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КОСТИ ТЕЛА ЧЕЛОВЕКА

BONES OF HUMAN BODY

Учебно-методическое пособие



Минск БГМУ 2024

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Ж34

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Содержит сведения о строении скелета, его частей и отдельных костей тела человека.

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обучающихся на английском языке.

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INTRODUCTION

The human **skeletal system**, or **skeleton**, in adults is composed of around 206 bones. The skeleton forms the internal framework of the body, which provides support for the soft tissues and protection of the internal organs, brain and spinal cord. The bones of the skeleton articulate with each other to form joints, provide attachment sites for skeletal muscles, and participate in body movements. Bones serve as a storage site for minerals and fats, as well as a source of blood cells.

The skeleton consists of the axial and appendicular skeleton. The **axial skeleton** includes the *skull*, *vertebral column*, *ribs*, and *sternum*. The **appendicular skeleton** includes *bones of the upper and lower limbs* (Fig. 1).

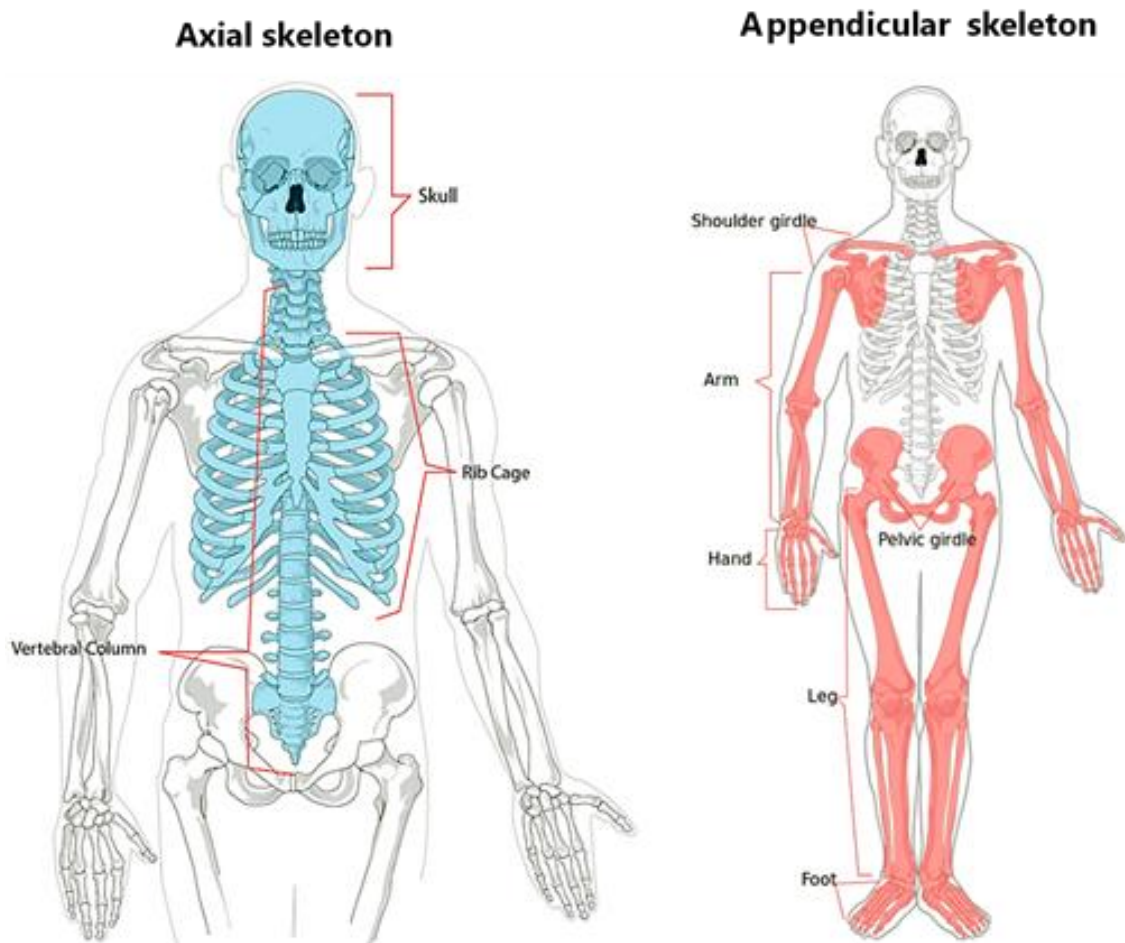


Fig. 1. Parts of human skeleton

The skeletal system is composed of *bones* (primarily) and *cartilages*. Cartilages contribute to formation of the skeleton of the nose, ear, and larynx.

Bone (*bony part of bone*) is a calcified connective tissue, which consists of *bone cells* (osteogenic cells, osteoblasts, osteocytes and osteoclasts) and an *extracellular matrix*. The matrix has an *organic component* (collagen fibers), which gives bones elasticity, and an *inorganic component* (composed of calcium salts, primarily calcium phosphate and lesser amounts of calcium carbonate), which gives bones hardness and strength.

There are 2 types of bone: **compact bone** (dense or cortical bone), formed by tightly packed cylindrical osteons, and **spongy bone** (trabecular or cancellous bone), formed by a network of trabeculae with spaces between them filled with red bone marrow (Fig. 2).

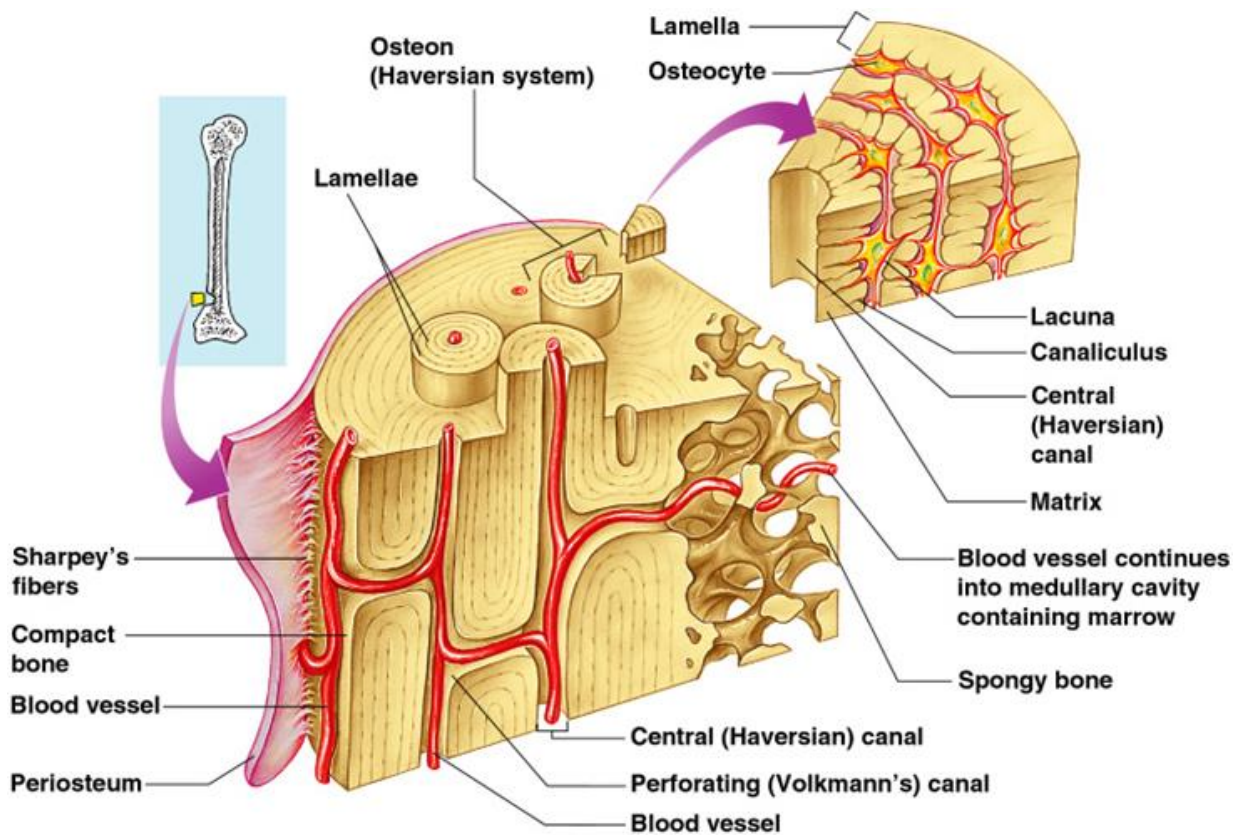


Fig. 2. Internal structure of bone

Red bone marrow is the site of hematopoiesis — the production of blood cells (red and white blood cells, platelets). **Yellow bone marrow** contains fat tissue and can serve as a source of energy. It occupies *medullary cavity* in the diaphysis of long bones.

The **endosteum** is a thin membrane that lines the wall of the medullary cavity and trabeculae of the spongy bone.

The surface of the bone is covered by a layer of dense fibrous connective tissue (*membranous part of bone*), called the **periosteum**. It contains blood vessels and sensory nerves whose branches supply the bone, as well as progenitor cells capable of forming new bone during appositional growth (“growth from outside”) and bone repair.

The surface of the bone facing the cavity of the synovial joints, called the **articular surface**, is covered with hyaline cartilage (*cartilaginous part of bone*). Cartilage is an avascular, semi-rigid type of connective tissue. **Articular cartilage** provides a smooth surface for articulating bones and resists compression during movement. In addition, hyaline cartilage is found in most growing bones and forms parts of the ribs.

CLASSIFICATION OF BONES

Bones are classified by their *shape* as:

1. *Long bones*. These are most bones of the limbs — bones of the arm, forearm, metacarpus, and fingers in the upper limb; and bones of the thigh, leg, metatarsus, and toes in the lower limb. A long bone has a tubular **diaphysis (shaft)** and two ends — the proximal and distal **epiphyses**. The diaphysis contains the **medullar cavity**, filled with yellow bone marrow (in adults) and surrounded by a thick layer of compact bone. The epiphyses are formed by spongy bone, their articular surfaces are covered with hyaline cartilage. The narrow area between the epiphysis and diaphysis is the **metaphysis**. In growing bones, this area contains a layer of hyaline cartilage — the *epiphyseal plate* (growth plate), which is eventually replaced by bone. **Apophyses** are bony outgrowths near the epiphyses that serve as attachment sites for ligaments and muscles.

2. *Short bones*. They are roughly cubic in shape and form the carpus (proximal part of the hand) and the tarsus (proximal part of the foot). Sesamoid bones (“like a sesame seed”) are a special type of short bones that develop inside a tendon. Examples are the patella and the pisiform bone. The short bones are made of spongy bone covered with a thin layer of compact bone.

3. *Flat bones*. They are thin, flattened and usually slightly curved, such as the ribs, sternum, scapula, and most cranial bones. The structure of flat bones is similar to that of short bones only the layer of spongy bone is much thinner.

4. *Irregular bone*. These are bones of various complex shapes that do not fit into the above categories, such as the vertebrae and hip bones.

5. *Pneumatized bones*. These are bones of the skull, which are hollow or contain many air cells — the frontal and ethmoid bones, maxilla, mastoid process of the temporal bone.

According to their development, bones are classified as *membranous (membrane bone)* and *endochondral (cartilaginous bone)*.

DEVELOPMENT OF BONES

The bones of the human skeleton are developed by two ways (Fig. 3):

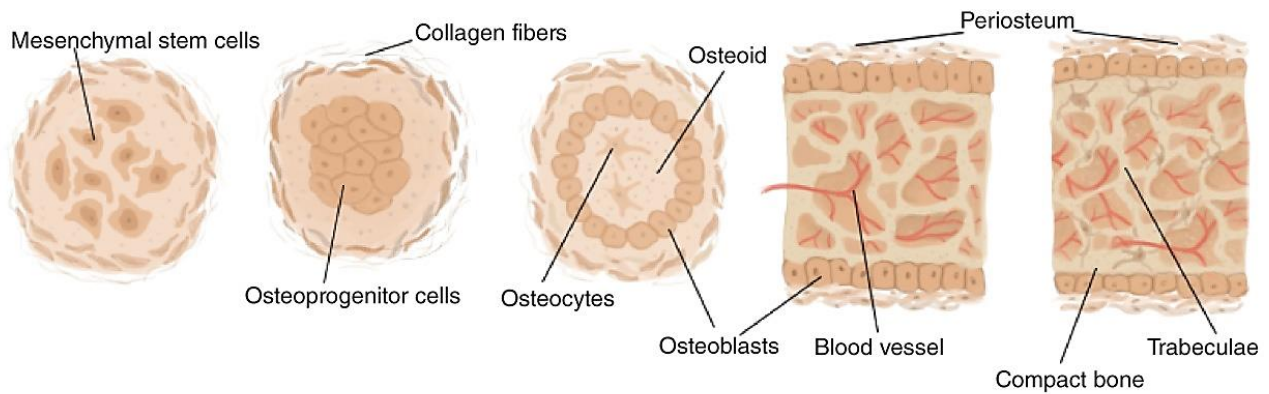
1. **Intramembranous ossification**, by which the flat bones of the skull, maxilla, mandible, and body of the clavicle are formed.

2. **Endochondral ossification**, by which the rest of the skeleton is formed, that is, the bones of the cranial base, chest, spine, and limbs.

– The first stage of both processes is the **condensation of mesenchymal progenitor cells**¹ at the sites of future bones, which occurs during the *2nd–3rd week* of prenatal development. In *intramembranous ossification*, the cells of the mesenchymal primordium directly differentiate into bone, whereas in *endochondral*

¹ Mesenchyme is embryonic connective tissue.

ossification, mesenchymal progenitor cells are first replaced by cartilaginous cells (in the 5th–6th weeks) to form a **hyaline cartilaginous model** of the bone.



Intramembranous ossification

Endochondral ossification

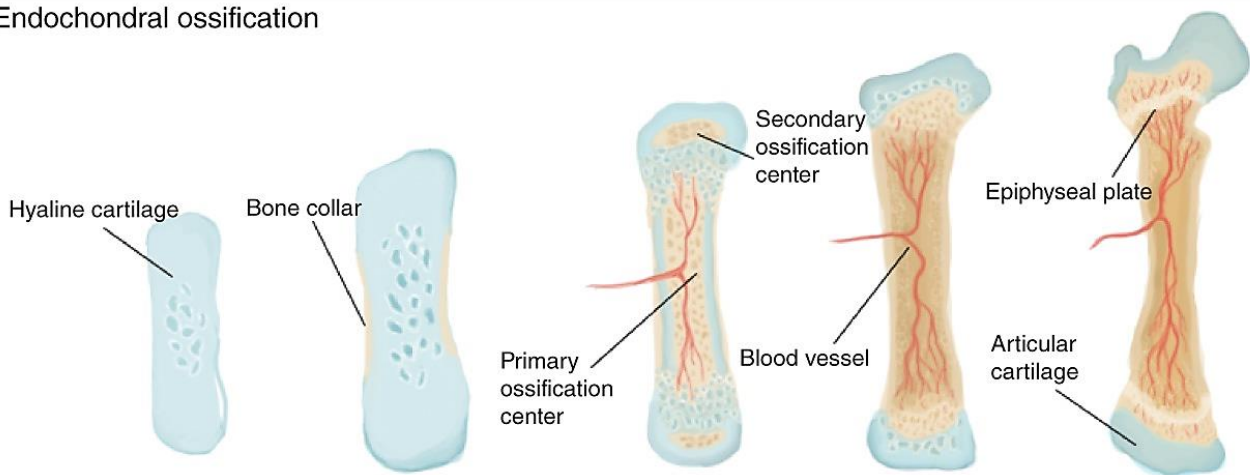


Fig. 3. Types of ossification

– By the 6th–7th week of embryonic life, **ossification begins**: in the membranous and cartilaginous primordia, clusters of osteoblasts appear, called *primary ossification centers*. As the bone grows, the area of ossification increases and eventually occupies the entire bone.

In long bones osteogenesis begins from *primary ossification centers* in the diaphysis. *Secondary ossification centers*, in the epiphyses, usually appear after birth or shortly before it.

– By the time the fetus is born, most of the skeleton has ossified. Only in the carpal bones and cuneiform bones of tarsus osteogenesis begins after birth. Throughout childhood and adolescence, the cartilaginous and membranous parts of the bones slowly grow and are gradually replaced by bone. Cartilage retained in the epiphyseal plates of long bones (between the diaphysis and epiphyses) allows them to grow in length. Longitudinal growth of the skeleton stops at around the age of 20, when the epiphyseal plates completely ossify.

AXIAL SKELETON

VERTEBRAL COLUMN

Vertebral column forms the skeleton of the neck and back, participates in formation of the pelvis and thoracic cage. It protects the spinal cord and spinal nerves; supports the weight of the head and trunk and transmits it to the pelvis and lower limbs; provides the central axis for the body; plays an important role in posture and movements of the trunk and head.

The vertebral column is usually composed of **33 vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, 4 coccygeal** (Fig. 4).

All vertebrae share a basic common structure.

Typical vertebra consists of the vertebral body in front and the vertebral arch behind:

– The **vertebral body** is the weight-bearing component, and its size increases as the vertebral column descends towards the sacrum. From the first sacral vertebra to the end of coccyx the size of vertebrae decreases.

– The **vertebral arch** is attached to the vertebral body by two **pedicles**. The upper portion of the vertebral arch, between the transverse and spinal processes, is called **lamina**.

The vertebral body and vertebral arch enclose the **vertebral foramen**. The succession of these foramina throughout the vertebral column forms the **vertebral canal**, which contains the spinal cord with its meninges and proximal parts of the spinal nerves.

The vertebral arch has a number of bony **prominences (processes)**, which serve as attachments for muscles and ligaments and sites of articulation with adjacent vertebrae:

– The **spinous process** projects posteriorly and generally inferiorly from the center of the vertebral arch;

– The **transverse processes** extend laterally from the pedicles;

– The **superior and inferior articular processes** articulate with the vertebrae above and below.

Semicircular recesses between the vertebral body and superior and inferior articular processes are called **superior and inferior vertebral notches**. The vertebral notches of two adjacent vertebrae combine to form the **intervertebral foramen** for passage of the spinal nerve and accompanying vessels.

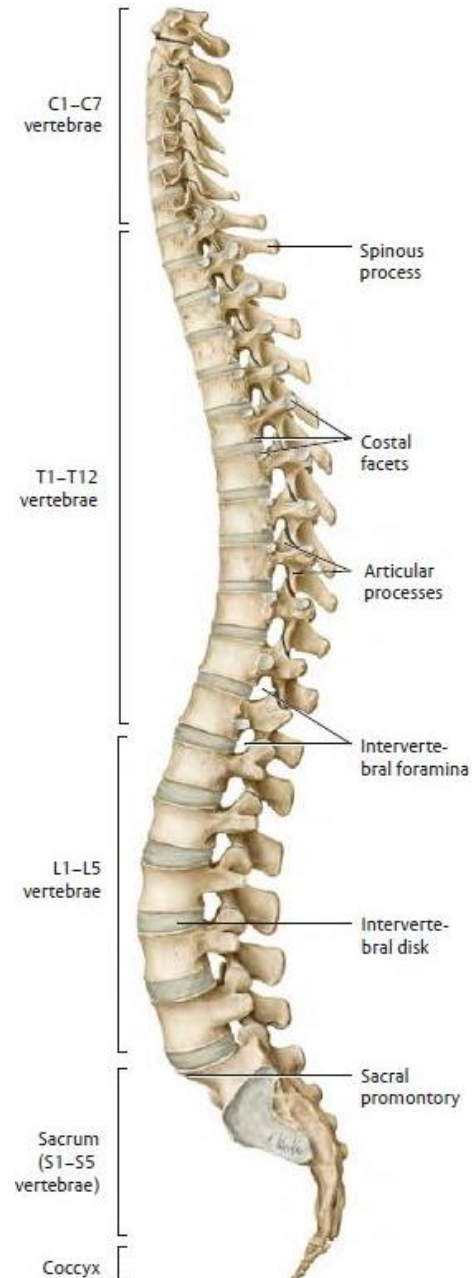


Fig. 4. Vertebral column

Cervical Vertebrae

A common feature for the cervical vertebrae (**vertebrae C1-C7**) is the presence of the **transverse foramen** (*foramen transversarium*) in the transverse processes for the passage of the vertebral artery (Fig. 5). The transverse process bears 2 tubercles:

- **anterior tubercle** (called the **carotid tubercle** in the vertebra C6);
- **posterior tubercle**.

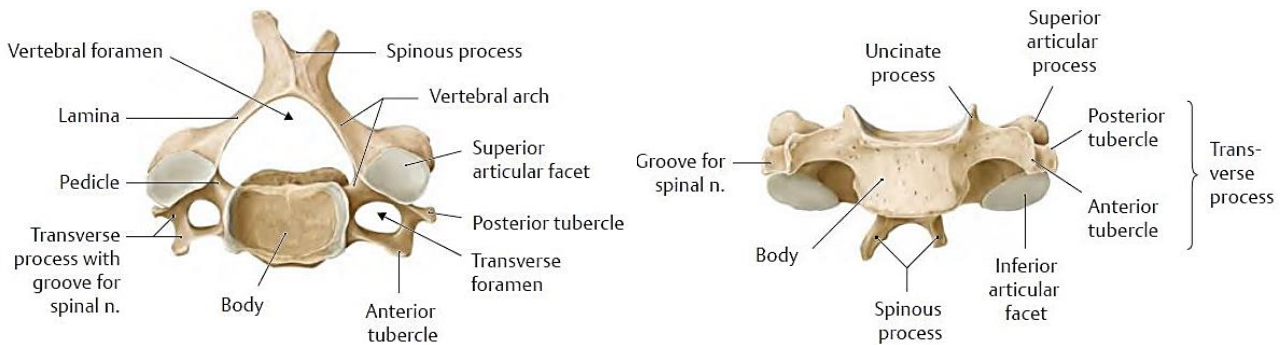


Fig. 5. Cervical vertebra

Distinctive features of the “typical” cervical vertebrae (from C3 to C6) are:

- short spinous process, which bifurcating at the tip;
- large triangular vertebral foramen.

The bodies of the cervical vertebrae are relatively small, shaped as a transverse oval. Lateral borders of their concave superior surface project upwards to form **uncinate processes (uncus of the body)**. Together with the narrow intervertebral foramina this increases the risk of spinal nerves compression.

The **vertebra prominens (vertebra C7)** reminds the upper thoracic vertebrae. It has a long protruding spinous process, which does not bifurcate.

The first 2 cervical vertebrae are specialized to allow for the movement of the head and are unique in structure.

The **atlas (vertebra C1)** supports the head (Fig. 6). It does not have a body and consists of the **anterior** and **posterior arches**, connected to each other by the **lateral masses**. Anterior arch is shorter and on the inner surface has a **facet for dens (fovea dentis)**. The outer surfaces of both arches have **tubercles**. Each **lateral mass** carries the deep **superior articular surface**, articulating with the condyle of the occipital bone, and the flat **inferior articular surface** for connection with the axis.

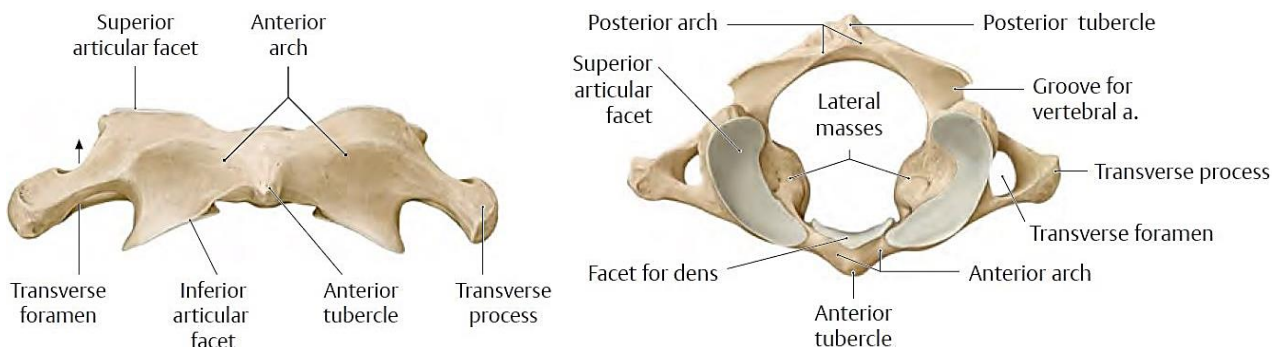


Fig. 6. Atlas

The **axis (vertebra C2)** serves as a pivot around which the atlas and head rotate (Fig. 7). Its body has a tooth-like process, the **dens**. The dens is the body of the atlas, fused with the axis during embryonic development.

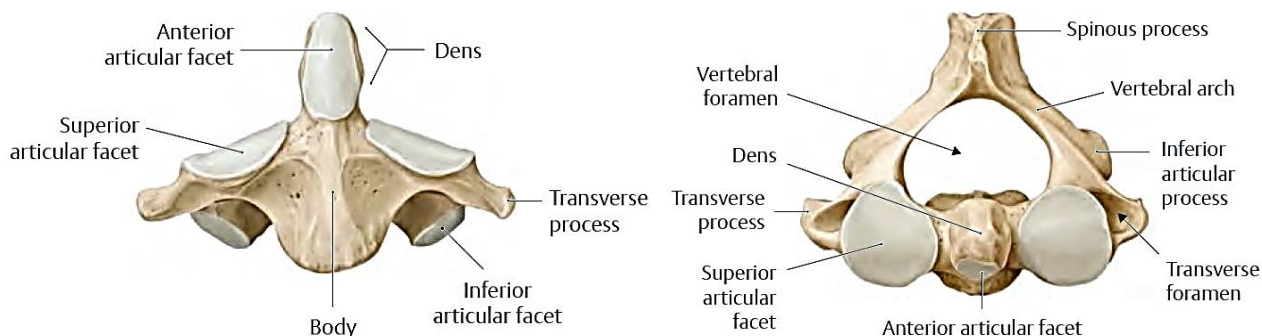


Fig. 7. Axis

Thoracic Vertebrae

The thoracic **vertebrae, T1-T12**, are characterized by the following features (Fig. 8):

- long downward *spinous processes*;
- frontally oriented *articular processes*;
- relatively large *bodies*;
- small *vertebral foramina* compared to the cervical and lumbar vertebrae;
- *costal facets* articulating with the ribs.

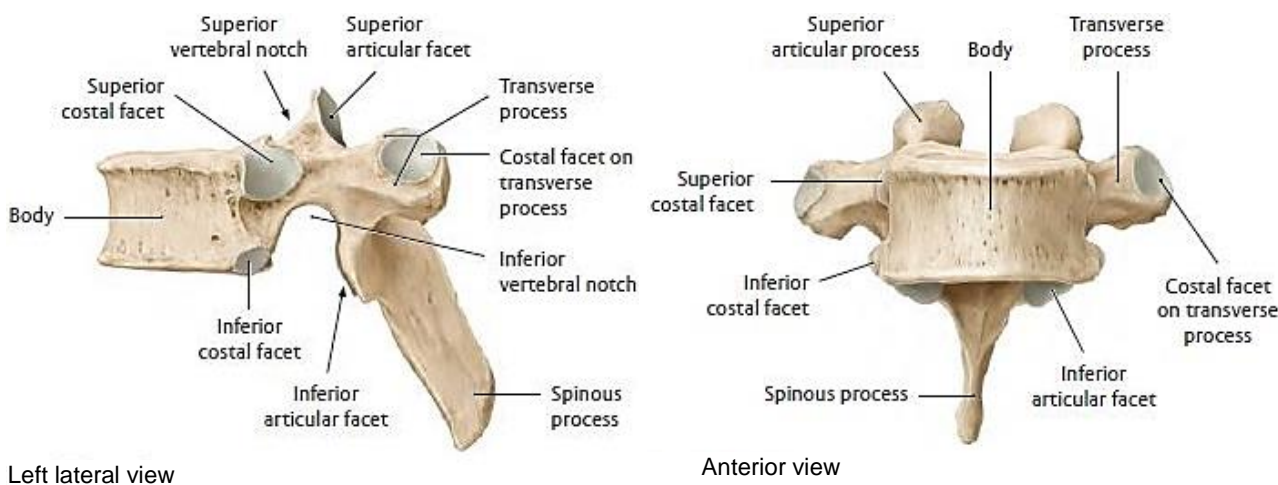


Fig. 8. Thoracic vertebrae

Since the head of the rib usually articulates with two adjacent vertebrae, each side of the *vertebral body* has 2 costal facets:

- the **superior costal facet** for the respective rib;
- the **inferior costal facet** for the underlying rib.

Only vertebrae T 10–12 have one costal facet for the corresponding rib.

The *transverse processes* direct laterally and posteriorly and have the **transverse costal facets** articulating with the tubercles of the respective ribs.

Lumbar Vertebrae

The lumbar vertebrae, **L1–L5**, have the following features (Fig. 9):

- massive kidney-shaped *body*;
- larger *vertebral foramen* than in the thoracic vertebrae;
- *spinous process* directed horizontally posteriorly;
- *articular processes* turned in the sagittal direction.

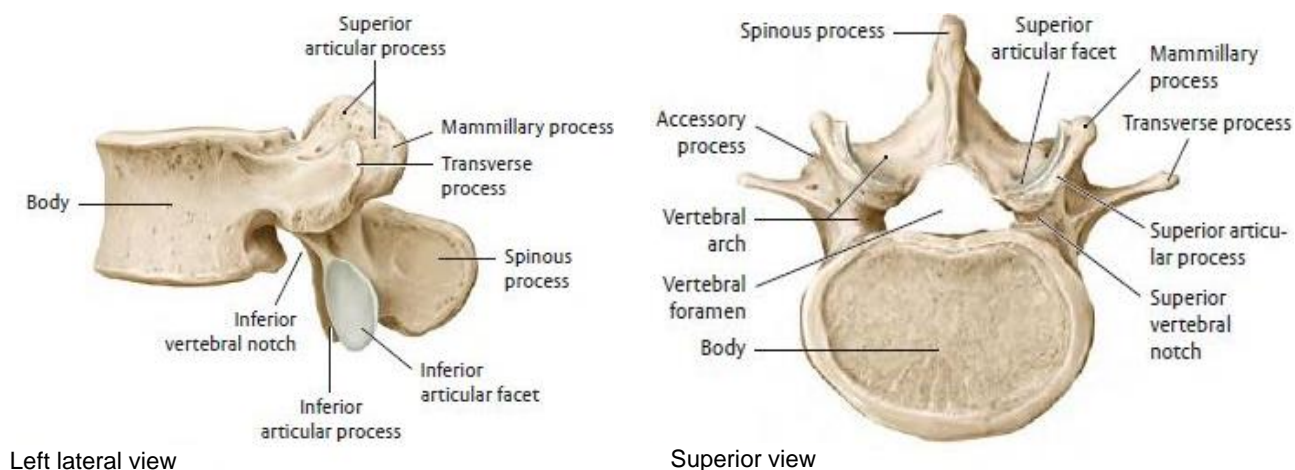


Fig. 9. Lumbar vertebra

On the vertebral arch, the lumbar vertebrae have two additional processes: the accessory and mammillary processes.

Sacrum

The **sacral vertebrae (S1–S5)** of adults are fused to form the triangular bone, the **sacrum** (Fig. 10). The sacrum has a wide upper part, the **base**, a pointed inferior end, the **apex**, massive **lateral parts**, and two surfaces — the anterior **pelvic surface** and posterior **dorsal surface**.

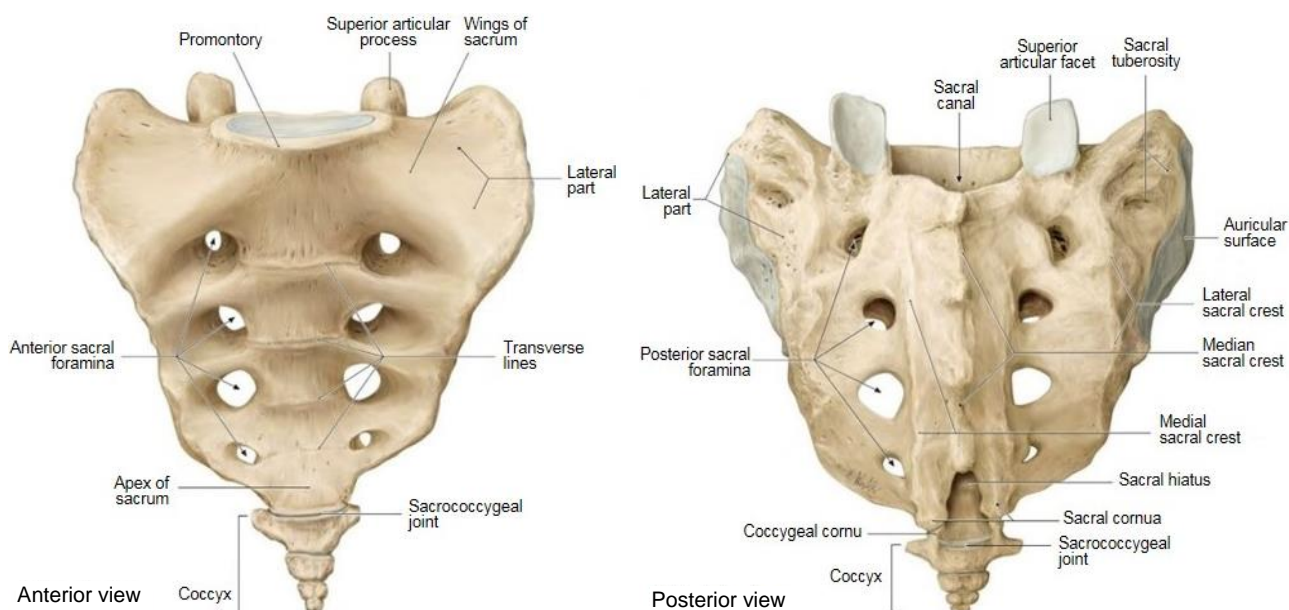


Fig. 10. Sacrum

The *base of sacrum* carries the **superior articular processes** of the first sacral vertebra. The prominent anterior edge of the base is the **promontory**.

The *lateral parts of sacrum* bear ear-shaped **auricular surfaces** that form the sacroiliac joints, and the **sacral tuberosities** located posterior to them for the attachment of ligaments.

The *pelvic surface of sacrum* is smooth and concave. It has four **transverse ridges** — sites of fusion of the sacral vertebrae, and four pairs of the **anterior sacral foramina**.

The *dorsal surface of sacrum* has the **posterior sacral foramina** and 5 ridges: the unpaired **median sacral crest**, and paired **intermediate** (located medial to the posterior foramina) and **lateral sacral crests**. The crests are formed by the fusion of the spinous, articular and transverse processes, respectively.

The **sacral canal** passes through the sacrum. The **intervertebral foramina** on its sides serve for the passage of the sacral spinal nerves, the anterior and posterior rami of which emerge from the corresponding sacral foramina. The lower end of the sacral canal opens with the **sacral hiatus**, bounded on the sides by the **sacral horns (sacral cornua)** (inferior articular processes of the vertebra S5).

Coccyx

The **coccyx** is a small triangular bone typically formed by 4 rudimentary **coccygeal vertebrae**. They lack vertebral arches and vertebral canal. The last 3 vertebrae are usually fused (Fig. 11).

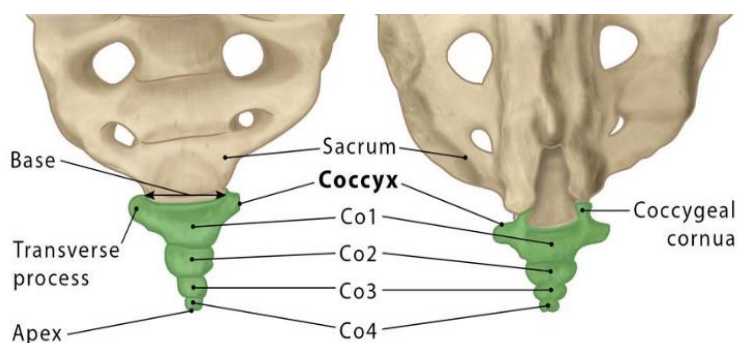


Fig. 11. Coccyx

BONES OF THORAX

Ribs

The 12 pairs of ribs (*Lat. costae*) make up most of the thorax (Fig. 12):

- **True ribs** (*Lat. costae verae*), the upper 7 pairs of ribs, connect to the sternum.
- **False ribs** (*Lat. costae spuriae*), the lower 5 pairs of ribs, do not articulate with the sternum. Of them:

- The ribs 8 to 10 are attached by their cartilaginous ends to the ribs above and form the *costal arch*;

- The ribs 11 and 12, **floating ribs** (*Lat. costae fluctuantes*) articulate only with the vertebrae.

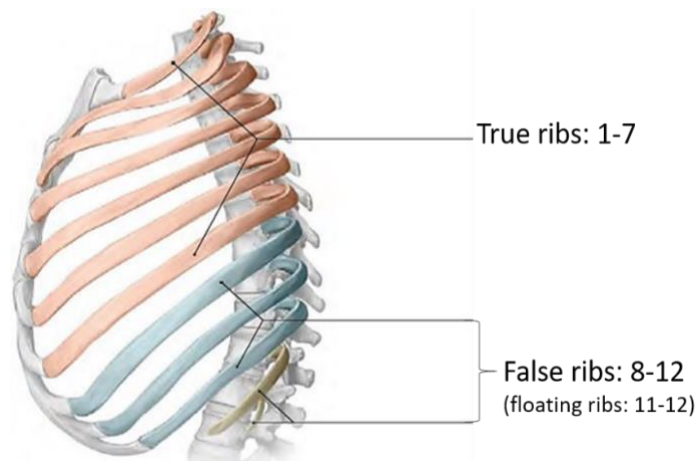


Fig. 12. Types of ribs

Each rib consists of two parts: the **bone** posteriorly and the **costal cartilage** anteriorly (Fig. 13).

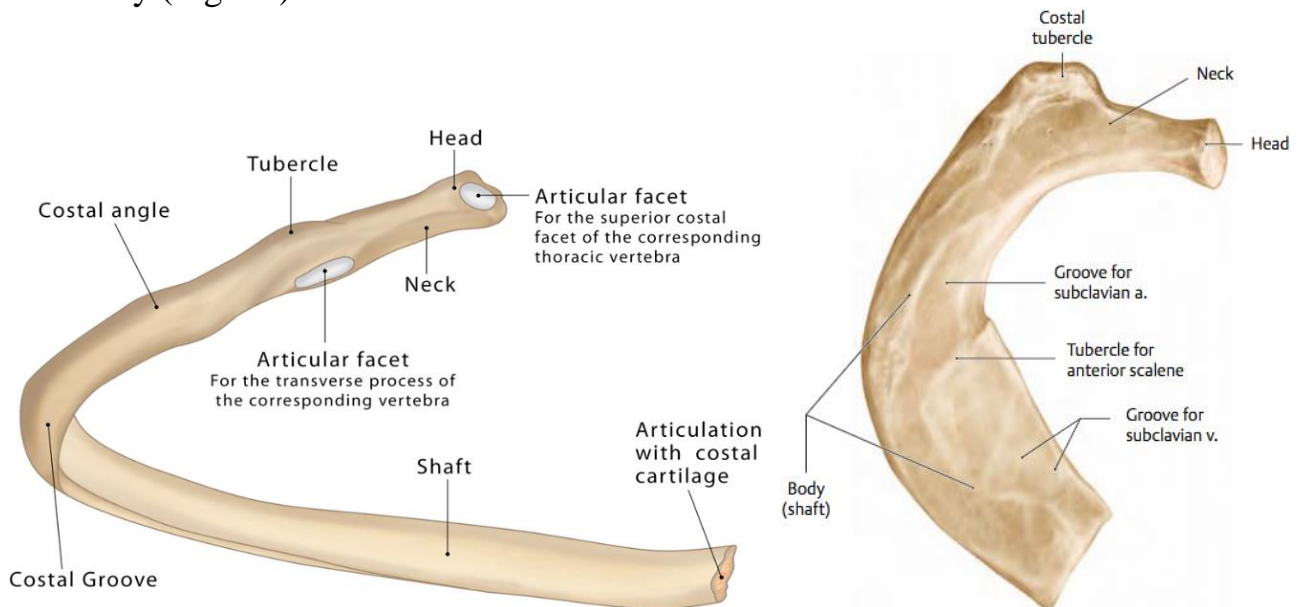


Fig. 13. Ribs (on the right — 1st rib)

The bony part consists of 3 main parts: **head, neck and body**.

The **head of rib** (*Lat. caput costae*) is the posterior end of the rib. In most ribs (except the ribs 1, 11 and 12) it articulates with two adjacent vertebral bodies and has two articular facets separated by the **crest of head of rib**.

The **neck of rib** (*Lat. collum costae*) is a short flat part of the rib. It ends by the **tubercle** at the junction with the body. The tubercle articulates with the transverse process of the corresponding vertebra.

The **body of rib** (shaft) (*Lat. corpus costae*) is a longer flat part of the rib, having outer and inner surfaces, and curved downward and forward. The curvature of the body changes lateral to the tubercle, at the **angle of rib**. The upper margin of the body is rounded. The lower margin is sharp and has a distinct **costal groove** along the inner surface for adjacent vessels and nerves.

The **first rib** differs from the other ribs. It is flattened in the horizontal plane; therefore, it has superior and inferior surfaces, lateral and medial edges. The **tubercle of the first rib** is located on its lateral edge and coincides with the **angle**. The inferior surface of the body is smooth. On the superior surface, closer to the medial margin, there is the **scalene tubercle**, which separates two shallow grooves: the **groove for subclavian vein** anteriorly, and the **groove for subclavian artery** posteriorly (Fig. 13).

Sternum

The **sternum** (breastbone) is a flat bone situated in the middle of the anterior aspect of the thorax. The sternum consists of 3 parts: the **manubrium**, **body of sternum**, and **xiphoid process** (Fig. 14). In children, these parts are connected by cartilages that mostly ossify during adulthood.

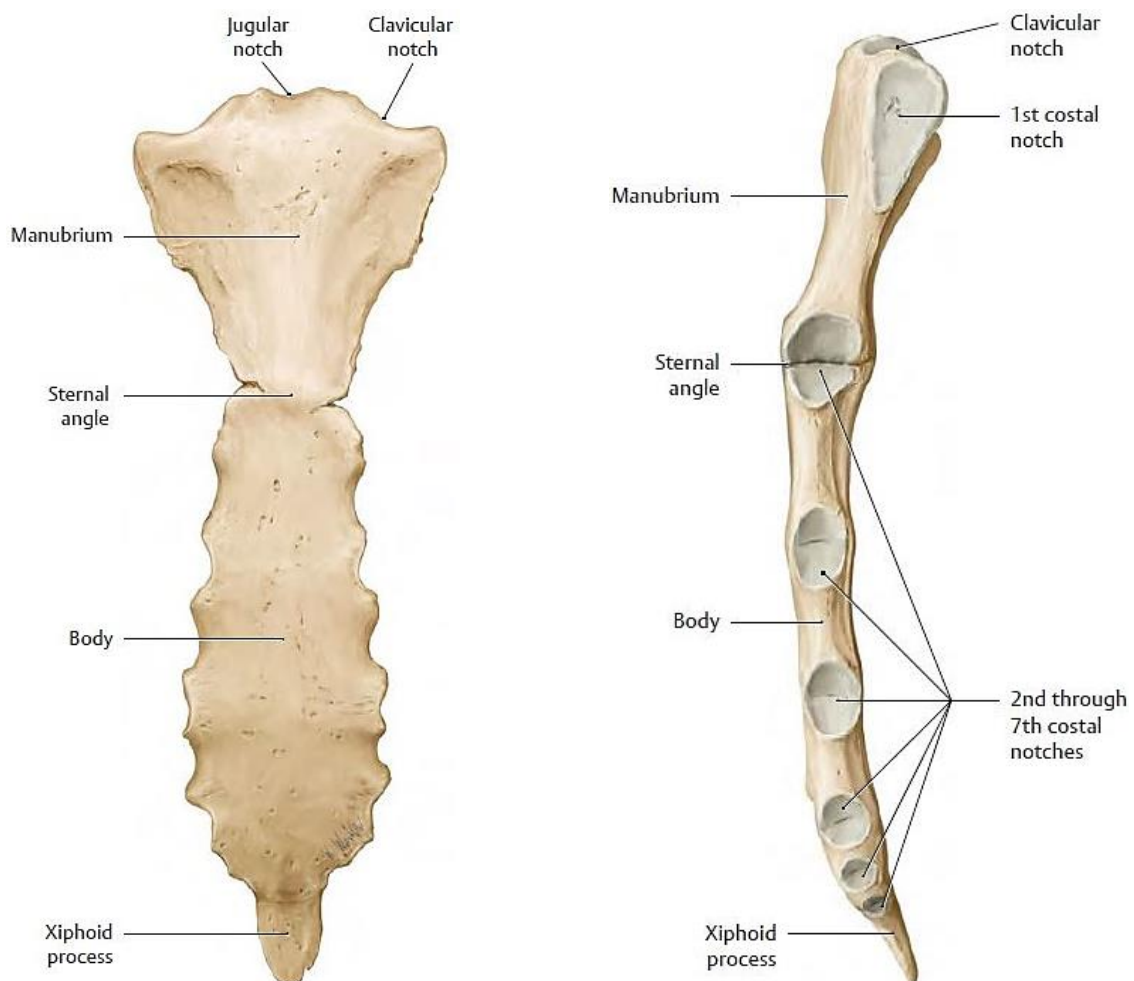


Fig. 14. Sternum

The **manubrium** is the upper, wider part of the sternum. It has several notches along the edges:

- **jugular notch** on the upper edge;
- **clavicular notches** for the clavicles, on either side of the jugular notch;
- **costal notches** for the first ribs cartilages, on the lateral margins below the clavicular notches.

The *costal notch for the second costal cartilage* is located at the junction of the manubrium and the body of sternum. At this point, the **sternal angle** is formed, slightly directed forward.

On the sides of the **body of sternum**, are the *costal notches* for the ribs 3 to 6; and that for the 7th rib lies at the junction with the xiphoid process.

The **xiphoid process** is the smallest part of the sternum, variable in shape and size. It can retain a cartilaginous structure in adults and is completely ossified around the age of 40.

THORACIC SKELETON

The **thoracic skeleton (thoracic cage)** is formed by the 12 pairs of ribs separated by the **intercostal spaces**, the thoracic part of the vertebral column, and the sternum. It surrounds the **cavity of bony thorax**, protects the thoracic organs and is involved in breathing. The **pulmonary grooves** run vertically on both sides of the vertebral column.

The **superior thoracic aperture (thoracic inlet)** is bounded by the upper border of the sternum, first ribs on the sides, and the first thoracic vertebra posteriorly.

The **inferior thoracic aperture (thoracic outlet)** is limited by the xiphoid process of the sternum, the right and left costal arches, the 11th and 12th ribs on both sides, and the 12th thoracic vertebra. The thoracic outlet is wider in the transverse direction than from front to back. It is closed by the diaphragm that separates the thoracic and abdominal cavities.

The **costal arch** is formed by the connecting cartilages of the ribs from the 7th to 10th. An area bounded by the costal arches and the xiphoid process is called the **infrasternal (subcostal) angle**.

CRANIUM (SKULL)

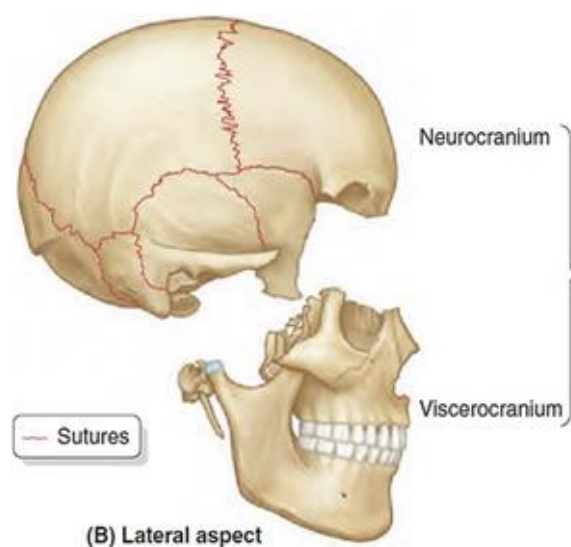


Fig. 15. Cranium

The **cranium**, or **skull**, is the skeleton of the head, which consists of 23 bones (excluding the hyoid bone and auditory ossicles). It houses the brain, sense organs, the upper parts of the respiratory and digestive systems, provides support for facial structures, and area for the attachment of many muscles.

The cranium can be subdivided into the **neurocranium**, and the **facial skeleton**, or **viscerocranium** (Fig. 15).

The upper dome-shaped part of the cranium is called the **calvaria** (cranial vault). The calvaria and the **cranial base** (*syn.* **basicranium**) surround the **cranial cavity** containing the brain.

The *facial skeleton* forms the antero-inferior part of the skull. The mandible and hyoid bone are not directly connected to other bones of the skull and are classified as **extracranial bones**.

The bones surrounding the cranial cavity and forming the *neurocranium* are:

- Frontal bone (1)
- Occipital bone (1)
- Sphenoid bone (1)
- Parietal bone (2)
- Temporal bone (2)
- Ethmoid bone (1)

The bones of the *facial skeleton* are:

- Maxilla (2)
- Mandible (1)
- Zygomatic (2)
- Nasal (2);
- Lacrimal (2)
- Palatine (2)
- Inferior nasal concha (2)
- Vomer (1)

Frontal Bone

The **frontal bone** (*Lat. os frontale*) is unpaired bone which forms the forehead and participates in formation of the orbits and nasal cavity. It consists of the **squamous part**, **orbital part**, and **nasal part** (Fig. 16).

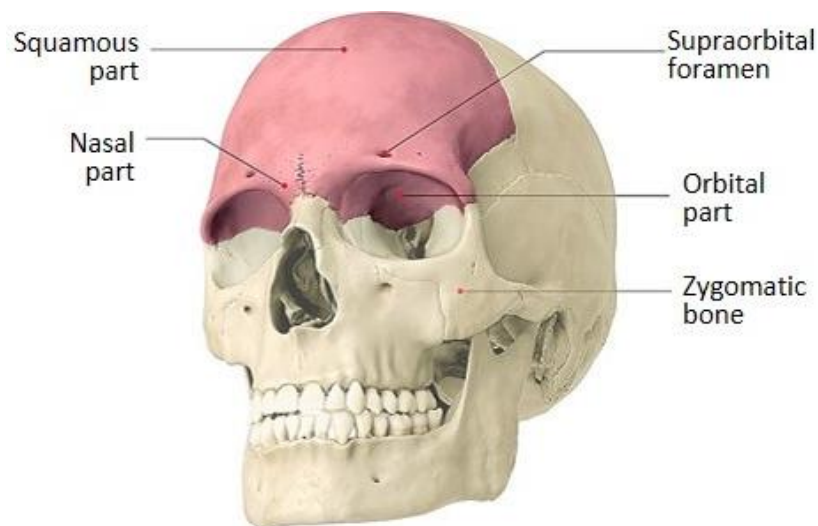


Fig. 16. Position of the frontal bone in the skull

The *squamous part* is oriented vertically and forms the forehead (Fig. 17). In some cases, the **frontal (metopic) suture** remains in the midline. The squamous part houses an air cavity, the **sinus of frontal bone** (*syn. frontal sinus*), which extends along its lower edge from the midline to varying distances. Usually it is divided by a septum into two chambers.

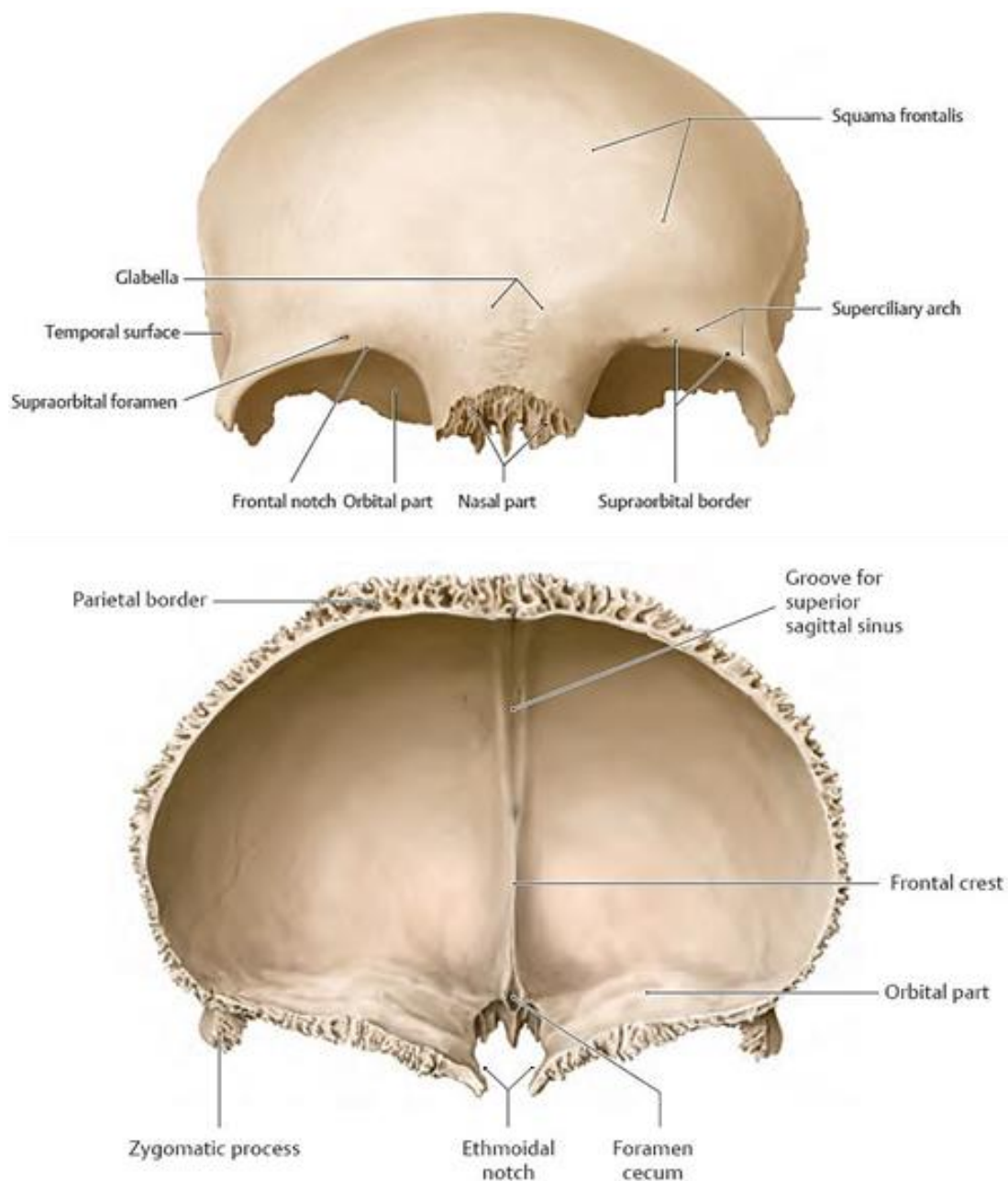


Fig. 17. Frontal bone: squamous part

The *external surface of squamous part* has a rounded elevation in its either side — the **frontal eminence** (*syn.* **frontal tuber**).

The **supraorbital margin** is the lower edge of the squamous part. Closer to the medial end, it carries the **supraorbital notch (foramen)** and, medial to the latter, the inconstant **frontal notch (foramen)**. Laterally, the supraorbital margin it continues into the **zygomatic process**. The **temporal line** runs from the zygomatic process upward and backward limiting the **temporal surface**.

Thickened ridges, the **superciliary arches**, lie above the supraorbital margins. In the middle they are joined by a smooth elevation, the **glabella**.

The *internal surface of squamous part* has a ridge in the midline, the **frontal crest**, that continues upward as the **groove for sagittal sinus**. A small notch at the lower end of the crest forms the **foramen cecum** together with the ethmoid bone.

On the sides of the midline the **granular foveolae**, **impressions of cerebral gyri**, and **eminences of cerebral sulci** are visible.

The **orbital part** consists of two horizontal **orbital plates** forming the roof of the orbits (Fig. 18). The *orbital surface* of each plate has the deep **fossa for lacrimal gland** (*syn. lacrimal fossa*) in the lateral portion, and the shallow **trochlear fovea** in the medial part. On the *cerebral surface* there are pronounced impressions and eminences for the adjacent brain.

The **ethmoidal notch** is located between the orbital plates. Its edges cover the upper cells of the ethmoid bone.

The **nasal part** is a small area anterior to the ethmoidal notch with a **nasal spine** in the middle and the **opening of frontal sinus** on its either side (Fig. 18).

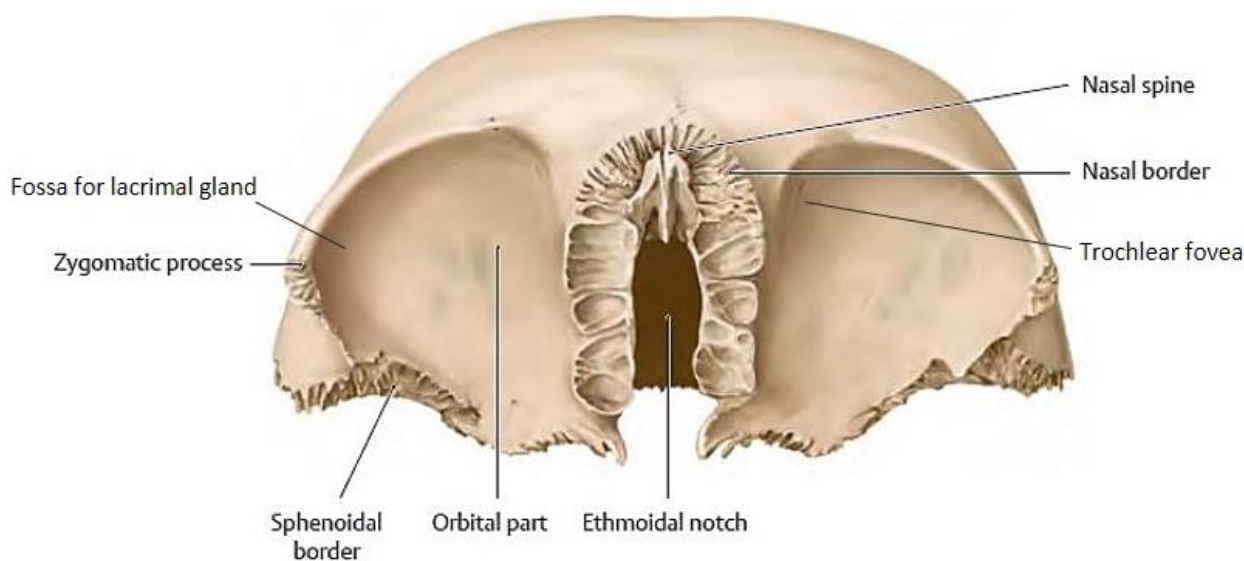


Fig. 18. Frontal bone: orbital and nasal parts (inferior view)

Occipital Bone

The **occipital bone** (*Lat. os occipitale*) contributes to the posterior part of the neurocranium. It consists of 4 parts surrounding the **foramen magnum**: the **squamous part**, **basilar part**, and two **lateral parts** (Fig. 19).

Squamous part: The *external surface* of this part bears several attachment sites for muscles and ligaments. The **external occipital protuberance** is in the center. On both sides of it are horizontal ridges, the **superior nuchal lines**, and above it the small **supreme nuchal line**. The **inferior nuchal lines** are on either side of the **external occipital crest** running downward from the external occipital protuberance to the foramen magnum.

The *internal surface* in the middle has the **internal occipital protuberance**, which is the center of the **cruciform eminence**. The latter is formed by the **internal occipital crest** (with the **groove for occipital sinus**) running down the midline; the **groove for superior sagittal sinus** going upward; and the **grooves for transverse sinus** lying on either side of the protuberance.

Lateral parts: On the external surface, each lateral part has the **occipital condyle** for articulation with the atlas. The **condylar fossa** with a small **condylar**

canal is behind the condyle. The **hypoglossal canal** pierces the bone above the occipital condyle.

The **jugular process** projects laterally. The **jugular notch**, located on its anterior border, surrounds the **jugular foramen**. A depression on the inner surface of the jugular process is a part of the **groove for sigmoid sinus**.

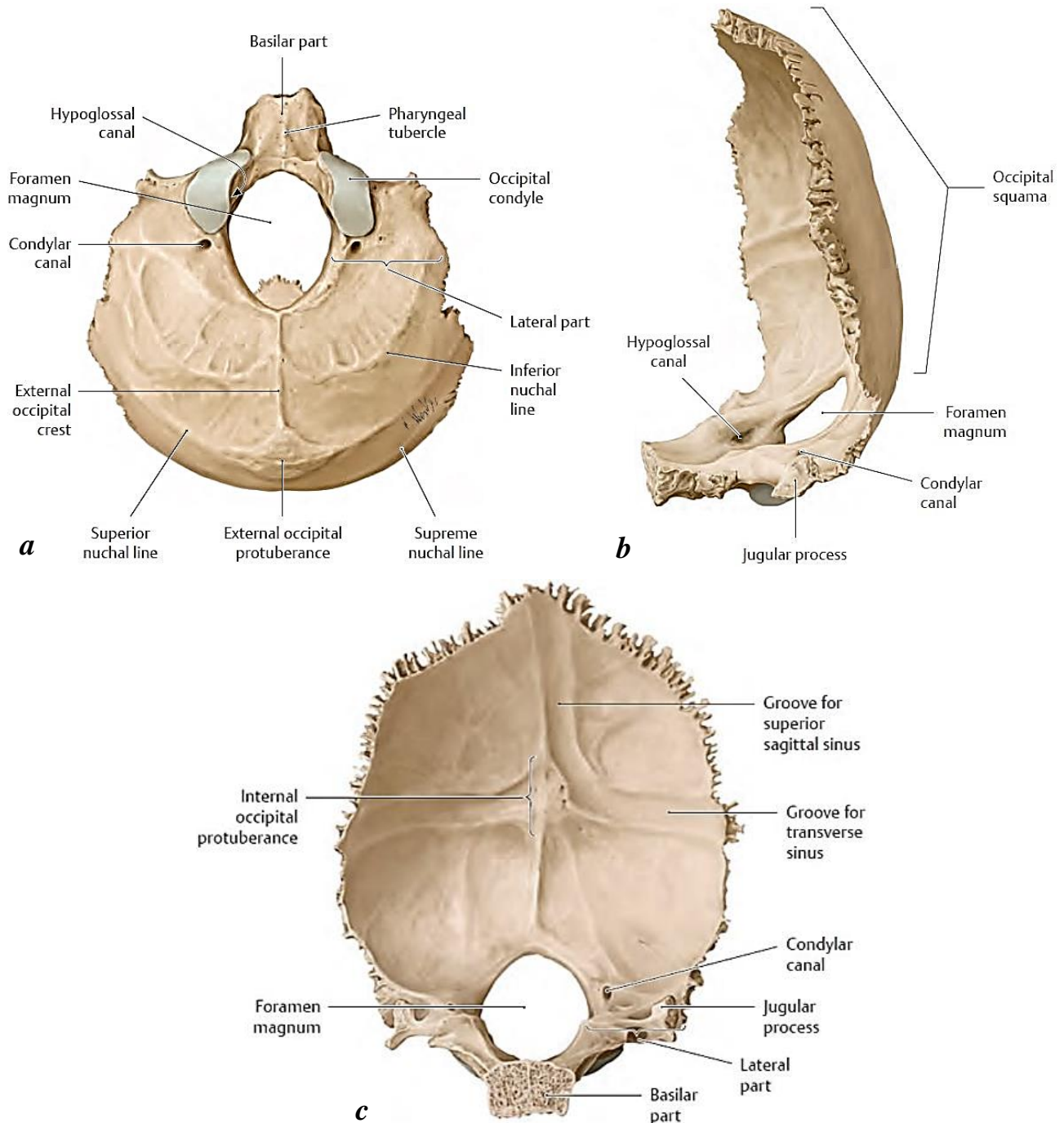


Fig. 19. Occipital bone: external (a), lateral (b), and internal view (c)

Basilar part: Its external surface forms the vault of the pharynx and has the **pharyngeal tubercle**. The internal surface is concave and forms a wide groove, the **clivus**, together with the body of sphenoid bone.

Parietal Bone

The right and left **parietal bones** (*Lat. os parietale*) are connected in the midline and contribute to the superolateral parts of the calvaria. The parietal bone is squared in shape and has 4 angles and 4 borders (Fig. 20).

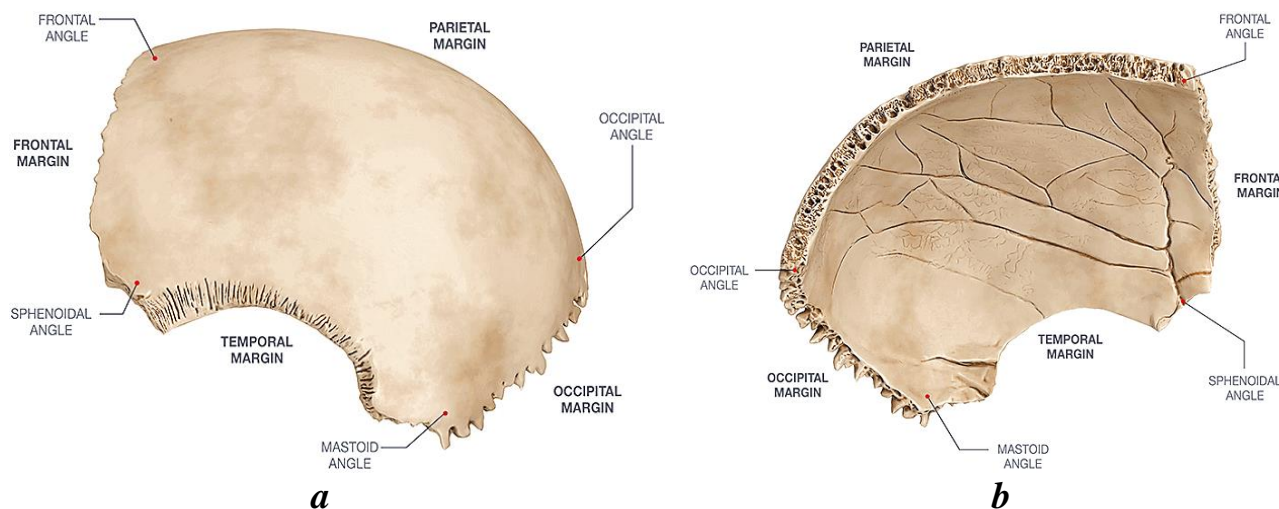


Fig. 20. Parietal bone: external (a), and internal (b) view

Borders:

- Superior, **sagittal border**, forms the sagittal suture with the other parietal bone;
- Anterior, **frontal border**, connects with the frontal bone;
- Posterior, **occipital border**, articulates with the occipital bone;
- Inferior, **squamosal border**, connects with the squamous part of the temporal bone forming the squamous suture; this border is smooth, in contrast to the other jagged borders.

Angles:

- Two superior, **frontal** and **occipital angles**, connect to the respective bones;
- Anterior inferior, **sphenoidal angle**, sharp, connects to the sphenoid bone;
- Posterior inferior, **mastoid angle**, connects with the mastoid process of the temporal bone.

The *external surface* of the parietal bone bears the **superior** and **inferior temporal lines**, running parallel to each other, and the **parietal eminence** (*syn. parietal tuber*) above them. The **parietal foramen** pierces the bone next to its sagittal border.

The *internal surface* has the **groove for middle meningeal artery** and grooves for its branches, which diverge from the sphenoidal angle. Impressions of the dural venous sinuses are located along the superior border — the **groove for superior sagittal sinus**, and at the mastoid angle — the **groove for sigmoid sinus**.

Sphenoid Bone

The **sphenoid bone** (*Lat. os sphenoidale*) is an unpaired bone located between the frontal and temporal bones (Fig. 21). It forms the anterior and middle cranial fossae of the cranial base and contributes to the formation of the orbit and nasal cavity.

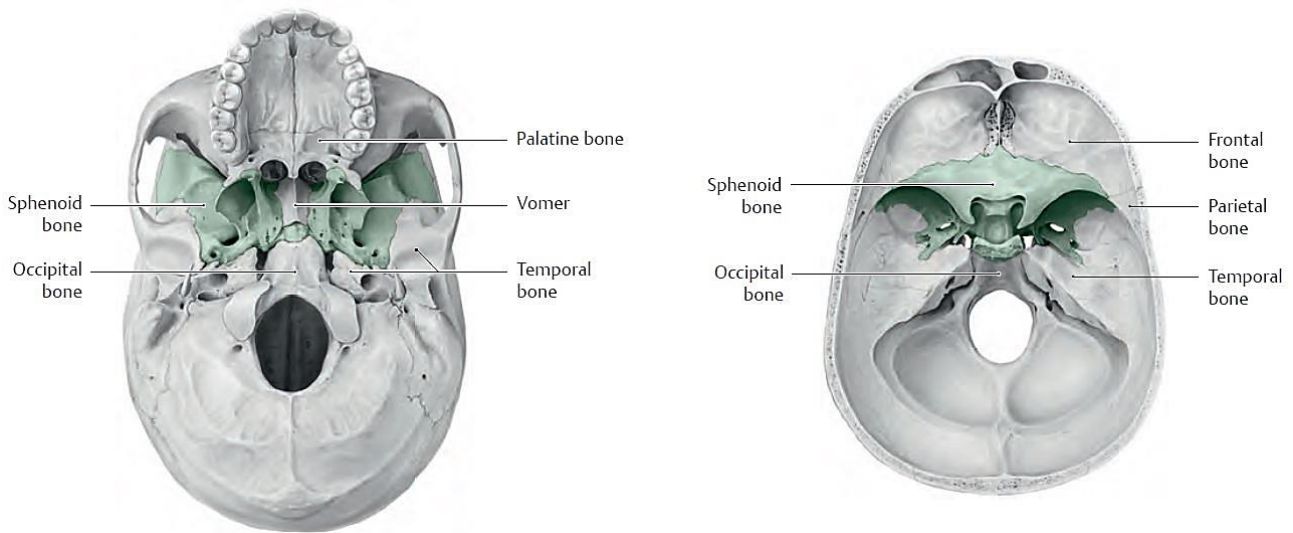


Fig. 21. Position of the sphenoid bone in the skull

The sphenoid bone consists of the **body**, **greater wings**, **lesser wings**, and **pterygoid processes** (Fig. 22, 23, 24).

The cuboid-shaped **body** is the central part of the bone, in which 6 *surfaces* can be distinguished:

The *superior surface* faces the cranial cavity and bears the **sella turcica**, which consists of the **dorsum sellae** posteriorly, **tuberculum sellae** anteriorly, and **hypophysial (pituitary) fossa** between them (Fig. 22). The **chiasmatic sulcus** (*syn. prechiasmatic sulcus*) runs transversally between the optic canals, anterior to the tuberculum sellae.

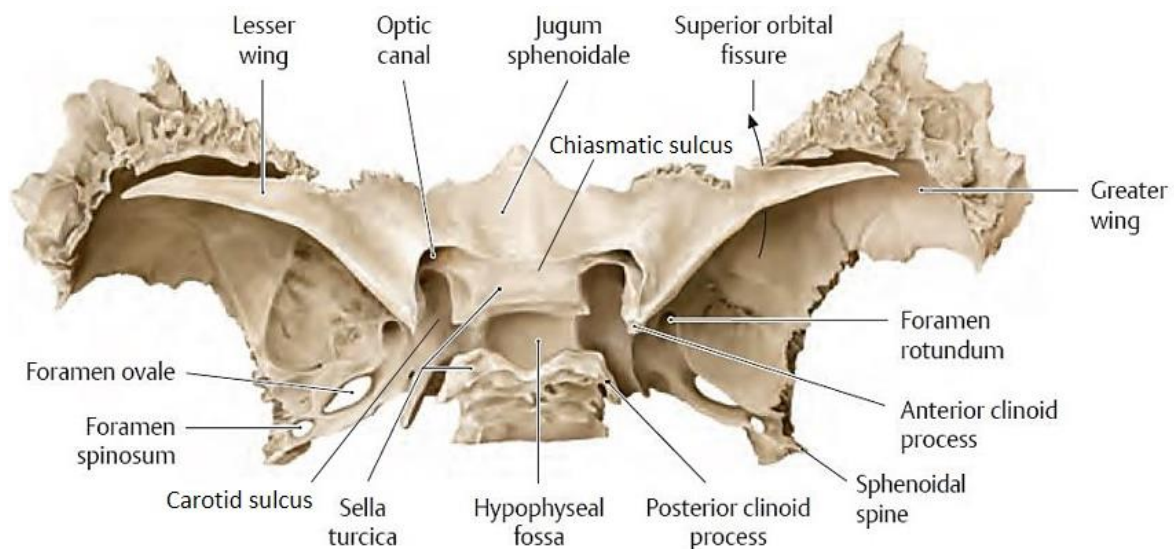


Fig. 22. Sphenoid bone: superior view

The **carotid sulci** are located on the *lateral sides* of the sella turcica above the attachment of the **greater wings**.

The *anterior* and *inferior surfaces* of the body face the nasal cavity (Fig. 23). The **sphenoidal crest** projects forward along the midline and ends on the inferior surface with the **sphenoidal rostrum**. The **sinus of sphenoid bone** (*syn. sphenoidal*

sinuses) is a cavity in the sphenoid body with the **septum** in the middle. It connects to the nasal cavity through the **openings** (*syn. apertures*) of **sphenoidal sinus** on the sides of the sphenoidal crest.

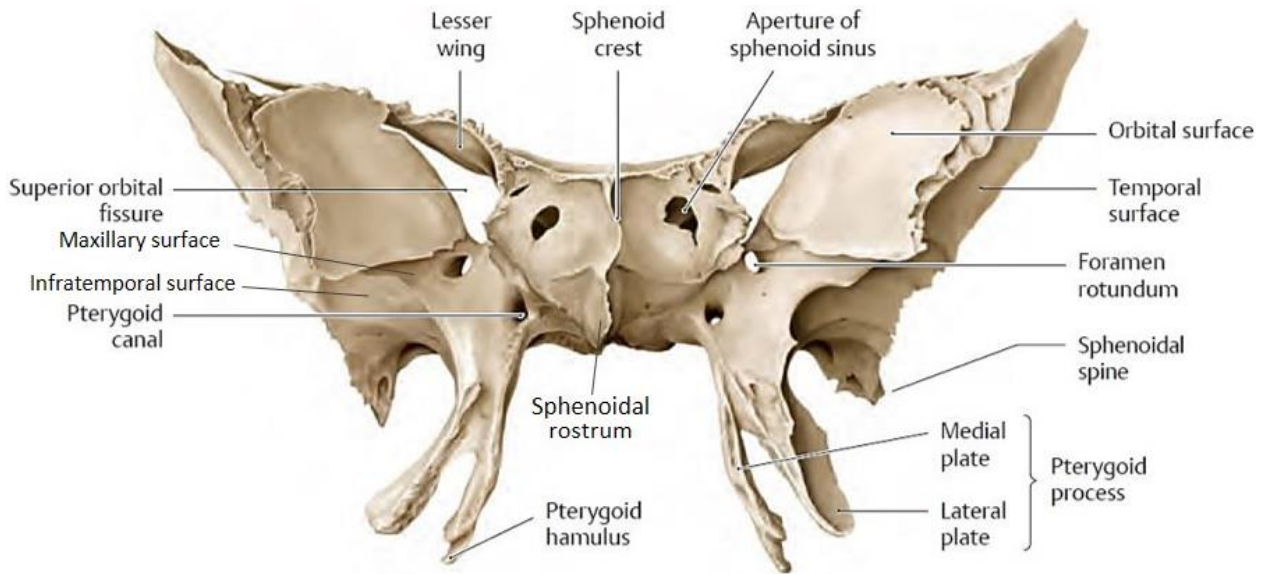


Fig. 23. Sphenoid bone: anterior view

The *posterior surface* of the body connects with the basilar part of the occipital bone forming the **clivus**, a wide groove facing the brainstem (Fig. 24).

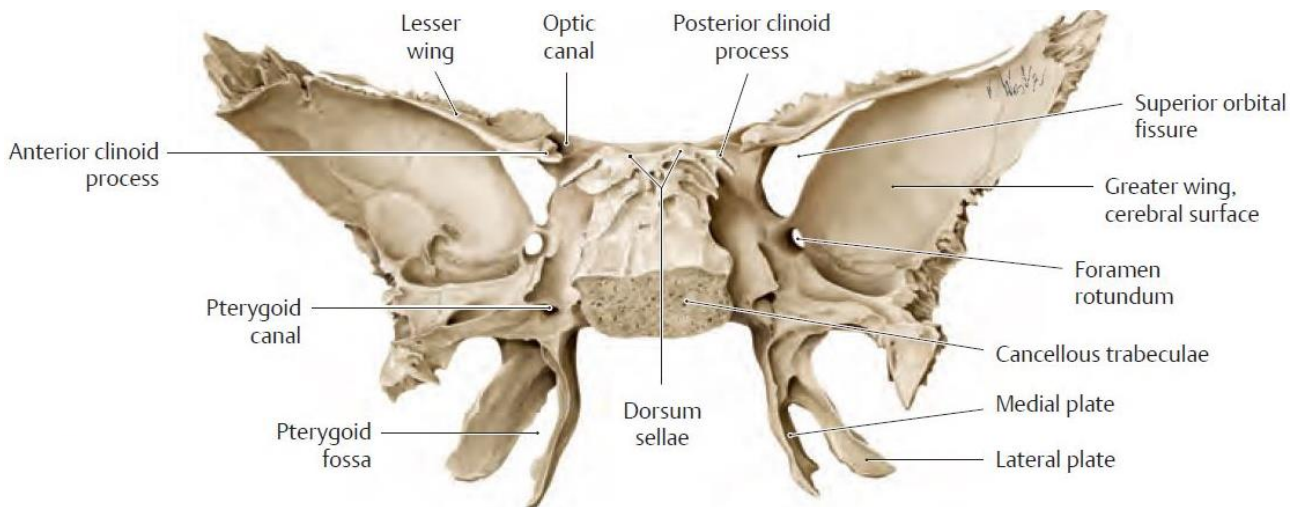


Fig. 24. Sphenoid bone: posterior view

The **greater wings** have 5 surfaces: *cerebral, temporal, infratemporal, orbital, and maxillary*.

The *cerebral surface* forms the middle cranial fossa and contains three openings piercing the greater wings (Fig. 22). From front to back these are the **foramen rotundum**, **foramen ovale**, and the smallest **foramen spinosum**, located at the angle of the greater wing, near the **spine of sphenoid bone** (Fig. 23).

The *temporal surface* is a part of the temporal fossa on the lateral aspect of the skull. Below it is separated by the **infratemporal crest** from the *infratemporal surface*.

The *orbital surface* forms the lateral wall of the orbit (Fig. 23).

The small anterior triangular *maxillary surface* faces the maxilla.

The **lesser wings** are two plates that arise from the anterosuperior edges of the sphenoid body. They join with the orbital part of the frontal bone forming the upper wall of the orbit. Two openings related to the lesser wings connect the orbit and the cranial cavity: the **optic canal** at the root of the lesser wing; the **superior orbital fissure** between the lesser and greater wings.

The **pterygoid processes** direct downward from the junction of the body and greater wings. The **pterygoid canal** passes through the base of each process in the sagittal direction (Fig. 23, 24). The **medial** and **lateral pterygoid plates** form the pterygoid process. They are separated posteriorly by the **pterygoid fossa** and inferiorly by the **pterygoid fissure**. The lower end of the medial plate bends posteriorly, forming the hook-shaped process, **pterygoid hamulus**.

Ethmoid Bone

The **ethmoid bone** (*Lat. os ethmoidale*) is an unpaired bone located between two orbits. It forms medial walls of the orbit, participates in formation of walls of the nasal cavity (nasal septum, superior and lateral walls) and the anterior cranial fossa.

The ethmoid bone consists of two plates: **cribriform** and **perpendicular** plates; and paired **ethmoidal labyrinths** (Fig. 25).

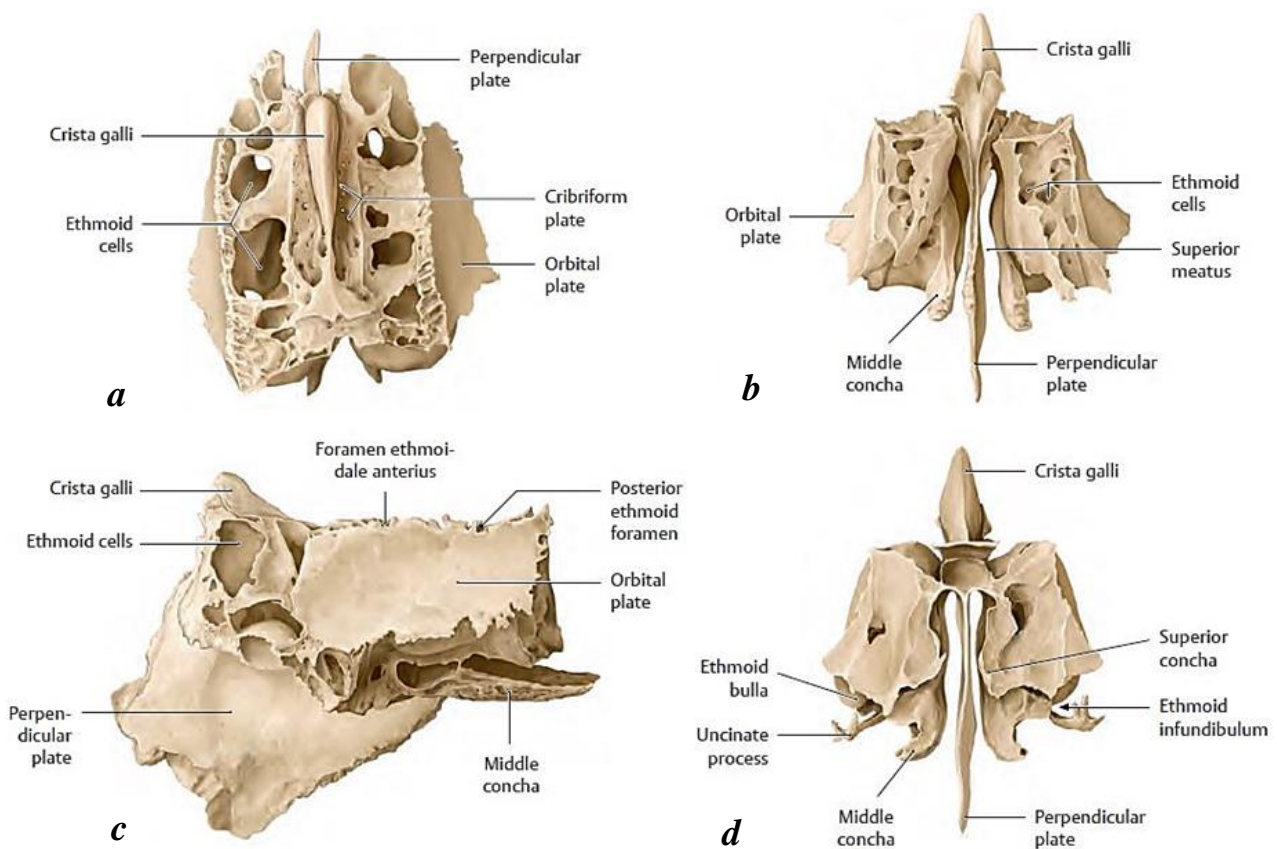


Fig. 25. Ethmoid bone: superior (a), anterior (b), lateral (c), and posterior (d) view

The **cribriform plate** lies horizontally. It has about 20 small openings for the olfactory nerves and a ridge along the midline — the **crista galli**.

The crista galli continues with the vertical **perpendicular plate**, which contributes to the nasal septum.

The **ethmoidal labyrinths** are attached to the cribriform plate and hang down on either side of the perpendicular plate. They consist of air cells that open into the nasal cavity and are collectively called the **ethmoidal sinus**. The **ethmoidal cells** are divided into *anterior*, *middle*, and *posterior* groups.

The lateral surface of each ethmoidal labyrinths is the **orbital plate**, which forms the medial wall of the orbit. The medial surface is represented by the *middle* and *superior nasal conchae*, limiting the *superior nasal meatus*. The presence of the supreme nasal concha is variable.

Temporal Bone

The **temporal bone** is a paired bone, which contributes to the calvaria (cranial vault) and base of the skull. It houses organs of hearing and balance.

The temporal bone consists of 3 parts: the **squamous**, **tympanic**, and **petrous parts** (Fig. 26).

The **squamous part** forms the lateral wall of the calvaria. On the *cerebral surface* it has digital impressions for cerebral gyri and grooves for arteries. The outer *temporal surface* at its inferior margin forms the **zygomatic process**. It directs forward and connects to the zygomatic bone, forming the **zygomatic arch**.

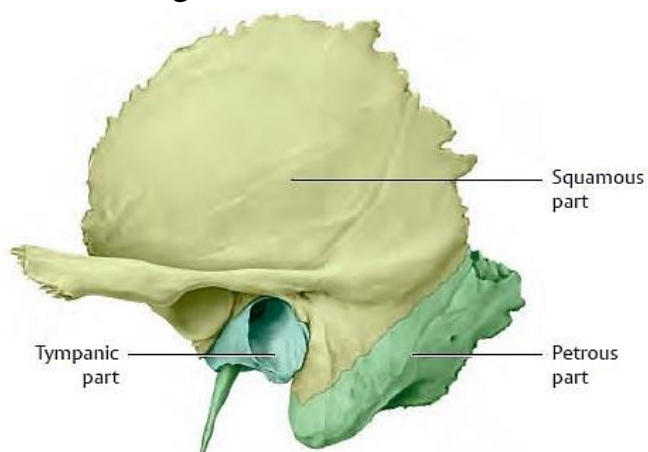


Fig. 26. Parts of temporal bone

At the base of the zygomatic process is the **mandibular fossa** and the **articular tubercle** anterior to it. They bear surfaces that articulate with the mandible.

The **tympanic part** is located posterior to the mandibular fossa. It forms the walls of the **external acoustic meatus** (*syn.* **external auditory canal**), except for its roof and upper posterior wall, and surrounds the entrance of the meatus — the **external acoustic opening**. Posteriorly and medially, the tympanic part connects with the petrous part, bordering the mastoid and styloid processes. At the mandibular fossa, it connects with the squamous part, forming the **tympanosquamous fissure**. The process of the petrous part divides the medial segment of the fissure into two — the **petrosquamosal** and **petrotympanic fissures** (Fig. 27).

The **petrous part** is the most massive part of the temporal bone. It surrounds the middle and internal ear and contributes to the base of the skull. The petrous part has shape of the trihedral pyramid with the **mastoid process** at its base. The mastoid process lies posterior to the external acoustic meatus and forms the lateral portion of the petrous part. The apex of the pyramid is directed anteromedially towards the center of the cranial base.

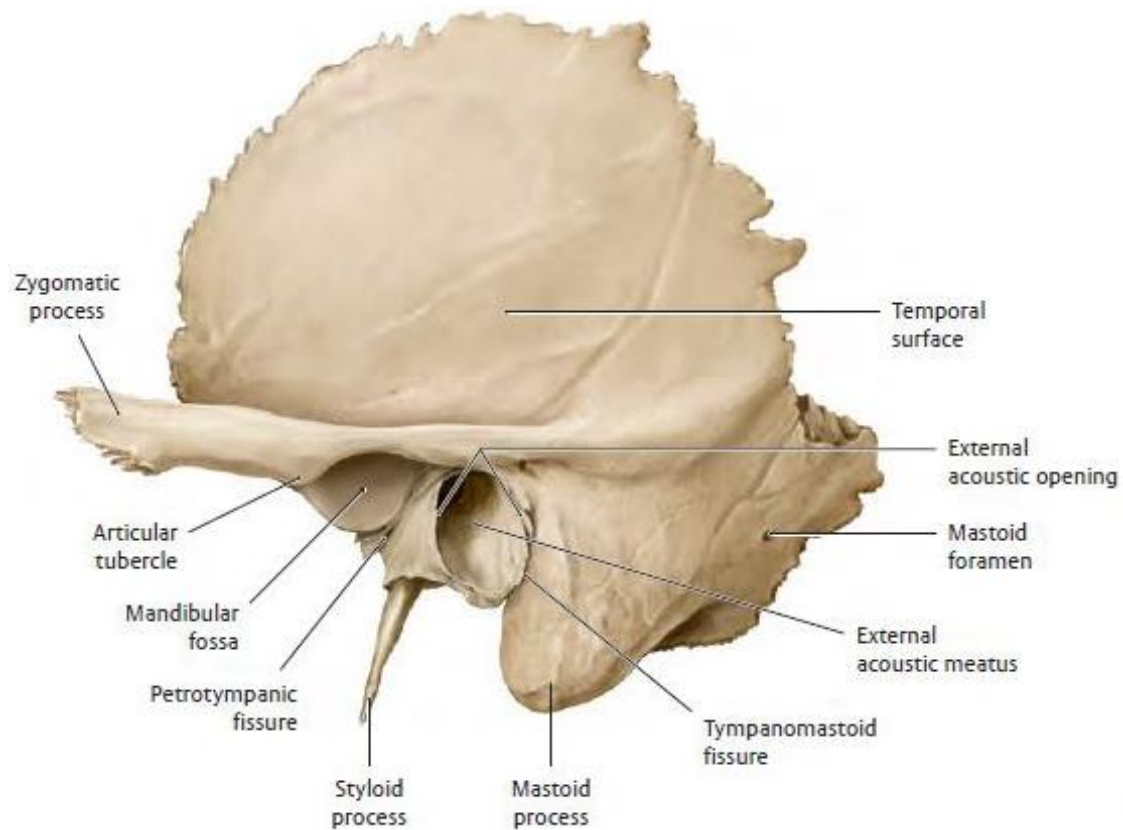


Fig. 27. Temporal bone: external view

In the petrous part, **3 surfaces** — anterior, posterior, and inferior, are distinguished. The **anterior** and **posterior surfaces** form the middle and posterior cranial fossae, respectively. The **inferior surface** is a part of the external cranial base.

The surfaces of the petrous part are separated by **3 borders**:

- The **anterior border** connects with the greater wing of the sphenoid bone.
- The **superior border**, or **petrous ridge**, separates the anterior and posterior surfaces and bears the **groove for superior petrosal sinus**.
- The **posterior border** connects with the occipital bone and contains the **groove for inferior petrosal sinus**.

The **anterior surface of petrous part** at the apex has the **trigeminal impression** — a fossa formed by the trigeminal ganglion (Fig. 28, a). Posterior to it are two parallel grooves — the **sulcus for greater petrosal nerve** medially and **sulcus for lesser petrosal nerve** laterally. At the posterior ends, the grooves continue into small canals through corresponding openings — the **hiatus for greater petrosal nerve** and **hiatus for lesser petrosal nerve**. Behind the hiatuses is the **arcuate eminence**, which rises above the internal ear. The roof of tympanic cavity, the **tegmen tympani**, lies between the arcuate eminence and the **petrosquamous fissure** separating the squamous part.

On the **posterior surface of petrous part**, the most prominent structures are the **internal acoustic opening**, leading into the **internal acoustic meatus**, and the **groove for sigmoid sinus** at the base of the pyramid (Fig. 28, b).

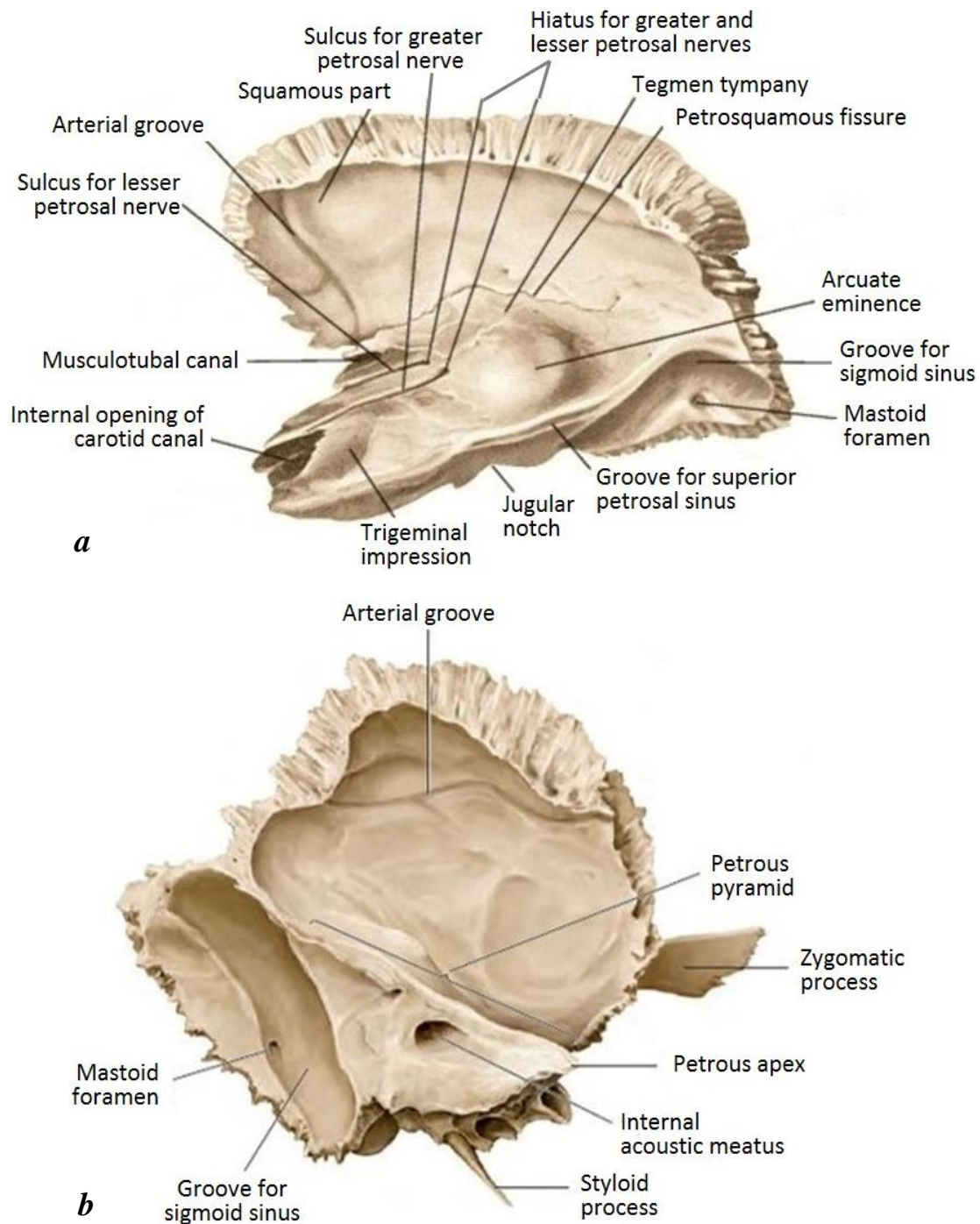


Fig. 28. Temporal bone: internal view, anterior (a) and posterior (b) surfaces of petrous part

The *inferior surface of petrous part* posteriorly is occupied by the **mastoid process** (Fig. 29). It contains air cells, connected to the tympanic cavity through the largest of them, the **mastoid antrum**. Two grooves run along the medial side of the mastoid process: the wide **mastoid notch** laterally and the small **occipital groove** (for the occipital artery) medially. Closer to the occipital border of the temporal bone is the **mastoid foramen**.

The sharp **styloid process** is located anterior to the mastoid process. Between the two processes is the **stylomastoid foramen**. The **jugular fossa** lies medial to the styloid process and the **carotid canal** opens anterior to it.

Many smaller and larger canals pass through the temporal bone. The *major canals* are as follows:

1) The **carotid canal** is the path for the internal carotid artery to enter the cranial cavity (Fig. 29). It begins on the inferior surface of petrous part with the **external opening of carotid canal**, then rises upward and bends at a right angle anteriorly, to open at the petrous apex with the **internal opening of carotid canal**.

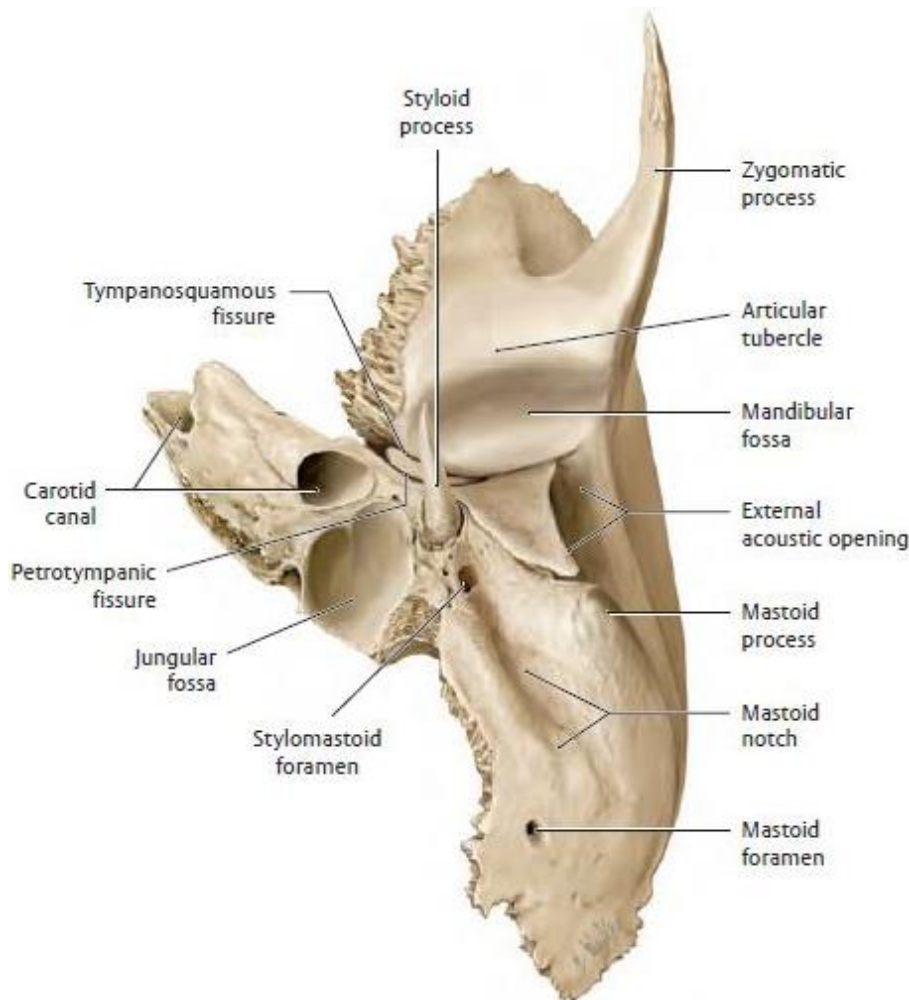


Fig. 29. Temporal bone: inferior view

2) The **facial canal** begins in the depth of the internal acoustic meatus. It runs in the anterolateral direction. Having reached the level of the *hiatus for greater petrosal nerve*, the canal bends posteriorly at a right angle in the horizontal plane (the bend is called the *geniculum of facial canal*). Then it makes a second bend in the vertical direction and descends to the inferior surface of petrous part, ending at the *stylomastoid foramen*.

3) The **musculotubal canal** is located anterior and lateral to the carotid canal, having a common wall with it. The musculotubal canal opens at the corner between the squamous part and anterior border of the petrous part. The canal leads into the tympanic cavity and divides into 2 semicanals: the upper one is the **semicanal for tensor tympani**, and the lower one is the **semicanal for auditory tube** (*syn.* canal for Eustachian tube).

Maxilla

The **maxilla** (*syn.* **maxillary bone**) is a paired facial bone, which articulates with all other facial bones, except the mandible. The right and left maxillae form the upper jaw.

The maxilla consists of the **body** and **4 processes** (Fig. 30):

1. The **frontal process** connects with the frontal and nasal bones. It has the vertical **anterior lacrimal crest** on the lateral surface, and the transverse **ethmoidal crest** on the medial surface (for attachment of the middle concha of the ethmoid bone).

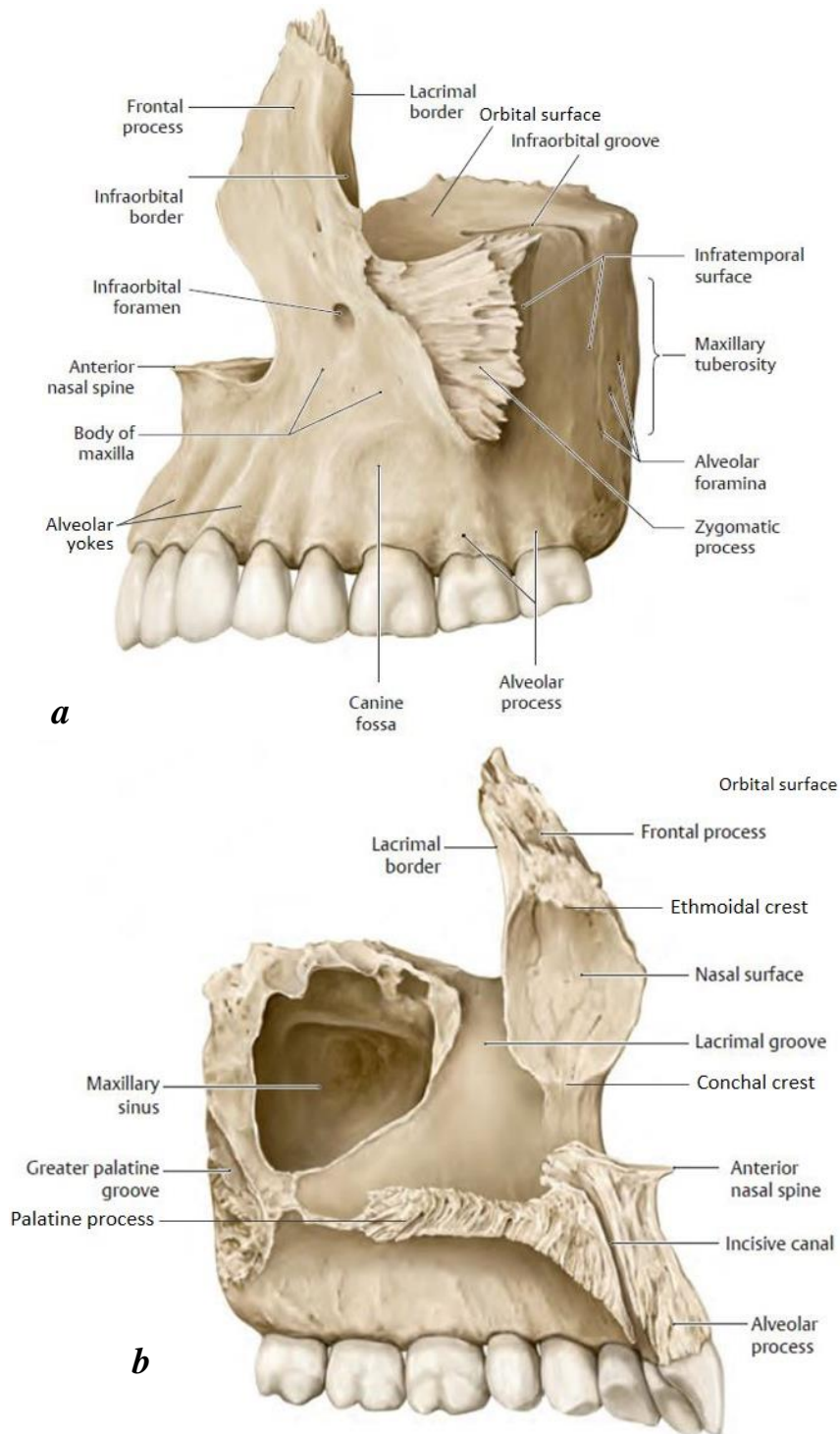


Fig. 30. Maxilla: external (a) and internal (b) view

2. The **alveolar process** forms the lower margin of the maxilla. It contains sockets for upper teeth — the **dental alveoli**, separated from each other by the **interalveolar septa**. The **alveolar yokes** on the outer surface of the process are elevations formed above the roots of the teeth.

3. The **palatine process** forms the bony palate with the process of the opposite side. Each process has the **nasal crest** on its free border, which connects with the vomer and contributes to the nasal septum.

4. The **zygomatic process** articulates with the zygomatic bone.

The **body** of the maxilla has **4 surfaces**:

– The **orbital surface** forms the inferior wall of the orbit, which contains the **infraorbital groove**, leading into the **infraorbital canal**. Its anterior border contributes to the **orbital margin** (*syn.* **infraorbital margin**).

– The **anterior surface** is bounded superiorly by the orbital margin. Inferior to it is the **infraorbital foramen**, an opening of the same name canal. The **canine fossa** lies below the foramen and above the canine tooth. The medial border of the anterior surface forms the **nasal notch**.

– The **infratemporal surface** is posterior to the zygomatic process. It elevates in the middle as **maxillary tuberosity**, pierced by small **alveolar foramina** leading to **alveolar canals**.

– The **nasal surface** faces the nasal cavity. In the middle, it has the **hiatus of maxilla** (*syn.* **bony maxillary hiatus**), which is a big opening of the cavity located inside the bone — **sinus of maxilla** (*syn.* **bony maxillary sinus**). The horizontal **conchal crest** lies below the frontal process and the vertical **lacrimal groove** is behind it. The **greater palatine sulcus** is located on the border with the infratemporal surface.

Mandible

The **mandible**, or the lower jaw, is an unpaired mobile bone, which consists of the horizontal **body** anteriorly and two ascending **rami** posteriorly (Fig. 31).

The *body of mandible* includes the **base of mandible** and **alveolar part**.

On the *outer surface of the base*, along the midline, there is the **mental protuberance** with two **mental tubercles** on its sides. Laterally located is the **mental foramen** — the opening of the **mandibular canal**. Posterior to it, a ridge, the **oblique line**, ascends to the coronoid process.

On the *inner surface of the base*, muscles attachment sites are located: a small midline projection, the **mental spine**; the **digastric fossae** on either side of the spine; the **mylohyoid line**, running backward and upward towards the ramus. Below and above the mylohyoid line are depressions from the adjacent salivary glands — the larger **submandibular fossa** and the smaller **sublingual fossa**, respectively.

The *alveolar part*, similar to the alveolar process of the maxilla, contains the **dental alveoli**, separated from each other by the **interalveolar septa**, and the **alveolar yokes** on the outer surface. The **retromolar triangle (fossa)** is the area behind the alveolus of the last molar, limited laterally by the continuation of the oblique line.

Each *ramus of mandible* is connected with the body at the **angle of mandible**. On the surfaces of the angle there are muscle attachment sites: on the outer surface — the **masseteric tuberosity**, on the inner one — the **pterygoid tuberosity**.

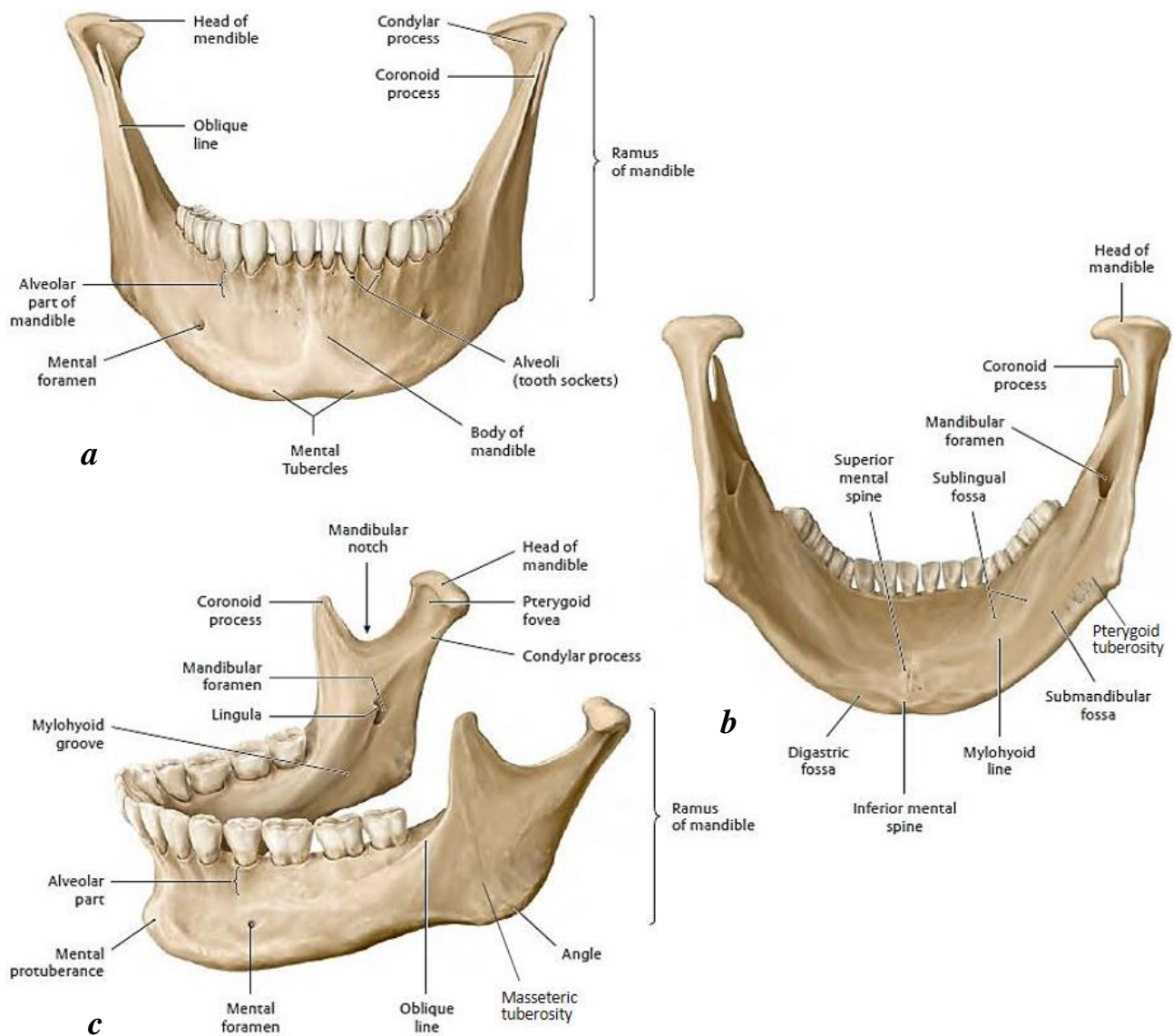


Fig. 31. Mandible: external (a), internal (b), and lateral (c) view

The **mandibular foramen** on the inner surface of the ramus leads into the mandibular canal. The anterior edge of the foramen forms a small protrusion, the **lingula**. The **mylohyoid groove** descends from the lower border of the foramen.

The superior border of the ramus ends by two processes separated by the **mandibular notch**: the **coronoid process** anteriorly and the **condylar process** posteriorly. The latter consists of the **mandibular condyle** (*syn.* **head of mandible**) and the **neck of mandible** with the **pterygoid fovea** on its anterior surface.

Zygomatic Bone

The **zygomatic bone** is a paired bone, which takes part in the framework of the orbit and cheek (Fig. 32). Three surfaces are distinguished in the bone:

- The convex **lateral surface** forms the prominence of cheek;
- The **temporal surface** is medial; it faces the temporal fossa forming its anterior wall;
- The **orbital surface** participates in the formation of the lateral and inferior walls of the orbit.

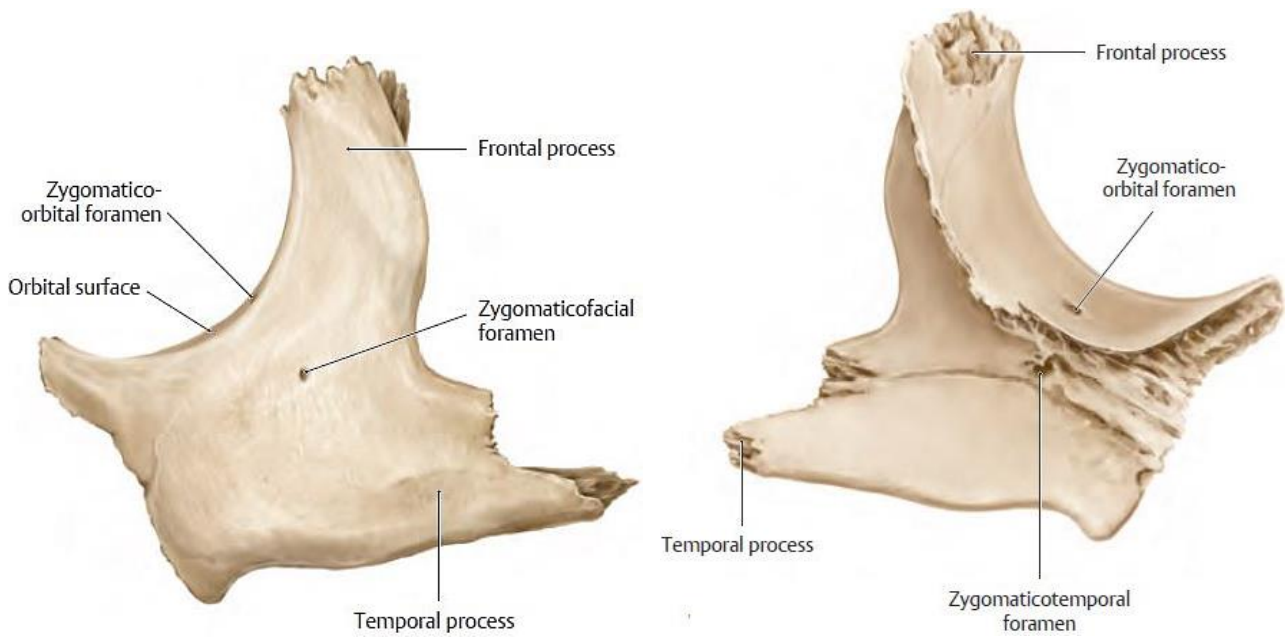


Fig. 32. Zygomatic bone: lateral and temporal surfaces

Each surface has an opening — the zygomatico-orbital, zygomaticofacial, and zygomaticotemporal foramina, connecting with each other.

The zygomatic bone has *two processes* connecting to the respective bones:

- The **frontal process** directing upward;
- The **temporal process** directing backward, forming the anterior part of the zygomatic arch.

The anterior end of the zygomatic bone articulates with the maxilla and may contribute to the wall of the maxillary sinus.

Nasal Bone

The **nasal bone** is a small paired bone (Fig. 33). The two nasal bones connect along the midline and form the bridge of the nose. Superiorly they articulate with the frontal bone, laterally with the maxillae.

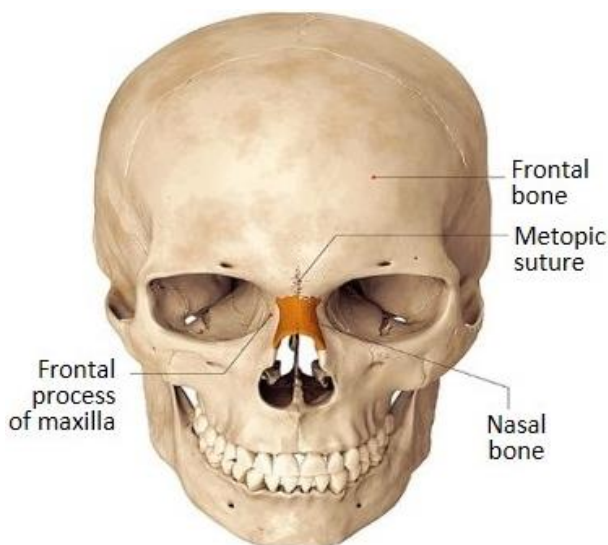


Fig. 33. Nasal bone

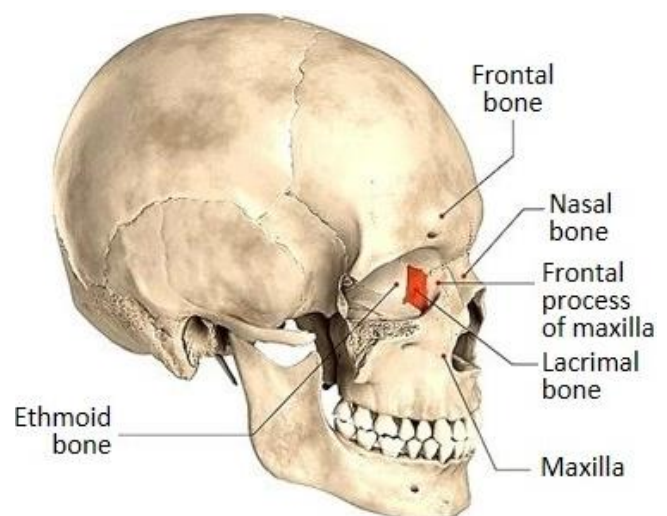


Fig. 34. Lacrimal bone

Lacrimal Bone

The paired **lacrimal bone** is the smallest bone of the skull. It is located behind the frontal process of maxilla in the medial wall of the orbit (Fig. 34). A ridge in the middle of the bone, the **posterior lacrimal crest**, limits the **lacrimal groove** lying in front of it. The medial surface of the lacrimal bone faces the nasal cavity.

Vomer

The **vomer** is a thin flat unpaired bone of trapezoid shape, which forms the posteroinferior part of the nasal septum (Fig. 35). It has 4 borders:

- The *anterior border* articulates with the perpendicular plate of the ethmoid bone and the nasal septal cartilage;
- The *posterior border* is free and separates the choanae, which connect the nasal cavity with the pharynx;
- The *inferior border* attaches to the palate;
- The thicker *superior border* divides to form two **wings**, **ala of vomer**, that enclose the rostrum of the sphenoid bone.

Inferior Nasal Concha

The **inferior nasal concha** is a curved paired bony plate (Fig. 36). It attaches to the maxilla and palatine bone on the lateral wall of the nasal cavity, and separates the middle and inferior nasal meatuses.

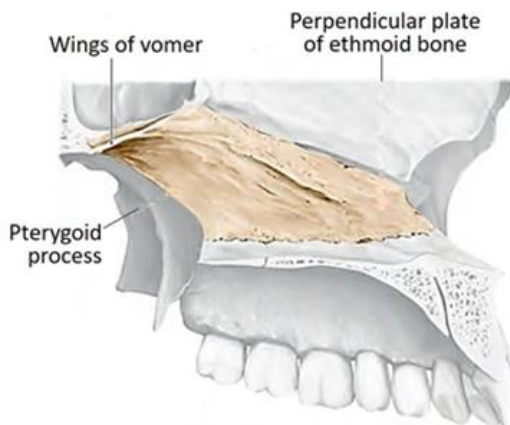


Fig. 35. Vomer

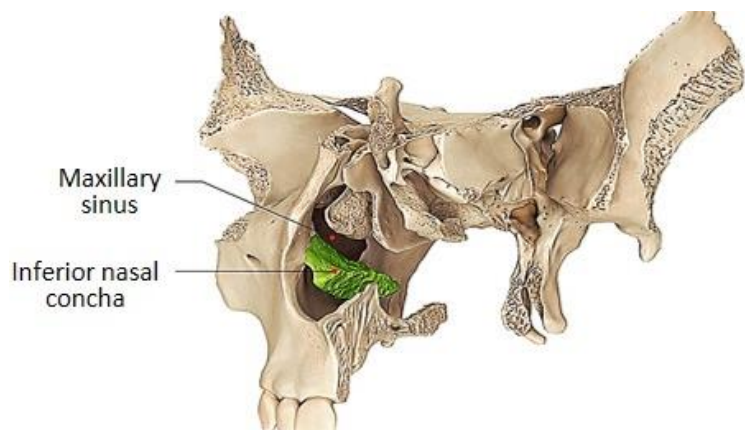


Fig. 36. Inferior nasal concha

Palatine Bone

The **palatine bone** is paired bone which consists of 2 bony plates, connecting at the right angle, and 3 processes (Fig. 37).

The **horizontal plate** attaches to the palatine process of the maxilla and forms the posterior portion of the hard palate.

The **perpendicular plate** is attached to the medial surface of the maxilla and contributes to the lateral wall of the nasal cavity. On the **nasal surface**, the perpendicular plate has crests for attachment of the inferior and middle nasal conchae. The posterior edge forms the *greater palatine canal* (together with the maxilla and the pterygoid process of the sphenoid bone), which ends with

the **greater palatine foramen** on the horizontal plate and the **lesser palatine foramina** on the pyramidal process.

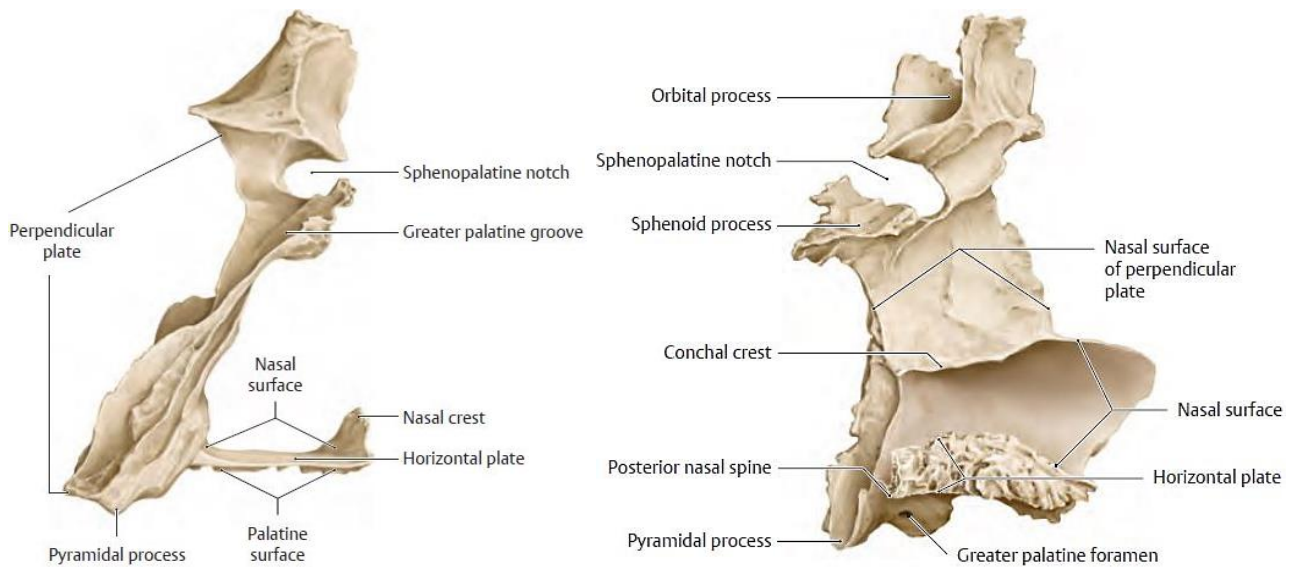


Fig. 37. Palatine bone: posterior edge and nasal surface

The **pyramidal process** projects posteriorly at the junction of the palatine bone plates and fills the pterygoid notch. Two other processes are located on the upper edge of the perpendicular plate — the **orbital process** anteriorly and the **sphenoid process** posteriorly. Between them is the **sphenopalatine notch**.

Hyoid Bone

The **hyoid bone** is an unpaired mobile bone, located between the mouth floor and the anterior surface of the neck and suspended from the skull by the stylohyoid ligament.

The hyoid bone consists of the arch-shaped **body** and two pairs of processes, called horns (Fig. 38). The **greater horns** are the posterior extensions of the body. The **lesser horns** project upward and backward.

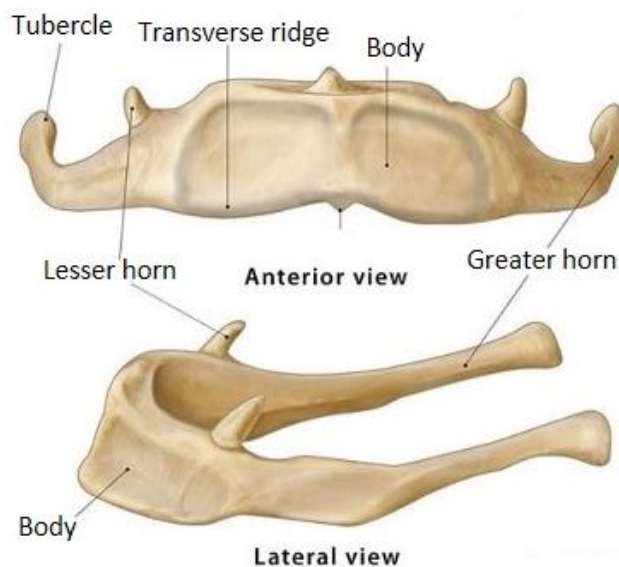


Fig. 38. Hyoid bone: anterior and lateral view

CRANIAL BASE

Internal Surface of Cranial Base

The internal surface of the cranial base faces the brain and is subdivided into **3 cranial fossae: anterior, middle, and posterior** (Fig. 39, 40).

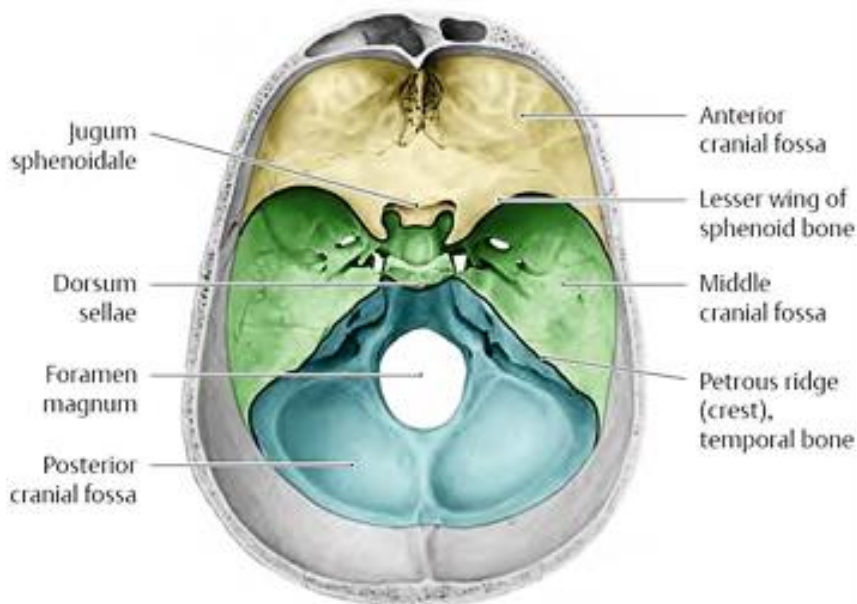


Fig. 39. Cranial fossae

The **anterior cranial fossa** is formed by the orbital parts of the frontal bone anteriorly, the cribriform plate of the ethmoid bone in the center, and the lesser wings of the sphenoid bone posteriorly. The **cribriform plate** is pierced by many small openings. In the middle, it carries the **crista galli**, in front of which is the **foramen cecum**.

The **middle cranial fossa** is formed by the body and greater wings of the sphenoid bone and by the temporal bones — the anterior surfaces of the petrous parts (pyramids) and the squamous parts.

The **sella turcica**, located in the middle, has a depression, the **hypophyseal fossa**, limited posteriorly by the **dorsum sellae**, and anteriorly by the **tuberculum sellae**. The **chiasmatic groove** connects the **optic canals** that pass to the orbits at the roots of the lesser wings. The **superior orbital fissures** are located between the lesser and greater wings.

Each greater wing has 3 openings. From front to back they are: the **foramen rotundum**, **foramen ovale**, and the smallest **foramen spinosum**.

The **carotid sulci** lie on the lateral sides of the sella turcica. Posterior to it is the **lacerum foramen**. It is surrounded by 3 bones — the sphenoid bone, the basilar part of the occipital bone, and the apex of petrous part of the temporal bone, which contains the **internal opening of carotid canal**.

On the anterior surface of the petrous part, from front to back, the following structures are located: the **trigeminal impression**, at the tip of the pyramid; **hiatuses** and **grooves for greater and lesser petrosal nerves**, running parallel to the petrosquamous fissure; **arcuate eminence** posteriorly, and **tegmen tympani** lateral to it.

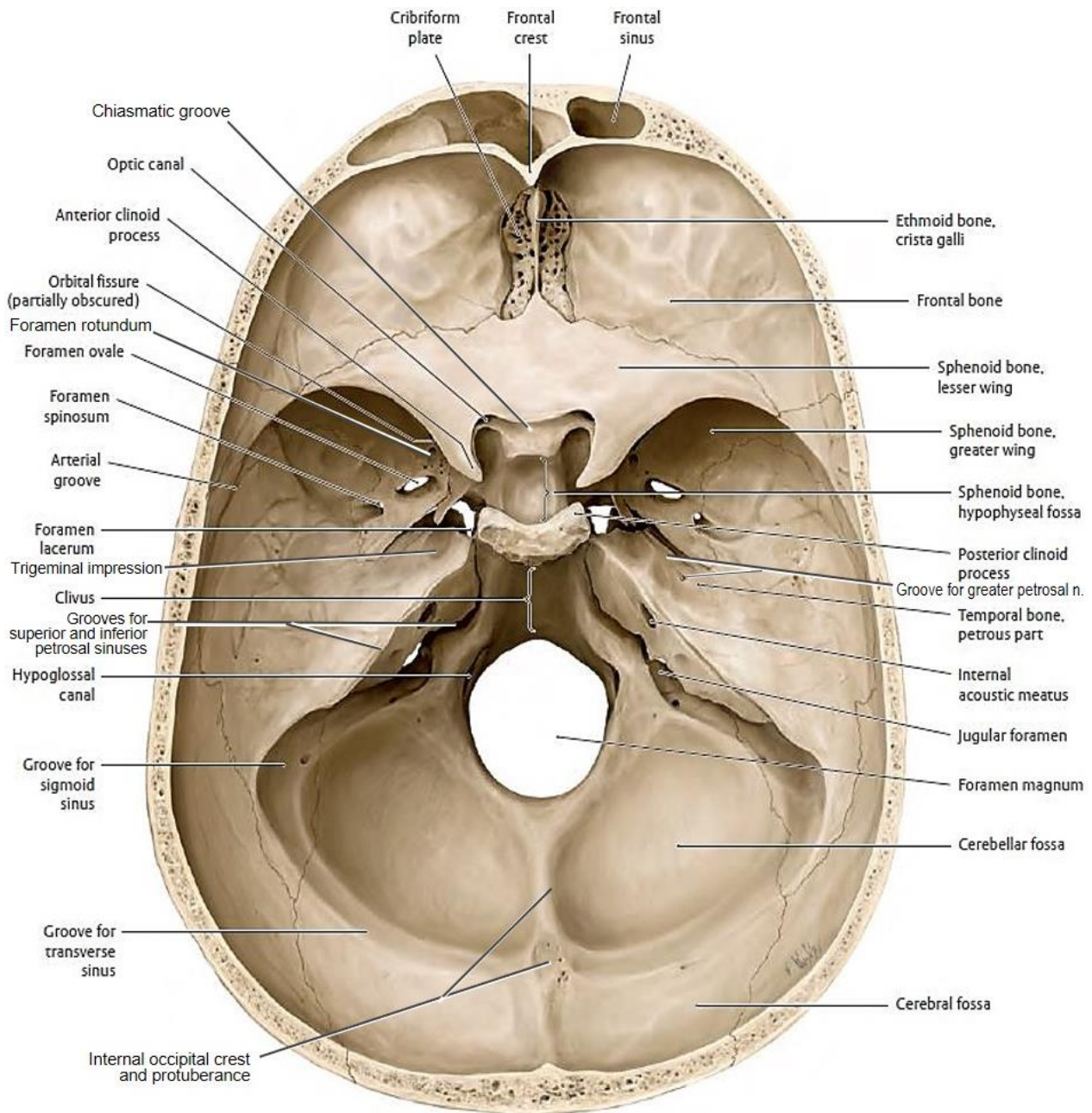


Fig. 40. Internal cranial base

The superior border of the petrous part separates the middle and posterior cranial fossae and carries the **groove for superior petrosal sinus**.

The **posterior cranial fossa** is formed by the posterior surface of the petrous part of the temporal bone and by the occipital bone.

In the center it contains the **foramen magnum** and in front of it the **clivus**, a slope formed by the fusion of the sphenoid body and basilar part of the occipital bone. On the sides of the foramen magnum are the **hypoglossal canals**.

The **internal acoustic meatus** opens on the posterior surface of the petrous part. The **groove for sigmoid sinus** occupies its base and the adjacent parts of the occipital and parietal bones. Between the posterior border of the temporal pyramid and the occipital bone there is the **groove for inferior petrosal sinus** and the **jugular foramen** lying posterior to it.

The **internal occipital crest and protuberance, grooves for transverse sinuses** are located on the squamous part of the occipital bone, posterior to the foramen magnum. The **groove for superior sagittal sinus** ascends from the occipital protuberance to the calvaria.

External Surface of Cranial Base

The external surface of cranial base contributes to the formation of the facial structures, forms the joints with the mandible and the 1st vertebra, and serves for the attachment of muscles and ligaments. The facial bones, connected to the cranial base, cover its anterior third.

For descriptive purposes the inferior surface of the cranium can be divided into 3 parts (Fig. 41):

- the anterior part, which includes the bony palate and the superior alveolar arch, formed by the alveolar processes of the maxilla;
- the middle part, which extends from the palate to the anterior margin of the foramen magnum;
- the remaining posterior part, which reaches the superior nuchal line.

The **bony palate** consists of the palatine processes of the maxillae and horizontal plates of the palatine bones connected by the *median* and *transverse palatine sutures*. The **incisive foramen** lies posterior to the upper medial incisors. The **greater palatine foramen** and **lesser palatine foramina** on each palatine bone, are openings of the **greater palatine canal**, formed by three adjacent bones — the palatine bone, maxilla, and pterygoid process.

Large openings, the **choanae**, are located posterior to the palate. On the sides, they are limited by the **pterygoid processes**. Each pterygoid process includes the medial and lateral pterygoid plates, pterygoid fossa between them, and pterygoid hamulus of the medial plate. The **pterygoid canal** passes through the base of the pterygoid process. It opens on the anterior margin of the lacerum foramen and connects it with the pterygopalatine fossa. The **foramen ovale** and **foramen spinosum** pierce the greater wing of the sphenoid bone.

The **lacerum foramen** lies posterior to the pterygoid processes, surrounded by 3 bones: temporal, occipital and sphenoid. The **internal opening of carotid canal** is located right above the posterior margin of the lacerum foramen.

On the external surface of the temporal bone the following structures are located in the medial-lateral direction: the **external opening of carotid canal** and a small opening of the **musculotubal canal** lateral and anterior to it; the **styloid process**; **stylo mastoid foramen**; **mastoid process** with the mastoid notch and occipital groove on its medial side, and **mastoid foramen** behind it.

Anterior to the mastoid process is the **extremal acoustic opening and meatus**, surrounded by the tympanic part of the temporal bone. In front of them is the **mandibular fossa** with 3 fissures in its bottom (tympanosquamous, petrosquamous and petrotympanic fissures), and anterior to the fossa is the root of the **zygomatic process** with the articular tubercle.

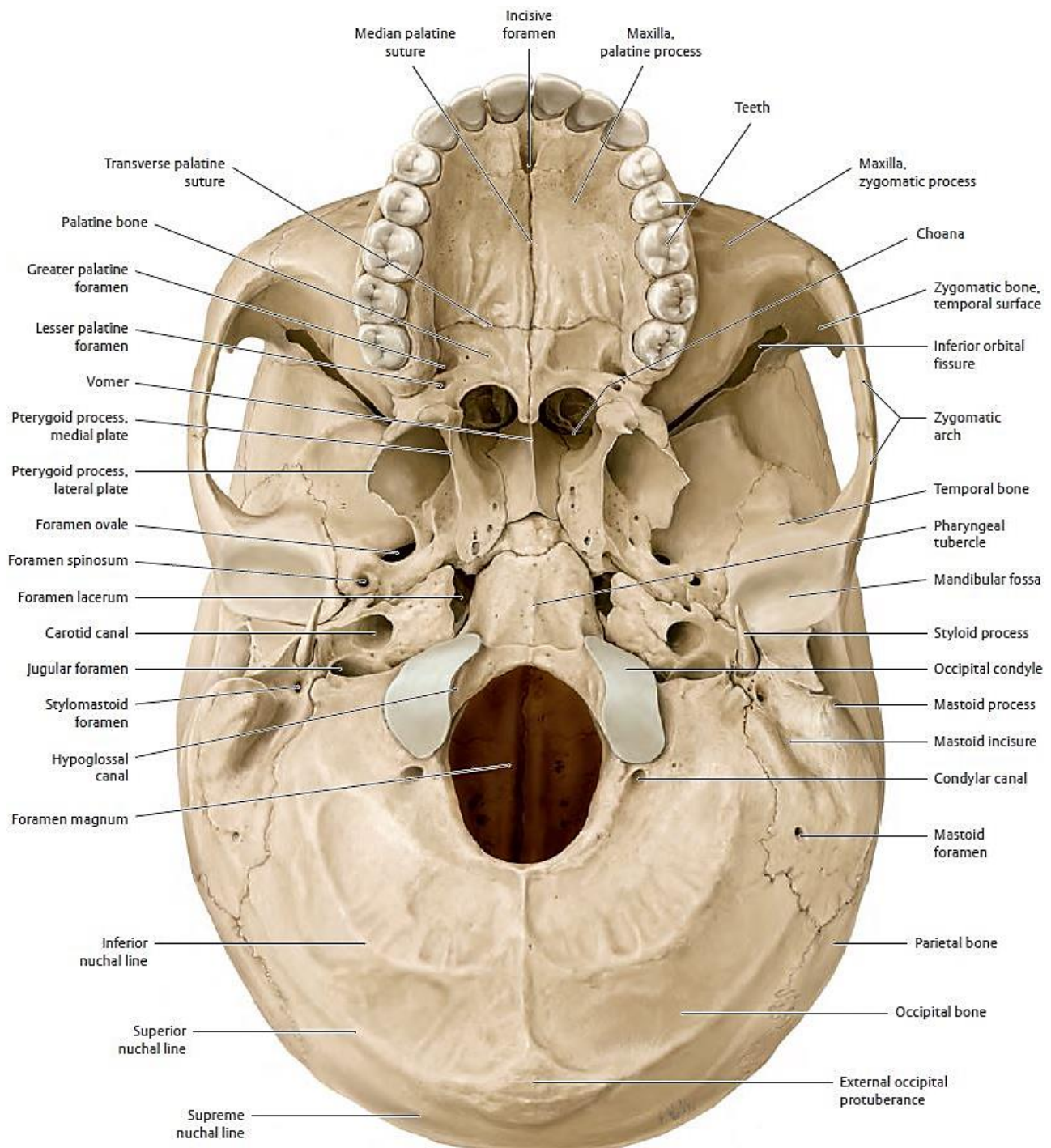


Fig. 41. External cranial base

The **foramen magnum** is surrounded by the occipital bone. The **pharyngeal tubercle** rises anterior to the foramen magnum. The **occipital condyles** are located on the sides of the foramen magnum. The **condylar fossae** with the **condylar canals** lie behind the **condyles**. The **hypoglossal canal** crosses the bone above the occipital condyle. The **jugular foramen** is located lateral to the condyle between the jugular fossa of the temporal bone and the jugular notch of the occipital bones.

On the squamous part, lying posterior to the foramen magnum, there are several ridges: the **external occipital crest** in the middle, reaching the **external occipital protuberance**, and transverse **superior** and **inferior nuchal lines**.

LATERAL VIEW OF THE SKULL

Three fossae are distinguished on the lateral surface of the skull: the largest and uppermost temporal fossa, the underlying infratemporal fossa, and the pterygopalatine fossa in the depths of the latter (Fig. 42).

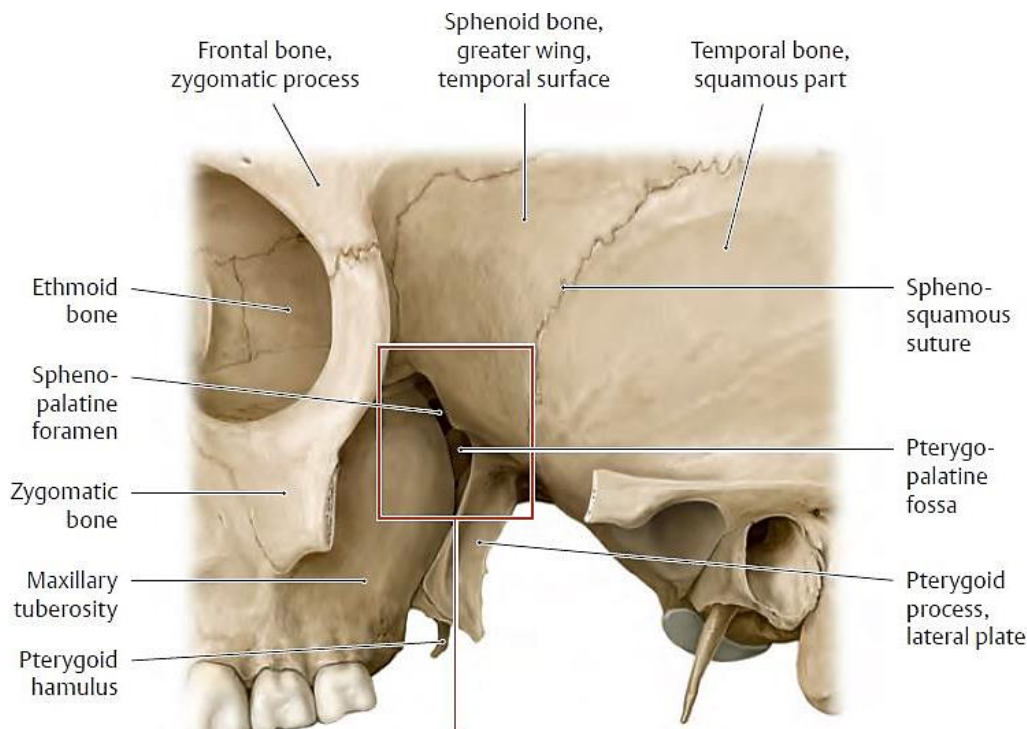


Fig. 42. Lateral aspect of the skull

Temporal Fossa

The temporal fossa is a shallow depression in the temporal region of the skull, superior to the zygomatic arch and inferior to the superior temporal line, mainly occupied by the temporalis muscle. It is formed by four bones: parietal, temporal, frontal and sphenoid bones. Inferiorly, the temporal fossa communicates with the infratemporal fossa through an opening medial to the zygomatic arch.

Infratemporal Fossa

The infratemporal fossa is located deep to the zygomatic arch, communicates with the temporal fossa above, and with the pterygopalatine fossa medially, through the **pterygomaxillary fissure**.

The *bony walls* of the infratemporal fossa are: anterior — maxilla; medial — pterygoid process; superior (roof) — greater wing of the sphenoid bone; lateral — ramus of mandible.

Pterygopalatine Fossa

The pterygopalatine fossa is a depression extending deep from the infratemporal fossa towards the nasal cavity.

Its *bony walls* are: anterior — maxilla; posterior — pterygoid process; medial — perpendicular plate of the palatine bone.

The pterygopalatine fossa communicates with other regions of the skull through 4 openings and 1 canal (Fig. 43):

- With the nasal cavity through the **sphenopalatine foramen**;
- With the oral cavity through the **greater palatine canal**;
- With the orbit through the **inferior orbital fissure**;
- With the middle cranial fossa through the **foramen rotundum**;
- With the external cranial base (foramen lacerum) via the **pterygoid canal** running through the base of the pterygoid process of the sphenoid bone.

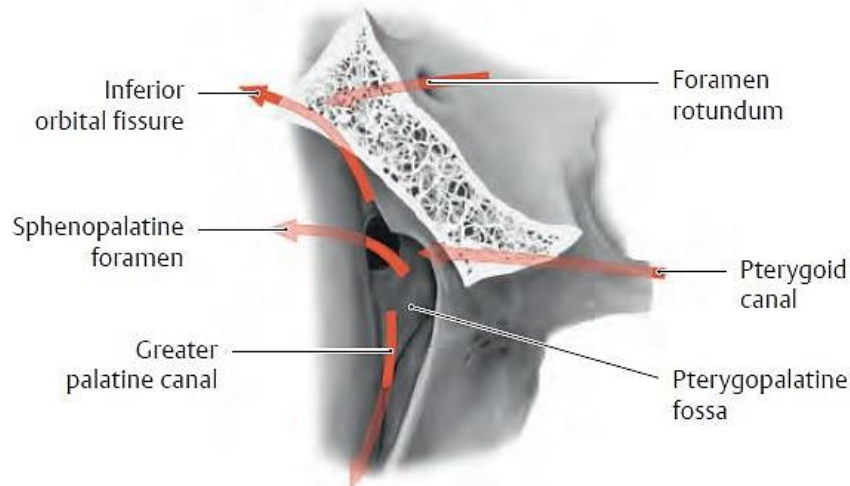


Fig. 43. Pterygopalatine fossa: canals and foramina

ORBIT

The orbits are bony recesses that contain the eyeball and related structures and occupy a significant part of the face. The **orbital opening** is surrounded by the **orbital margin**, which includes the supra- and infraorbital margins, lateral and medial margins. The **orbital cavity** has the shape of a tetrahedral pyramid. Seven different bones are involved in the formation of the *4 walls of the orbit* (Fig. 44):

1. The **roof (superior wall)** is formed by the *frontal* bone and lesser wing of the *sphenoid* bone. It separates the orbit from the anterior cranial fossa.

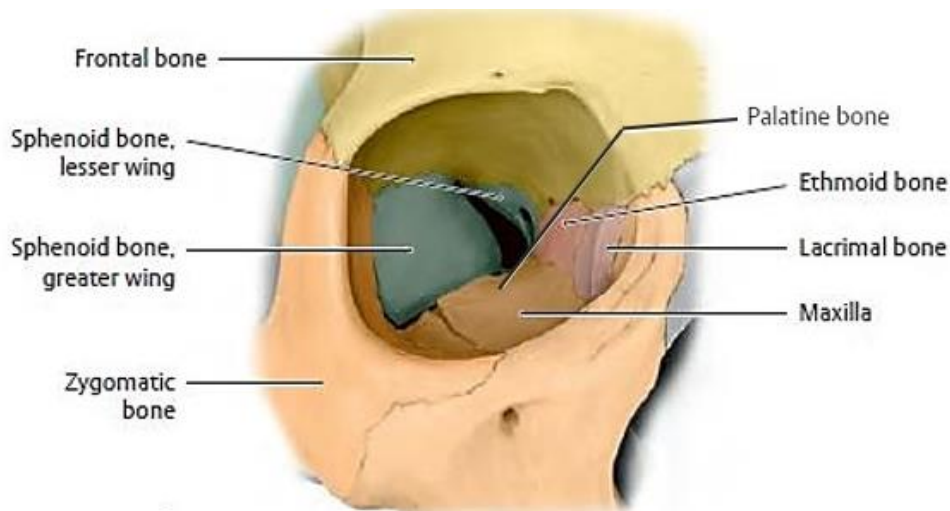


Fig. 44. Walls of the orbit

2. The **floor (inferior wall)** is formed mainly by the *maxilla* and *zygomatic* bones, and posteriorly by the small orbital process of the *palatine* bone.

3. The **lateral wall** is formed by the *zygomatic* bone and greater wing of the *sphenoid* bone.

4. The **medial wall** is formed from front to back by the frontal process of the *maxilla*, *lacrimal* and *ethmoid bones*, and the *sphenoid body*.

Openings, canals, and fossae of the orbit (Fig. 45, 46):

- **Optic canal** at the apex of the orbit;
 - **Superior orbital fissure** between the greater and lesser wings of the sphenoid bone;
 - **Inferior orbital fissure** (sphenomaxillary fissure) between the greater wing of the sphenoid bone and maxilla;
 - **Anterior** and **posterior ethmoidal foramina** in the medial wall, above the upper border of the ethmoid bone;
 - **Infraorbital groove** and **canal** in the floor of the orbit;
 - **Supraorbital notch (foramen)** in the supraorbital margin;
 - **Fossa for lacrimal gland (lacrimal fossa)** in the superolateral corner of the orbit;
 - **Fossa for lacrimal sac** in the lower medial corner of the orbit (between the lacrimal crests of the lacrimal bone and maxilla);
- Nasolacrimal canal** connects the fossa for lacrimal sac with the nasal cavity.

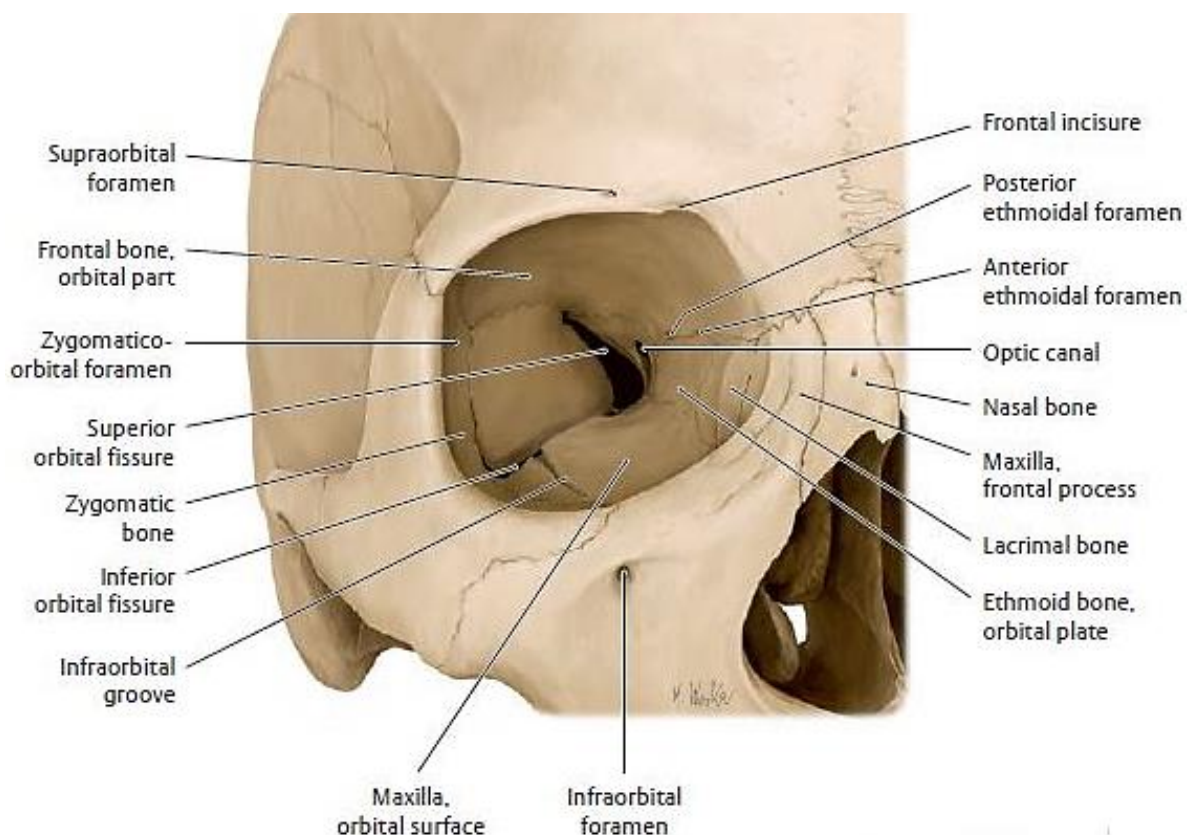


Fig. 45. Right orbit: anterior view

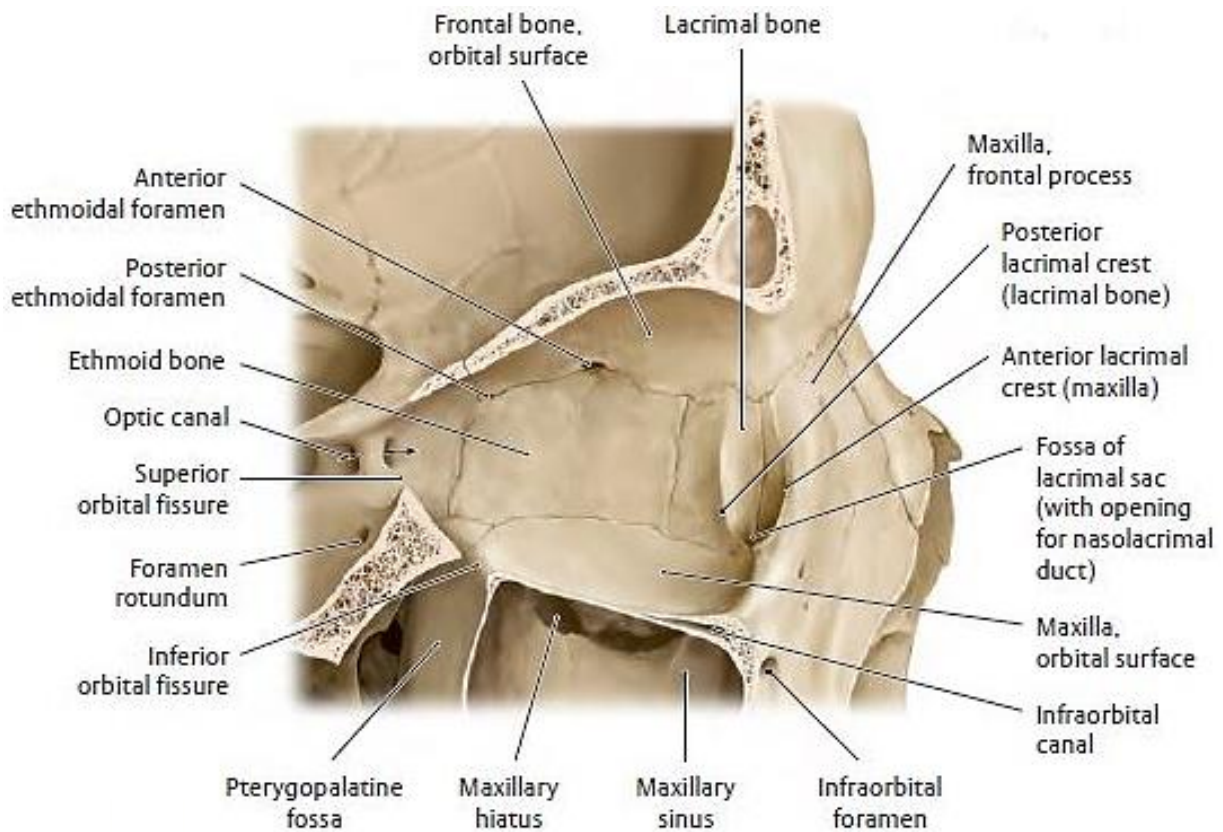


Fig. 46. Medial wall of the right orbit

NASAL CAVITY

The **nasal cavity of cranium**, or **bony nasal cavity** is a paired air-filled space of irregular shape located above the roof of the oral cavity. It forms the bony frame of the initial part of the respiratory system (Fig. 47).

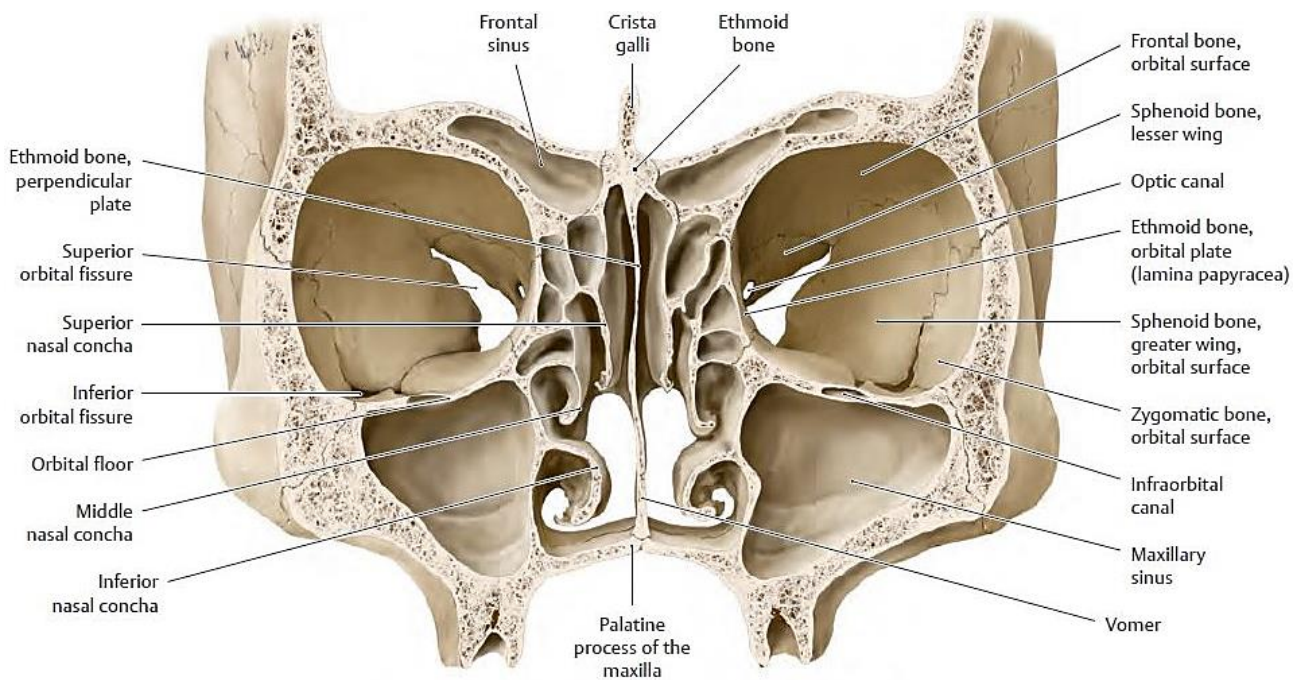


Fig. 47. Frontal section through the nasal cavity and paranasal sinuses

The anterior opening of the bony nasal cavity is the unpaired **piriform aperture**, bounded by the nasal notches of the maxillae and superiorly by the nasal bones.

Posteriorly, the nasal cavity opens with two **choanae**, separated by the vomer. The boundaries of the choanae are formed: above by the sphenoid body, laterally by the pterygoid processes, and below by the horizontal plates of the palatine bones.

Along the midline, the nasal cavity is divided into two halves by the **nasal septum**, which at the same time serves as the medial wall of the nasal cavity.

The nasal cavity connects to the **paranasal sinuses**, air-filled cavities in the surrounding bones (Fig. 47, 48). These include: 1) **Maxillary sinus**; 2) **Frontal sinus**; 3) **Sphenoidal sinus**; 4) **Ethmoidal cells (sinus)**.

The following bones form the *walls of the nasal cavity* (from front to back):

Medial wall (bony nasal septum) (Fig. 48):

- 1) Vomer;
- 2) Perpendicular plate of the ethmoid bone.

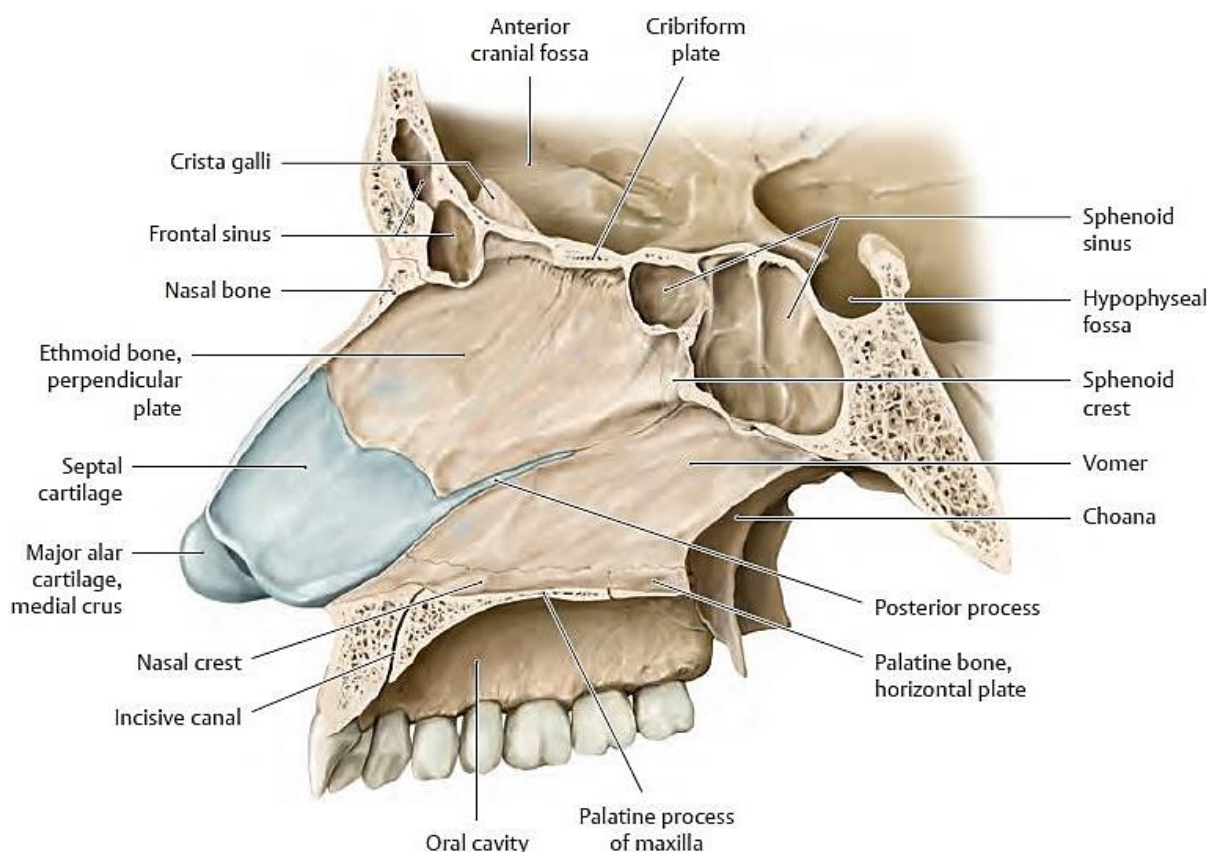


Fig. 48. Medial wall of the nasal cavity (nasal septum)

Superior wall (Fig. 49):

- 1) Nasal bone;
- 2) Nasal part of the frontal bone;
- 3) Cribriform plate of the ethmoid bone;
- 4) Body of the sphenoid bone.

Inferior wall (bony palate):

- 1) Palatine process of the maxilla;
- 2) Horizontal plate of the palatine bone.

The sphenopalatine (incisive) canal passes through the medial border of the palatine process at its anterior end to open on the oral surface of the palate.

Lateral wall (Fig. 49):

- 1) Nasal bone;
- 2) Frontal process and body of maxilla;
- 3) Lacrimal bone;
- 4) Labyrinth of ethmoid bone with the superior and middle conchae;
- 5) Inferior nasal concha;
- 6) Pterygoid process of sphenoid bone.

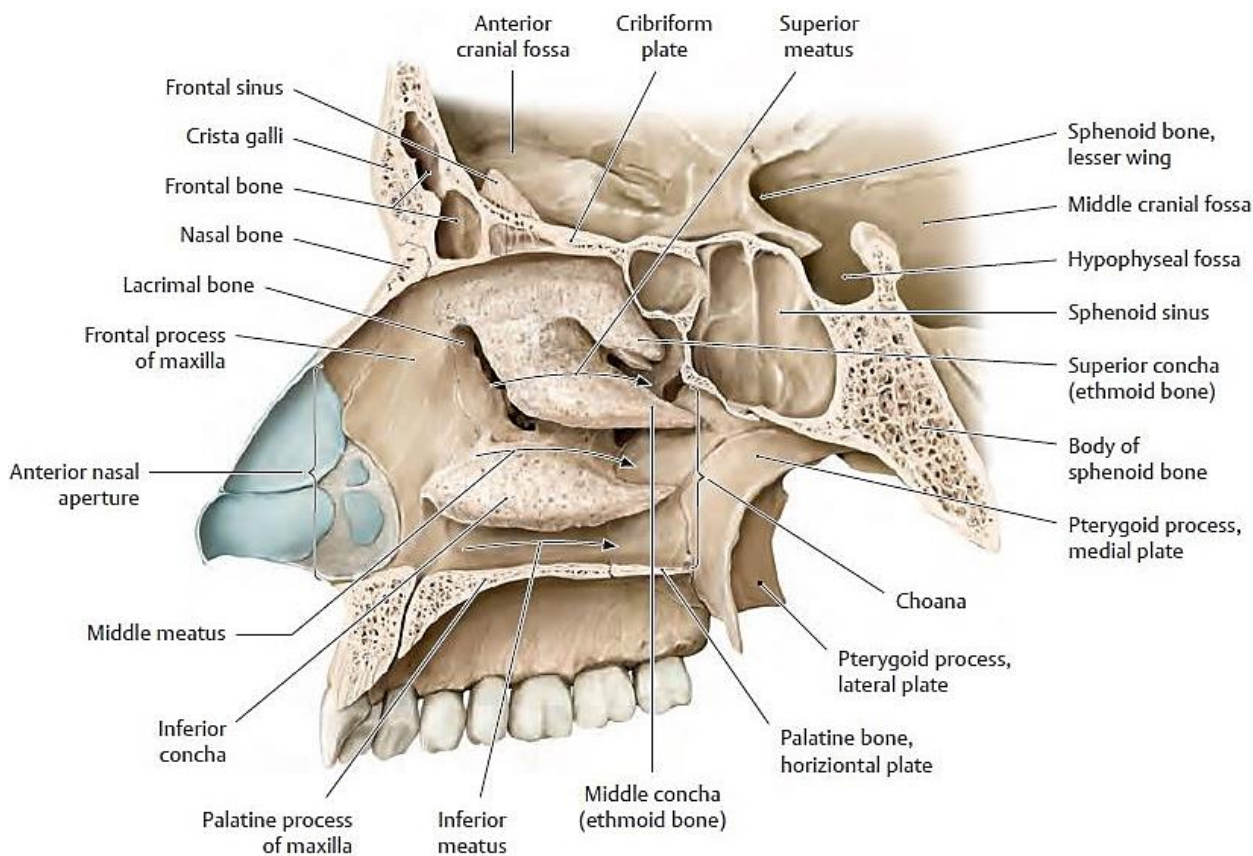


Fig. 49. Lateral wall of nasal cavity

The nasal conchae, located on the lateral wall of the nasal cavity, bound the **nasal meatuses**:

1. The **superior nasal meatus** is the space between the superior and middle nasal conchae. It is shorter than the others and is located in the posterior part of the nasal cavity. It has openings of:

- *posterior ethmoidal cells*;
- *sphenoidal sinus*.

2. The **middle nasal meatus** is the space between the middle and inferior nasal conchae. A semicircular slit on its lateral wall, the **hiatus semilunaris**, serves as an opening for the following sinuses:

- *frontal sinus*;
- *anterior and middle ethmoidal cells*;
- *maxillary sinus*.

The *sphenopalatine foramen*, which leads to the pterygopalatine fossa, lies at the posterior end of the middle nasal concha (in some cases lies in both the superior and middle nasal meatuses).

3. The **inferior nasal meatus** is the space between the inferior nasal concha and palate. It has an opening of the **nasolacrimal canal**, which contains the duct draining tears from the lacrimal sac to the nasal cavity.

The **common nasal meatus** is the part of the nasal cavity between the conchae and the nasal septum (Fig. 47).

CRANIUM OF THE NEWBORN

Compared to the skull of the adult, the skull of the newborn has the following main differences (Fig. 50):

- The facial skeleton makes up only 1/8 of the whole cranium, while in the adult, it is 1/3;
- The orbits are relatively large;
- The maxilla and mandible are proportionally small;
- There are no air-filled paranasal sinuses;

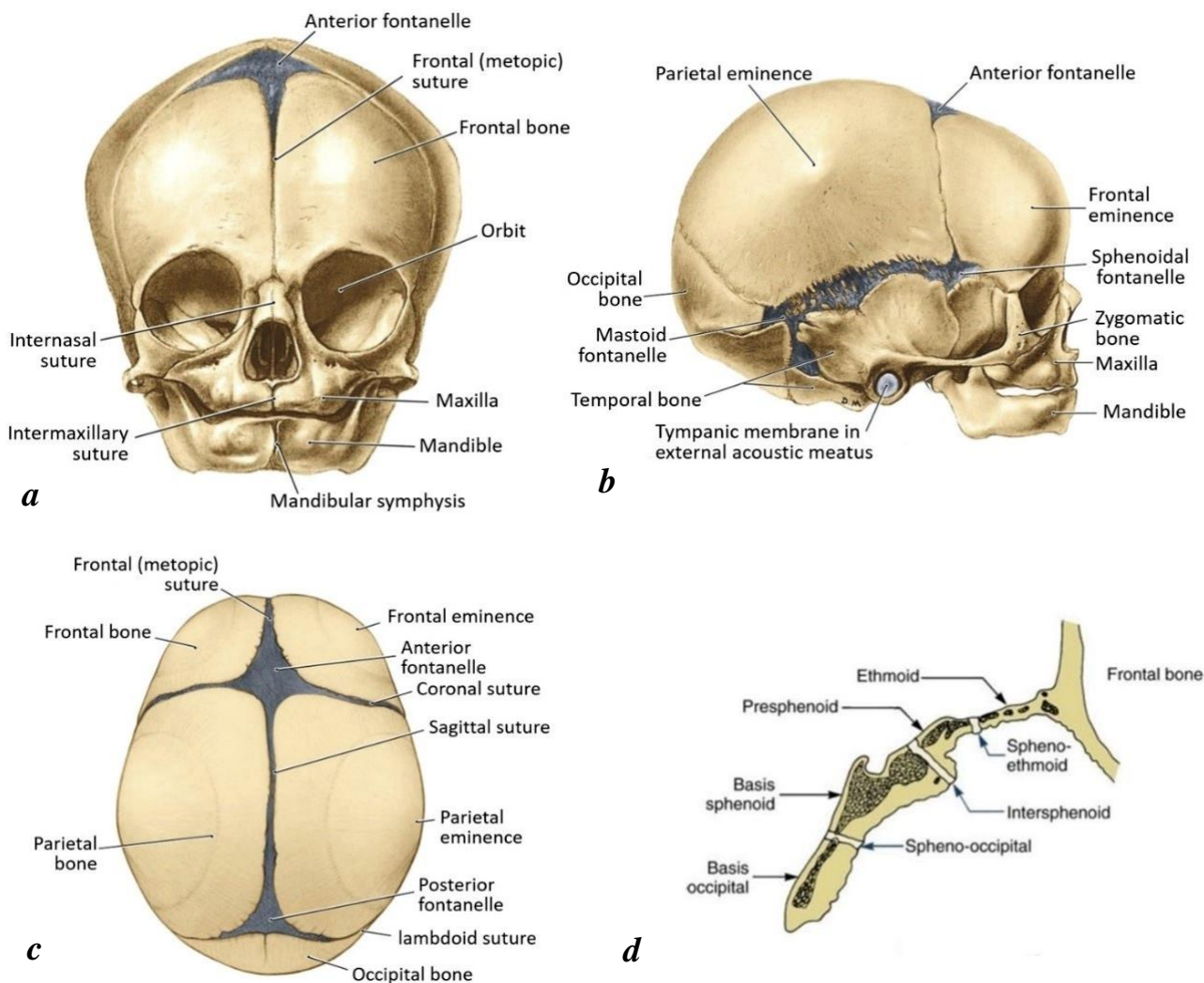


Fig. 50. Cranium of the newborn: anterior (a), lateral (b), and superior (c) aspects; synchondroses of the cranial base (d)

– The mandibular symphysis (closes during the 2nd year) and the frontal suture (closes during the 6th year; or sometimes preserved in adults) are present;

– The bony part of the external acoustic meatus is not developed and the tympanic membrane lies superficially at the bony external acoustic opening; no mastoid process (until 2nd year);

– The cranial vault (calvaria) from above has a pentagonal shape due to the pronounced parietal, frontal eminences and occipital protuberance, which are the ossification points. The edges of these bones remain membranous, sutures are not formed;

– **Fontanelles** are gaps at the junction of 3 or 4 bones filled with fibrous tissue: the largest, anterior, is usually closed by the 2nd year (during 12–18 months); others during 1st year (posterior in 2–3 months; sphenoid and mastoid in 6–12 months).

– In the cranial base cartilage remains at the intersphenoid synchondrosis, between the body and lesser wings of the sphenoid bone (ossifies at the time of birth); speno-ethmoid synchondrosis (ossifies in 6–7 years); speno-occipital synchondrosis (ossifies in 13–15 years).

APPENDICULAR SKELETON

UPPER LIMB

Bones of the upper limb include **bones of pectoral girdle** (*syn.* shoulder girdle) — the *scapula* and *clavicle*, and **bones of free part of upper limb**. These are bones, which form the *arm (brachium)*, *forearm (antebrachium)*, and *bones of hand* (Fig. 51).

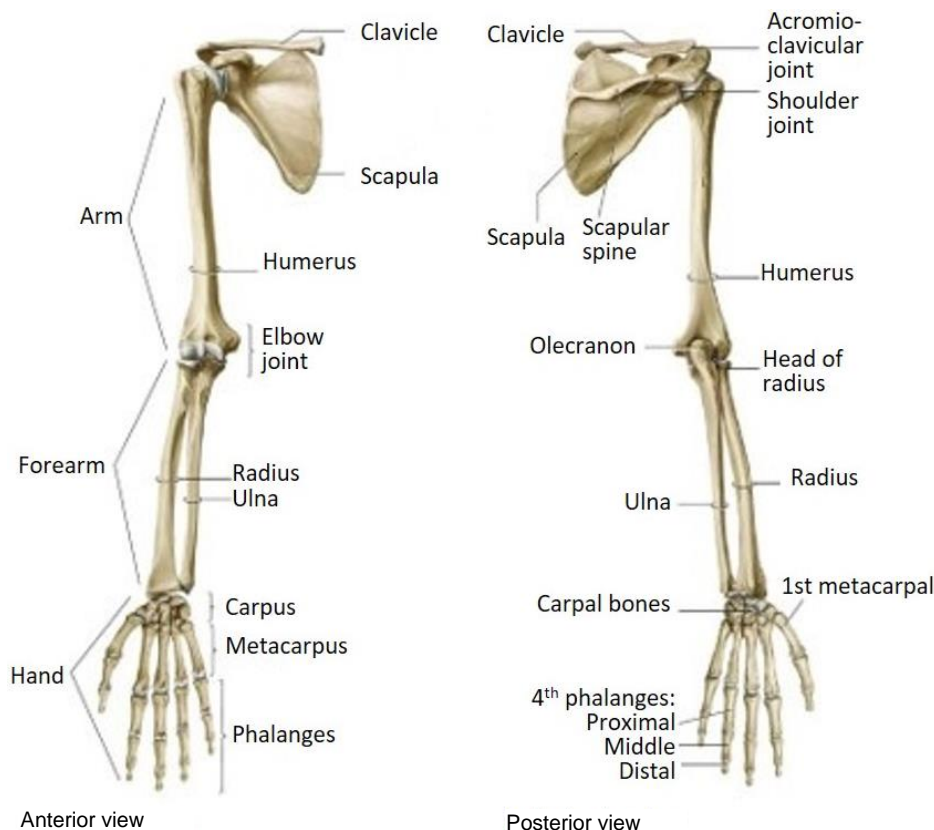


Fig. 51. Bones of upper limb

BONES OF PECTORAL GIRDLE

The bones of the pectoral girdle attach the free upper limb to the trunk and the clavicle is the only bone connecting the upper limb to the axial skeleton. The clavicle articulates with the sternum medially and with the scapula laterally, holding the shoulder joint apart from the body that allows for maximal freedom of motion for the upper limb. The scapula is fixed to the trunk by muscles.

Scapula

The **scapula** is a flat triangular bone with **2 surfaces** — **costal (anterior)** and **posterior (dorsal)**, **3 angles** — **superior, inferior, and lateral**, and **3 borders** — **superior, lateral, and medial** (Fig. 52, 53).

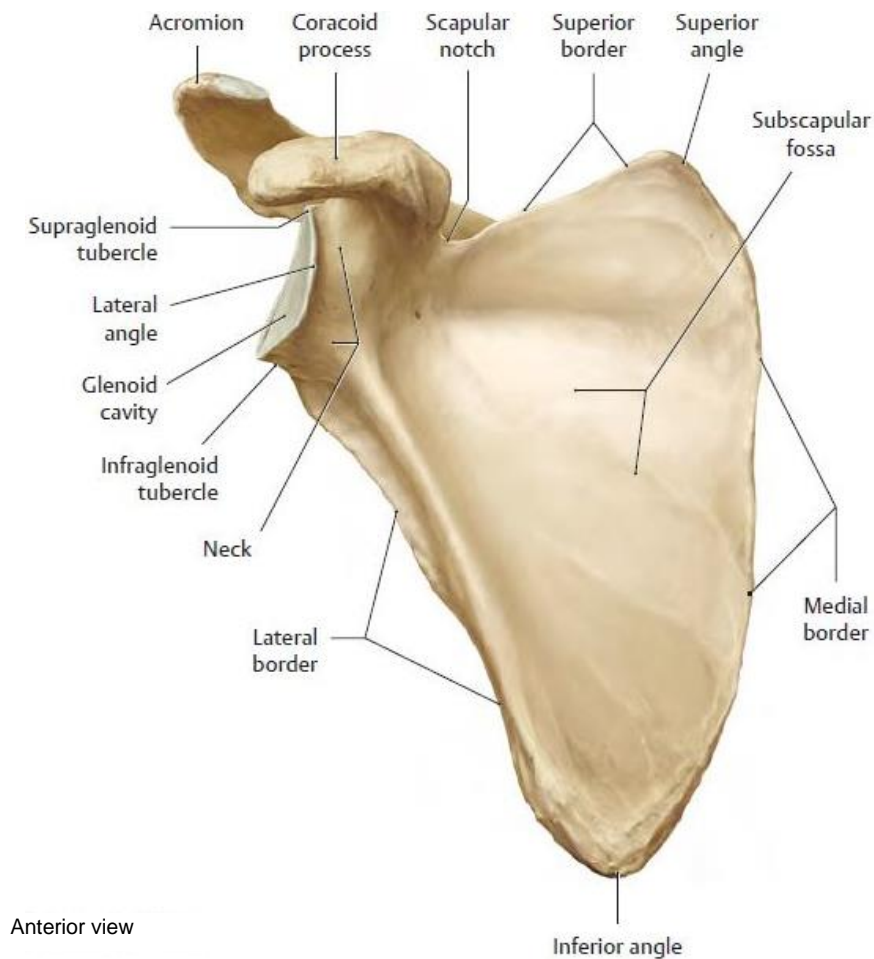


Fig. 52. Scapula: anterior view

The **costal (anterior) surface** contains the **subscapular fossa** for attachment of the subscapular muscle.

The beak-like **coracoid process** projects forward at the lateral angle of scapula. The scapular notch is located medial to the coracoid process on the superior border of the scapula.

The **lateral angle** of scapula has a shallow depression, the **glenoid fossa (cavity)**, articulating with the head of humerus at the shoulder joint. Above and below the glenoid cavity are the **supraglenoid** and **infraglenoid tubercles**.

The **posterior surface** is crossed by a prominent ridge, the **scapular spine**, which divides the bone into two concave areas — the **supraspinous** and **infraspinous fossae**. The scapular spine ends laterally with the **acromion**, a process that articulates with the clavicle.

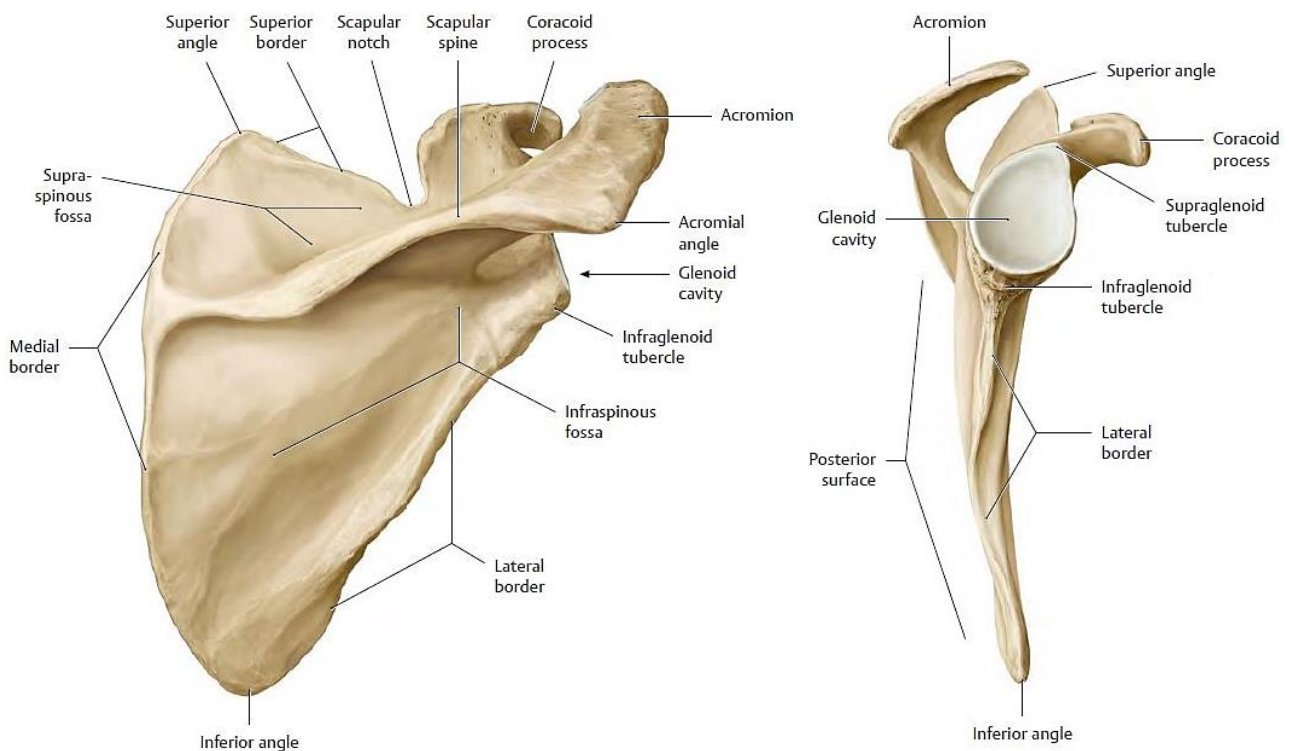


Fig. 53. Scapula: posterior and lateral view

Clavicle

The **clavicle**² has the **body (shaft)** and two ends, the medial **sternal end** (*Lat. extremitas sternale*) and the lateral **acromial end** (*Lat. extremitas acromiale*). Each end has an articular surface. The **sternal end** articulates with the manubrium of sternum (Fig. 54). It is roughly pyramidal in shape and thicker than the flattened acromial end.

The **body of clavicle** is S-shaped. Its medial part is convex, and its lateral part is concave.

The *superior surface* of the body is smooth.

The *inferior surface* is rough. It has the **groove for subclavius muscle** (*syn.* subclavian groove) on the middle third of the body and the **tuberosity for coracoclavicular ligament** (formed by the conoid tubercle and trapezoid line) at the lateral end.

² The name “collarbone” is used to refer to the clavicle because it is located between the neck and shoulder.

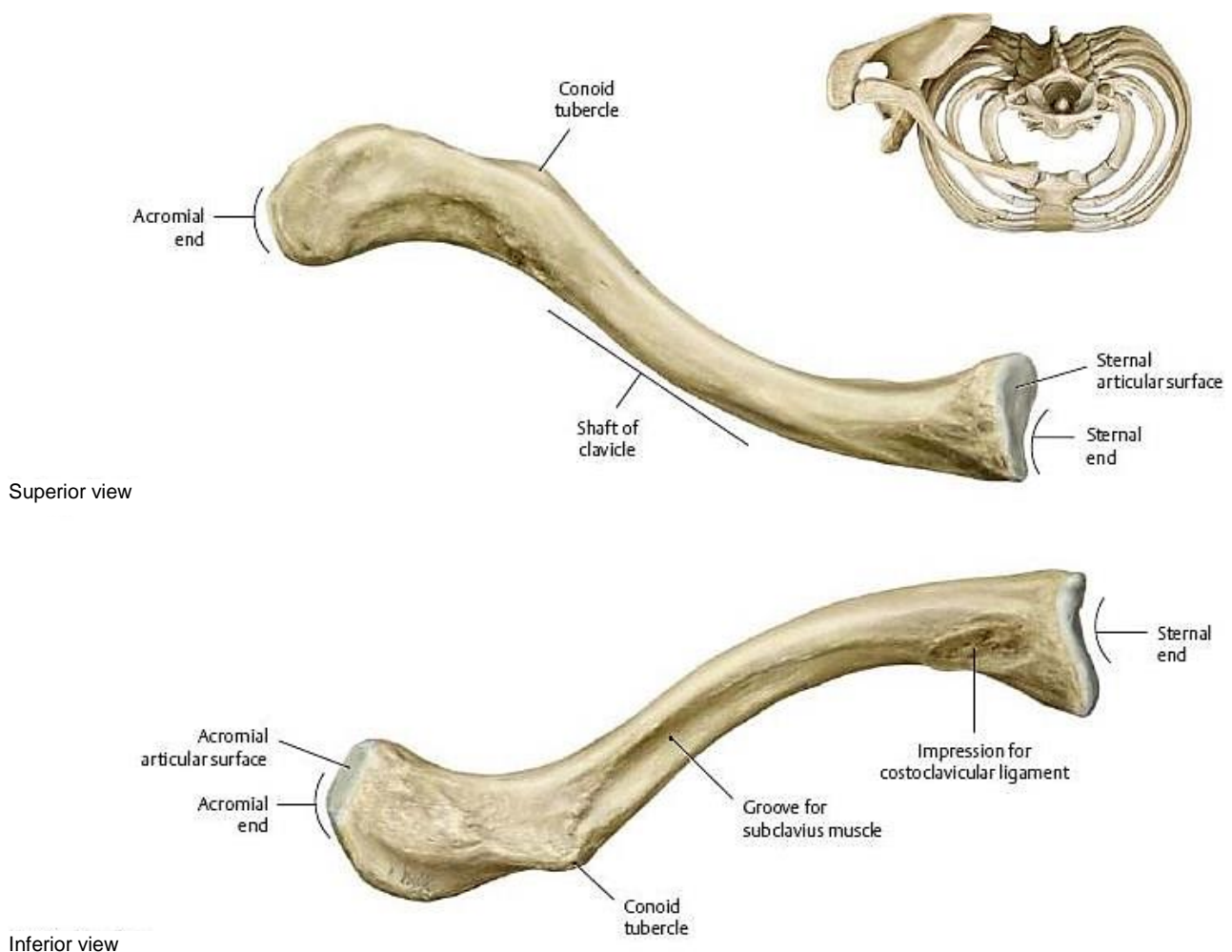


Fig. 54. Clavicle

BONES OF FREE UPPER LIMB

Humerus

The **humerus** is a bone of the arm. It is a typical long bone, which has the *proximal epiphysis* (head of humerus), *distal epiphysis* (condyle), *diaphysis* (body), and *apophyses* near both epiphyses (tubercles and epicondyles) (Fig. 55, 56).

The *proximal end* of the humerus is the rounded **head of humerus**, which articulates with the glenoid fossa of the scapula at the shoulder joint. A slight constriction, the **anatomical neck**³, separates the head from the rest of the bone.

Two tubercles are located right near the head:

- The **greater tubercle** is a larger lateral prominence;
- The **lesser tubercle** is an elevation on the antero-medial surface of the bone.

The **intertubercular sulcus** (*syn. bicipital groove*) separates the two tubercles and continues downward between two ridges (for muscle attachments) — the **crests of greater and lesser tubercle** (*syn. lateral and medial lips of intertubercular sulcus*).

³ The anatomical neck is the metaphysis of the humerus; it corresponds to the location of the epiphyseal cartilage in the growing bone.

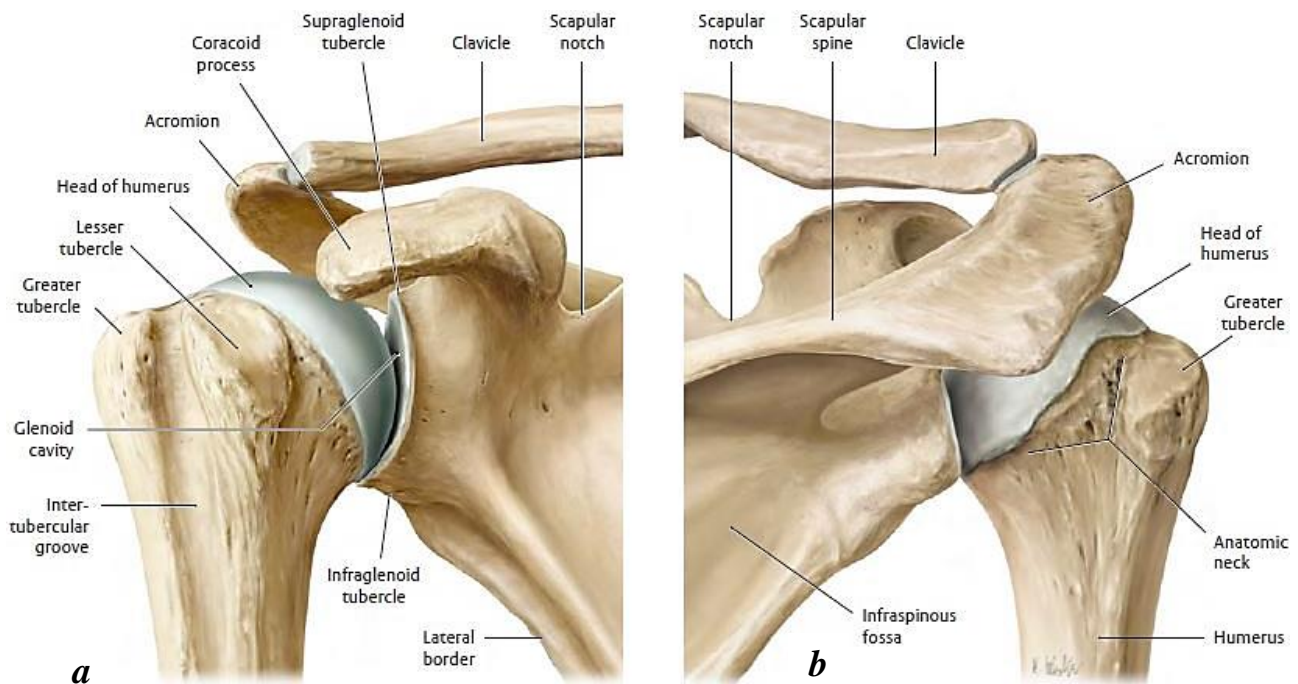


Fig. 55. Proximal epiphysis of humerus: anterior (a) and posterior (b) view

The narrowing of the body of humerus distal to the tubercles is called the *surgical neck* because it is a common site of humeral fractures.

The **body of humerus** (*syn. shaft of humerus*) is cylindrical in the upper half and triangular in cross-section in the lower half.

The **deltoid tuberosity** is located approximately in the middle of the anterolateral surface of the body. The **radial groove** (*syn. spiral groove*) for the radial nerve runs on the posterior surface behind the deltoid tuberosity.

The *distal end* of the humerus consists of the **condyle** and **medial** and **lateral epicondyles** above it on both sides. The **medial** and **lateral supracondylar ridges** rise from the epicondyles onto the body of humerus. The **groove for ulnar nerve** (*syn. ulnar groove*) lies posterior to the medial epicondyle.

The **condyle** consists of 2 parts that articulate with the bones of the forearm:

- The **trochlea** is the medial part of a roughly cylindrical shape that articulates with the ulna.

- The **capitulum** is the lateral rounded part that articulates with the radius.

There are **3 fossae** above the condyle:

- **Olecranon fossa** posteriorly; it is the deep depression that accommodates the olecranon of the ulna at the elbow joint in full extension;

- **Radial fossa** anteriorly above the capitulum; it accommodates the head of radius during flexion;

- **Coronoid fossa** anteriorly above the trochlea; it accommodates the coronoid process of ulna during flexion at the elbow joint.

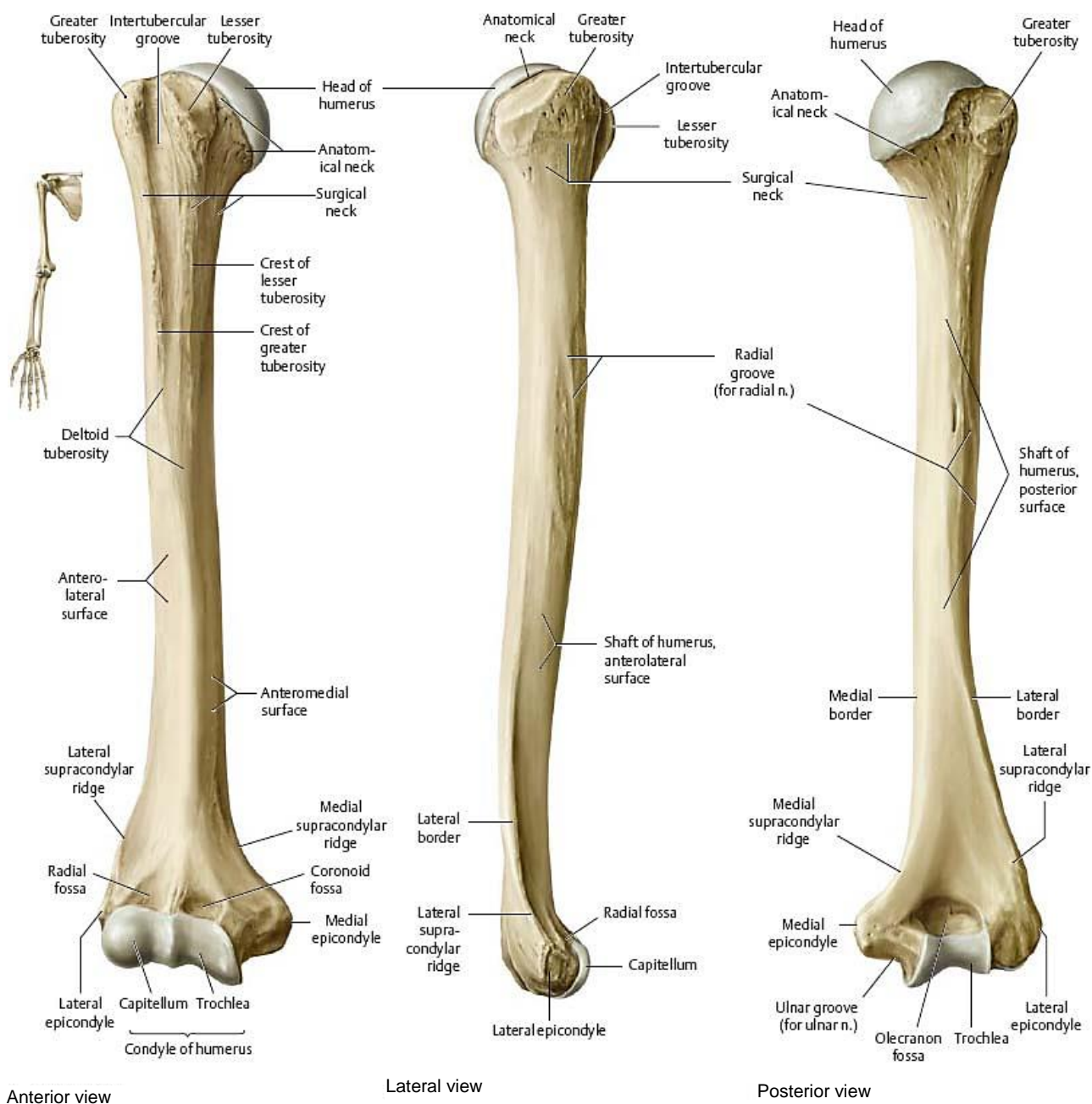


Fig. 56. Humerus

Bones of Forearm

The **radius** and **ulna** are long bones that support the forearm. In the anatomical (supinated) position they lie parallel to each other, with the radius located lateral to the ulna. In the radius, the distal epiphysis is more massive than the proximal one, while in the ulna, the proximal epiphysis is larger (Fig. 57).

Radius

The *proximal end* (epiphyses) of the **radius** is the cylindrical **head of radius** (Fig. 57). On the superior aspect, it has a concavity to articulate with the capitulum of humerus. The **articular circumference** around the head articulates with the ulna.

The head of radius connects with the **body** by the **neck**. The **radial tuberosity** (for the attachment of the *biceps brachii muscle*) lies anteromedially distal to the neck.

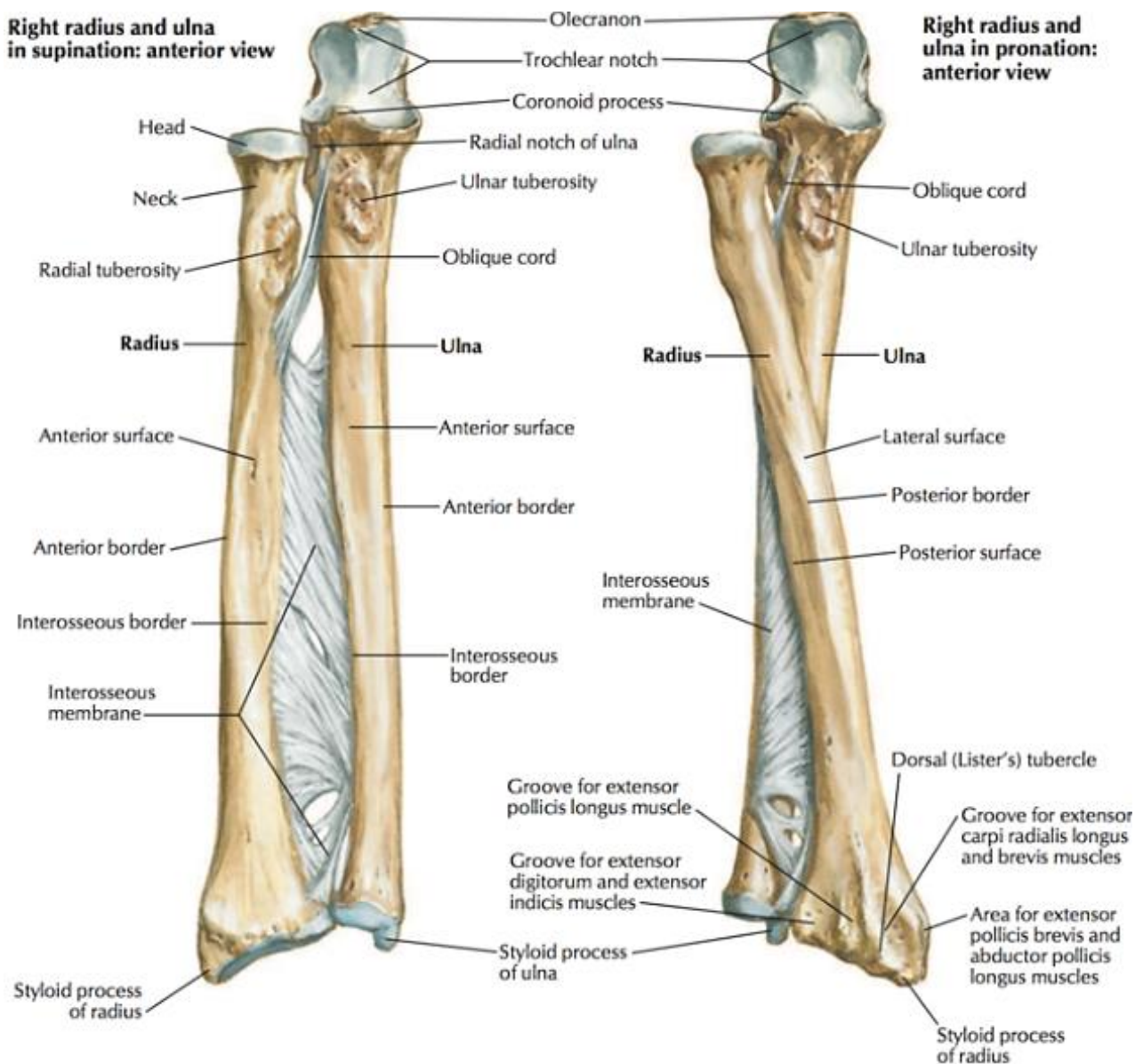


Fig. 57. Bones of forearm

The **body (shaft) of radius** is triangular in cross-section and has 3 surfaces separated by 3 borders:

- the **anterior, posterior, and lateral surfaces**;
- the **anterior, posterior, and interosseus borders**.

The interosseous border is sharp, directed medially to the ulna and gives attachment to the interosseous membrane of forearm.

The *distal end* (epiphysis) of the radius is broader than the proximal one. On the lateral aspect it ends with the **radial styloid process**. On the medial aspect it has the **ulnar notch** articulating with the head of ulna. The inferior surface of the distal end, the **carpal articular surface**, articulates with the carpal bones of the hand at the wrist joint.

Ulna

The **ulna** is the medial bone of the forearm (Fig. 57).

The larger *proximal end* of the ulna is formed by 2 processes separated by the deep **trochlear notch**, which articulates with the trochlea of humerus:

– The **olecranon** is a thick process behind the trochlear notch, its subcutaneous part forms the elbow;

– The **coronoid process** projects anteriorly below the trochlear notch. On the lateral aspect it has the **radial notch** articulating with the head of radius.

Distal to the coronoid process the body of ulna has the **ulnar tuberosity**.

The **body (shaft) of ulna** is broad above and narrow below. Similar to the body of radius, it has 3 surfaces and 3 borders:

– the **anterior** (has a nutrient foramen in the upper part), **posterior**, and **medial surfaces**;

– the **anterior, posterior, and interosseus borders**.

The sharp interosseous border is directed laterally towards the radius.

The *distal end* of the ulna is the rounded **head of ulna** with the **articular circumference** for articulating with the radius. The **ulnar styloid process** projects on the posteromedial aspect of the distal end.

Bones of Hand

In the hand there are 3 groups of bones (Fig. 58):

– **8 carpal bones** that form the carpus (wrist);

– **5 metacarpal bones** that form the metacarpus;

– **phalanges of hand** that form the skeleton of the fingers.

Carpal bones are short bones arranged in 2 rows: proximal and distal. Each consists of 4 bones.

The **proximal row** includes the following bones (from medial to lateral):

1. **Scaphoid bone**, the largest boat-shaped bone;

2. **Lunate bone**, nearly semilunar in shape;

3. **Triquetrum bone**, the 3-sided bone;

4. **Pisiform bone**, the pea-shaped sesamoid bone, developed in the tendon of the flexor carpi ulnaris.

The scaphoid, lunate and triquetrum bones articulate with the radius. The pisiform bone articulates with the anterior surface of the triquetrum bone.

The **distal row** of the carpal bones includes (from medial to lateral):

1. **Trapezium bone**, the irregularly shaped bone;

2. **Trapezoid bone**, smaller than the trapezium bone;

3. **Capitate bone**, the central largest bone of the carpus with the proximally projected head;

4. **Hamate bone**, the wedge-shaped bone with a prominent hook-like process on its anterior surface.

The bones of the distal row articulate with the bases of the 5 metacarpals.

Metacarpal bones (*syn. metacarpals 1–5*) are classified as long bones⁴. The 1st metacarpal is the shortest one. It is related to the thumb and stands apart from the rest metacarpals.

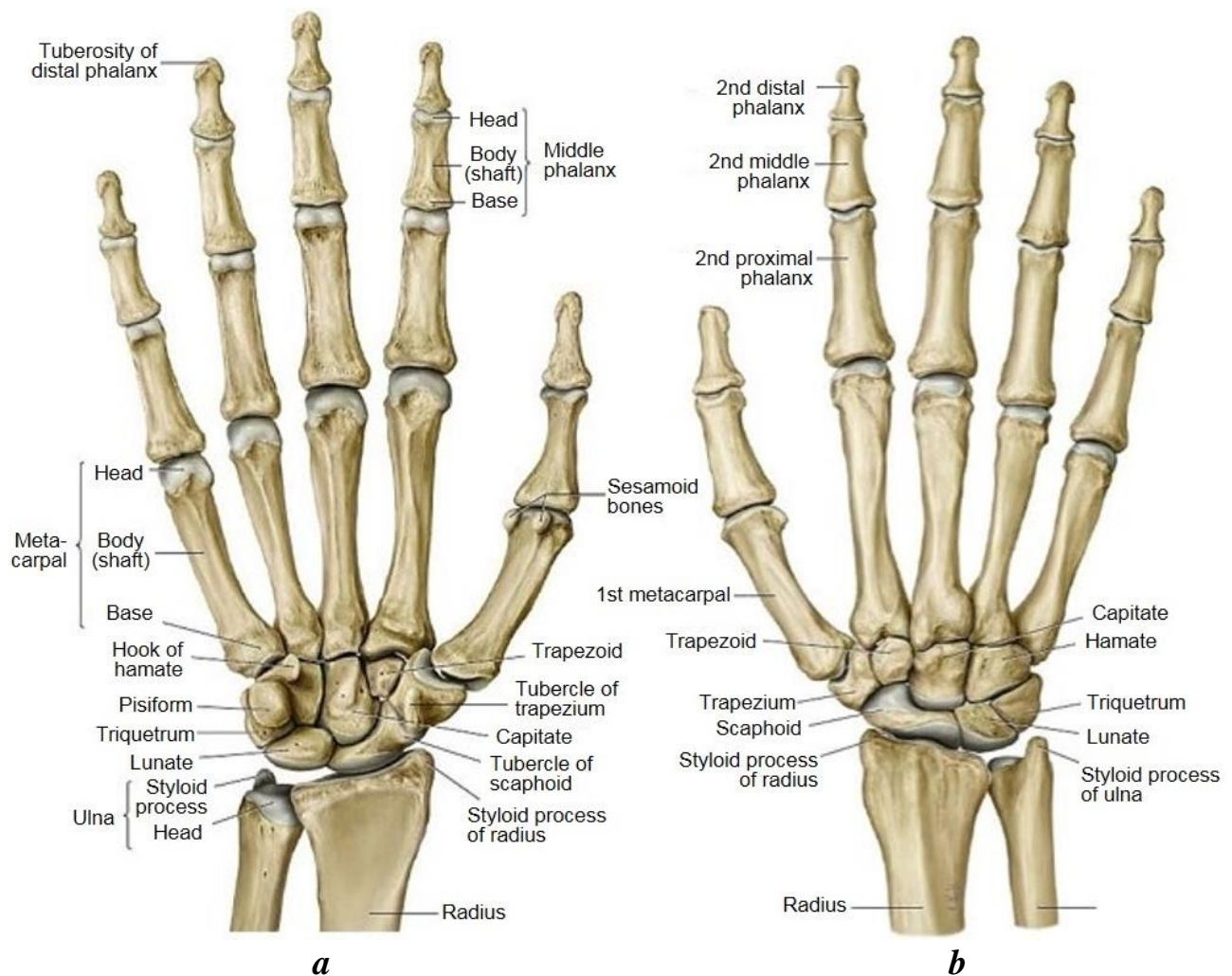
Each of **5 metacarpals** has:

- **base**, the proximal end articulating with the carpal bones;
- **body** (shaft);
- **head**, the distal end articulating with the proximal phalanx.

Phalanges of hand are bones of fingers (digits).

The **thumb** has **2 phalanges** — **proximal** and **distal**. Other four fingers have 3 phalanges: **proximal**, **middle** and **distal**.

Each phalanx has the **base** at the proximal end (these are true epiphyses), **body (shaft)** in the middle, and **head** at the distal end. The head of each distal phalanx has the **tuberosity of distal phalanx**.



*Fig. 58. Bones of hand:
a — palmar surface, b — dorsal surface*

⁴ They have only one true epiphysis (secondary ossification point) at the distal ends, with the exception of the 1st metacarpal, which has the true epiphysis at the proximal end.

LOWER LIMB

Bones of pelvic girdle. Bones of the lower limb include bones of pelvic girdle — paired *hip bones*, and bones of free part of upper limb — bones of the *thigh*, *leg*, and *foot* (Fig. 59). The two hip bones connect the free lower limbs to the axial skeleton — the sacrum.

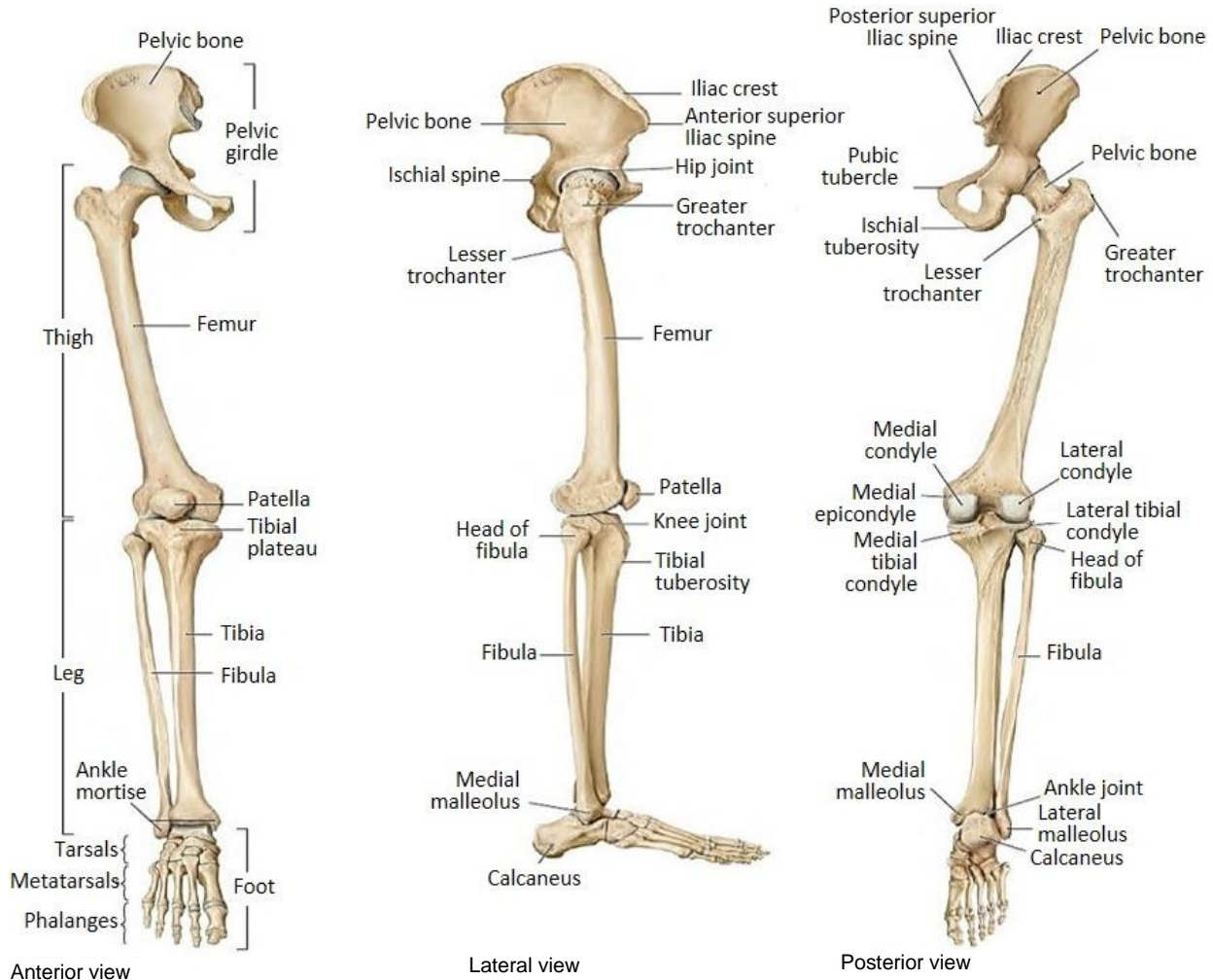


Fig. 59. Lower limb

Hip Bone

The **hip bone** (*syn.* coxal or pelvic bone) is a paired, large, irregular bone that together with the sacrum forms the bony pelvis (Fig. 60, 61, 62).

The hip bone consists of **3 bones: ilium, ischium, and pubis.**

On the lateral surface of the hip bone, at the site of fusion of the three bones, there is a cup-shaped depression — the **acetabulum**. It contains a smooth **lunate surface**, articulating with the head of femur, and a rough surface in the center — the **acetabular fossa**. Inferiorly, the wall of the acetabulum is interrupted by the **acetabular notch**.

Ilium

The **ilium** (*syn.* **iliac bone**) is the largest upper part of the hip bone. It consists of the **body** and **ala of ilium** (*syn.* **wing of ilium**), separated from each other on the inner surface by the **arcuate line** (Fig. 60, 61, 62).

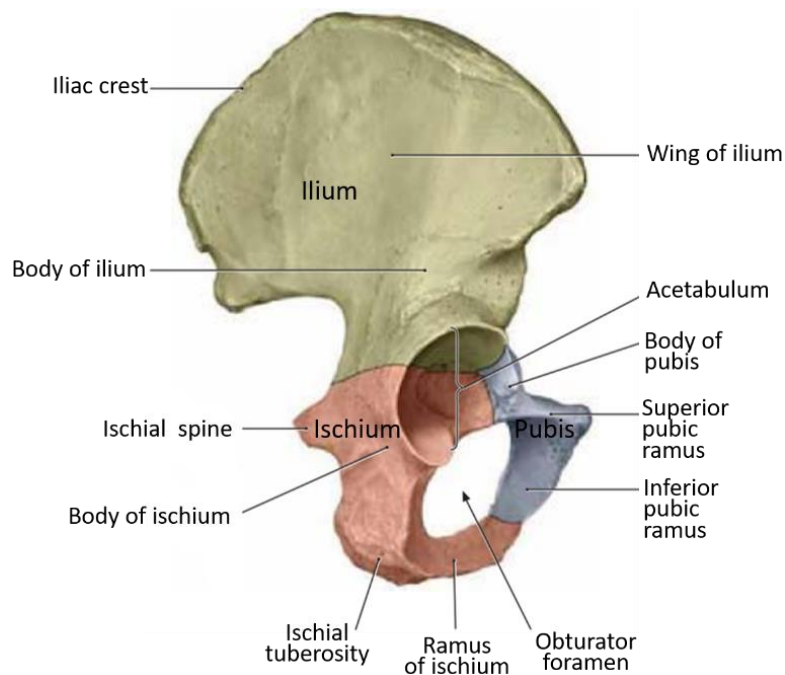


Fig. 60. Composition of hip bone: lateral view

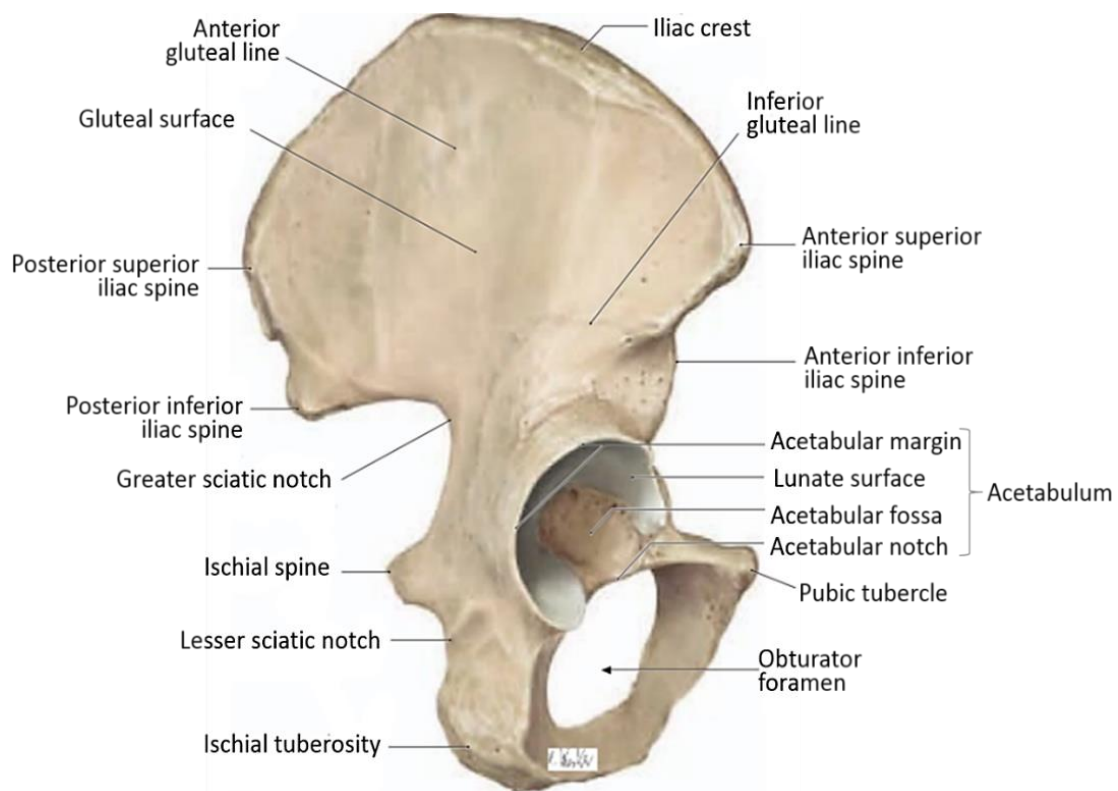


Fig. 61. Hip bone: lateral view

The **body of ilium** forms the superior part of the acetabulum.

The **wing of ilium** is the expanded part of the bone above the body.

The **iliac crest** is the thickened superior edge of the wing. In front it ends at the **anterior superior iliac spine** and behind at the **posterior superior iliac spine**. Accordingly, below them are the **anterior inferior** and **posterior inferior iliac spines**. The latter limits the **greater sciatic notch** superiorly.

The *inner sacropelvic surface* of the wing is concave and forms the **iliac fossa**. Posterior to the iliac fossa is the **auricular surface**, which articulates with the sacrum, and behind it is the rough **iliac tuberosity**.

The *outer gluteal surface*, has the **anterior, posterior, and inferior gluteal lines** at the attachment points of the three gluteal muscles.

Pubis

The **pubis** (*syn.* **pubic bone**) is the most anterior portion of the hip bone (Fig. 60, 62). It forms the anterior part of the acetabulum, surrounds most of the obturator foramen, and forms the pubic symphysis with the same bone of the opposite side. The pubis consists of the **body of pubis**, the **superior and inferior pubic rami** extending from the body⁵:

– The **body** is the medial part of the pubis. The oval **symphyseal surface** of the body faces the midplane. The **pubic crest** on the upper edge of the body reaches laterally the **pubic tubercle**.

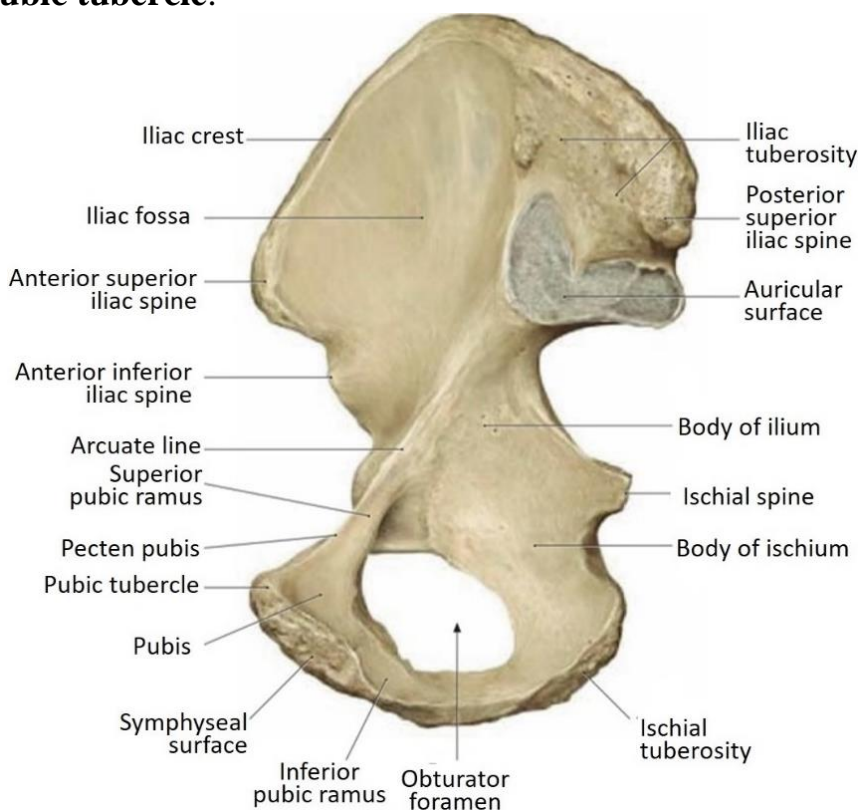


Fig. 62. Hip bone: medial view

– The **superior pubic ramus** extends from the symphyseal surface to the acetabulum. The **pecten pubis** is a ridge, which runs along its upper surface from the pubic tubercle to the *iliopubic eminence*. The superior pubic ramus forms the upper margin of the obturator foramen. The **obturator groove** crosses its lower surface.

– The **inferior pubic ramus** connects below with the ramus of ischium.

⁵ The position of the body of pubis is given here as described in most modern anatomy textbooks, although in classical anatomy the body of pubis is a part fused with the bodies of the ilium and ischium. “The body (corpus oss. pubis) forms one-fifth of the acetabulum, contributing by its external surface both to the lunate surface and the acetabular fossa.” (from Henry Gray. *Anatomy of the Human Body*. 1918. <http://www.bartelby.com/107/57.html>)

Ischium

The **ischium** (*syn.* **ischial bone**) is the posteroinferior part of the hip bone. It consists of the **body** and **ramus of ischium** (Fig. 60, 61, 62):

- The **body of ischium** forms more than $\frac{1}{3}$ of the acetabulum.

- The **ramus**, together with the pubic rami, surrounds the **obturator foramen**.

The thickening at the lower point of the ramus represents the **ischial tuberosity**, which bears the weight of the body when sitting.

The sharp bony prominence, the **ischial spine**, is located on the posterior border of the ischium. It separates two notches: the **greater sciatic notch** above and the **lesser sciatic notch** below.

PELVIS

The bony pelvis is divided into the greater pelvis (*syn.* false pelvis) and lesser pelvis (Fig. 63, 64). The **greater pelvis** is a lower part of the abdominal cavity between the wings of ilium.

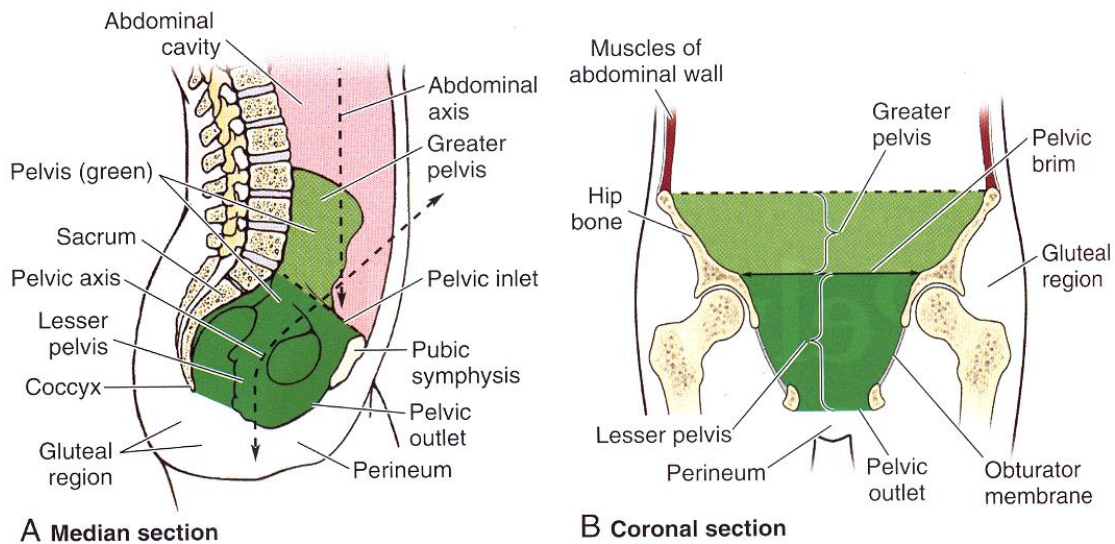


Fig. 63. Greater and lesser pelvis

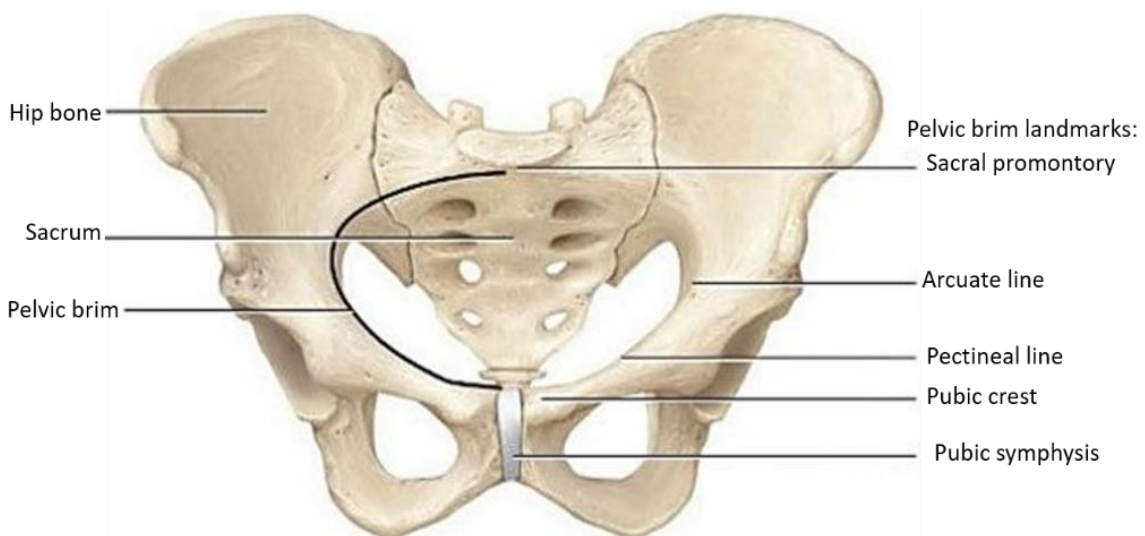


Fig. 64. Pelvic inlet

The **lesser pelvis** surrounds the **bony pelvic cavity** below the **terminal line** (*syn.* iliopectineal line). The lesser pelvis is formed by the hip bones (pubis, ischium, and lower parts of the ilium), sacrum and coccyx. The lesser pelvis protects the pelvic organs and serves as birth canal in female.

The lesser pelvis has two openings — pelvic inlet and pelvic outlet. The upper one is the **pelvic inlet** (*Lat. Aperture superior pelvis*). Its boundary, called the *pelvic brim*, includes: the upper border of the pubic symphysis, pubic crest and tubercle, terminal line (pecten pubis, iliopubic eminence, arcuate line), and promontory of sacrum.

The **pelvic outlet** (*Lat. Aperture inferior pelvis*) is bounded by the lower edge of the pubic symphysis, inferior pubic ramus and ramus of ischium, ischial tuberosity, coccyx, sacrotuberous and sacrospinous ligaments. The angle between the inferior pubic rami, the **subpubic angle**, is smaller in men. In women it is wider and is called the **pubic arch**.

Gender Differences of the Pelvis

The shape and average dimensions of the pelvis of men and women are different due to adaptation of the female pelvis to childbearing and childbirth (Fig. 65).

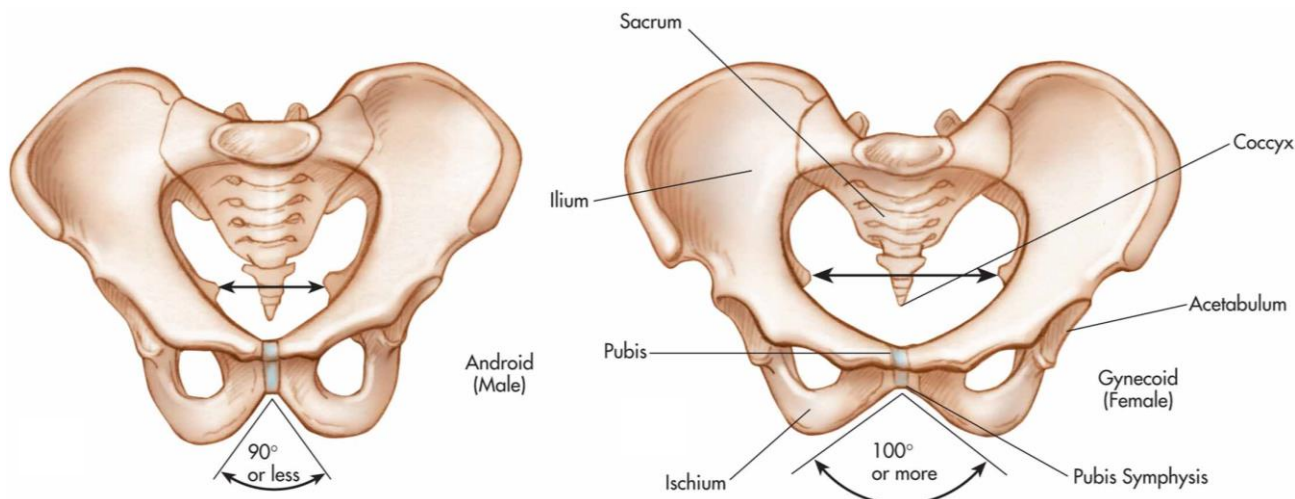


Fig. 65. Gender differences of the pelvis

The female pelvis has the following features (compared to the male pelvis):

- The distance between the wings of ilium is greater;
- The pelvic inlet is oval in the transverse direction, the promontory is less projecting;
- The pelvic cavity is relatively wider, rounder (closer to cylindrical) and lower (in men — funnel-shaped):
- Sacrum is flatter (less curved than in men), wider and shorter;
- The pelvic outlet is larger:
- The apex of sacrum and coccyx do not project forward;
- The distance between the acetabulum and ischial tuberosity is greater;
- Wider subpubic arch — 100° or more (subpubic angle in men < 90°).

The main measurements of the female pelvis, used for obstetric purposes, are shown in Table and Fig. 66.

Main measurements of the female pelvis

Name of diameter	Description	Average dimensions
<i>Transverse diameters:</i>		
Intercristal distance	Between furthest lateral points of iliac crest	~29 (28–29) cm
Interspinous distance	Between anterior superior iliac spines	~26 (25–27) cm
Intertrochanteric distance	Between trochanters of femurs	~31 (30–31) cm
<i>Antero-posterior diameters:</i>		
Anatomical, or true conjugate	From sacral promontory to upper border of pubic symphysis. True conjugate = External conjugate (20 cm) – 9	~11 cm
Obstetric conjugate	From sacral promontory to most bulging point on the back of pubic symphysis	~10.5 cm
External conjugate (measured from outside by pelvimeter)	From depression below the 5th lumbar spinous process to upper anterior margin of pubic symphysis	~20 cm
Diagonal conjugate	From sacral promontory to lower border of pubic symphysis	~12.5 cm

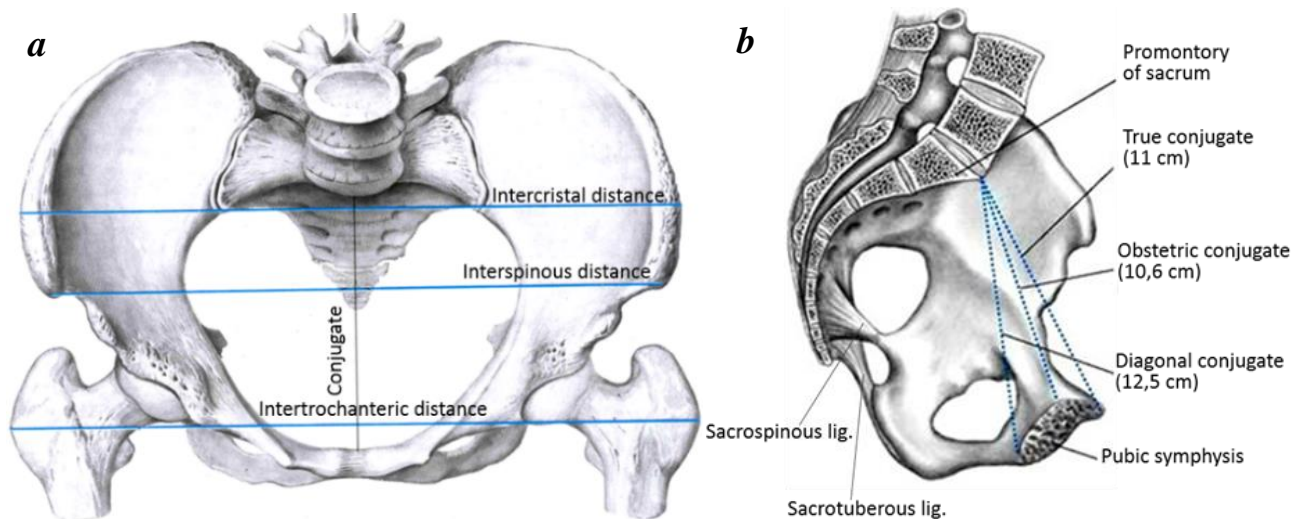


Fig. 66. Measurements of the female pelvis:
a — transverse diameters; *b* — antero-posterior diameters

BONES OF FREE LOWER LIMB

Femur

The **femur** (*syn.* thigh bone) is the longest and strongest bone in the body. It consists of following parts: the *proximal epiphysis* (head of femur), *distal epiphysis* (condyles of femur), *diaphysis* (body), and *apophyses* located near both epiphyses (trochanters and epicondyles) (Fig. 67).

The *proximal end* of the femur consists of the head, neck, and two trochanters.

The ball-like **head** articulates with the acetabulum to form the hip joint. It has a small depression in the middle, the **fovea for ligament of head of femur** (*Lat. fovea capitis femoris*).

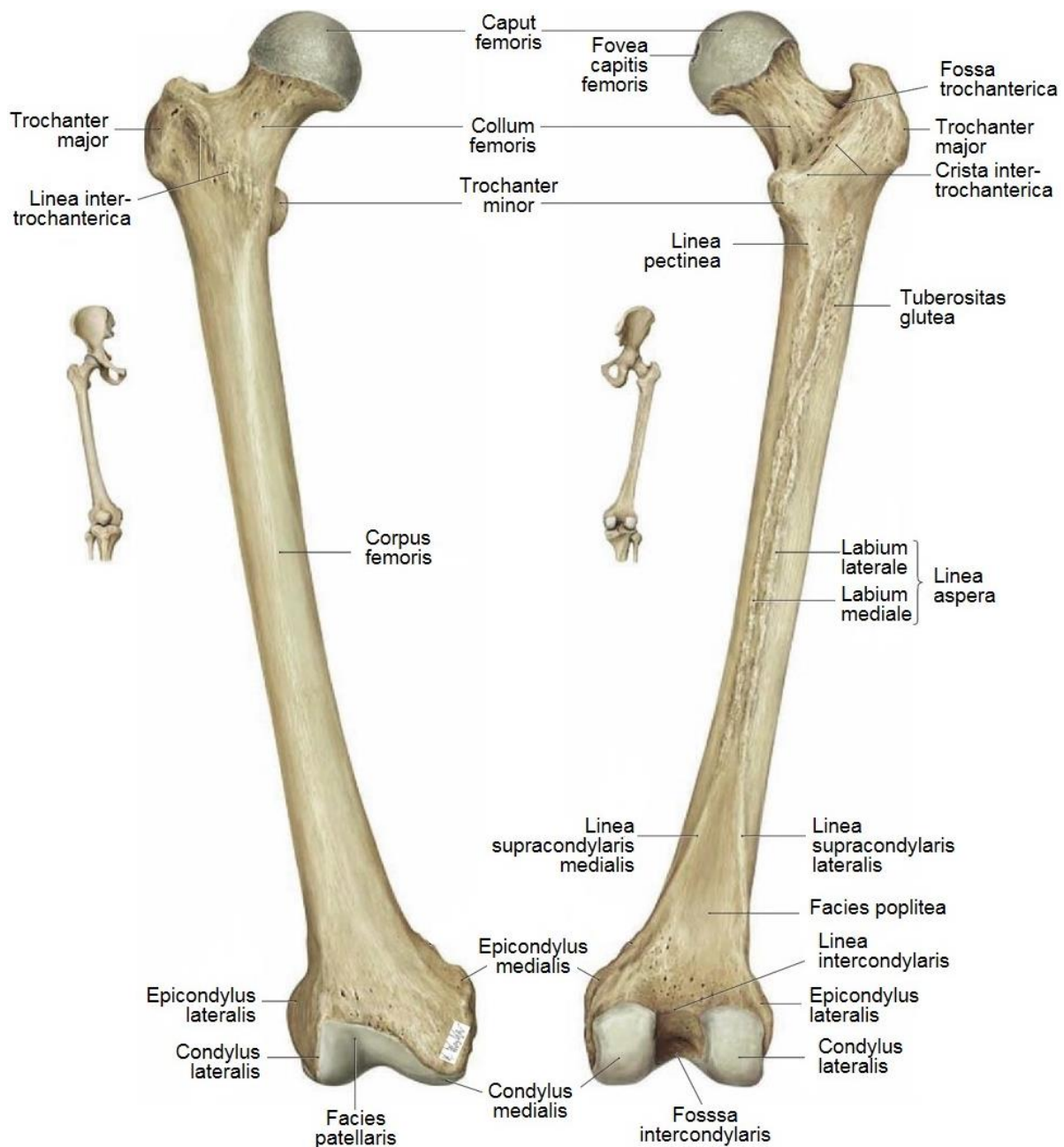


Fig. 67. Femur: anterior (left) and posterior (right) view

The **neck of femur** connects with the body at an angle of approximately 135 degrees. This allows greater mobility at the hip joint.

Two bony processes are located next to the neck:

- the **greater trochanter**, projected above the neck on the lateral side of the femur, with the *trochanteric fossa* on its medial aspect;
- the **lesser trochanter**, lying inferior to the neck on the posteromedial aspect of the femur.

Two bony ridges connect the greater and lesser trochanters:

- the **intertrochanteric line** anteriorly;
- the more pronounced **intertrochanteric crest** posteriorly.

The **body (shaft) of femur** below the trochanters is cylindrical until it widens at the distal end. On the posterior aspect the body has a longitudinal ridge, the **linea**

aspera (meaning: rough line). It is prominent in the middle third of the femur and consists of the **lateral** and **medial lips**. At the upper end, the lateral lip reaches the **gluteal tuberosity**, the medial lip becomes the **pectineal line** reaching the lesser trochanter. At the lower end, the lips diverge, forming the **medial** and **lateral supracondylar lines**, which limit the **popliteal surface**.

The *distal end* of the femur consists of two rounded condyles articulating with the tibia: the larger **medial condyle** and smaller **lateral condyle**. The smooth **patellar surface** connects the condyles on the anterior surfaces. A deep notch, the **intercondylar fossa** is between the two condyles on the posterior surface of the femur.

On the sides of the condyles are the **medial** and **lateral epicondyles**.

Patella

The **patella** (kneecap) is located in front of the knee joint. It is the largest sesamoid bone, which develops in the quadriceps femoris tendon (Fig. 68).

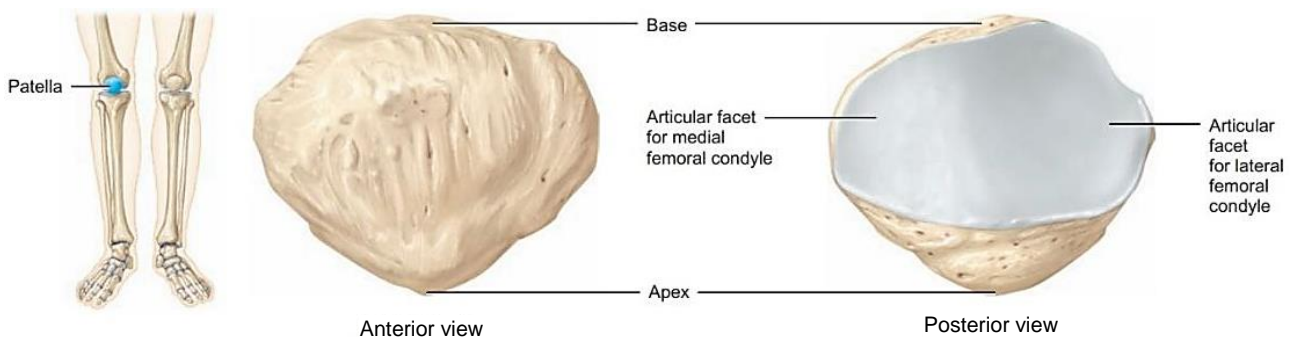


Fig. 68. Patella

The **patella** has a triangular shape with a wider upper part — the **base**, and a pointed lower end — the **apex**.

The **anterior surface** of the patella faces the skin; the **posterior surface** articulates with the femur.

Bones of Leg

Tibia. The tibia is the medial bone of the leg, known as the *shin bone* (Fig. 69). It is a large weight-bearing bone, which articulates with the femur at the knee joint, and with the talus at the ankle joint.

The *proximal end* (*epiphysis*) of the tibia consists of the **medial** and **lateral condyles** that form a flat surface, the **tibial plateau**. It consists of the following structures:

- **superior articular surfaces** of each condyle, articulating with the condyles of femur;
- **intercondylar eminence** formed by the *medial* and *lateral intercondylar tubercles*; they separate the articular surfaces of the medial and lateral condyles;
- **anterior** and **posterior intercondylar areas** (fossae) — shallow depressions in front and behind the intercondylar eminence.

Posteroinferiorly on the lateral condyle of tibia is the **fibular articular facet**.

The *diaphysis* is the **body (shaft) of tibia**, has **3 borders** and **3 surfaces**.

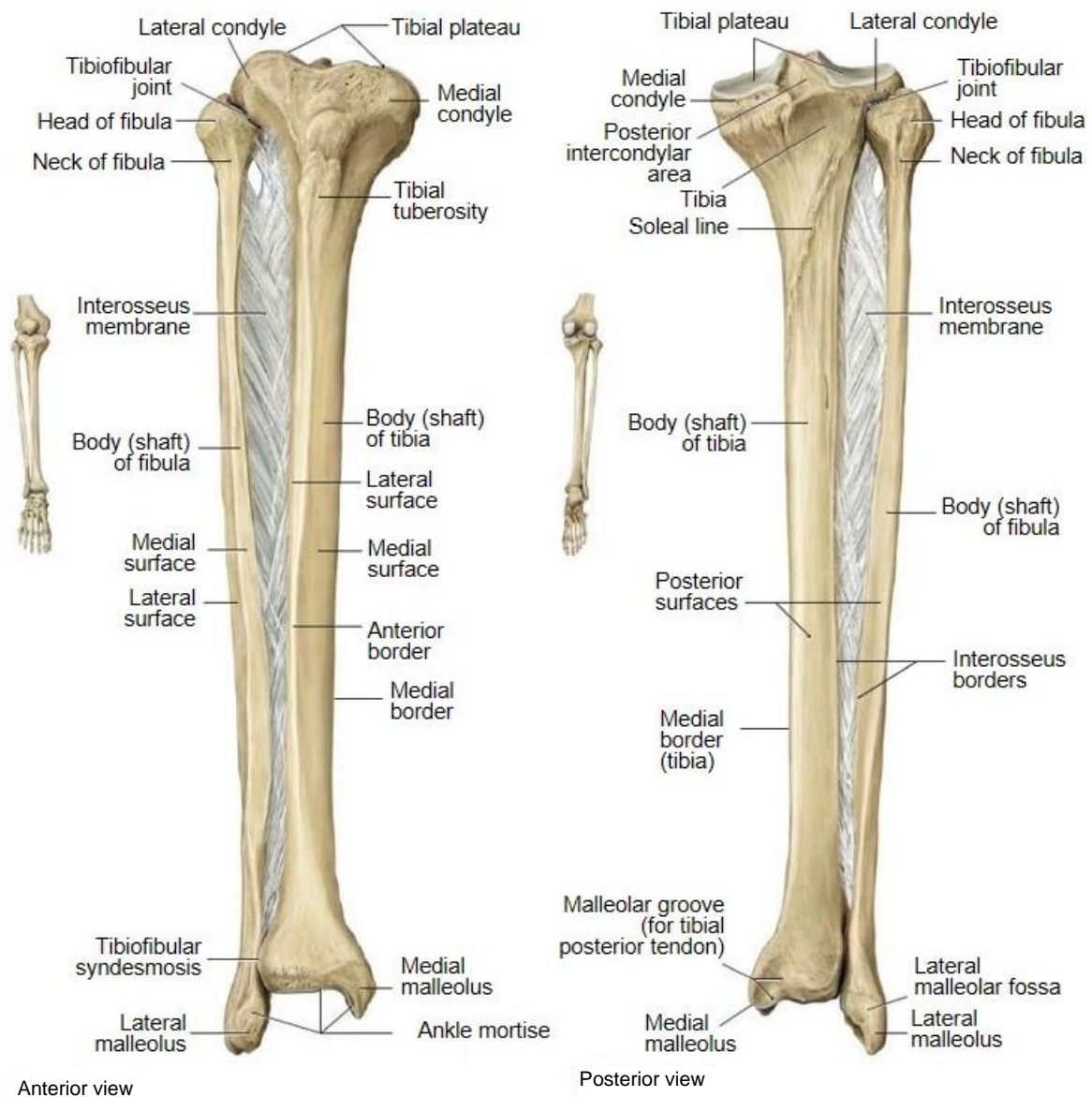


Fig. 69. Bones of leg

The *borders* are the following:

- The **anterior border** is easily palpable subcutaneously; proximally it ends in the prominent **tibial tuberosity**;
- The **medial border** is more rounded than the others;
- The **interosseous border** directs laterally; it is sharper than others and gives attachment to the interosseous membrane connecting the tibia and fibula.

The *surfaces* of the tibia are clearly distinguished:

- The **medial surface** of tibia has no muscle attachments and is palpable subcutaneously;
- The **lateral surface** is covered with muscles;
- The **posterior surface** is also covered with muscles. In the upper third it has an oblique ridge, the **soleal line**, running from the lateral condyle to the medial border of tibia (the attachment site of the soleus muscle).

The *distal end (epiphysis)* of the tibia widens. The **medial malleolus** projects downward from the medial aspect of the distal end. The malleolus and **inferior**

articular surface articulate with the talus at the ankle joint. The **fibular notch** is located on the lateral aspect of the distal end.

Fibula. The fibula is located within the lateral part of the leg (Fig. 69). Similar to the tibia, it is a long bone.

The *proximal end (epiphysis)* of the fibula is the rounded **head**, which ends with the pointed **apex of head**. The **articular facet** of head is connected with the lateral condyle of tibia.

The **body (shaft) of fibular (diaphysis)** has 3 surfaces (lateral, medial, and posterior), and 3 borders (anterior, posterior, and medial), but it is quite difficult to trace them. More pronounced is the **interosseous crest (border)**, directed anteromedially.

The *distal end* of the fibula is the **lateral malleolus**. On the medial surface it has the **articular facet** for articulation with the talus at the ankle joint. Posterior to the facet is the deep **malleolar fossa**.

Bones of Foot

The bones of the foot can be divided into 3 groups (Fig. 70):

- **Tarsal bones (7)** — irregularly shaped bones that form the tarsus;
- **Metatarsal bones (5)** — bones forming the metatarsus;
- **Phalanges of foot** — bones of the toes.

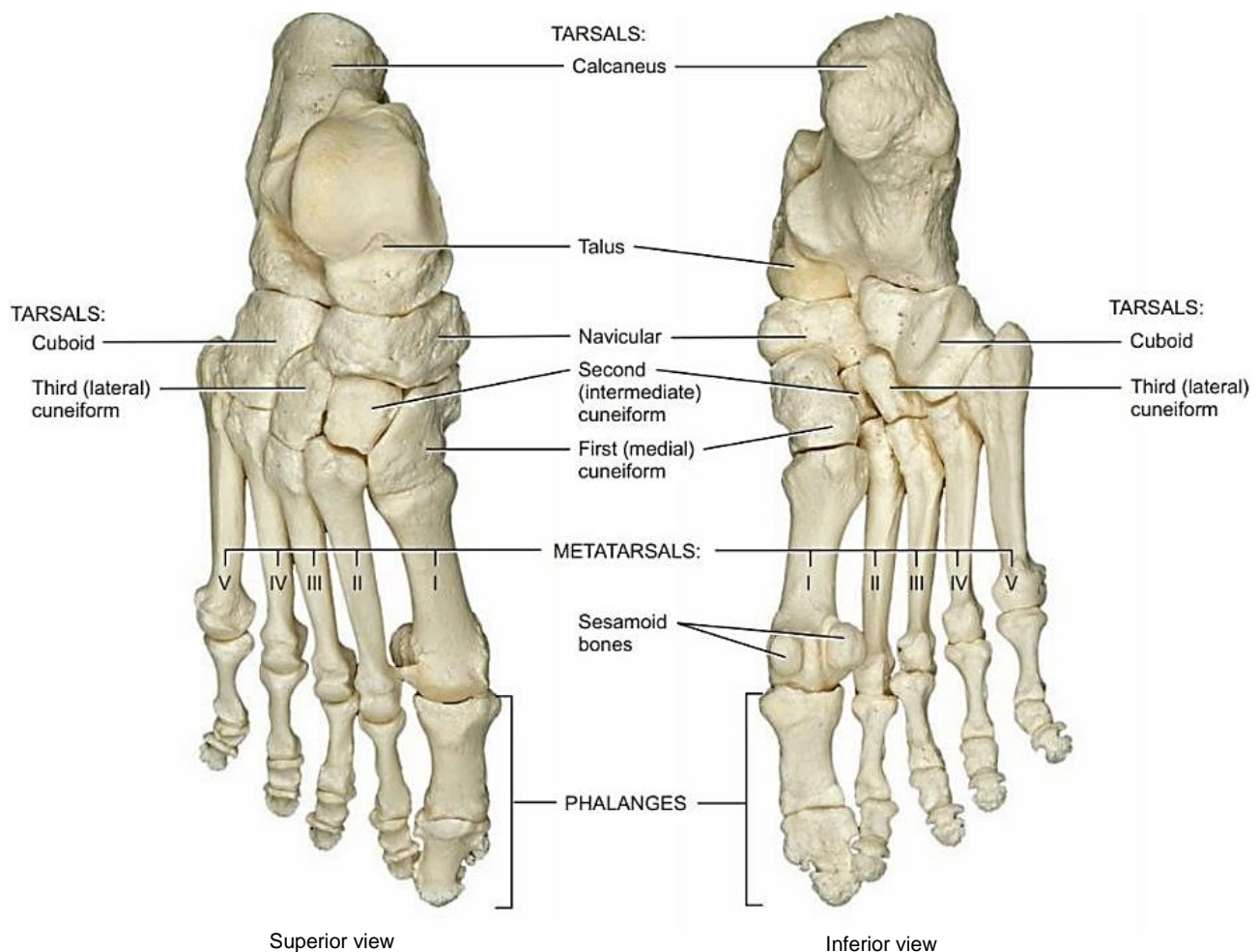


Fig. 70. Bones of foot

Tarsal Bones

In the tarsus 3 rows of bones can be distinguished: *proximal* (talus and calcaneus), *intermediate* (navicular), and *distal* (cuboid and three cuneiform bones).

Talus. The talus is the most superior of the tarsal bones. It transmits the weight of the body from the tibia to the foot.

The talus consists of the **head, neck, and body of talus**.

The **head** is the anterior rounded part, articulating with the navicular bone.

The **body** is the largest posterior part of the bone. Its upper part is the **trochlea of talus**, which has the **superior** and two **malleolar facets** articulating with the bones of the leg. On the inferior surface of the body, the **talar sulcus** separates **calcaneal articular facets** (middle and posterior). The **lateral** and **posterior processes** project from the respective aspects of the body.

Calcaneus. The calcaneus is the largest bone of the tarsus lying inferior and posterior to the talus. The posterior end of the calcaneus projects downward and forms the **calcaneal tuberosity**, which on the sides continues into the **medial** and **lateral processes**.

The thick process, the **sustentaculum tali** (syn. **talar shelf**), protrudes from the medial side of the calcaneus.

The upper surface of the calcaneus, has the **talar articular surfaces** that articulate with the corresponding (calcaneal) facets of the talus. The surfaces are separated by the **calcaneal sulcus** passing posterior to the sustentaculum tali. The calcaneal sulcus below and the talar sulcus above form a deep depression on the lateral surface of the foot — the **sinus tarsi**.

Navicular bone. The navicular bone (shaped like a boat) lies medially between the head of talus posteriorly and three cuneiform bones anteriorly. The **tuberosity of navicular bone** is located on the medial part of its plantar surface.

Cuneiform bones. The **medial** (largest), **intermediate** (smallest), and **lateral cuneiform bones** articulate with the navicular bone posteriorly and the metatarsals, from 1st to 3rd, anteriorly.

Cuboid bone. The cuboid bone lies in the lateral part of the tarsus in front of the calcaneus. Anteriorly it articulates with the 4th and 5th metatarsals.

Metatarsal Bones

There are **5 metatarsal bones (metatarsals 1–5)**. Each metatarsal has:

- **Base**, the proximal end, articulating with the corresponding tarsal bone;
- **Body (shaft)**;
- **Head**, the distal end, which forms the joint with the base of the proximal phalanx.

The first metatarsal bone is shorter and thicker than the others. Prominent medial and lateral sesamoid bones lie on the plantar surface of its head.

Phalanges of Foot

Similar to the fingers of the hand, the big toe (hallux) has **2 phalanges** — **proximal** and **distal**. Other four toes have **3 phalanges: proximal, middle** and **distal**.

Each phalanx has the **base** (proximal end), **body (shaft)**, and **head** (distal end). The head of each distal phalanx has the **tuberosity of distal phalanx**.

ARCHES OF FOOT

The shape and arrangement of the tarsal and metatarsal bones give the foot an arched shape raising it above the ground (Fig. 71). The ligaments of the foot and the muscles that cross its plantar surface strengthen the arches. The arches support the weight of the body and distribute it throughout the foot, provide shock absorption and propulsion of the foot during locomotion.

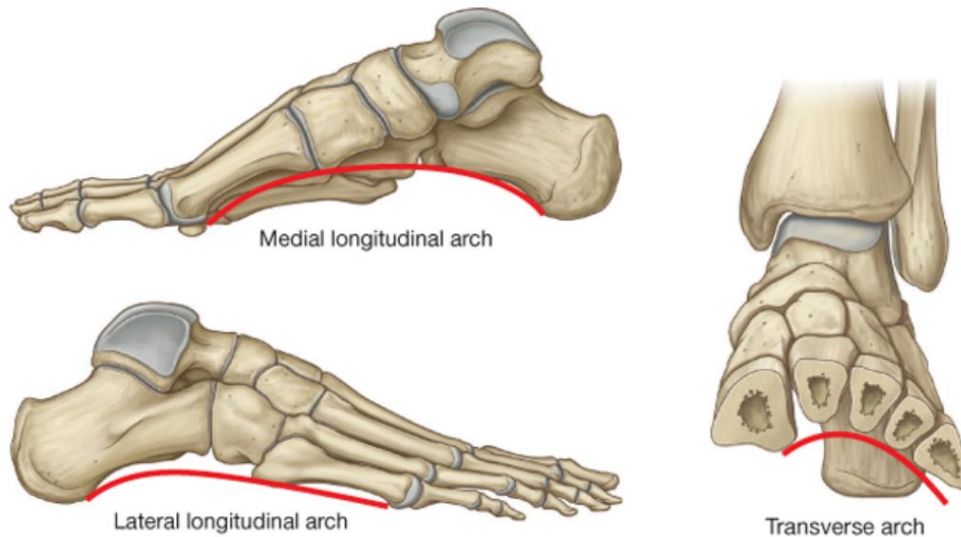


Fig. 71. Arches of foot

The two longitudinal arches connect the calcaneus with the heads of the metatarsals. The **medial longitudinal arch** is higher; it passes through the talus, navicular, and cuneiform bones, to the heads of the three medial metatarsals.

The **lateral longitudinal arch** is low, it rests on the ground during standing. It passes through the cuboid bone to the heads of the two lateral metatarsals.

The **transverse arch** connects the medial and lateral sides of the foot in the coronal plane at the level of the distal part of the tarsus and bases of the metatarsals. The transverse arch is the highest in the medial part, corresponding the navicular and cuneiforms, and bases of the 1st to 3rd metatarsals.

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Учебно-методическое пособие

На английском языке

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