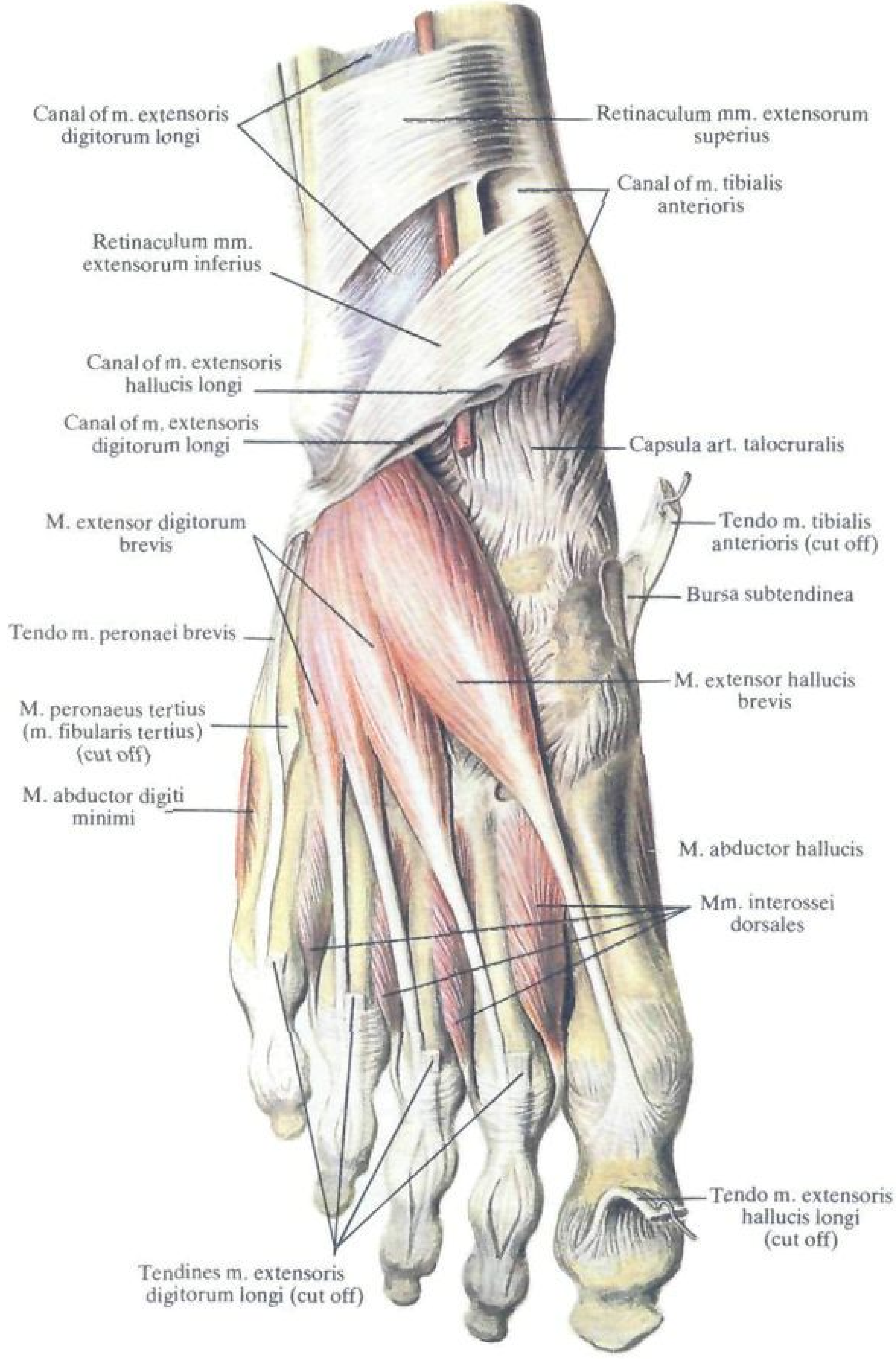
The fascia of the internal surface of the pelvis is called the **fascia iliaca** (see Fig. 297). It arises on the inner lip of the iliac crest and the lateral surfaces of the bodies of the lumbar vertebrae and covers the iliacus and the psoas major and minor muscles.

On reaching the lateral end of the inguinal ligament, the fascia iliaca fuses with it closely; medially it is separated from the inguinal ligament and covers here the iliopsoas muscle, passes over to the pectineus muscle and forms a lining for the iliopectineal furrow. Bands of the fascia iliaca, which are called the **iliopectineal arch** *(arcus iliopectineus)*, arise from the inferior surface of the inguinal ligament and reach the iliopubic eminence as a result of which lateral and medial spaces form under the ligament. The lateral, larger, space is called the **lacuna musculorum** and lodges the iliopsoas muscle and the femoral nerve. The medial space is known as the **lacuna vasorum** and transmits the femoral artery laterally and the femoral vein medially with a lymphatic gland (in some cases) or fatty tissue lodged between them. From the direction of the abdominal cavity this place is covered by the fascia transversalis and the peritoneum and corresponds to the deep femoral ring.

The **fascia lata** (see Figs 354, 366) is a thick sheet investing the



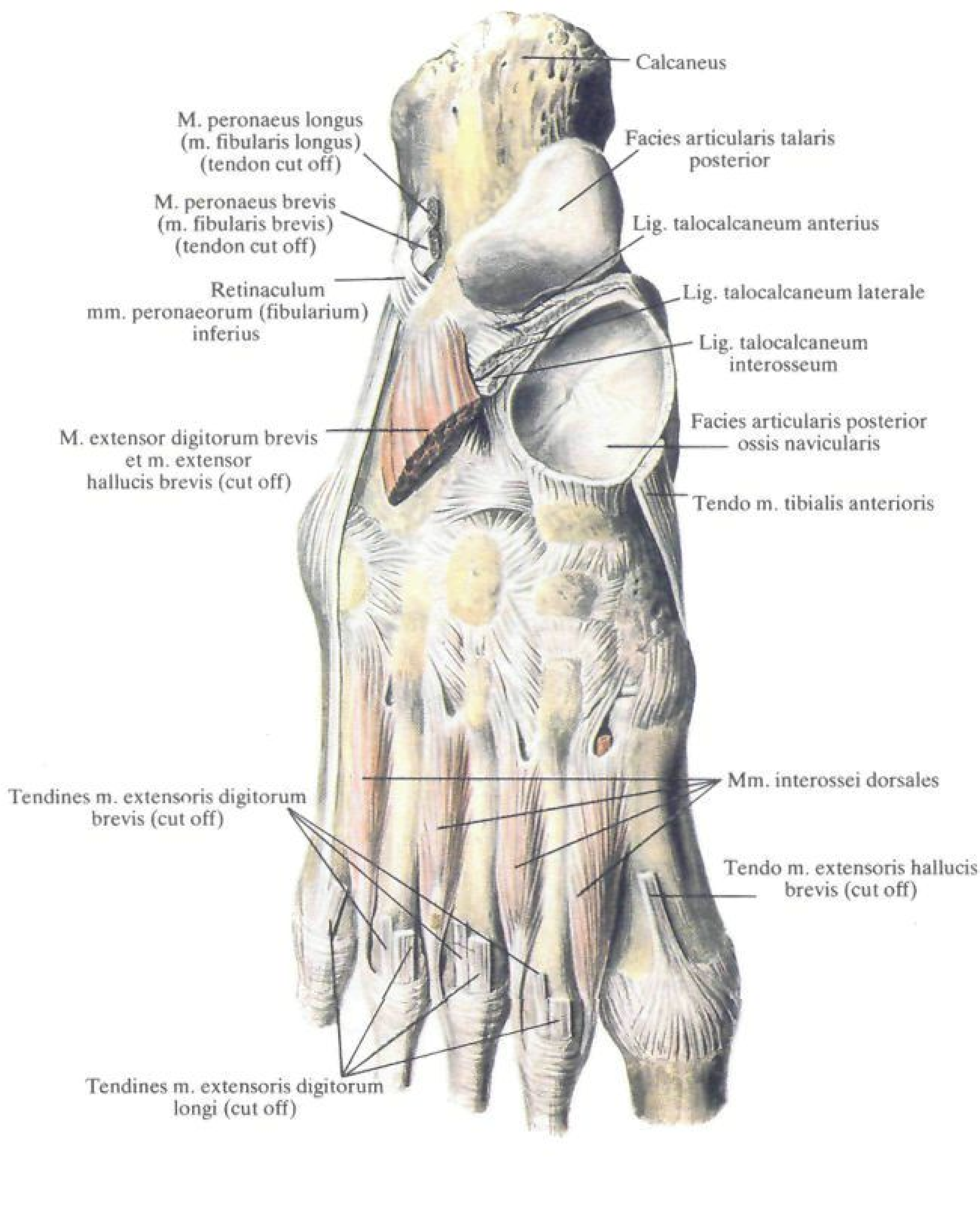
388. *Muscles of right foot*; dorsal surface ($\frac{2}{5}$).



389. *Muscles of right foot*; dorsal surface ($^2/_5$).

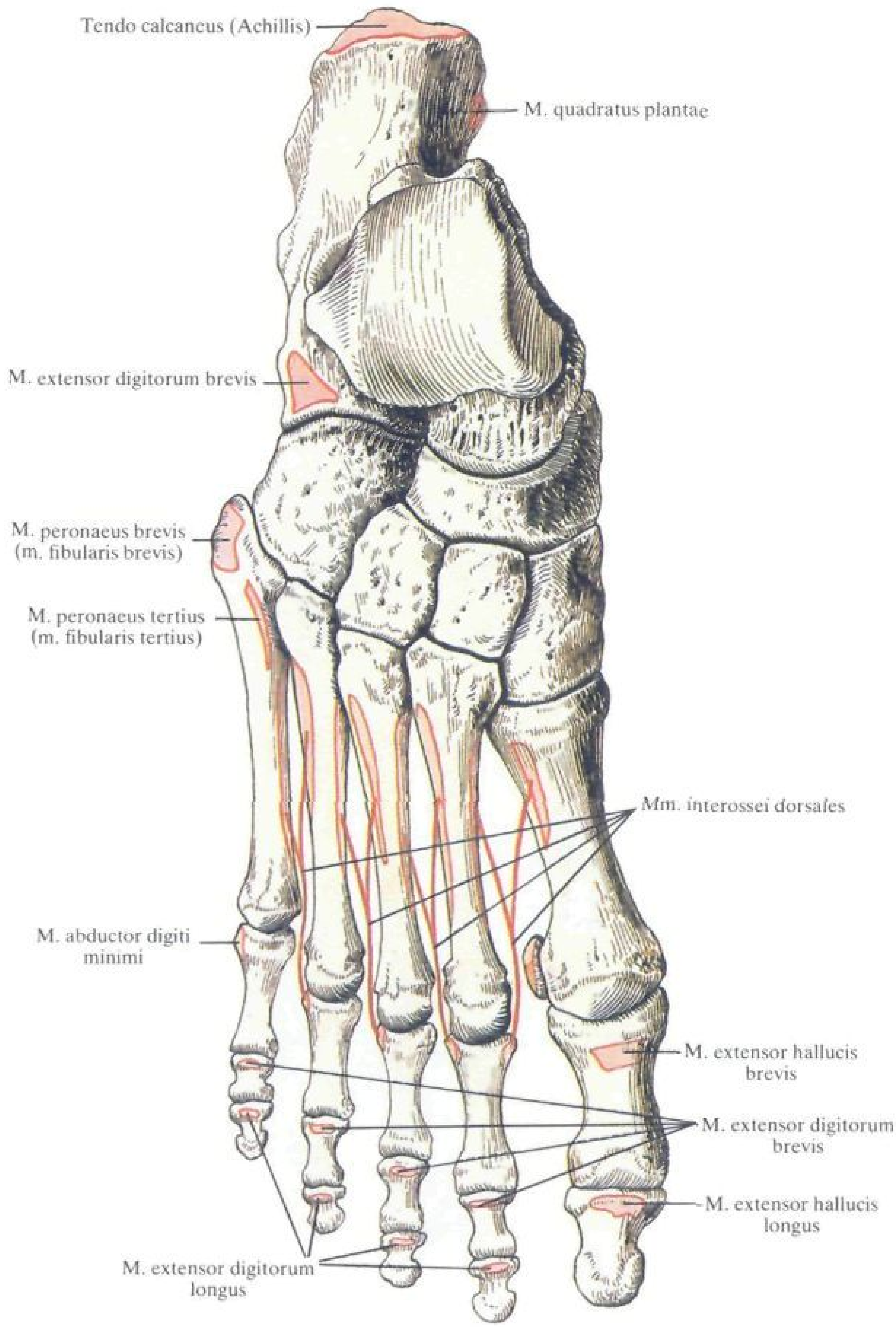
(The extensor digitorum longus and tibialis anterior tendons are removed.)

muscles of the thigh. It is fused with the inguinal ligament in front and above and with the gluteus fascia in back, and is continuous downwards with the crural fascia. On the lateral surface of the thigh the fascia lata is thickest and forms a band called the **iliotibial tract** *(tractus iliotibialis)* which arises in the region of the anterior superior iliac spine and stretches to the region of the lateral condyle of the tibia. The proximal part of the tract receives the tensor fasciae latae muscle and some fibres of the gluteus maximus muscle. On the anterior surface of the proximal part of the thigh is a small oval depression of fascia. It is called the **saphenous opening** *(hiatus saphenus)* (see Fig. 303). The lateral margin of the depression is thick and called the **falciform margin** *(margo falciformis)*. The upper part of the margin is attached to the inguinal ligament and is called the **superior cornu** *(cornu superius)*, the lower part is called the **inferior cornu** *(cornu inferius)*. The depression, or the oval fossa, itself is covered by a lamina which has many openings and is called the **cribriform fascia** *(fascia cribrosa)* (see Fig. 301).

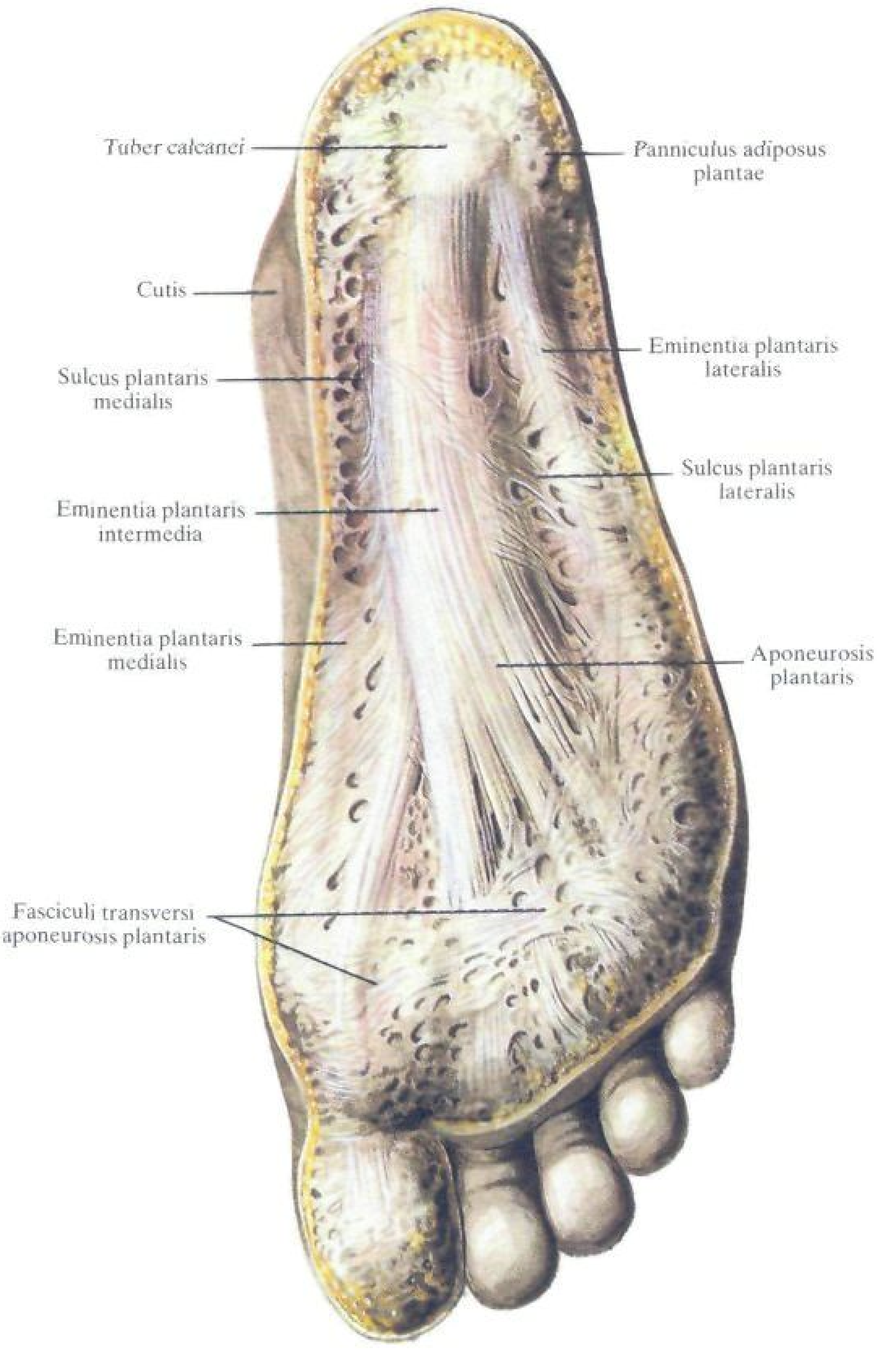


390. *Muscles of right foot*; dorsal surface (2/5).

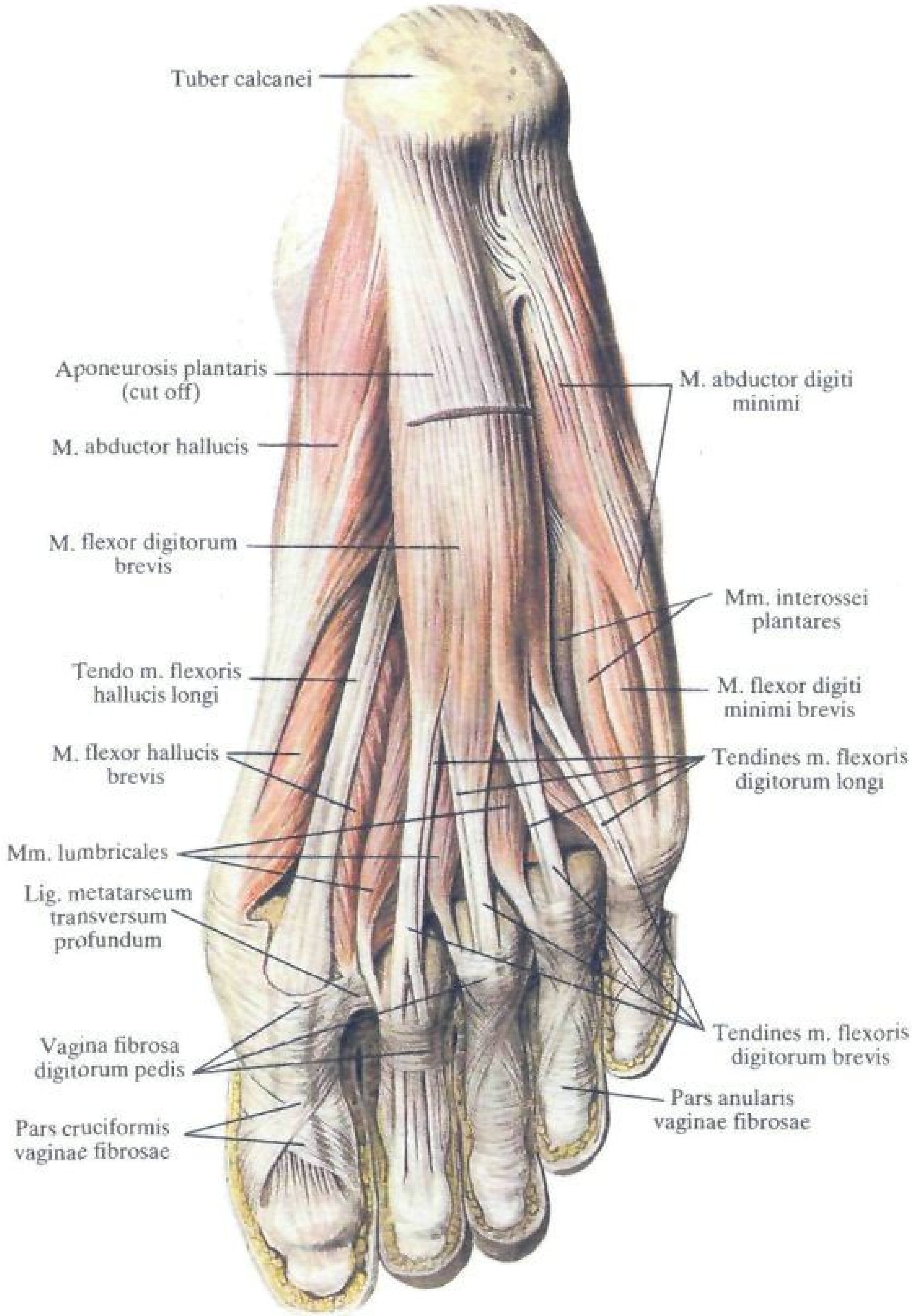
(Interossei muscles.)



391. *Sites of origin and insertion of muscles on bones of right foot*; dorsal surface (schematical representation).



392. *Plantar aponeurosis (aponeurosis plantaris)* (½).



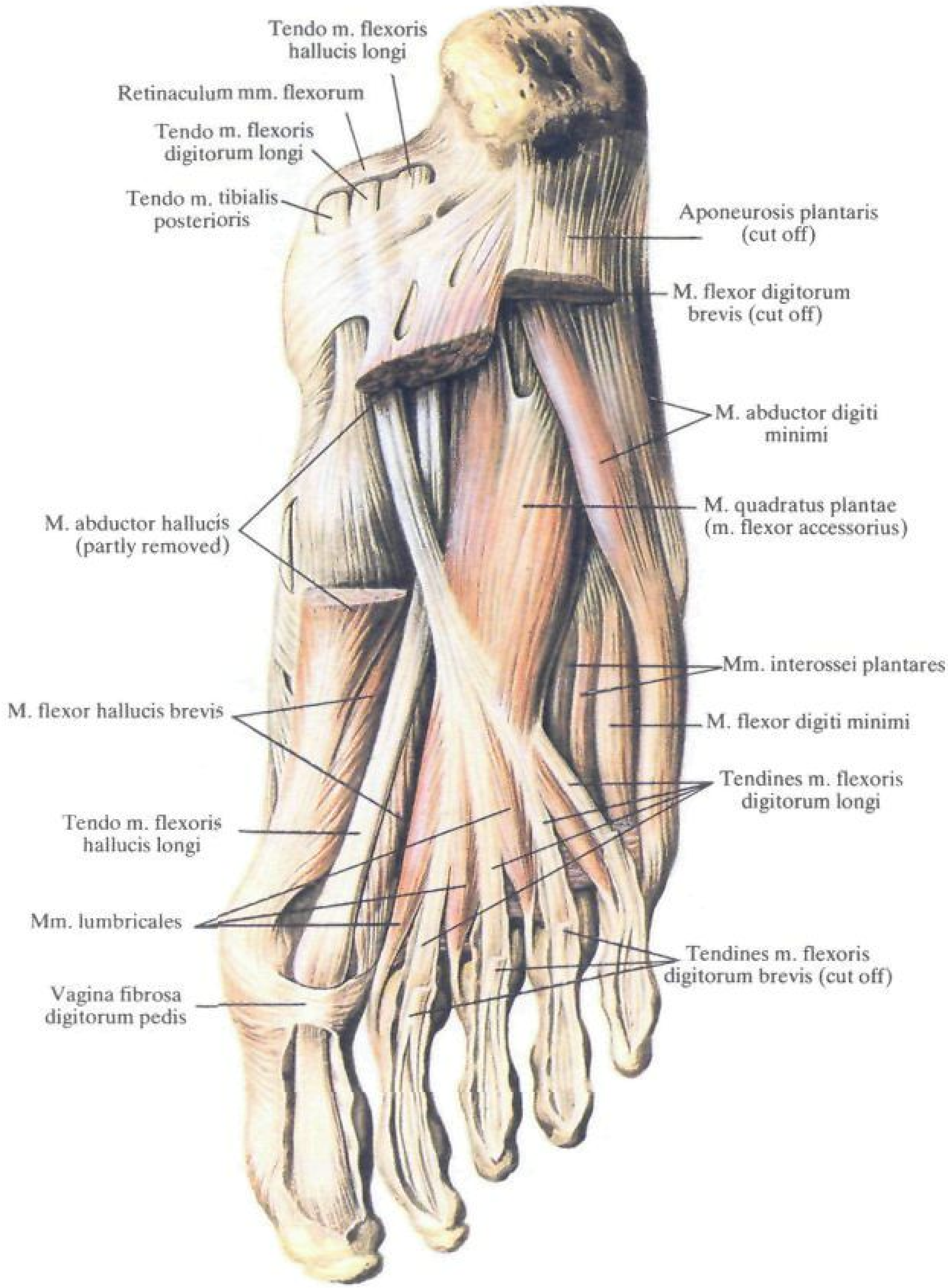
393. *Muscles of right foot*; plantar surface ($\frac{1}{2}$).

The fascia lata gives off septa penetrating deeply between the muscles; a lateral, medial, and posterior septa are distinguished.

The **lateral intermuscular septum of the thigh** *(septum intermusculare femoris laterale)* is attached to the lateral lip of the linea aspera of the femur. It separates the anterior group of thigh muscles from the posterior group.

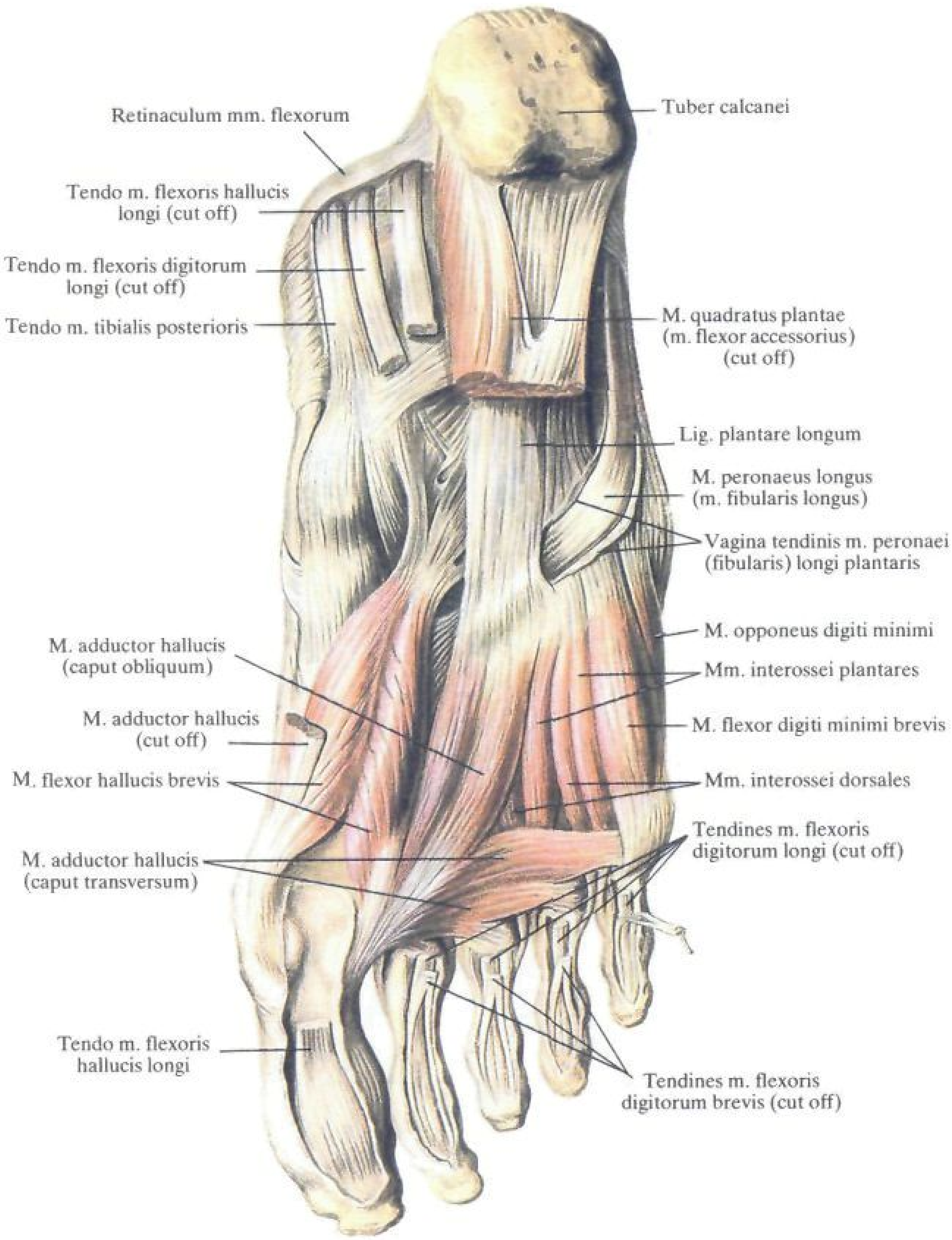
The **medial intermuscular septum of the thigh** *(septum intermusculare femoris mediale)* is attached to the medial lip of the linea aspera of the femur. It is the boundary between the medial and anterior groups of the thigh muscles.

The posterior intermuscular septum is defined less clearly. It is attached, like the medial septum, to the medial lip of the linea aspera. It separates the medial group of muscles from the posterior group.



394. *Muscles of right foot*; plantar surface (½).

In the upper third of the anterior surface of the femur, in the region of the **femoral triangle** *(trigonum femorale)* which is bounded by the inguinal ligament and the sartorius and the adductor longus muscles, the fascia lata separates into two layers, superficial and deep, the space between which is filled with a large amount of loose fatty tissue with vessels passing and lymphatic glands lodged in it. In the upper part of the femoral triangle the deep layer is fused with the pectineal line in the region of the iliopubic eminence. On the lateral side of the femoral triangle the deep layer is continuous with the fascia iliaca covering the iliopsoas muscle, while on the medial side both layers of the fascia lata fuse. The floor of the triangle is formed by the iliopsoas and the pectineus muscles.



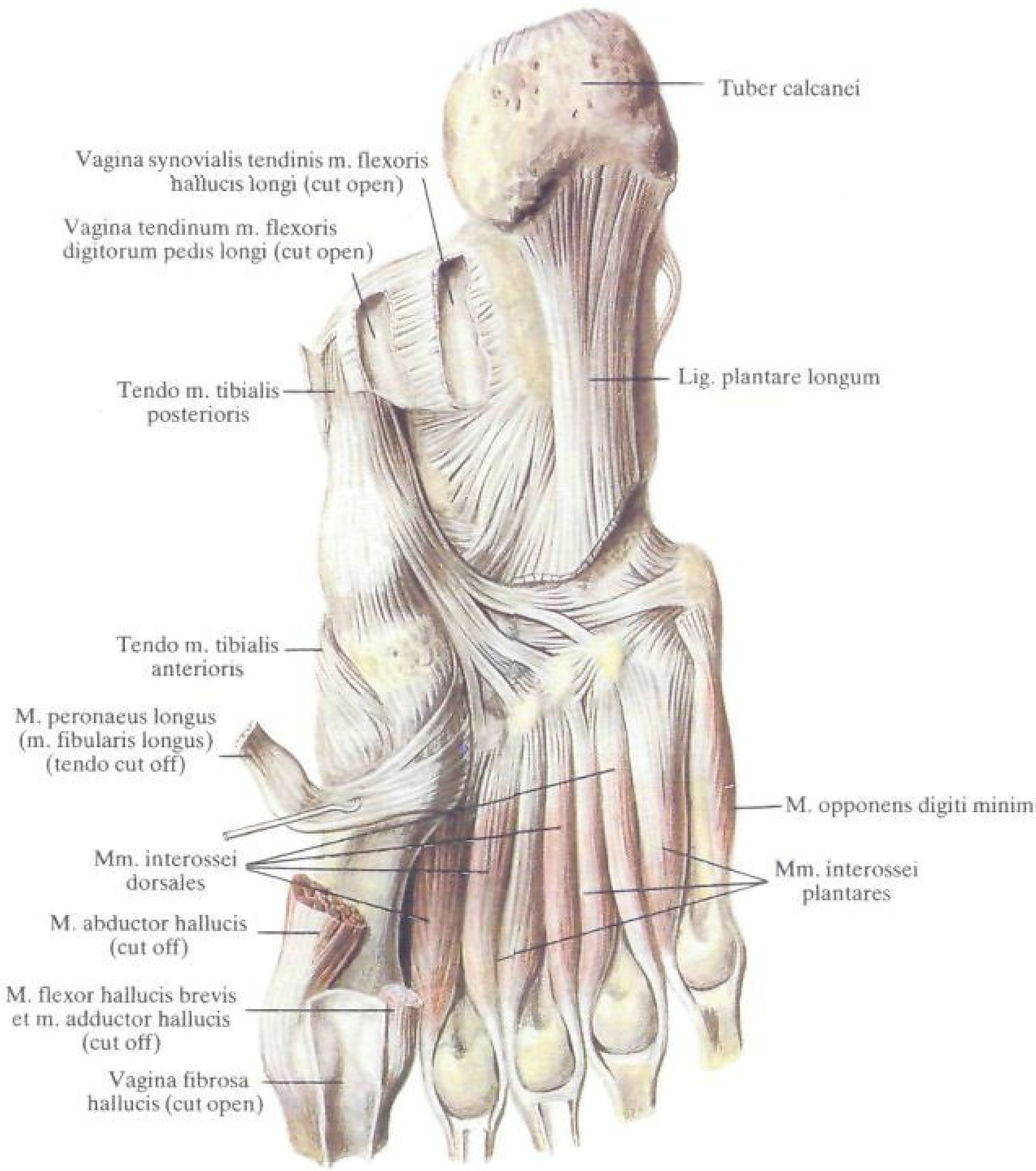
395. *Muscles of right foot*; plantar surface (½).

THE FEMORAL CANAL

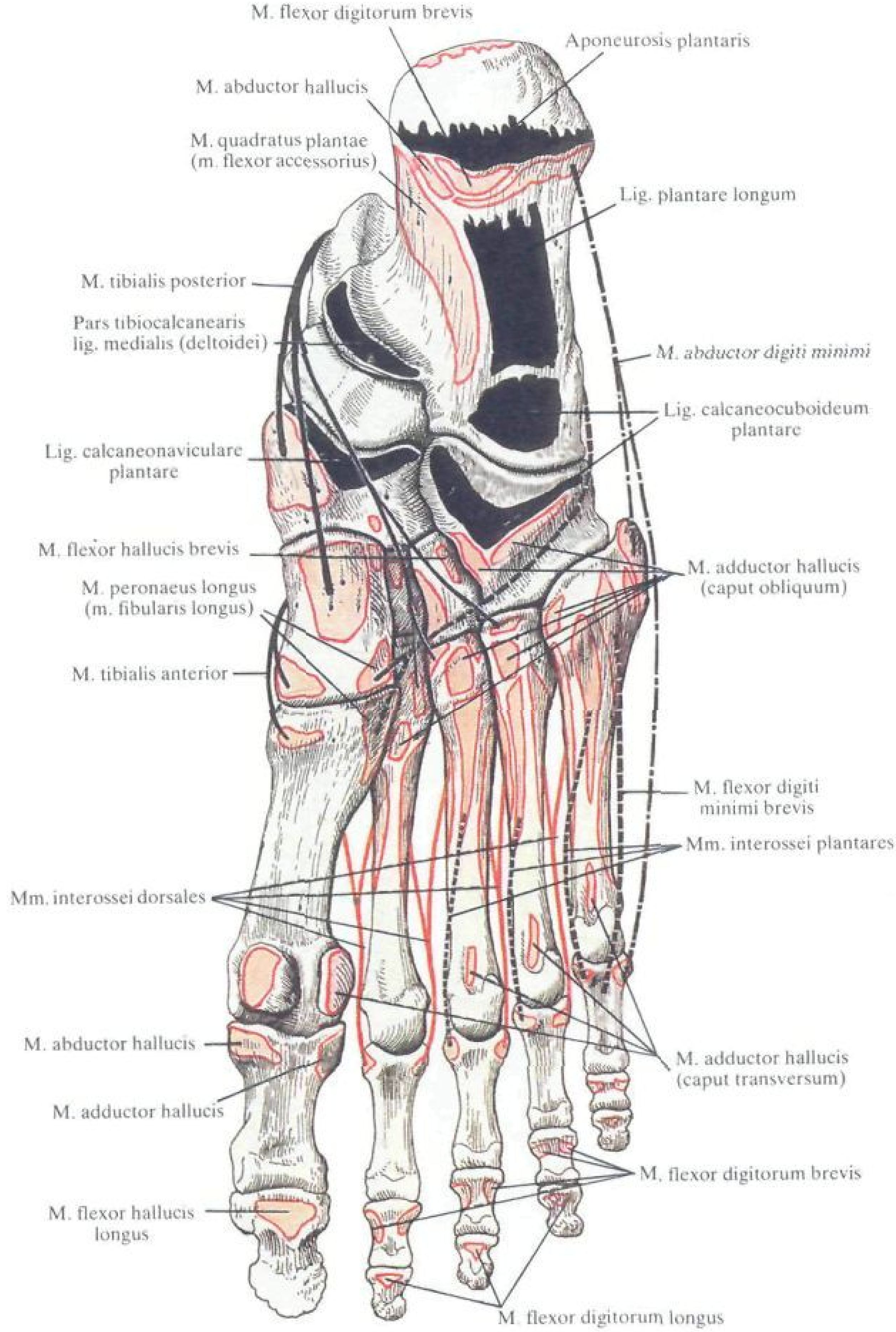
The **femoral canal** *(canalis femoralis)* (see Figs 301–307) does not exist under normal conditions. It forms only with the occurrence of a femoral hernia, i.e. in protrusion of the abdominal organs (an intestinal loop, omentum, etc.) under the inguinal ligament in the lacuna vasorum. Thus, there is only the **deep femoral ring** *(anulus femoralis profundus)* normally. It is closed by an area of the transversalis fascia in the form of the **femoral septum** *(septum femorale)* whose surface facing the abdominal cavity is lined with the parietal peritoneum. The deep femoral ring is bounded by the pectineal part of the inguinal ligament medially, by the femoral vein laterally, by the inguinal ligament superiorly and anteriorly, and by the pectineal ligament inferiorly and posteriorly.

The deep femoral ring itself is filled by loose fatty tissue or a large lymph gland.

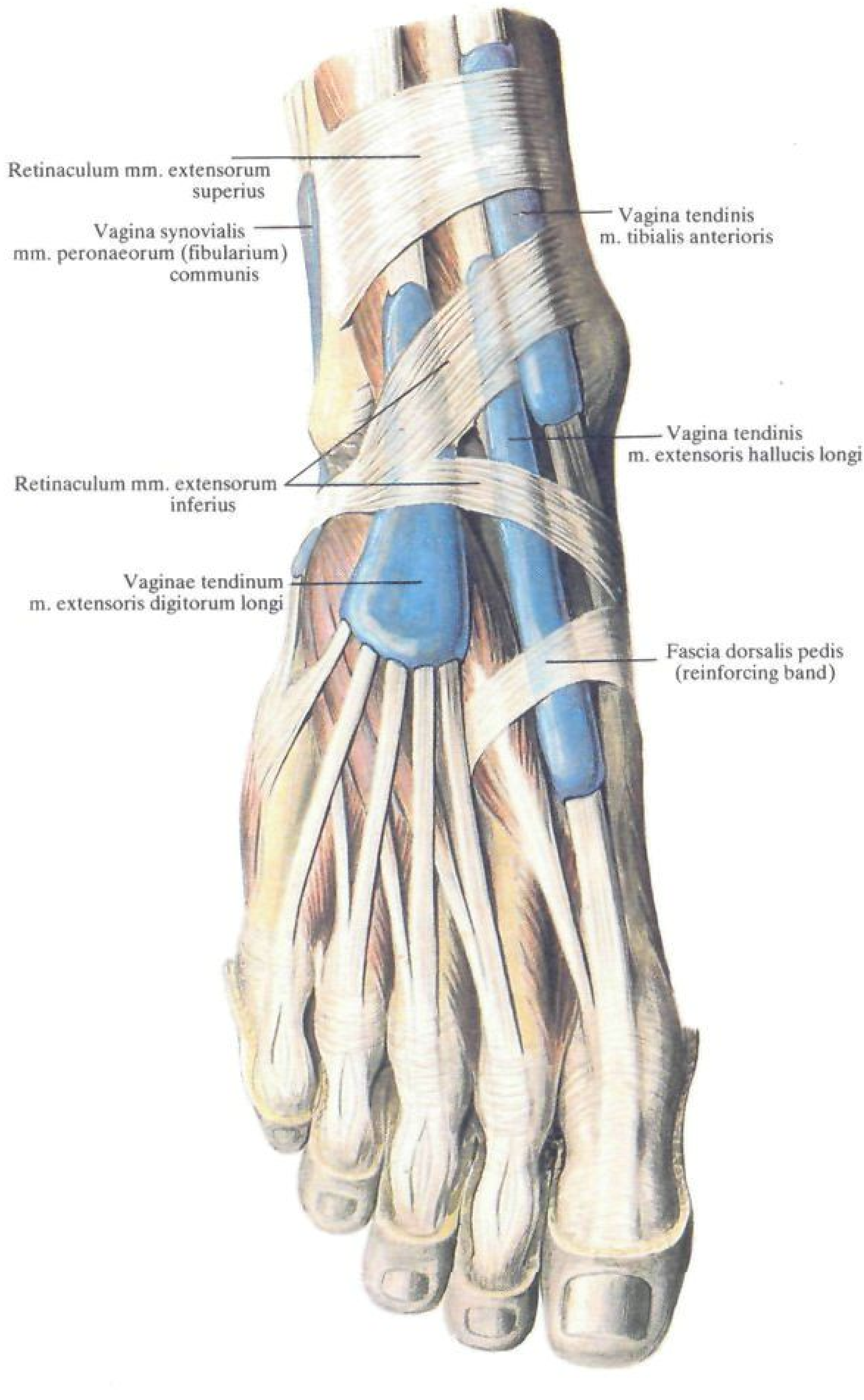
When a femoral hernia forms, the femoral septum bulges out, pushes the lymph gland aside, thus forming a space which the protruding viscera enter and then descend between the superficial and deep layers of the fascia lata. This space produced between the fascial layers is actually the cavity of the femoral canal whose anterior wall is the inguinal ligament and the superior cornu of the falci-



396. *Muscles of right foot*; plantar surface (½).
(Interossei muscles.)



397. *Sites of origin and attachment of muscles and ligaments on bones of right foot*; plantar surface (schematical representation).



398. *Synovial sheaths of tendons (vaginae synoviales tendinum) on right foot*; dorsal surface (½).

(A coloured mass is administered into the sheath.)

form margin of the fascia lata, the posterior wall is the deep layer of the fascia lata, and the lateral wall is the femoral vein.

On reaching the weakest place in the fascia lata, the hiatus saphenus, the hernial sac distends the cribriform fascia and protrudes under the skin through the hiatus which is as if the external opening of the femoral canal.

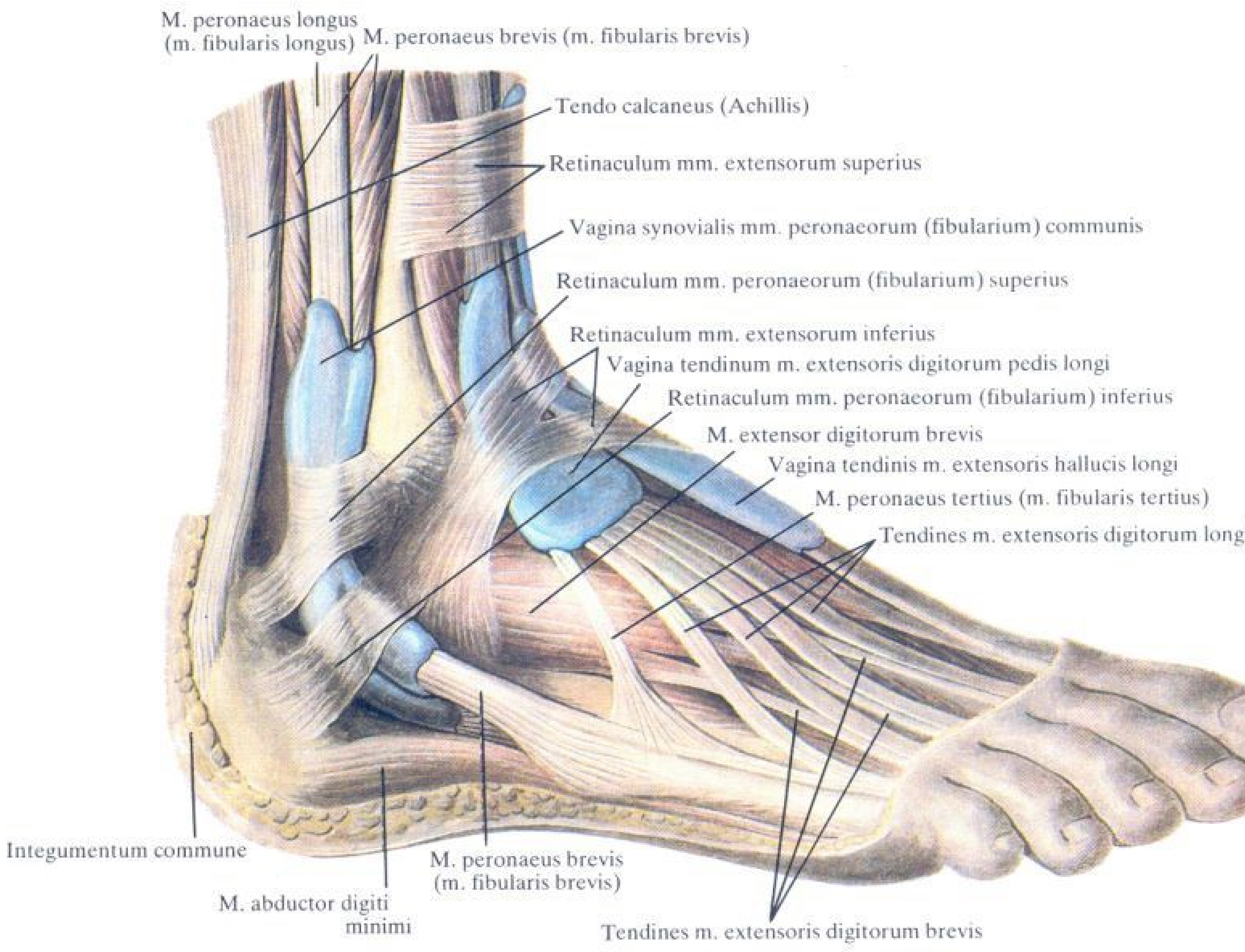
FASCIAE OF THE LEG

The fascia of the leg, which is called the **crural fascia** *(fascia cruris)* (see Figs 375, 384), is a direct continuation of the fascia lata but is much less conspicuous. It gives off two intermuscular septa, anterior and posterior, which penetrate deeply into the leg to form the fascial beds for the anterior, posterior, and lateral groups of muscles. It should be pointed out that the posterior fascial bed is subdivided by a frontal septum into a superficial and a deep seat. The **anterior intermuscular septum** *(septum intermusculare anterius)* separates the anterior group of muscles from the lateral group. The **posterior intermuscular septum** *(septum intermusculare posterius)* passes between the lateral and the posterior groups of muscles.

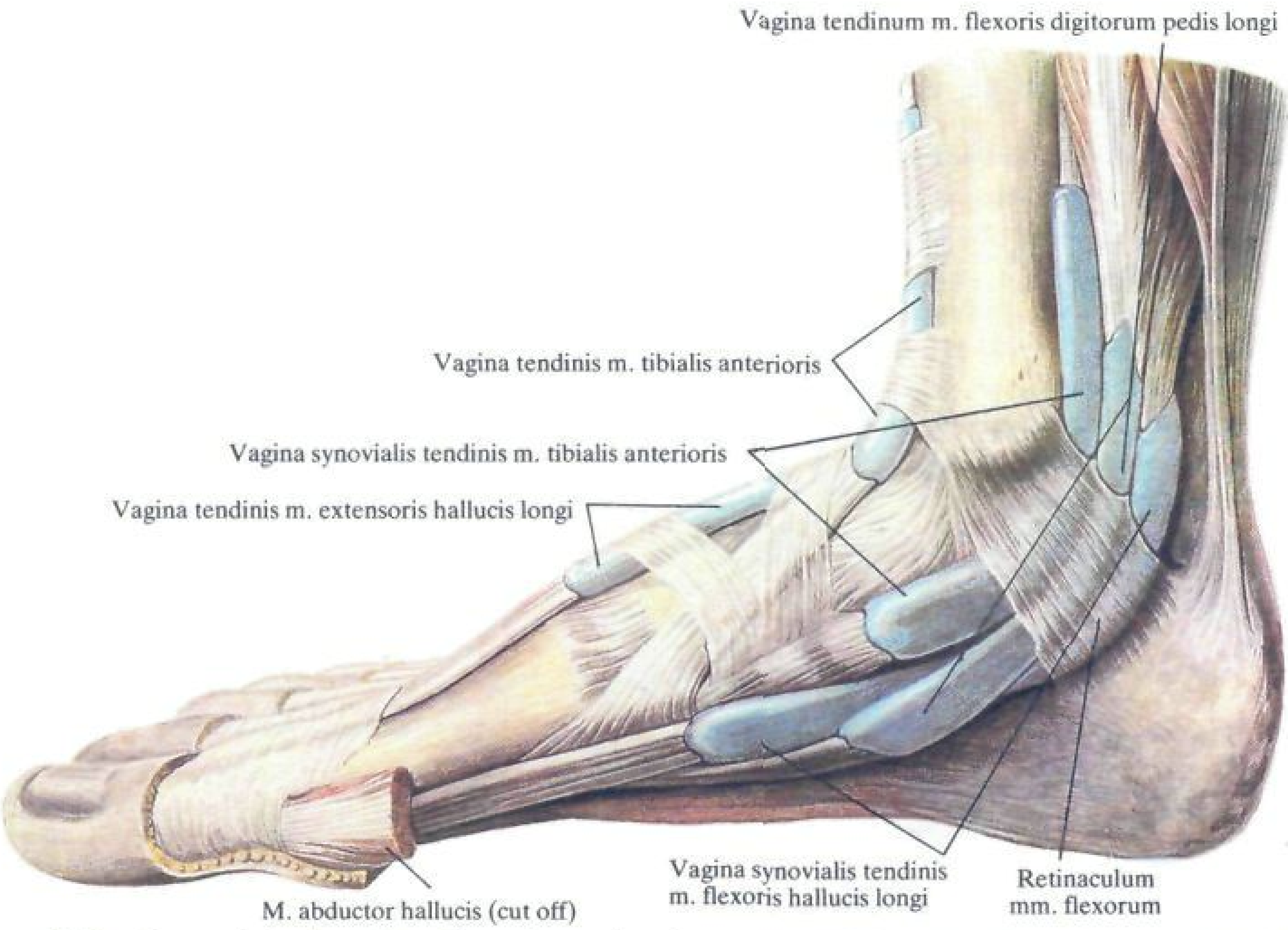
In the lower third of the anterior surface of the leg the crural fascia is poorly developed, as the result of which transverse bands are clearly distinguishable. They form the **superior extensor retinaculum** *(retinaculum musculorum extensorum superius)* which is stretched between the anterior border of the tibia and the lateral surface of the fibula.

In the lower third in the region of the malleolus the crural fascia forms a thickening called the **inferior extensor retinaculum** *(retinaculum musculorum extensorum inferius)* in which one lateral and two medial (superior and inferior) bands are distinguished.

On the lateral surface of the leg the fascia thickens slightly to



399. *Synovial sheaths of tendons (vaginae synoviales tendinum) on right foot*; dorsolateral surface (½).



400. *Synovial sheaths of tendons (vaginae synoviales tendinum) on right foot*; medial aspect (½).

form the **superior** and **inferior peroneal retinacula** *(retinacula musculorum peroneorum [fibularium] superius* et *inferius)*. Together with the bones of the leg and foot these ligaments hold the peroneus longus and brevis muscles in place. The superior retinaculum is stretched between the lateral malleolus and the calcaneus. Some of the bands of the retinaculum are interlaced into the deep layer of the crural fascia. The inferior retinaculum is located on the lateral surface of the calcaneus and forms osteofibrous canals lodging the tendons of the peroneus muscles.

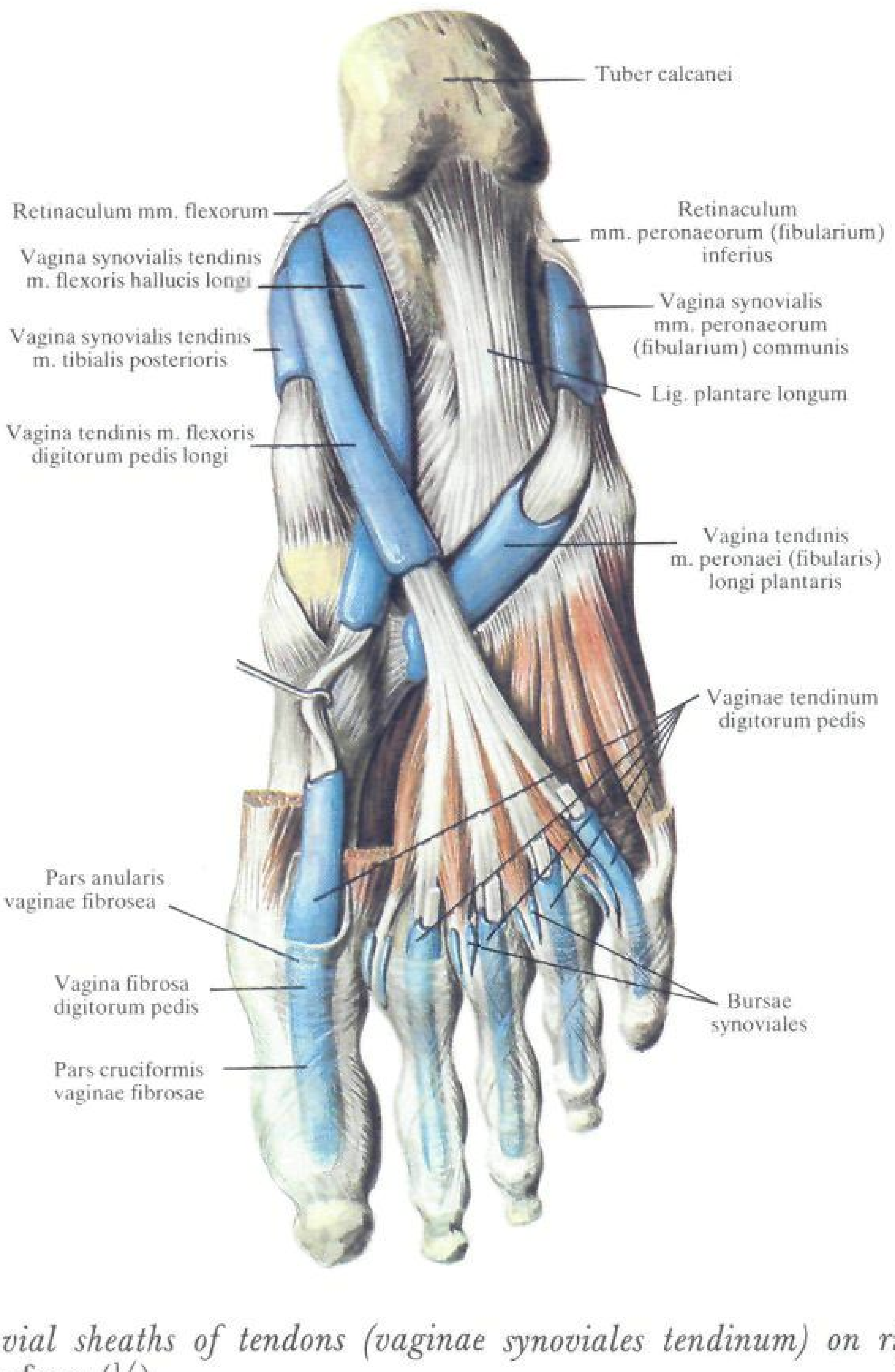
In the region of the medial malleolus the crural fascia thickens to form the **flexor retinaculum** *(retinaculum musculorum flexorum)* which stretches between the medial malleolus and the calcaneus. It assists in the formation of four separate fibrous canals.

Three of these canals transmit tendons: the medial canal transmits the tibialis posterior tendon, the lateral canal the flexor hallucis longus tendon, and the canal located between these two transmits the flexor digitorum longus tendon. The fourth canal lodges the posterior tibial artery and vein and the tibial nerve.

FASCIAE OF THE FOOT

The **fasciae of the foot** *(fasciae pedis)* (see Figs 375, 392) are a direct continuation of the crural fascia. The fascia on the dorsal surface of the foot is thin and attached to some points of the bones. Where there are muscles, the fascia separates into two layers to form sheaths for the superficial muscles of the dorsal surface of the foot. The deep layer of the fascia separates the interossei muscles from the extensors of the toes.

The superficial fascia is thicker on the plantar than on the dorsal surface. The middle part of the plantar fascia is very thick and is made up of longitudinal fibrous bands; it is called the **plantar aponeurosis** *(aponeurosis plantaris)*. In the distal part the fibrous bands forming the aponeurosis are directed transversely and are called the **superficial transverse ligaments** *(fasciculi transversi)*. Most of the fibres of the plantar aponeurosis arise from the posterior



401. *Synovial sheaths of tendons (vaginae synoviales tendinum) on right foot*; plantar surface (½).

surface of the calcaneum, run forwards, and separate into five slips according to the number of toes. On the way, the inner surface of the aponeurosis fuses with the flexor digitorum brevis muscle passing here. On the posterior surface of the calcaneum some bands of the aponeurosis are a continuation of the triceps surae tendon. The outer surface of the plantar aponeurosis is fused with the skin by means of separate connective-tissue bands. The spaces between the bands are filled with fatty tissue.

The deep plantar fascia fuses with the plantar surfaces of the metatarsals to form together with the dorsal fascia of the foot (fused with the dorsal surface of the metatarsals) four intermetatarsal spaces containing the interossei muscles.

The plantar aponeurosis and the deep fascia of the sole are joined by means of two longitudinal septa to form three fascial sheaths: medial, lateral, and intermediate. Each sheath contains the respective group of muscles of the plantar surface of the foot.

The **medial** and **lateral plantar grooves** *(sulcus plantaris medialis* et *lateralis)* lie on both sides of the middle sheath (Fig. 392).

SYNOVIAL SHEATHS OF MUSCLE TENDONS ON THE FOOT

Synovial sheaths (Figs 398-401) containing the long tendons of the leg muscles are located in the distal part of the leg and on the foot. Three anterior sheaths lying under the inferior extensor retinaculum are distinguished. The tendon of the tibialis anterior muscle lies in the medial sheath, the tendons of the extensor digitorum longus and peroneus tertius muscles are in the lateral sheath, and the tendon of the extensor hallucis longus muscle occupies the intermediate sheath.

The **common synovial sheath of the peroneal tendons** *(vagina synovialis musculorum peroneum [fibularium] communis)* is located on the lateral surface of the ankle joint under the superior peroneal retinaculum.

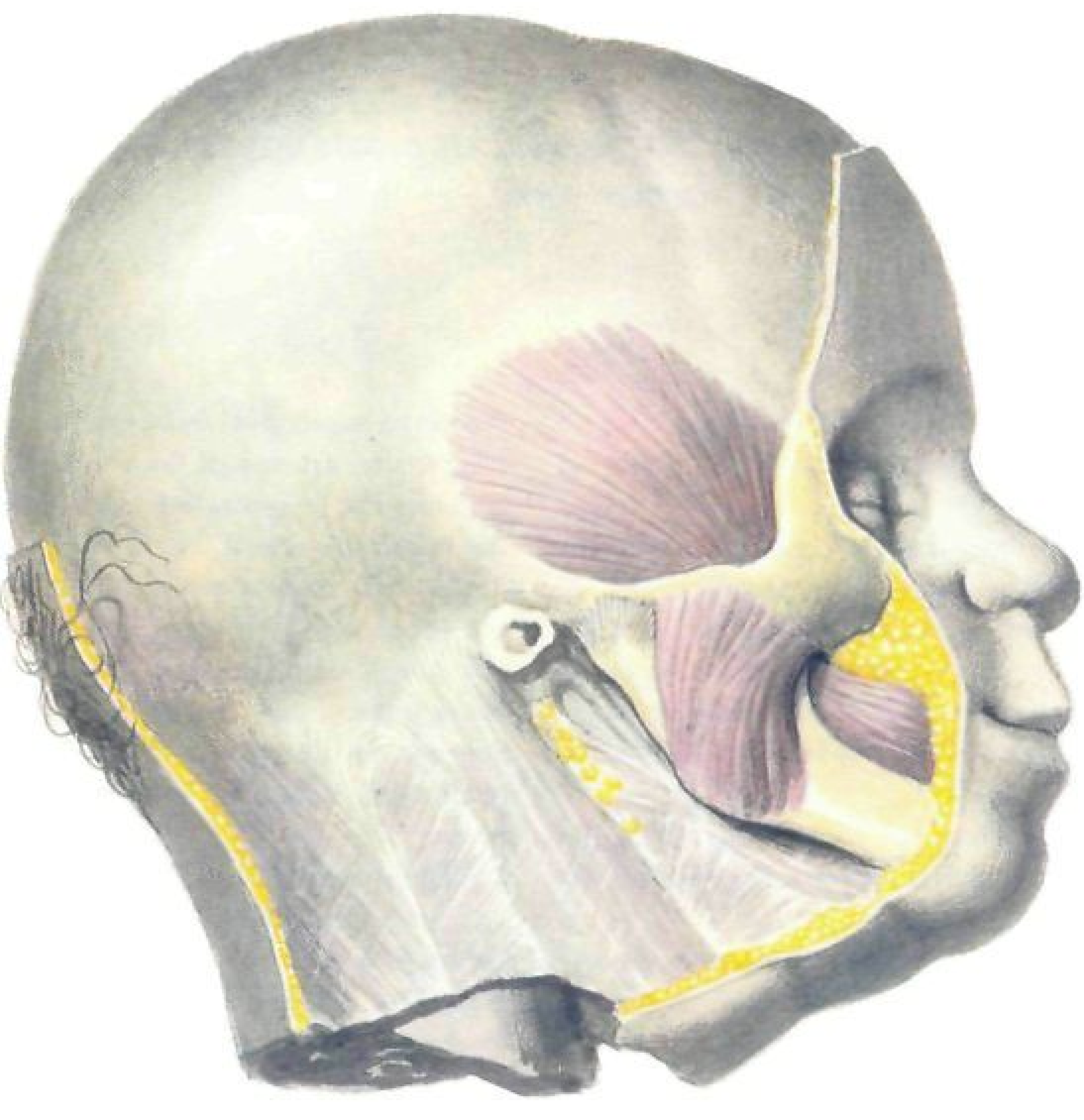
Three separate synovial sheaths are situated on the medial surface of the ankle joint under the flexor retinaculum. The **synovial sheath of the tibialis posterior tendon** *(vagina synovialis tendinis musculi tibialis posterioris)* lies directly behind the medial malleolus, slightly to the back is the **synovial sheath of the flexor digitorum longus tendon** *(vagina tendinis musculi flexorum digitorum pedis longi)*, and still further to the back is the **synovial sheath of the flexor hallucis longus tendon** *(vagina synovialis tendinis musculi flexoris hallucis longi)*.

On the plantar surface of the foot the **digital synovial sheaths of the tendons of the foot** *(vaginae tendinum digitales pedis)* are fused with the walls of the osteofibrous canals stretching on the plantar surface of the phalanges of the toes. The flexor digitorum tendons are lodged in these canals. The **synovial sheath of the extensor hallucis longus tendon** *(vagina tendinis musculi extensoris hallucis longus)* is the longest.

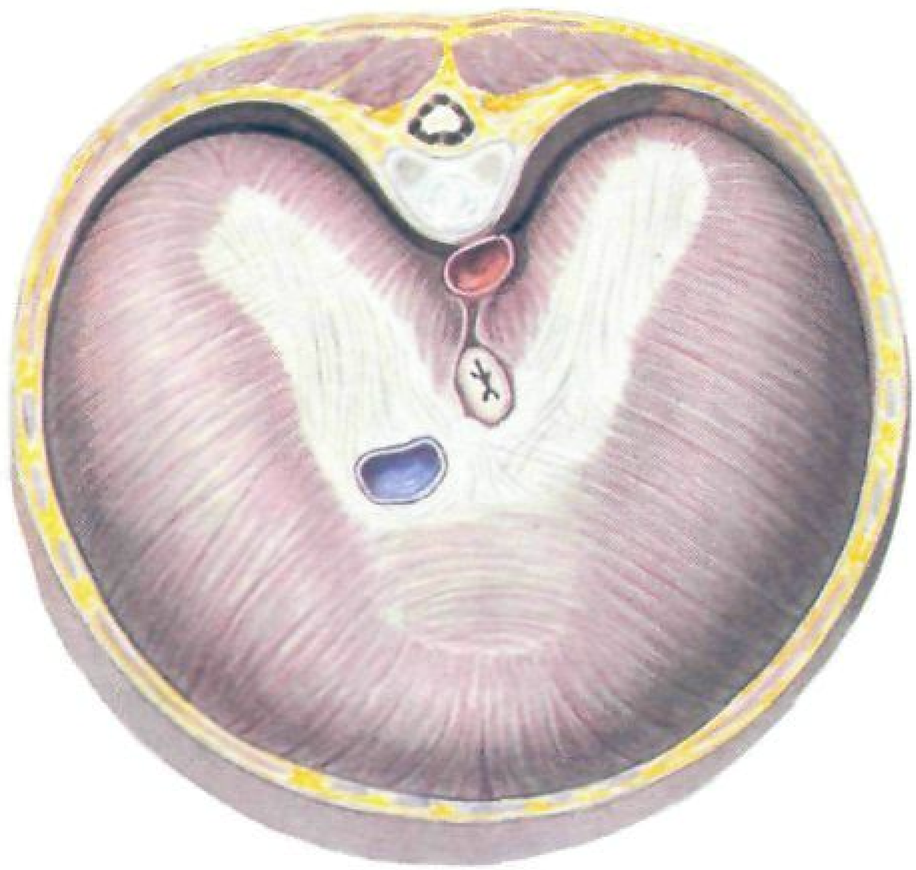
AGE FEATURES OF MUSCLES

The number of muscles in the newborn is the same as that in an adult; there are more than 650 of them. But macroscopic and microscopic differences exist which are relative to the mass and size of the muscles, their connection to the bones and skin, and the character of the intermuscular connective tissue. The muscles account for up to 40-45 per cent of the total body mass of a human adult and for 20 to 22 per cent of the total body mass of a newborn. This index considerably reduces at the age of 6-8 months (the beginning of the period of eruption of the teeth) and amounts to 16.6 per cent of the total mass, but again increases to 22 per cent by the age of 6 years.

The internal perimysium in the newborn is a fine-fibrillar con-



401a. *Temporal and masseter muscles (musculus temporalis et musculus masseter) on right side (in the newborn).*



401b. *Diaphragm (diaphragma)*; superior aspect *(in the newborn)*.

nective tissue. The external perimysium, which lies in contact with the subcutaneous fat, is loose and thus affords the skin a good range of mobility.

The organization of the tendinous part of a skeletal muscle is a very important feature with regard to age. Beginning from the neonatal period, the tendinous component forming the tendon of the muscle grows intensely with age; the existence of this component determines the definite relation of the muscle to the site of its insertion into the bone. This is one of the main factors affecting the function of the muscle.

Microscopically, the muscle fibres are slightly thinner in the newborn than in an adult, the nuclei are more spherical, and the transverse striations are less defined.

The muscles of some regions of the body have some specific features. For instance, the superficial fibres of the masseter muscle spread fan-wise in the adult but are almost parallel in the newborn. The masseter muscle forms actively beginning from the period of eruption of the deciduous teeth. The tendon of this muscle is also marked by a certain difference: it is very short in the newborn, but is almost half the length of the muscle in an adult (Fig. 401a).

The attachment of the temporal muscle is distinguished by topographo-anatomical features. In the newborn it is attached to the edge of the squama of the temporal bone, whereas in an adult it occupies the temporal fossa completely and its upper fibres reach the inferior temporal line of the parietal bone (see Fig. 401a).

Certain changes occur in the position of the diaphragm: under the effect of respiratory movements its height changes in the first place beginning from birth and this process continues with age because it is not only associated with inspiration and expiration but depends on the position of the liver, the extent to which the stomach is filled, and the individual features of the structure of the trunk.

The connective-tissue bands in the region of the central tendon, nearer to the sternal part of the diaphragm, have a semicircular position with the curvature directed towards the vertebral column (Fig. 401b). After birth the curvature is lost and the bands gradually take a sagittal direction.

In general, the skeletal muscles of an infant possess all the properties of these muscles of an adult, but the transverse striations are less defined, the fibres are rather thin, the nuclei are slightly spherical, the tendinous part is less pronounced, the area of muscle insertion is smaller, and there is a difference in the direction of the muscular bands.

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