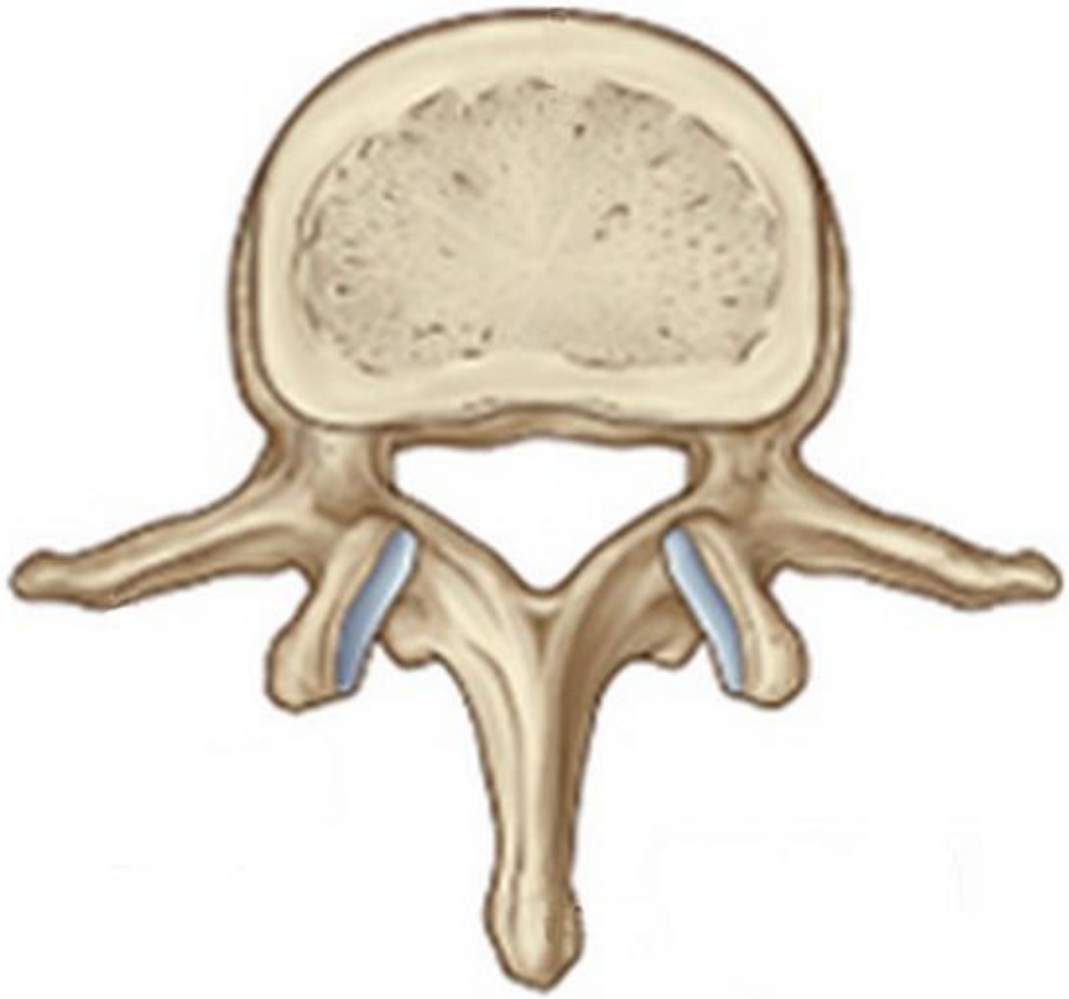
Введение в анатомию человека. Строение позвонков, крестца и копчика

Introduction to Human anatomy. Structure of the vertebrae, sacrum and coccyx



THE FORM, SIZE AND SEX OF THE HUMAN BODY

The human body is made up of the **head** (*caput*), **neck** (*collum*), **trunk** (*truncus*), and two pairs of **limbs**, or **extremities**, the **upper** (*membra* s. *extremitates* [BNA] *superiores*) and **lower** (*membra* s. *extremitates* [BNA] *inferiores*). The following parts are distinguished in the head: the **forehead** (*frons*); the **highest point of the skull** (*vertex*); the **back of the head** (*occiput*); the **temples** (*tempora*) and the **face** (*facies*). The trunk consists of the **chest** (*thorax*), the **abdomen** (*abdomen*) and the **back** (*dorsum*). The following linest are drawn for orientation on the chest surface: 1) **midline** (*linea mediana anterior*); (2) **sternal line** (*linea sternalis*) stretching along the sternal border; (3) **mamillary line** (*linea mamillaris* s. *medioclavicularis*) passing through the nipple or the middle of the clavicle; (4) **parasternal line** (*linea parasternalis*) passing midway between the sternal and mamillary lines; (5) **anterior,** (6) **middle,** and (7) **posterior axillary lines** (*lineae axillarea anterior, media* and *posterior*), the first and last passing through the anterior and posterior folds of the axilla, respectively, and the middle line passing through the point midway between these folds; (8) **scapular line** (*linea scapularis*) passing through the inferior angle of the scapula.

The abdomen is divided by two horizontal lines, one drawn between the ends of the 10th ribs and the other between both the anterior superior iliac spines, into three parts, one located above another: the **upper part of the abdomen** (*epigastrium*), the **middle part** (*mesogastrium*) and the **lower**

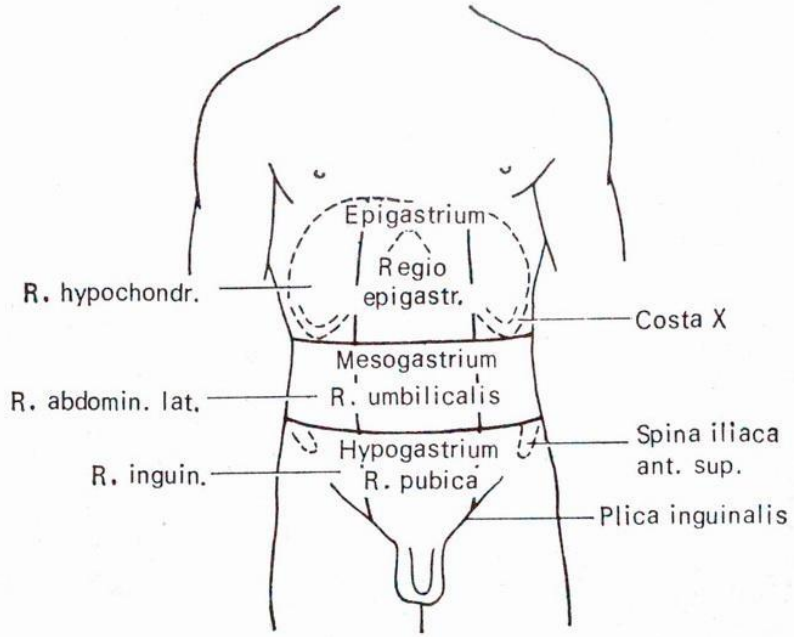
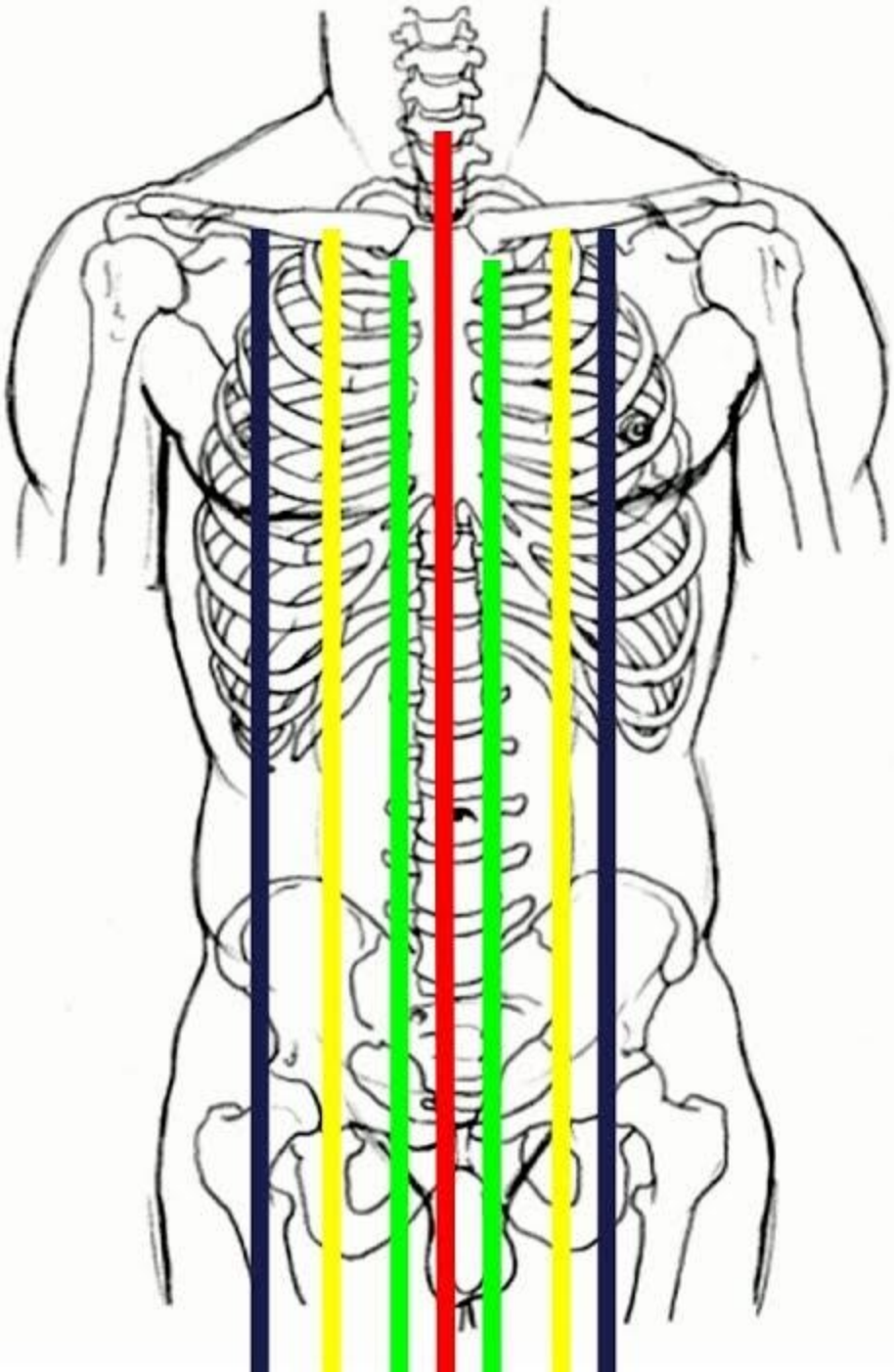
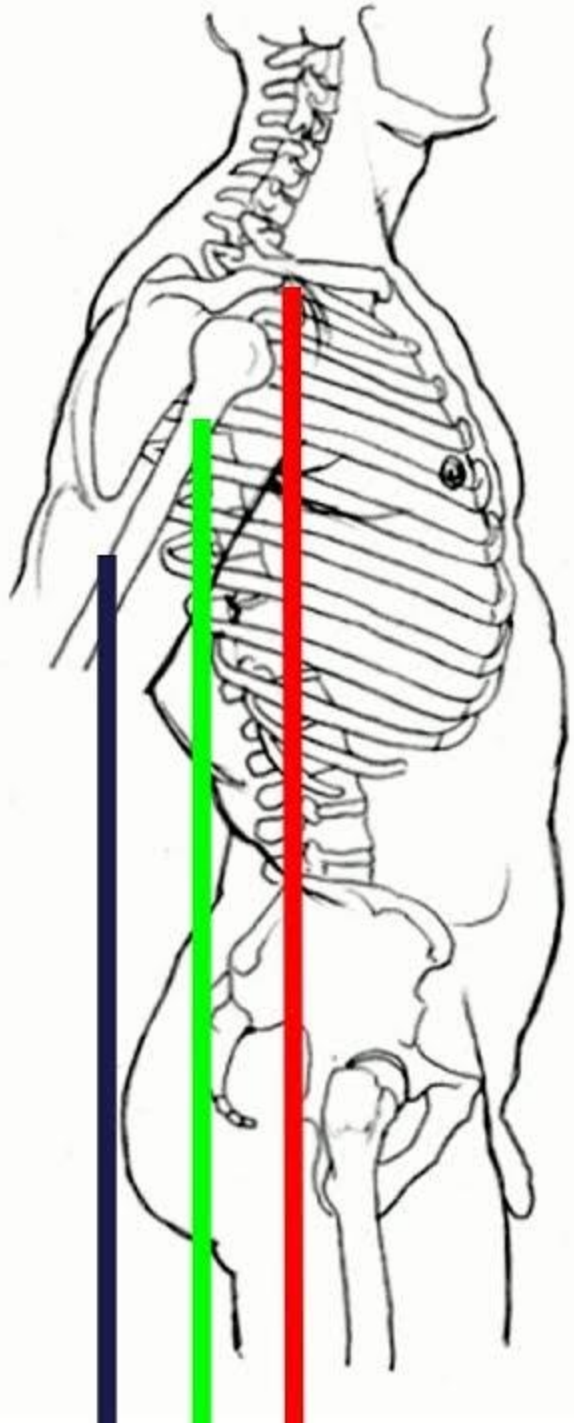
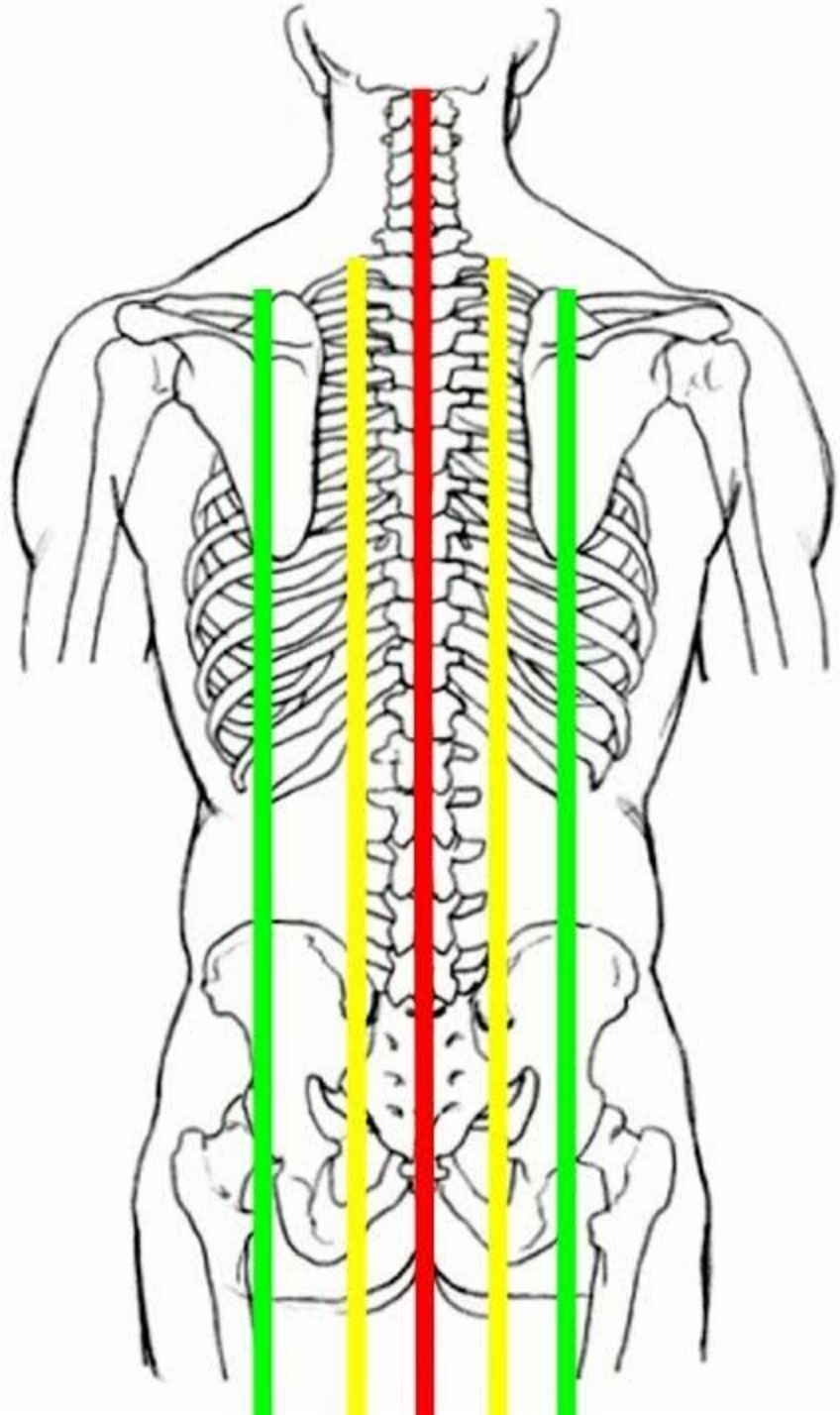


Fig. 7. Subdivision of the abdomen into regions

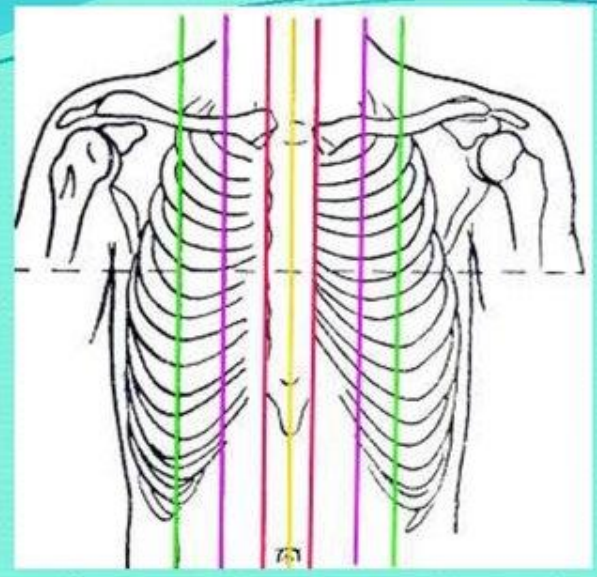
part (*hypogastrium*) (Fig. 7). Each of these three parts of the abdomen is subdivided by two vertical lines into three secondary regions: the epigastrium is divided into a **middle epigastric region** (*regio epigastrica*) and two **lateral regions,** the **right** and **left hypochondrium** (*regiones hypochondriacae dextra* and *sinistra*). The middle abdomen is divided in the same manner into a **medial umbilical region** (*regio umbilicalis*) and two **lateral, right** and **left lumbar regions** (*regiones abdominales laterales, dextra* and *sinistra*). Finally, the hypogastrium is divided into the **pubic region** (*regio pubica*) and two **lateral, right** and **left inguinal regions** (*regiones inguinales, dextra* and *sinistra*). The upper limb is divided into the **arm** (*brachium*), the **forearm** (*antebrachium*) and the **hand** (*manus*); the **palm** (*palma manus*), the **back** (*dorsum manus*) and the **fingers** (*digiti manus*) are distinguished in the hand. The lower limb, in turn, is divided into the following parts: the **thigh** (*femur*), the **leg** (*crus*), and the **foot** (*pes*), in which the **sole** (*planta*), the **dorsum of foot** (*dorsum pedis*), and the **toes** (*digiti pedis*) are distinguished.

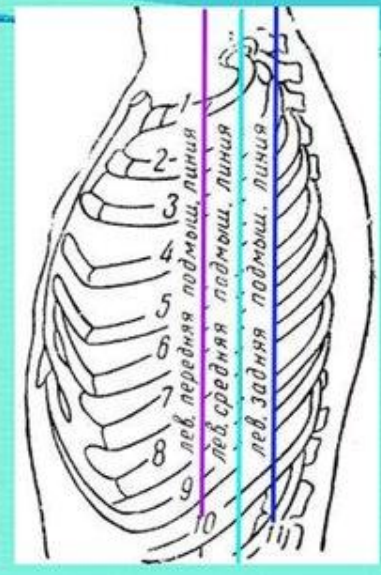


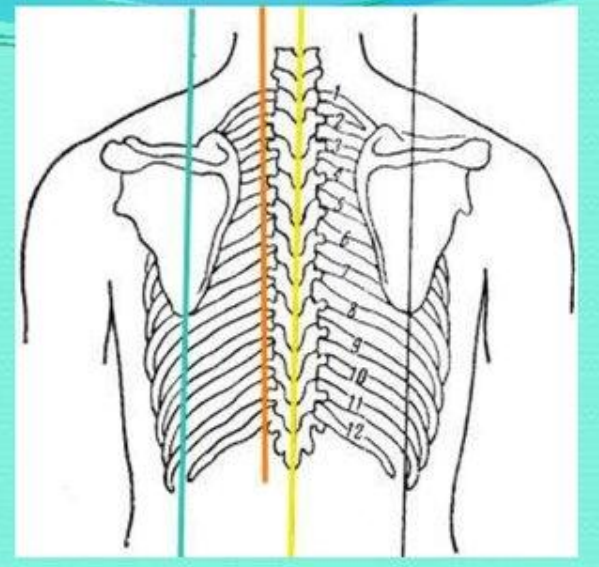


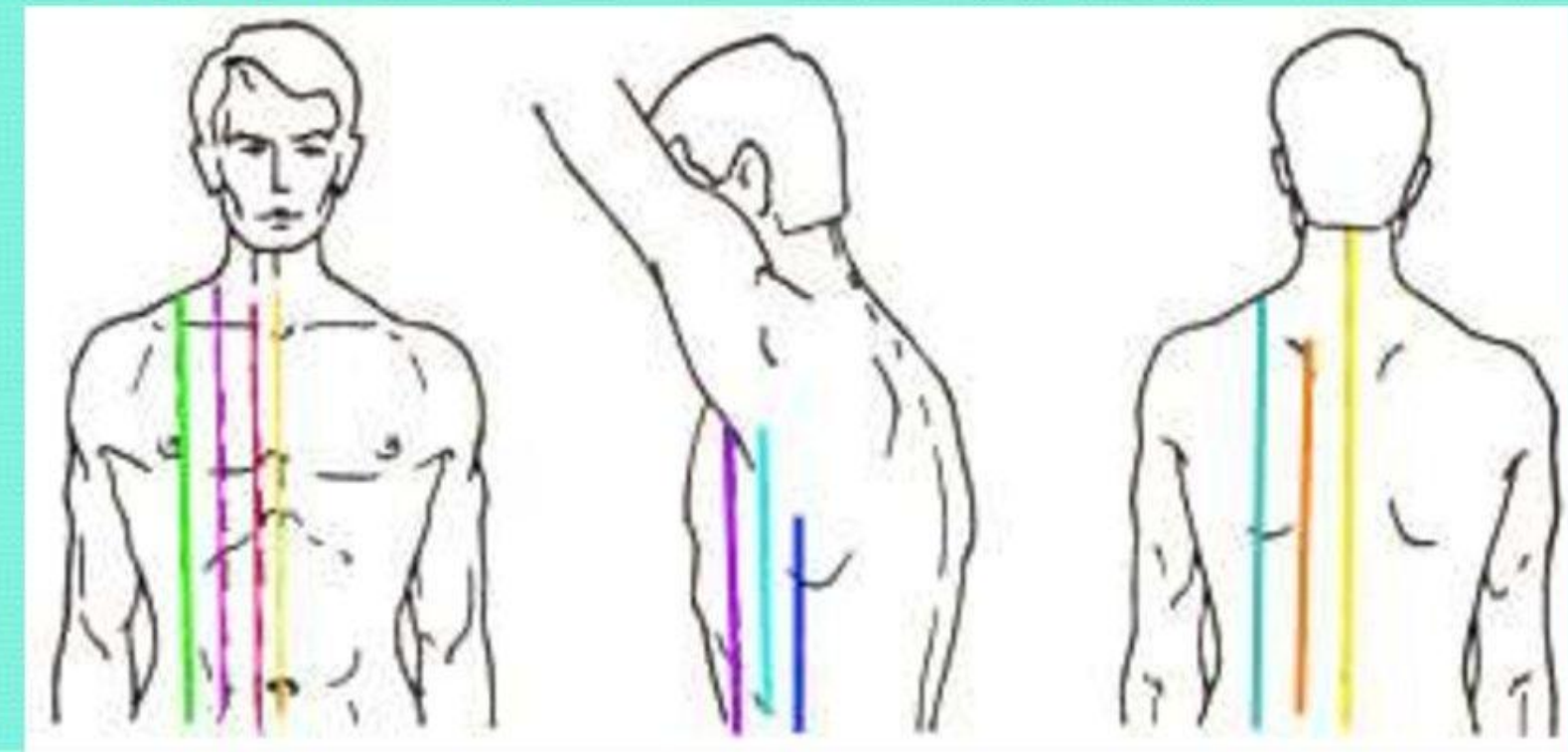


ПРОЕКЦИОННЫЕ ЛИНИИ









dia) or abnormal position of the viscera (situs viscerum inversus) serve to illustrate the point. Other anomalies are attended by impaired function of the organism or some of the organs. They disturb the equilibrium between the organism and the environment (e.g. cleft palate, see Fig. 230) or are even incompatible with life (e.g. absence of the skull or acrania, absence of the heart or acardia, etc.). Such a gross developmental anomaly is called a monstrosity or a teratism. The branch of anatomy and embryology concerned with the study of anomalies and malformations is called *teratology* (Gk *teras* monster, *logos* science). Teratology is also part of pathological anatomy because it studies structures pathological in essence.

ANATOMICAL TERMINOLOGY

A person beginning to study anatomy is struck first of all by the copious terminology that must be firmly understood and completely mastered by every student and physician. These terms usually designate spatial relations, the shape or size of various organs, and so forth.

In mathematics and physical geography, certain initial points and planes are accepted from which distances are measured to establish spatial relations. In anatomy as well, there are generally accepted designations of perpendicular planes by means of which the position of organs or their parts in space is determined exactly. Three such planes are of primary importance: sagittal, frontal, and horizontal. It should be borne in mind that the planes are related to an erect human body (Fig. 10).

The **sagittal** plane is a vertical plane by means of which we divide the body mentally (for example, a fixed, frozen cadaver) with an arrow (L *sagitta* arrow) piercing it from front to back and with an arrow along the length of the body. The sagittal plane that passes through the middle of the body and divides it into two symmetrical, right and left, parts is called the **median** plane (L *medius* middle) (Fig. 11). A plane drawn also vertically but at right angles to the sagittal plane is called the **frontal** plane and is parallel to the forehead (L *frons* forehead). The frontal plane divides the body into the front and back parts. The third, **horizontal,** plane in accordance with its name passes horizontally, i.e. at right angles to both the sagittal and the frontal planes. It divides the body into the upper and lower halves.

The positions of the different points or lines in these planes are designated as follows: those located nearer to the median plane are called **medial** (*medialis*) (L *medius* middle); those located further from the median plane are designated **lateral** (*lateralis*) (L *latus* side). Points and lines found on a front to back plane are designated as follows: those located nearer to the front surface of the body are called **anterior** or **ventral** (*ventralis*) (L *venter* belly); those nearer to the back are known as **posterior** or **dorsal** (*dorsalis*). The following points and lines are distinguished in the vertical plane: those nearer to the **upper** end of the body are called **upper, superior,** or **cranial** (*cranialis*) (Gk *kranion* skull); those nearer to the lower end are referred to as **lower, inferior** or **caudal** (*caudalis*) (L *cauda* tail).

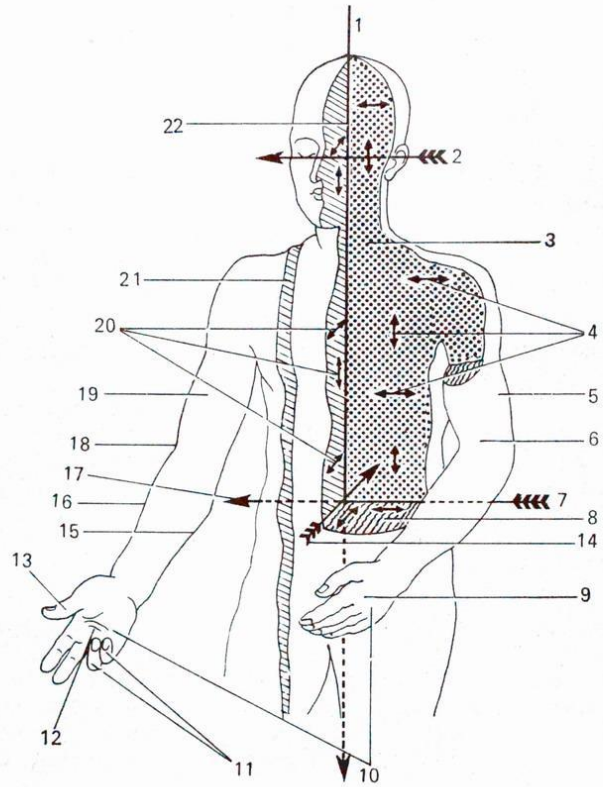


Fig. 10. Diagram of axes and planes of the human body.

1, vertical axis;
2, transverse axis;
3, one of the frontal planes;
4, horizontal and vertical lines on the frontal plane;
5, the arm is drawn to the trunk (adductio);
6, the left upper limb is flexed at the elbow joint (flexio);
7 and *17*, transverse axis, one of the horizontal axes in the frontal plane;
8, transverse plane (one of the horizontal planes), the arrows on it indicate the sagittal direction (from front to back) and the transverse direction (from left to right and from right to left);
9, the hand is pronated, the thumb is directed at the trunk (pronatio);
10, change from the pronated position to supination, example of rotation (rotatio);
11, the ring and little fingers are flexed (flexio);
12, the hand is supinated, the thumb faces outward (supinatio);
13, the thumb is drawn away from the median line (abduction);
14, sagittal axis;
15, medial margin of the forearm;
16, lateral margin of the forearm;
18, the right upper limb is extended at the elbow joint (extensio);
19, the arm is drawn away from the trunk (abductio);
20, horizontal and vertical lines in the sagittal plane (arrows);
21, one of the parasagittal planes;
22, median plane, plane of symmetry (one of the sagittal planes)

The terms proximal and distal are used in reference to the parts of the limbs. *Proximal* (L *proximus* nearest) is applied to parts nearer to the point of origin of the limb from the trunk; *distal*, in contrast, is a term ap-

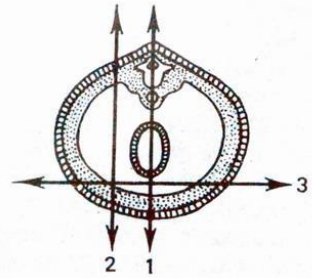


Fig. 11. Diagram of transverse section through the trunk.

1, median line (mediana);
2, sagittal line;
3, frontal line

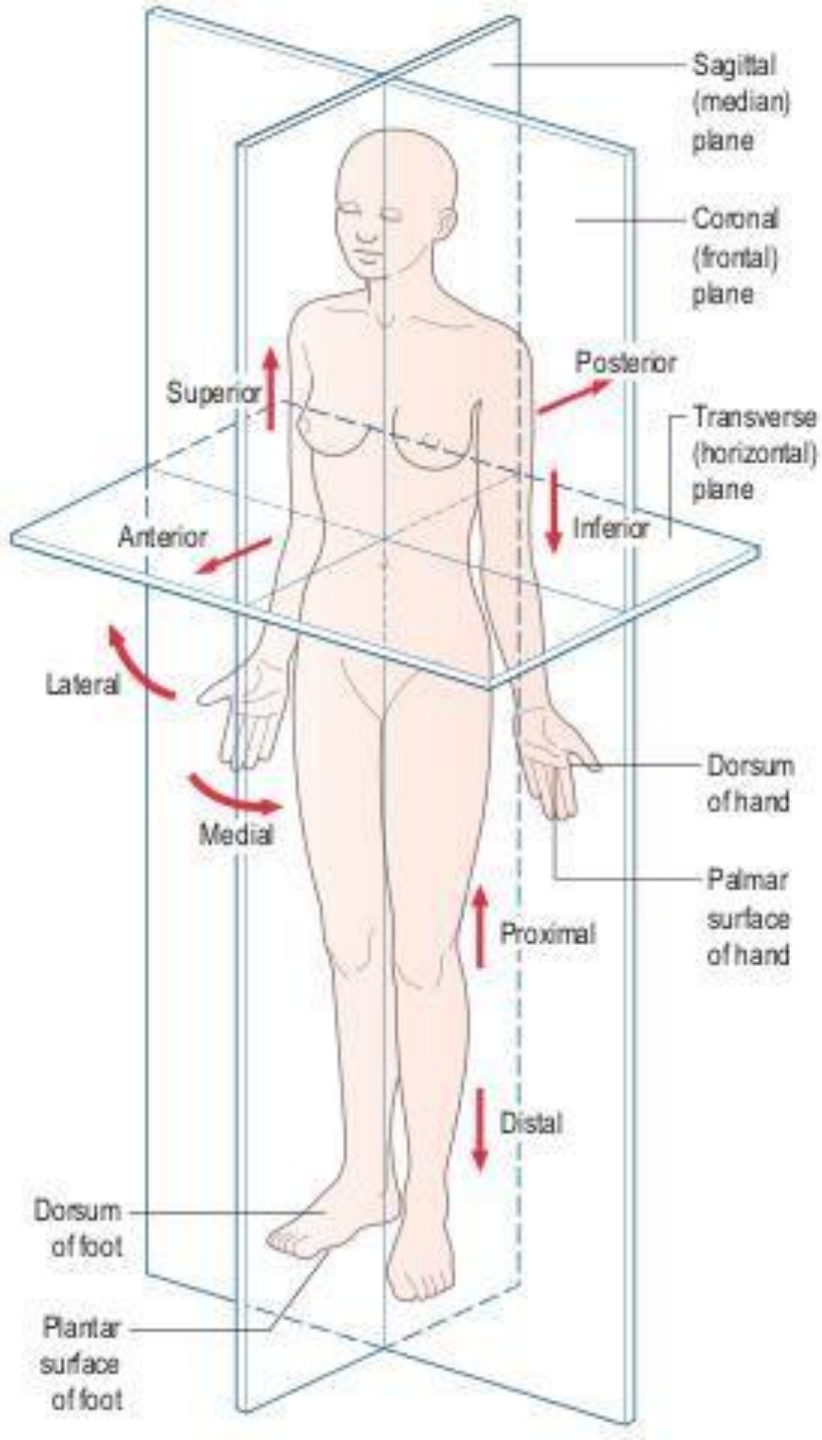
plied to parts farthest from the trunk (L *distare* to be distant). On the upper limb, for instance, the elbow is proximal in comparison to the fingers, while the latter are distal in relation to the elbow.

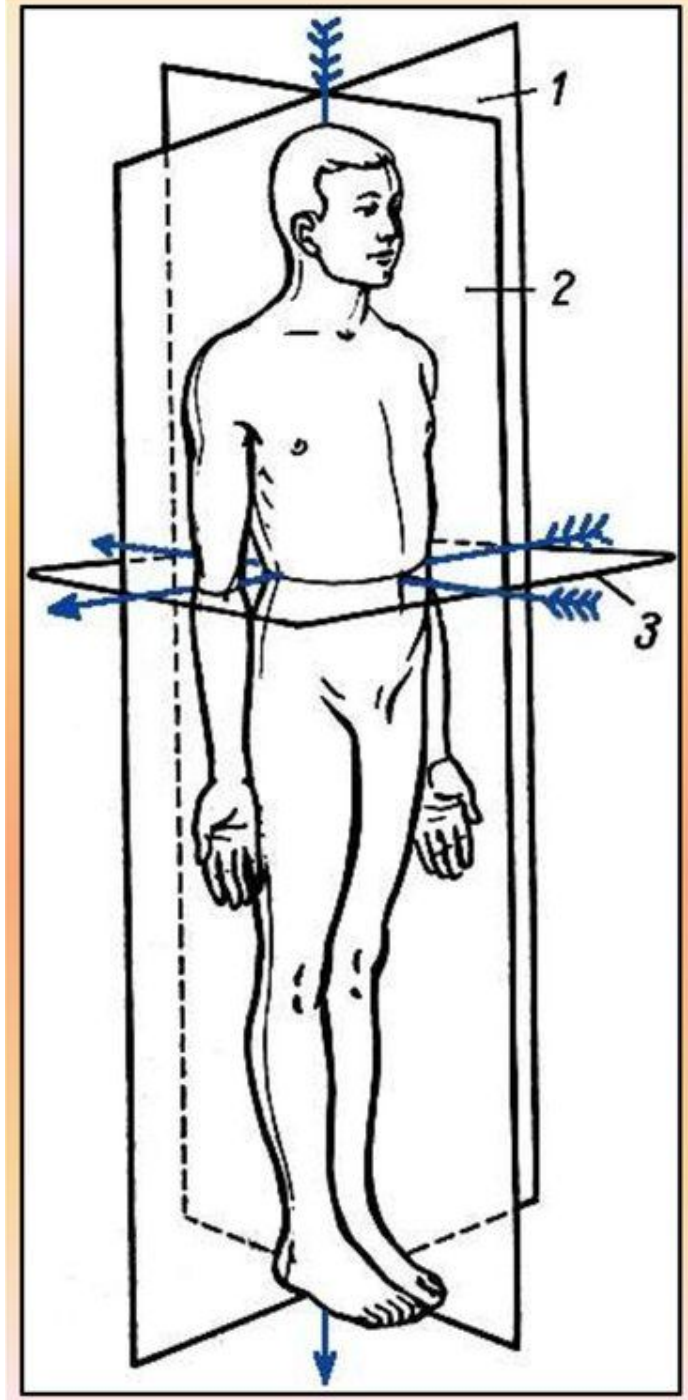
The terms **external** (*externus*) and **internal** (*internus*) are used mainly to designate positions in relation to the body cavities and whole organs, either outward or inward; the terms **superficial** (*superficialis*) and **deep** (*profundus*) are used for organs located "less deep" or "more deep" in relation to the surface of the body or organ.

The commonly used terms for size are **great** (*magnus*); **small** (*parvus*); **greater** (*major*); **lesser** (*minor*). The last two terms, major and minor, are used to designate the comparative size of two related or identical structures, e.g. tuberculum majus and minus on the humerus. The term magnus (great) does not imply the presence of another identical but smaller structure. For instance, nervus auricularis magnus, the great auricular nerve, is called so because of its thick trunk; there is no nervus auricularis parvus.

The shapes of the various structures, particularly in osteology, have many designations whose meaning is best mastered during study of these structures.

A new anatomical nomenclature, the Paris Nomina Anatomica, was approved by the Sixth International Congress of Anatomists held in Paris in 1955. This textbook, therefore, uses the terms of the Paris Nomina Anatomica (PNA) with amendments and additions approved by the seventh and eighth international congresses held in New York in 1960 and Wiesbaden in 1965, respectively, and by the latest international congresses including the tenth congress held in Tokyo in 1975. Some terms from the old Basle Nomina Anatomica, from which the names of diseases were derived and which became firmly established in clinical literature, are preserved. They are given in the text next to the new terms, followed by the letter s. (i.e. *seu* or) and by the abbreviation for the Basle Nomina Anatomica (BNA). For example: axis s. epistropheus (BNA). This means that axis is a new term from the Paris classification, while epistropheus is the old Basle term. Some of the terms are given in abbreviated form: art.—articulatio (joint); lig.—ligamentum (ligament), a.—arteria (artery), aa.—arteriae (arteries); v.—vena (vein), vv.—venae (veins); n.—nervus (nerve), nn.—nervi (nerves); m.—musculus (muscle), mm.—musculi (muscles).


Sagittal (median) plane
Coronal (frontal) plane
Transverse (horizontal) plane
Superior
Posterior
Inferior
Anterior
Lateral
Medial
Dorsum of hand
Palmar surface of hand
Proximal
Distal
Dorsum of foot
Plantar surface of foot



Уметь правильно определять оси и плоскости на скелете и живом человеке

Плоскости:

Горизонтальная плоскость - делит туловище на верхнюю (superior) и нижнюю (inferior) половины

Фронтальная плоскость - делит туловище на переднюю (anterior) и заднюю (posterior) половины

Сагиттальная плоскость - делит туловище на правую (dexter) и левую (sinister) половины

Оси:

Вертикальная (через стоящего человека вдоль тела независимо от положения)

Фронтальная (слева направо)

Сагиттальная (в переднезаднем направлении)

Оси и плоскости тела человека
1 - фронтальная
2 - сагиттальная
3 - горизонтальная

Anatomical position

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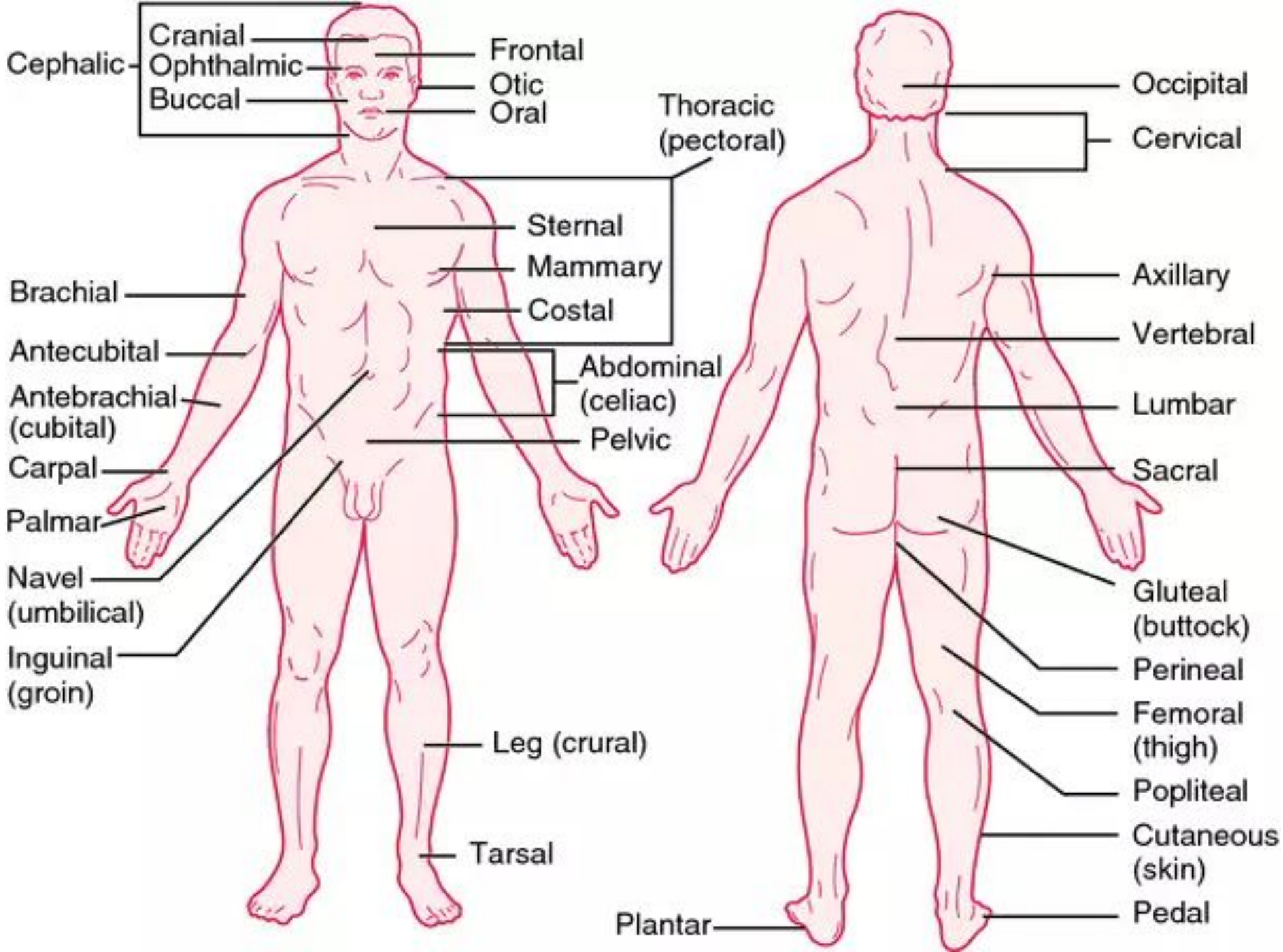
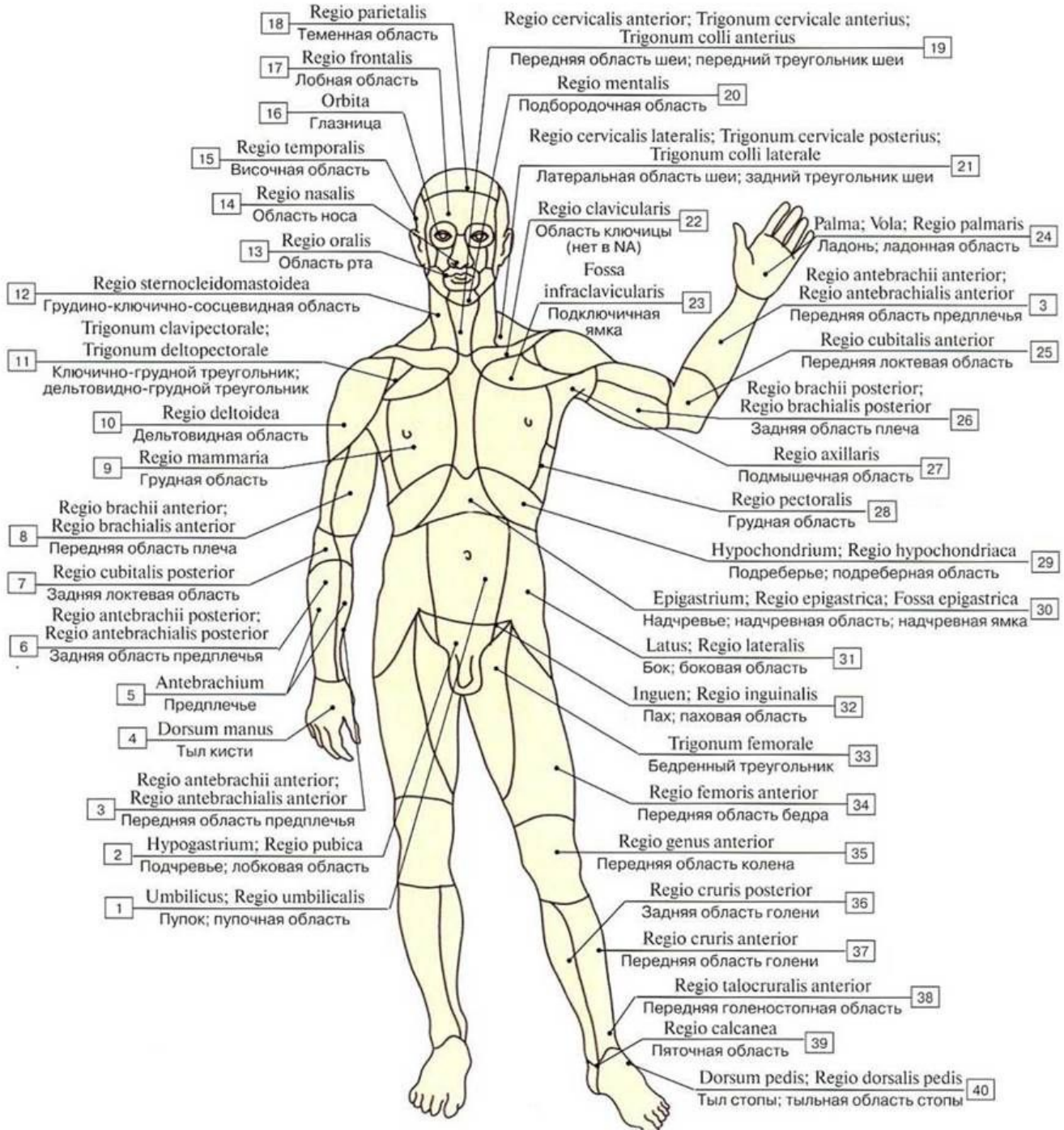
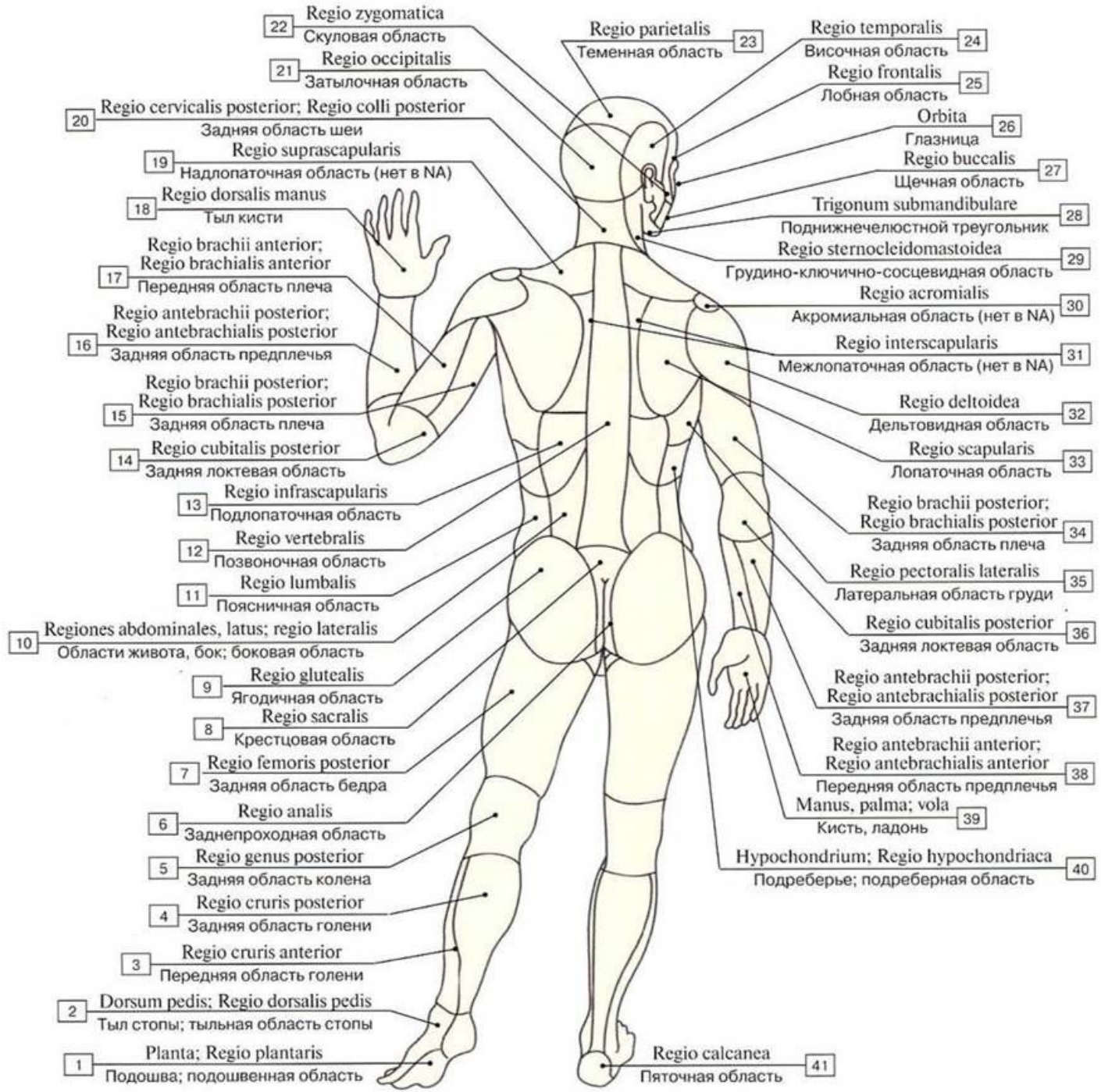
- Initial reference point - terminology used refers to bodies in this position
- Body is erect
- Feet parallel
- Arms hanging to side
- Palms facing forward

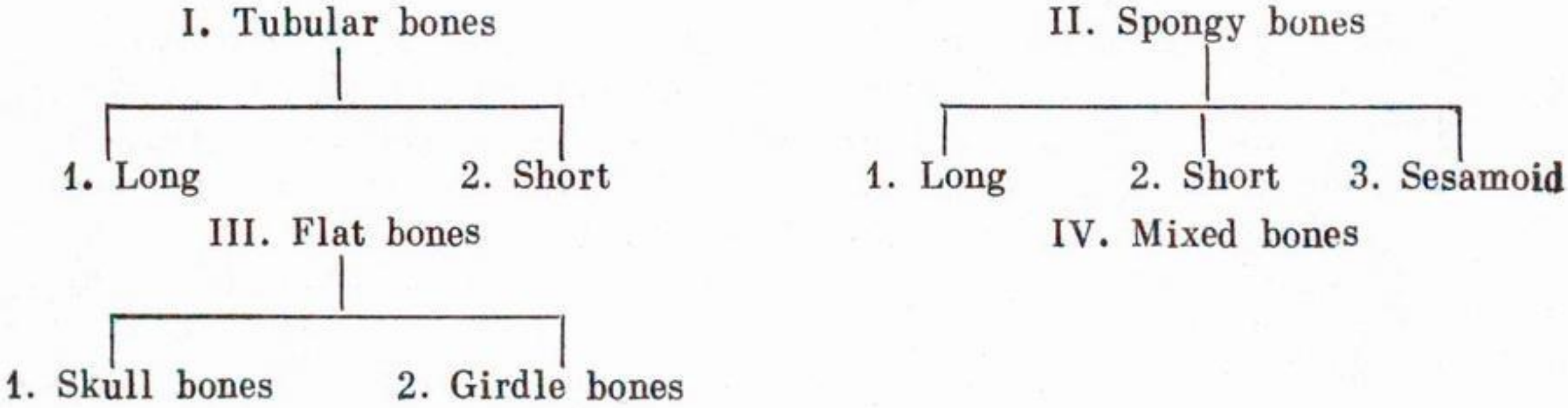
- **При изучении анатомии человека за исходное принимается естественное вертикальное положение тела человека с опущенными вдоль туловища руками, ладонями, обращёнными вперёд и большими пальцами кистей кнаружи.**


Cephalic
Cranial
Ophthalmic
Buccal
Frontal
Otic
Oral
Thoracic (pectoral)
Sternal
Mammary
Costal
Brachial
Antecubital
Antebrachial (cubital)
Carpal
Palmar
Navel (umbilical)
Inguinal (groin)
Abdominal (celiac)
Pelvic
Leg (crural)
Tarsal
Occipital
Cervical
Axillary
Vertebral
Lumbar
Sacral
Gluteal (buttock)
Perineal
Femoral (thigh)
Popliteal
Cutaneous (skin)
Pedal
Plantar


18 Regio parietalis
Теменная область
17 Regio frontalis
Лобная область
16 Orbita
Глазница
15 Regio temporalis
Височная область
14 Regio nasalis
Область носа
13 Regio oralis
Область рта
12 Regio sternocleidomastoidea
Грудино-ключично-сосцевидная область
11 Trigonum clavipectorale; Trigonum deltopectorale
Ключично-грудной треугольник; дельтовидно-грудной треугольник
10 Regio deltoidea
Дельтовидная область
9 Regio mammaria
Грудная область
8 Regio brachii anterior; Regio brachialis anterior
Передняя область плеча
7 Regio cubitalis posterior
Задняя локтевая область
6 Regio antebrachii posterior; Regio antebrachialis posterior
Задняя область предплечья
5 Antebrachium
Предплечье
4 Dorsum manus
Тыл кисти
3 Regio antebrachii anterior; Regio antebrachialis anterior
Передняя область предплечья
2 Hypogastrium; Regio pubica
Подчревье; лобковая область
1 Umbilicus; Regio umbilicalis
Пупок; пупочная область
Regio cervicalis anterior; Trigonum cervicale anterius; Trigonum colli anterius
Передняя область шеи; передний треугольник шеи
19
Regio mentalis
Подбородочная область
20
Regio cervicalis lateralis; Trigonum cervicale posterius; Trigonum colli laterale
Латеральная область шеи; задний треугольник шеи
21
Regio clavicularis
Область ключицы (нет в NA)
22
Fossa infraclavicularis
Подключичная ямка
23
Palma; Vola; Regio palmaris
Ладонь; ладонная область
24
Regio antebrachii anterior; Regio antebrachialis anterior
Передняя область предплечья
3
Regio cubitalis anterior
Передняя локтевая область
25
Regio brachii posterior; Regio brachialis posterior
Задняя область плеча
26
Regio axillaris
Подмышечная область
27
Regio pectoralis
Грудная область
28
Hypochondrium; Regio hypochondriaca
Подреберье; подреберная область
29
Epigastrium; Regio epigastrica; Fossa epigastrica
Надчревье; надчревная область; надчревная ямка
30
Latus; Regio lateralis
Бок; боковая область
31
Inguen; Regio inguinalis
Пах; паховая область
32
Trigonum femorale
Бедренный треугольник
33
Regio femoris anterior
Передняя область бедра
34
Regio genus anterior
Передняя область колена
35
Regio cruris posterior
Задняя область голени
36
Regio cruris anterior
Передняя область голени
37
Regio talocruralis anterior
Передняя голеностопная область
38
Regio calcanea
Пяточная область
39
Dorsum pedis; Regio dorsalis pedis
Тыл стопы; тыльная область стопы
40


22 Regio zygomatica
Скуловая область
21 Regio occipitalis
Затылочная область
20 Regio cervicalis posterior; Regio colli posterior
Задняя область шеи
19 Regio suprascapularis
Надлопаточная область (нет в NA)
18 Regio dorsalis manus
Тыл кисти
17 Regio brachii anterior; Regio brachialis anterior
Передняя область плеча
16 Regio antebrachii posterior; Regio antebrachialis posterior
Задняя область предплечья
15 Regio brachii posterior; Regio brachialis posterior
Задняя область плеча
14 Regio cubitalis posterior
Задняя локтевая область
13 Regio infrascapularis
Подлопаточная область
12 Regio vertebralis
Позвоночная область
11 Regio lumbalis
Поясничная область
10 Regiones abdominales, latus; regio lateralis
Области живота, бок; боковая область
9 Regio glutealis
Ягодичная область
8 Regio sacralis
Крестцовая область
7 Regio femoris posterior
Задняя область бедра
6 Regio analis
Заднепроходная область
5 Regio genus posterior
Задняя область колена
4 Regio cruris posterior
Задняя область голени
3 Regio cruris anterior
Передняя область голени
2 Dorsum pedis; Regio dorsalis pedis
Тыл стопы; тыльная область стопы
1 Planta; Regio plantaris
Подошва; подошвенная область
Regio parietalis 23
Теменная область
Regio temporalis 24
Височная область
Regio frontalis 25
Лобная область
Orbita 26
Глазница
Regio buccalis 27
Щечная область
Trigonum submandibulare 28
Поднижнечелюстной треугольник
Regio sternocleidomastoidea 29
Грудино-ключично-сосцевидная область
Regio acromialis 30
Акромиальная область (нет в NA)
Regio interscapularis 31
Межлопаточная область (нет в NA)
Regio deltoidea 32
Дельтовидная область
Regio scapularis 33
Лопаточная область
Regio brachii posterior; Regio brachialis posterior 34
Задняя область плеча
Regio pectoralis lateralis 35
Латеральная область груди
Regio cubitalis posterior 36
Задняя локтевая область
Regio antebrachii posterior; Regio antebrachialis posterior 37
Задняя область предплечья
Regio antebrachii anterior; Regio antebrachialis anterior 38
Передняя область предплечья
Manus, palma; vola 39
Кисть, ладонь
Hypochondrium; Regio hypochondriaca 40
Подреберье; подреберная область
Regio calcanea 41
Пяточная область

CLASSIFICATION OF BONES

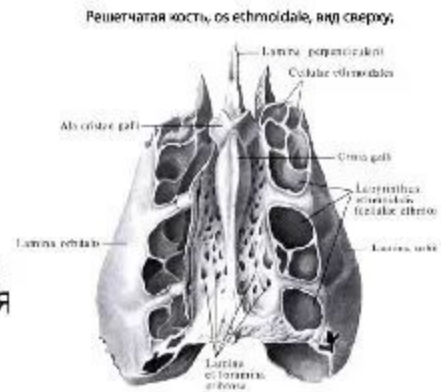


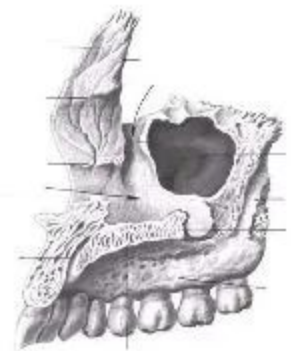
Классификация костей

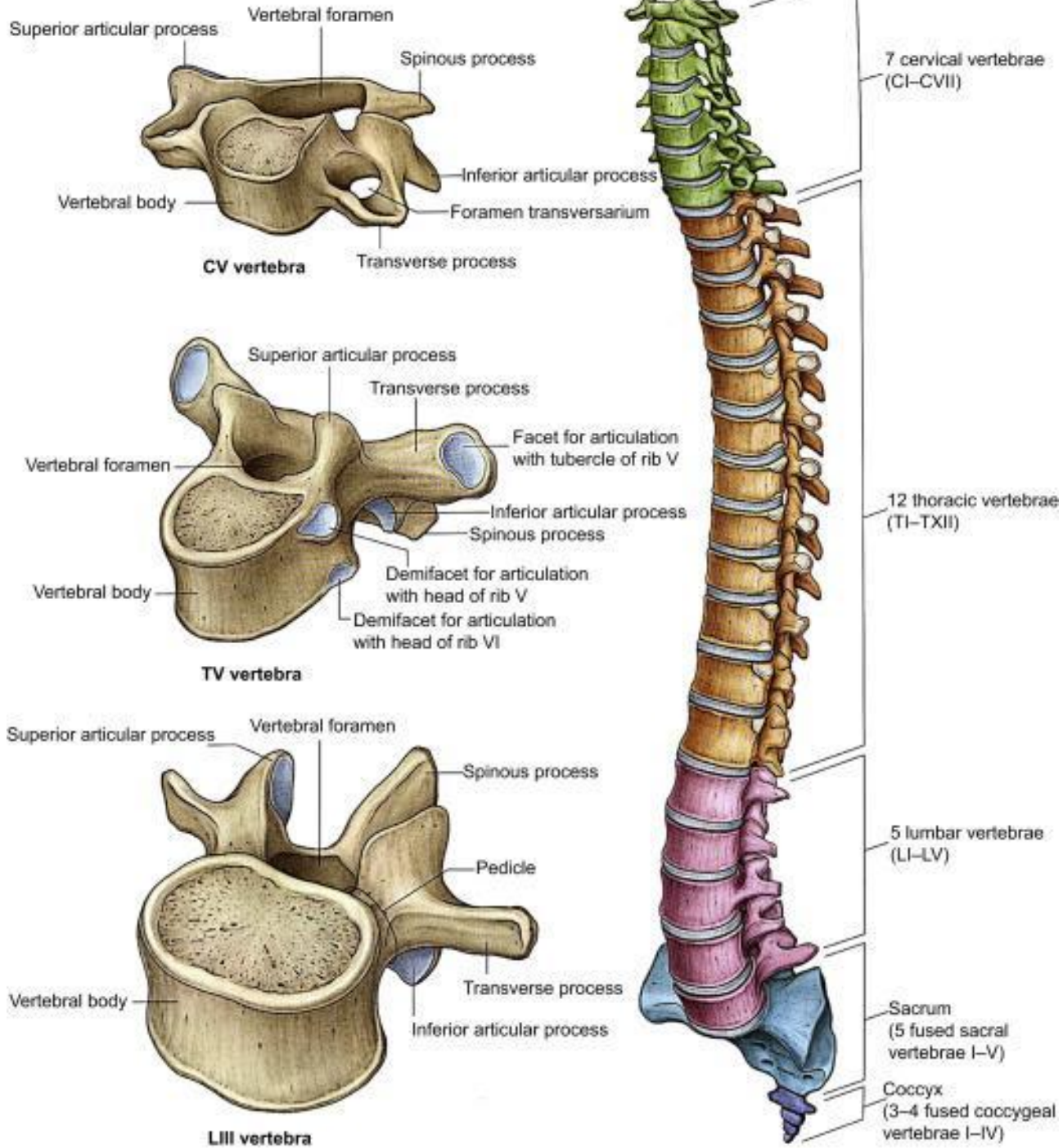
Основа классификации: форма и строение кости, ее развитие и функции.

Группы костей: трубчатые, губчатые, плоские (широкие), смешанные и воздухоносные.

- ***Трубчатые кости*** – образуют скелет конечностей, они имеют форму трубок. Эти кости имеют тело (диафиз) цилиндрической или трехгранной формы и два утолщенных конца – эпифизы. Среди трубчатых костей принято выделять длинные (плечевая, бедренная) и короткие (пястные, плюсневые).
- ***Губчатые кости*** – располагаются в тех частях скелета, где значительная подвижность костей сочетается с большой механической нагрузкой (кости запястья и предплюсны). К этой группе относятся и сесамовидные кости, расположенные в толщ сухожилий (гороховидная кость и надколенная чашечка).
- ***Плоские кости*** – формируют стенку полостей, выполняют защитные функции (кости крыши черепа, таза, грудина, ребра).
- ***Смешанные кости*** (неправильные) их форму трудно описать (позвонки, лобная кость верхнечелюстная кость).
- ***Воздухоносные кости*** – содержат полости, выстланные слизистой оболочкой и заполненные воздухом (лобная, клиновидная решетчатая, височные, верхнечелюстные кости черепа).






Superior articular process
Vertebral foramen
Spinous process
Inferior articular process
Vertebral body
Foramen transversarium
Transverse process
CV vertebra
Superior articular process
Transverse process
Facet for articulation with tubercle of rib V
Vertebral foramen
Inferior articular process
Spinous process
Demifacet for articulation with head of rib V
Vertebral body
Demifacet for articulation with head of rib VI
TV vertebra
Superior articular process
Vertebral foramen
Spinous process
Pedicle
Transverse process
Vertebral body
Inferior articular process
LIII vertebra
7 cervical vertebrae (CI–CVII)
12 thoracic vertebrae (TI–TXII)
5 lumbar vertebrae (LI–LV)
Sacrum (5 fused sacral vertebrae I–V)
Coccyx (3–4 fused coccygeal vertebrae I–IV)

may be located on the entire length of the vertebral column (in snakes), but usually they develop in the thoracic part and are rudimentary and fused with the vertebrae in the other parts.

In most mammals, the ribs articulate with the spine in two places: with the vertebral bodies and with the transverse processes. The ventral ends of the ribs are attached to the sternum which is found only in terrestrial vertebrates because of the development of the shoulder girdle adjoining it; that is why animals who have lost the limbs, e.g. snakes, do not have a sternum. The sternum of higher terrestrial vertebrates develops from the ventral ends of the ribs which during embryonic life (in the second month in humans) join to form paired thoracic plates which fuse on the midline into an unpaired bone.

The skeleton of the human trunk undergoes changes in association with the *upright position of the body*; as a result it differs from the skeleton of other mammals who have four legs. The vertebral column (except for the cervical segment) in these mammals has the shape of a shallow arch resting on all four limbs. As the result of different static conditions, the human spine is a curved vertical column carrying the head at the top and resting on the lower limbs (Fig. 24). The upright posture also has an effect on the configuration of the thoracic cage (see Fig. 41).

Thus, the *skeleton of the human trunk has the following characteristic features* determined by the upright posture and the development of the upper limb as an organ of labour:

(1) a vertical vertebral column with curvatures, particularly in the sacral region, where an anterior prominence (promontorium) forms;

(2) gradual increase in the size of the vertebral bodies in the direction from top to bottom where, in the region of their connection with the lower limbs through the pelvic girdle they fuse to form a single bone, the sacrum, consisting of five vertebrae;

(3) a wide and flat thoracic cage with a predominant transverse dimension and an extremely small anteroposterior dimension.

THE VERTEBRAL COLUMN

The **vertebral column** (*columna vertebralis*) or the spine has a metameric structure (a feature connecting the vertebrates with the earliest invertebrates) and consists of separate bone segments, vertebrae, placed one over another in a series; they are short spongy bones.

Function of the spine. The spine acts as the axial skeleton supporting the body. It protects the spinal cord enclosed in its canal and takes part in the movements of the trunk and head. The position and shape of the vertebral column are determined by the upright position of man.

Common features of the vertebrae. In accordance with the three functions of the spine, each vertebra (Gk *spondylos*[1]) has the following features (Fig. 25):

[1] Hence spondylitis, inflammation of the vertebrae.

(1) an anterior part, which is responsible for support and which thickens in the shape of a short column, this is the **body** (*corpus vertebrae*);

(2) an **arch** (*arcus vertebrae*), which is attached to the posterior surface of the body by two *pedicles* (*pediculi arcus vertebrae*) and contributes to the formation of the **vertebral foramen** (*foramen vertebrale*); a series of these foramina forms the **vertebral**, or **spinal, canal** (*canalis vertebralis*), which protects the spinal cord lodged in it from external injury. The vertebral arch, therefore, primarily fulfils a protective function;

(3) the arch also carries structures permitting movement of the vertebra called processes. A **spinous process** (*processus spinosus*) arises from the arch on the midline; a **transverse process** (*processus transversus*) projects laterally on each side; paired **superior** and **inferior articular processes** (*processus articulares superiores* and *inferiores*) project upward and downward. The articular processes bind **notches** on the posterior aspect; these are the paired *incisurae vertebrales superiores* and *inferiores* from which the **intervertebral foramina** (*foramina intervertebralia*) form when one vertebra is placed on another. The foramina transmit the nerves and vessels of the spinal cord. The articular processes serve for the formation of intervertebral joints at which movement of the vertebrae is accomplished; the transverse and the spinous processes serve for the attachment of ligaments and muscles which make the vertebrae move.

Some parts of the vertebrae in the different parts of the spine have a distinctive size and shape and the following vertebrae are consequently distinguished: cervical (seven), thoracic (twelve), lumbar (five), sacral (five), and coccygeal (one to five). The weight-bearing part of the cervical vertebrae (the body) is naturally relatively small (the first cervical vertebra has almost no body), but from the head down, the vertebral bodies gradually increase in size and are largest in the lumbar segment. The sacral vertebrae carry the whole weight of the head, trunk, and upper limbs, connect the

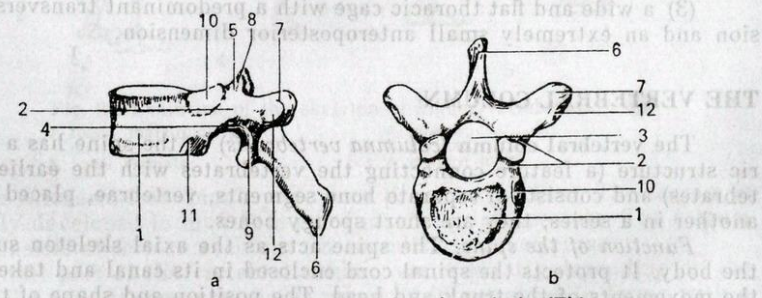


Fig. 25. Thoracic vertebra (vertebra thoracica). (Th).

a, viewed from the side;
b, viewed from above.
1, corpus vertebrae;
2, arcus vertebrae;
3, foramen vertebrale;
4, incisura vertebralis inf.;
5, incisura vertebralis sup.;
6, processus spinosus;
7, proc. transversus;
8, proc. articularis sup.;
9, proc. articularis inf.;
10, fovea costalis sup.;
11, fovea costalis inf.;
12, fovea costalis transversalis

skeleton of these parts of the body with the bones of the pelvic girdle, and, through them, fuse with the lower limbs to form a single sacral bone. In contrast, the coccygeal vertebrae, which in man are remnants of a tail, are small bony structures with a body that can hardly be detected and no arch. The vertebral arch, as a protective part, forms a wider vertebral foramen where the spinal cord is thickened (lower cervical, upper thoracic and upper lumbar vertebrae). Since the spinal cord terminates at the level of the second lumbar vertebrae, the vertebral foramen of the lower lumbar and the sacral vertebra, gradually narrows and disappears completely in the coccyx. The vertebrae transverse and spinous processes, the sites of muscle and ligament attachment, are more pronounced in those parts to which the most powerful musculature is attached (lumbar and thoracic segments); on the sacrum these processes are diminished because the tail musculature has disappeared, and they form small crests on the fused sacrum. As a consequence of fusion of the sacral vertebrae, the articular processes disappear; these processes are developed particularly well in the mobile parts of the spine, especially in the lumbar segment. Thus, to understand the structure of the vertebral column, one must bear in mind that the vertebrae and certain vertebral parts develop more in those segments which experience the greatest functional load. Reduction of the corresponding parts of the spine is encountered, in contrast, in segments of which fewer functional demands are made, for instance, in the coccyx which is a rudimentary structure in man.

INDIVIDUAL TYPES OF VERTEBRAE

1. **Cervical vertebrae** (*vertebrae cervicales*) (Fig. 26). Since the load suffered by the cervical vertebrae is lighter than that suffered by the more distally located spinal segments, their bodies are correspondingly smaller. The bodies are transverse-oval in shape, and the upper and lower surfaces are concave. Each transverse process is characterized by the presence of a hole (*foramen transversarium*), which forms as a result of fusion of the transverse process with the rib rudiment (*processus costarius*). The canal which forms from a series of these foramina protects the vertebral artery and the vein that it transmits. This fusion is manifested on the ends of the transverse processes as two *tubercles* (*tuberculum anterius* and *posterius*). The anterior tubercle of the sixth vertebra is enlarged and is called the *carotid tubercle* (*tuberculum caroticum*) (the carotid artery can be compressed against it to arrest bleeding). The spinous process is bifid, with the exception of that of the sixth and seventh vertebrae. The seventh cervical vertebra is distinguished by a large spinous process, and for that reason it is called the **vertebra prominens**. This vertebra is easily located in a living person and is often helpful in making diagnosis (Fig. 27).

The **first and second cervical vertebrae** have a specific shape because they form the mobile articulation with the skull. Most of the body of the first vertebra, the **atlas**[1], remains separate and joins the second vertebra as a

[1] It supports the skull as the mythical giant Atlas supported the heavens on his shoulders.

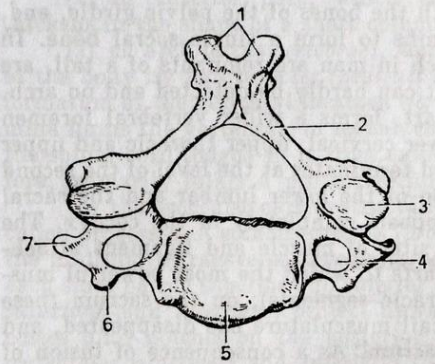


Fig. 26. Fourth cervical vertebra (vertebra cervicalis IV) (C), viewed from above.

1, processus spinosus;
2, arcus vertebrae;
3, processus articularis superior;
4, foramen transversarium;
5, corpus vertebrae;
6 and *7*, tuberculum anterius et posterius of the transverse process

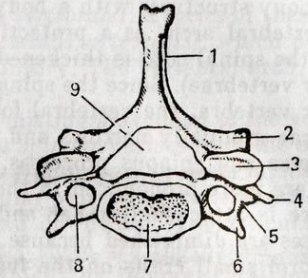


Fig. 27. Seventh cervical vertebra (vertebra cervicalis VII), viewed from above.

1, processus spinosus;
2, processus articularis inferior;
3, facies articularis superior;
4, tuberculum posterius;
5, processus transversus;
6, tuberculum anterius;
7, corpus vertebrae;
8, foramen transversarium;
9, foramen vertebrale

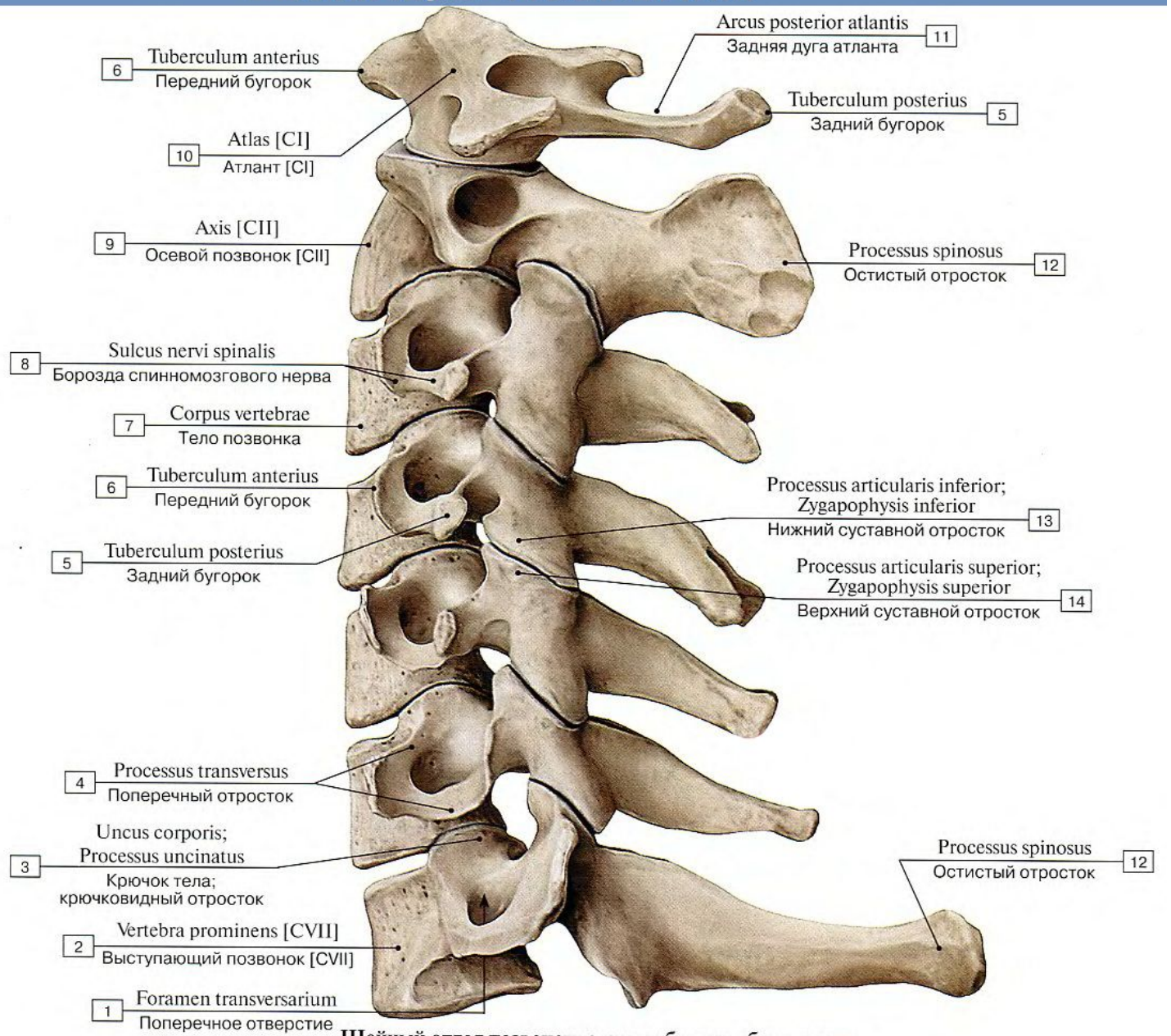
tooth-like process, the *dens*. As a result only the anterior arch is left; to make up for this, the vertebral foramen that receives the dens is larger. The **anterior** (*arcus anterior*) and **posterior** (*arcus posterior*) **arches** of the atlas are connected to each other by **lateral masses** (*massae laterales*). The superior and inferior surfaces of each arch articulate with the adjoining bones: the convex **superior articular facet** (*fovea articularis superior*) receives the corresponding condyle of the occipital bone; the flattened **inferior articular facet** (*fovea articularis inferior*) receives the articular surface of the second cervical vertebra.

The outer surfaces of the anterior and posterior arches carry *tubercles* (*tuberculum anterius* and *posterius*) (Fig. 28).

The second cervical vertebra, the **axis** (consequently the axial vertebra) s. *epistropheus* (BNA) (Gk *epistrephomai* pivot, consequently the pivotal vertebra) differs sharply from all the other vertebrae by the presence of the tooth-like process, the **dens** (Fig. 29). The dens has articular surfaces, which on the anterior aspect serve to articulate with the anterior arch of the atlas and on the posterior aspect to attach the transverse ligament. Another distinction of the axis is that its superior articular surfaces articulating with the atlas are not on the arch but on the superior surface of the body to the sides of the dens.

2. **Thoracic vertebrae** (*vertebrae thoracicae*) (Fig. 30) articulate with the ribs. Their distinctive feature, consequently, is the presence of articular facets for the ribs, **costal facets** (*fovea costales*), on the body of each vertebra close to the base of the arch. Since the ribs usually articulate with two adjoin-

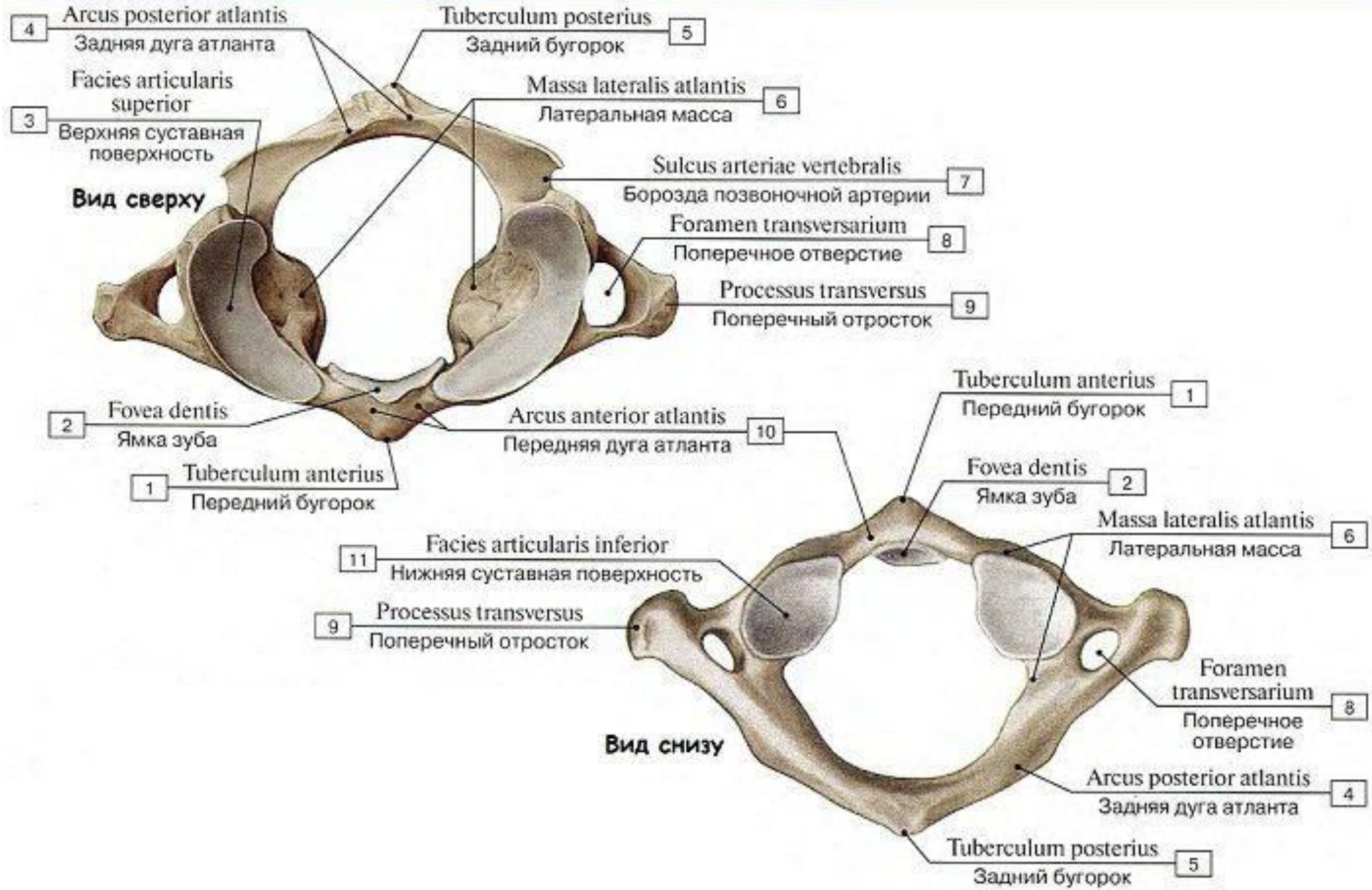
Шейные позвонки



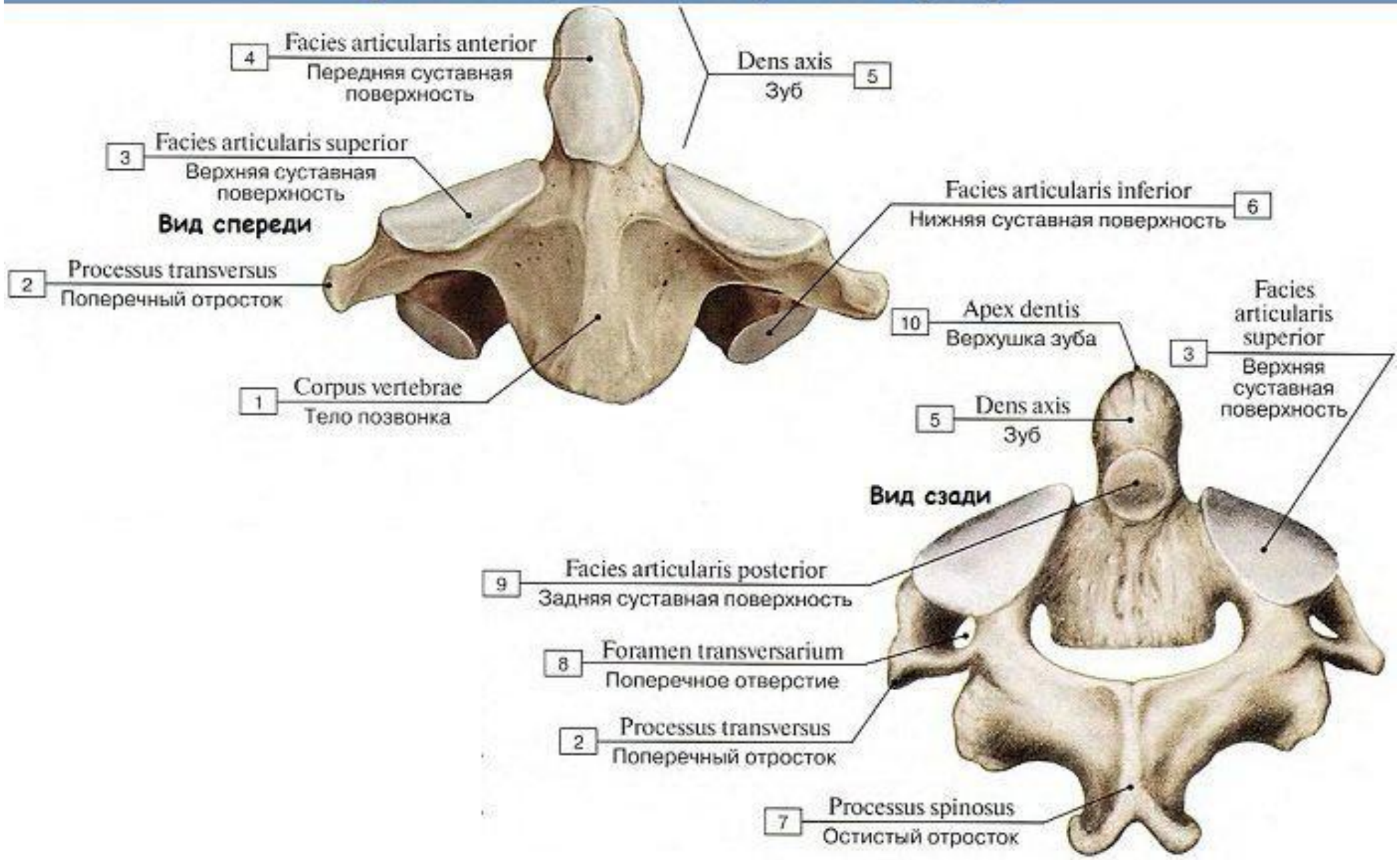
Шейный отдел позвоночного столба. вид сбоку, слева:

1 – Foramen transversarium; *2* – Vertebra prominens [CVII]; *3* – Uncus of body; Uncinate process; *4* – Transverse process; *5* – Posterior tubercle; *6* – Anterior tubercle; *7* – Vertebral body; *8* – Groove for spinal nerve; *9* – Axis [CII]; *10* – Atlas [CI]; *11* – Posterior arch; *12* – Spinous process; *13* – Inferior articular process; *14* – Superior articular process

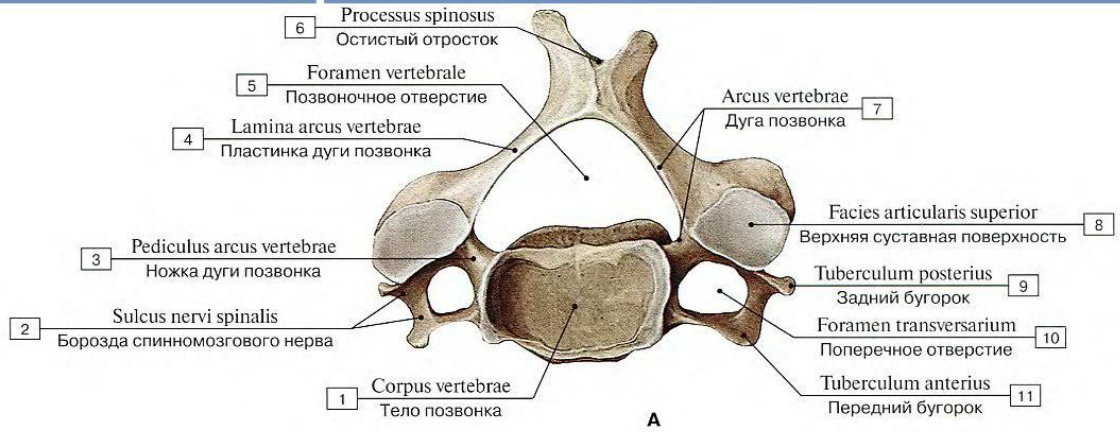
Первый шейный позвонок, атлант (CI)

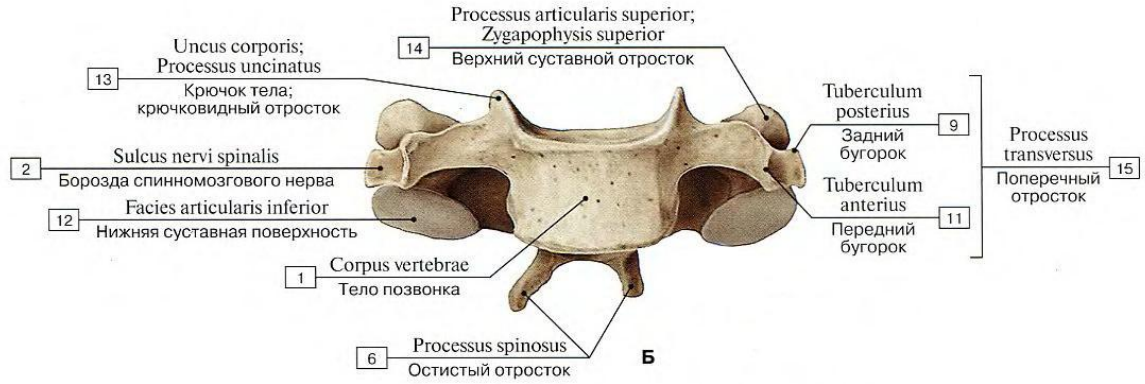


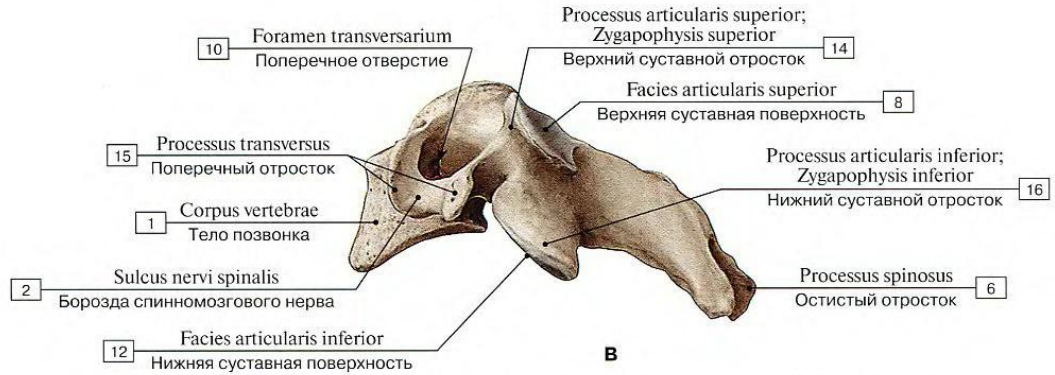
Второй шейный позвонок, осевой (CII)



Четвертый шейный позвонок

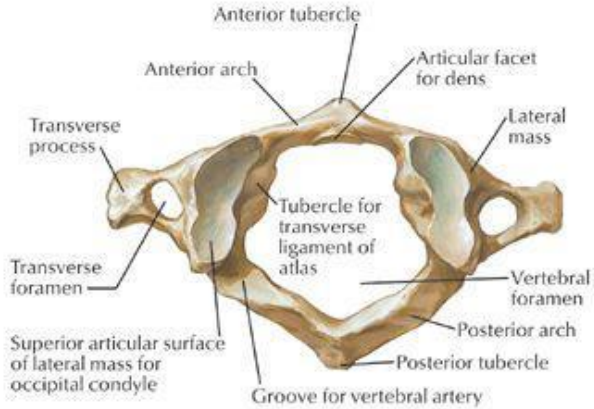




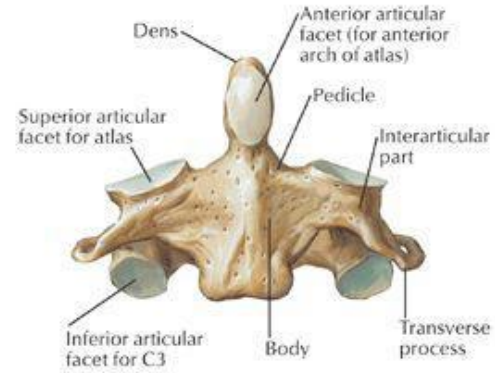


Четвертый шейный позвонок [CIV] (А – вид сверху, Б – вид спереди, В – вид сбоку, слева):

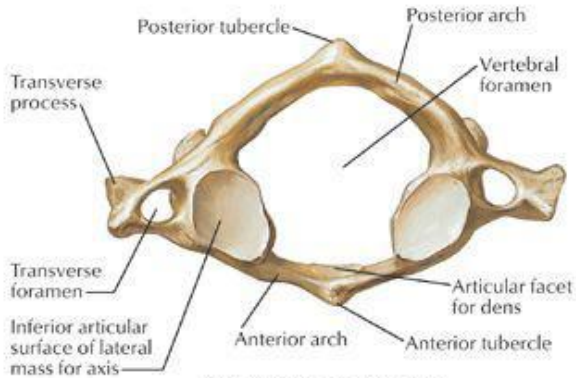
1 – Vertebral body; *2* – Groove for spinal nerve; *3* – Pedicle; *4* – Lamina; *5* – Vertebral foramen; *6* – Spinous process; *7* – Vertebral arch; *8* – Superior articular facet; *9* – Posterior tubercle; *10* – Foramen transversarium; *11* – Anterior tubercle; *12* – Inferior articular facet; *13* – Uncus of body; Uncinate process; *14* – Superior articular process; *15* – Transverse process; *16* – Inferior articular process



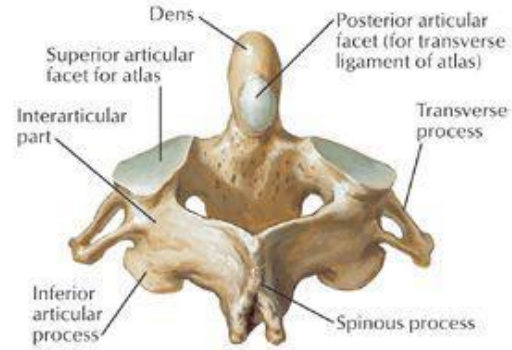
Atlas (C1): superior view



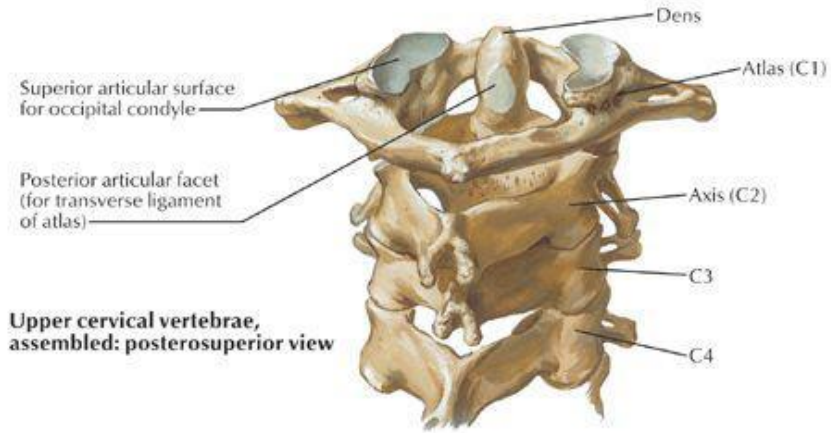
Axis (C2): anterior view



Atlas (C1): inferior view



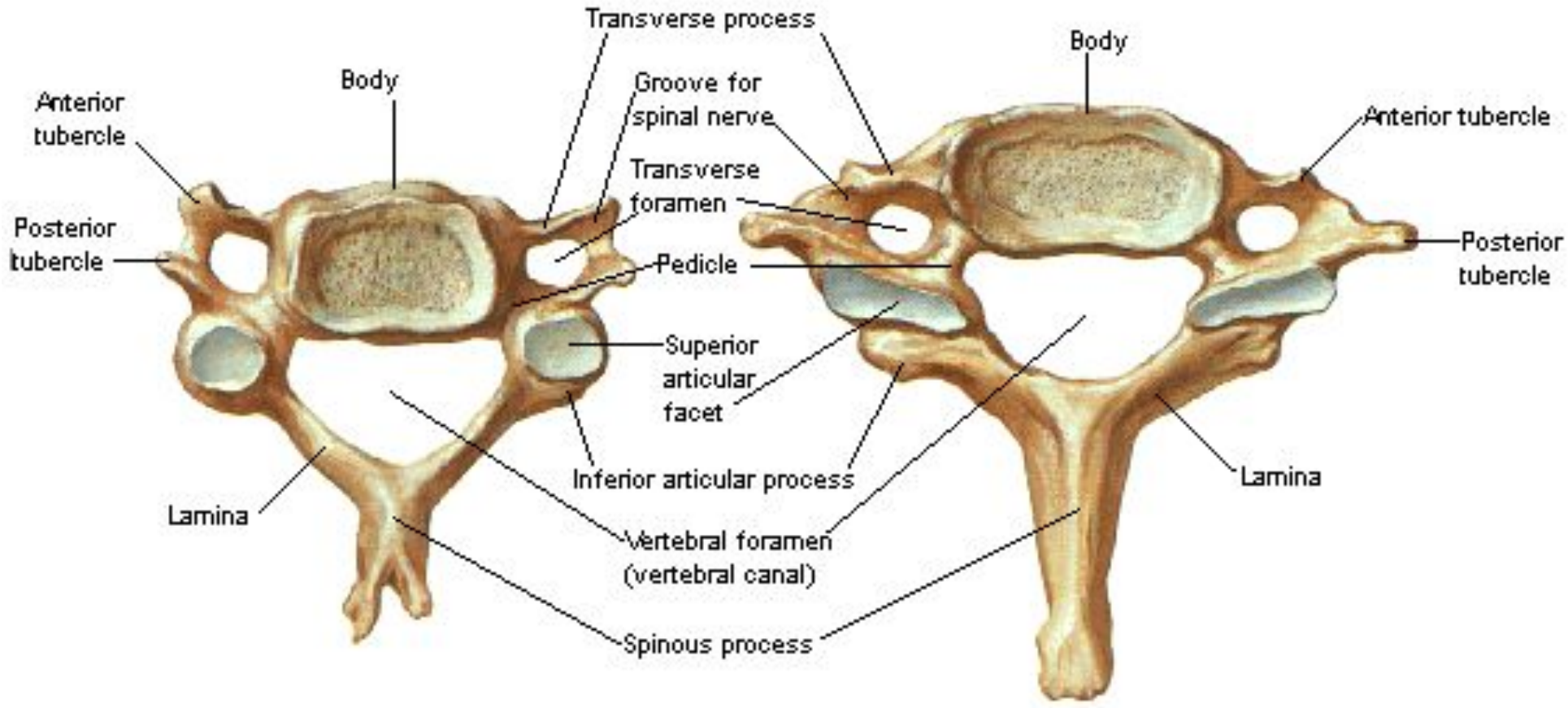
Axis (C2): posterosuperior view



Upper cervical vertebrae, assembled: posterosuperior view

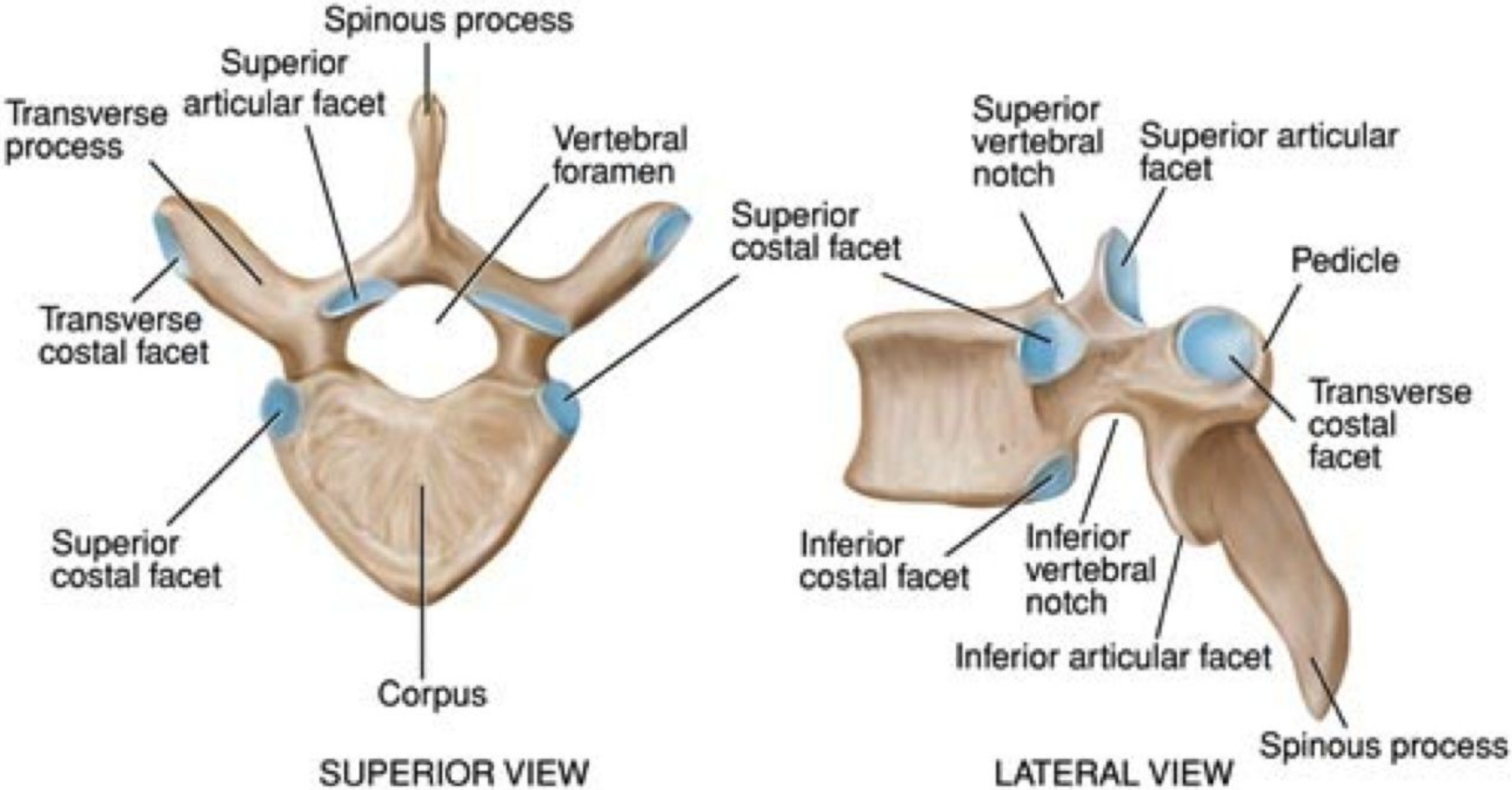
Cervical Vertebrae [C4 and C7]

Superior Views

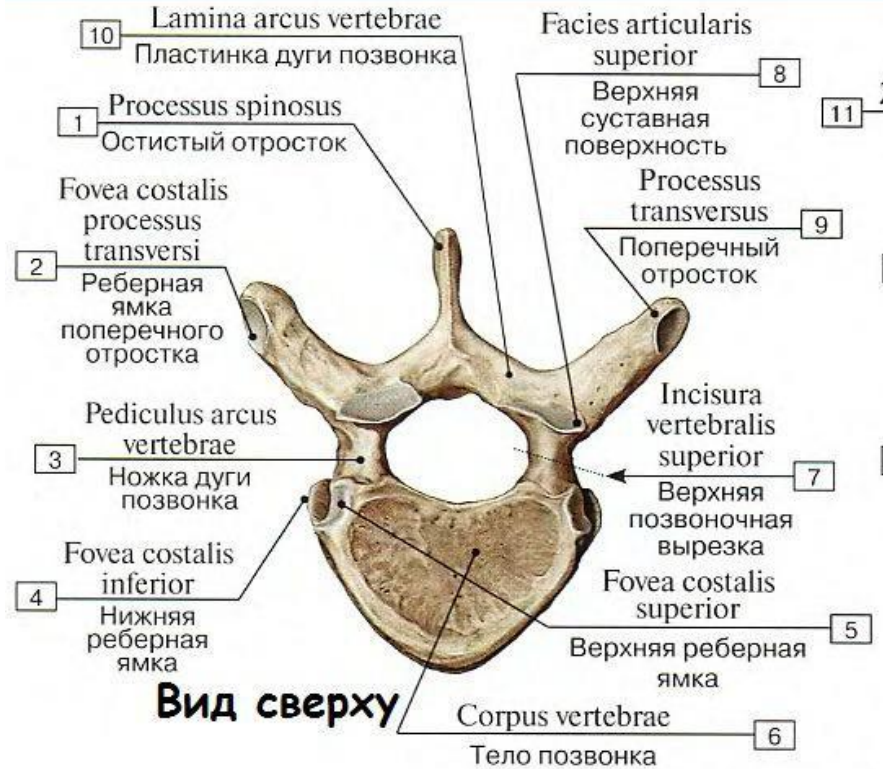


4th cervical vertebra: superior view

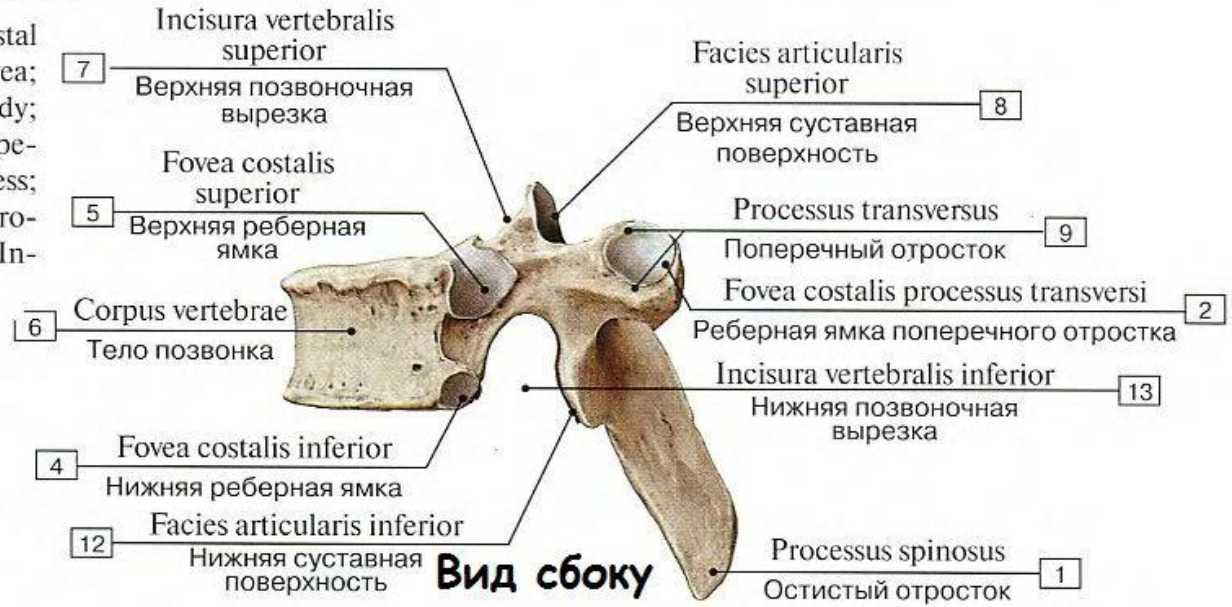
7th cervical vertebra: superior view

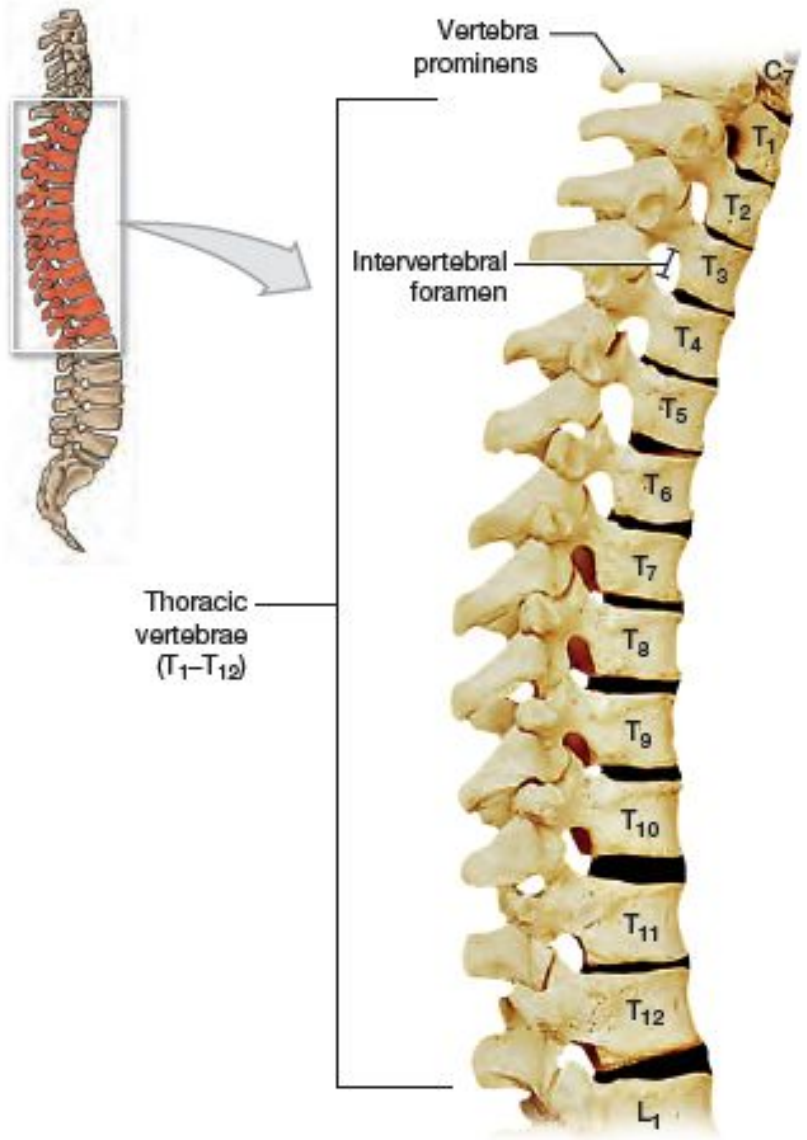

Spinous process
Superior articular facet
Transverse process
Vertebral foramen
Superior costal facet
Transverse costal facet
Superior costal facet
Corpus
SUPERIOR VIEW
Superior vertebral notch
Superior articular facet
Pedicle
Transverse costal facet
Inferior costal facet
Inferior vertebral notch
Inferior articular facet
Spinous process
LATERAL VIEW

Четвертый грудной позвонок, Th4

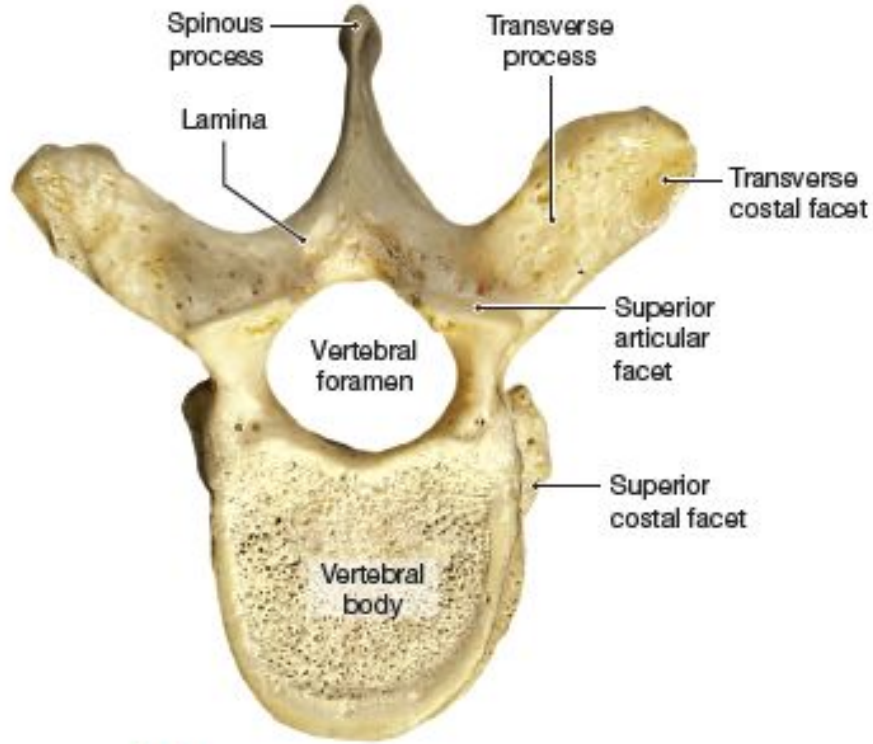


1 – Spinous process; *2* – Transverse costal fovea; *3* – Pedicle; *4* – Inferior costal fovea; *5* – Superior costal fovea; *6* – Vertebral body; *7* – Superior vertebral notch; *8* – Superior articular facet; *9* – Transverse process; *10* – Lamina; *11* – Superior articular process; *12* – Inferior articular facet; *13* – Inferior vertebral notch

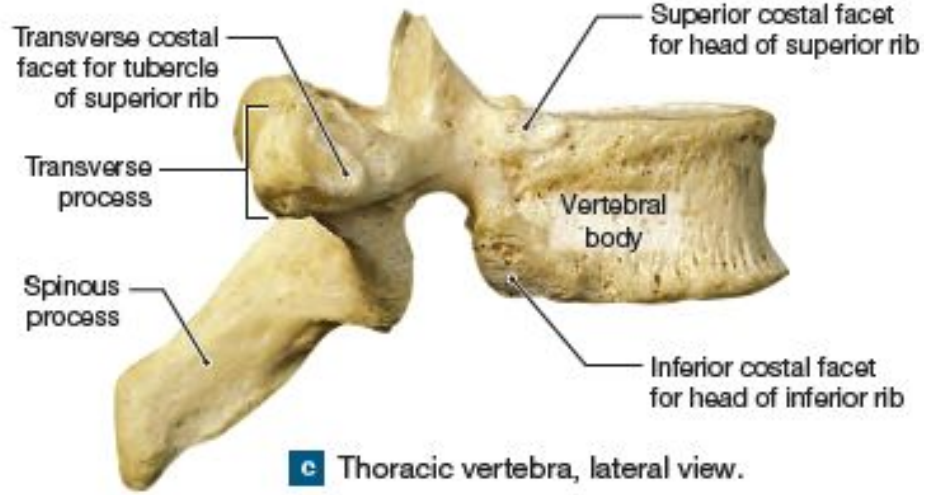




a A lateral view of the thoracic region of the vertebral column. The vertebra prominens (C_7) resembles T_1, but lacks facets for rib articulation. Vertebra T_{12} resembles the first lumbar vertebra (L_1) but has a facet for rib articulation.



b Thoracic vertebra, superior view.



c Thoracic vertebra, lateral view.

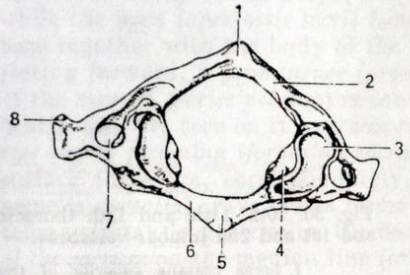


Fig. 28. Atlas, viewed from above.

1, tuberculum posterius;
2, arcus posterius;
3, fovea articularis sup.;
4, massa lateralis;
5, tuberculum anterius;
6, arcus anterior;
7, foramen transversarium;
8, processus transversus

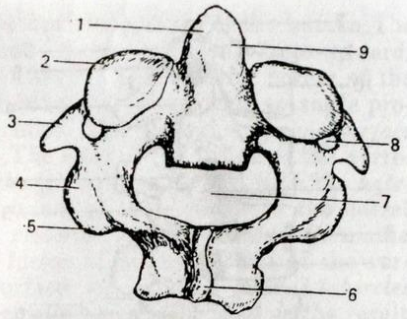


Fig. 29. Axis (epistropheus), viewed from above and from the back.

1, dens axis;
2, facies articularis sup.;
3, processus transversus;
4, processus articularis inf.;
5, arcus vertebrae;
6, processus spinosus;
7, foramen vertebrale;
8, foramen transversarium;
9, facies articularis posterior dentis

ing vertebrae, most vertebral bodies have two incomplete (half) costal facets: one on the superior edge of the vertebra (*fovea costalis superior*) and the other on the inferior surface (*fovea costalis inferior*). When one vertebra is placed on the other, the two half-facets form a single whole articular facet, which receives the head of the rib. The first thoracic vertebra is an exception: it has a complete articular facet on the superior edge for the first rib and a half-facet on the inferior edge for the second rib. The tenth vertebra has only one half-facet for the tenth rib, whereas the eleventh and twelfth ribs each have a complete facet for articulating with the corresponding ribs. These vertebrae (first, tenth, eleventh, and twelfth) can, therefore, easily be distinguished from the others. In accordance with the greater weight they bear, the bodies of the thoracic vertebrae are larger than the bodies of the cervical vertebrae. The articular processes are positioned frontally. The transverse processes are directed laterally and to the back. They have a small articular surface, *transverse costal facet* (*fovea costalis processus transversus*) for articulating with the tubercle of the ribs. The transverse processes of the last two vertebrae (eleventh and twelfth) lack these facets. The spinous processes of the thoracic vertebrae are long and are inclined sharply downward, as a result of which they overlie one another like tiles, mainly in the middle of the thoracic part of the spine. Such direction of the processes limits extension of the spine here, which is a protective accommodation for the heart.

3. **Lumbar vertebrae** (*vertebrae lumbales*) are distinguished by a massive body since they carry weight that is still greater than that borne by the part of the spine proximal to them (see Fig. 30). The spinous processes are

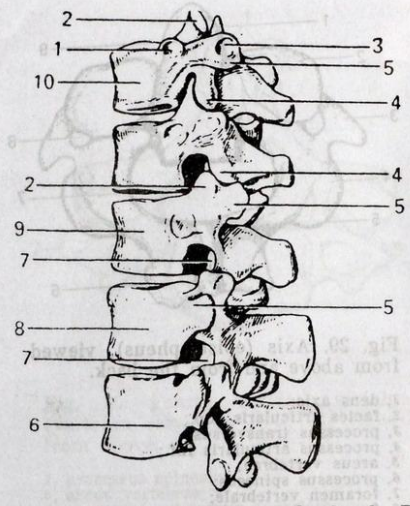


Fig. 30. 10th, 11th, and 12th thoracic and 1st and 2nd lumbar vertebrae.

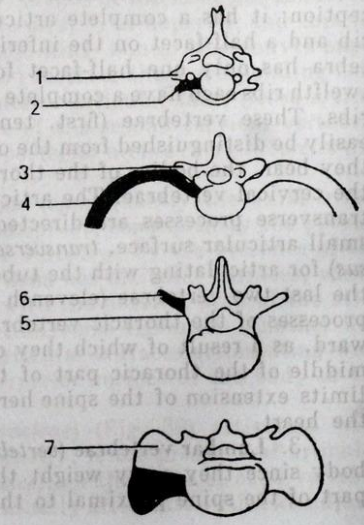
1, fovea costalis superior of the 10th vertebra (for the 10th rib);
2, processus articularis sup.;
3, fovea costalis transversalis;
4, processus articularis inf.;
5, processus transversus;
6, vertebra lumbalis II;
7, foramen intervertebrale;
8, vertebra lumbalis I;
9, vertebra thoracica XII;
10, vertebra thoracica X

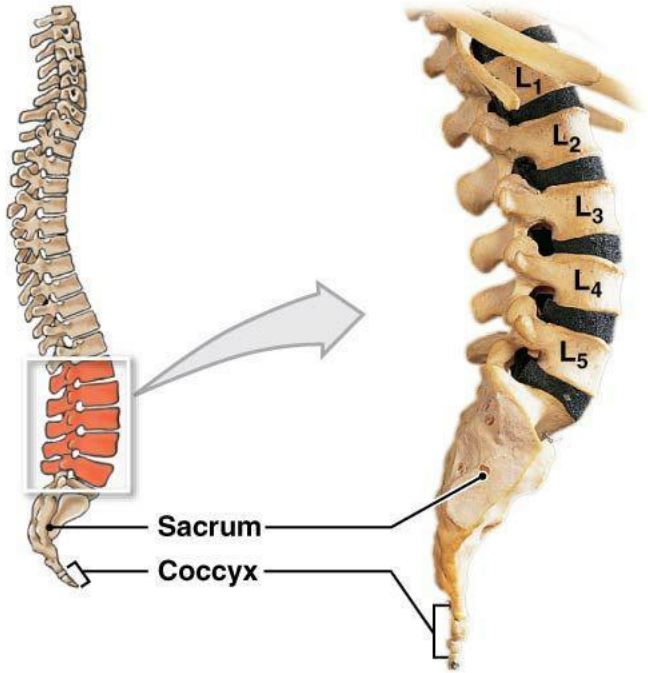
directed horizontally, to the back. The articular processes are in the sagittal plane. The main part of the transverse process is a rudimentary rib fused completely with a true transverse process, and a small part is preserved as a small process on the posterior aspects of its root and erroneously called the *accessory process* (*processus accessorius*) (Fig. 31).

4. **Sacral vertebrae** (*vertebrae sacrales*) fuse in youth to form a single bone, the **sacrum** (Fig. 32). This fusion is an adaptation to the considerable

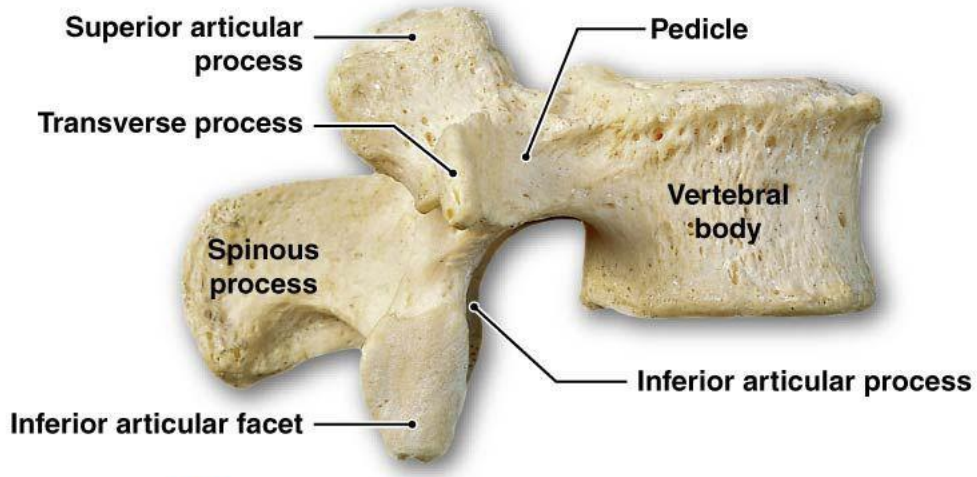
Fig. 31. Diagram of the development of a rib (shaded) and its relation to the transverse processes of four groups of vertebrae: cervical, thoracic, lumbar, and sacral.

1, processus transversus;
2, processus costarius (cervical vertebra);
3, processus transversus (thoracic vertebra);
4, costa;
5, processus transversus;
6, processus costarius (lumbar vertebra);
7, processus transversus (sacral vertebra)

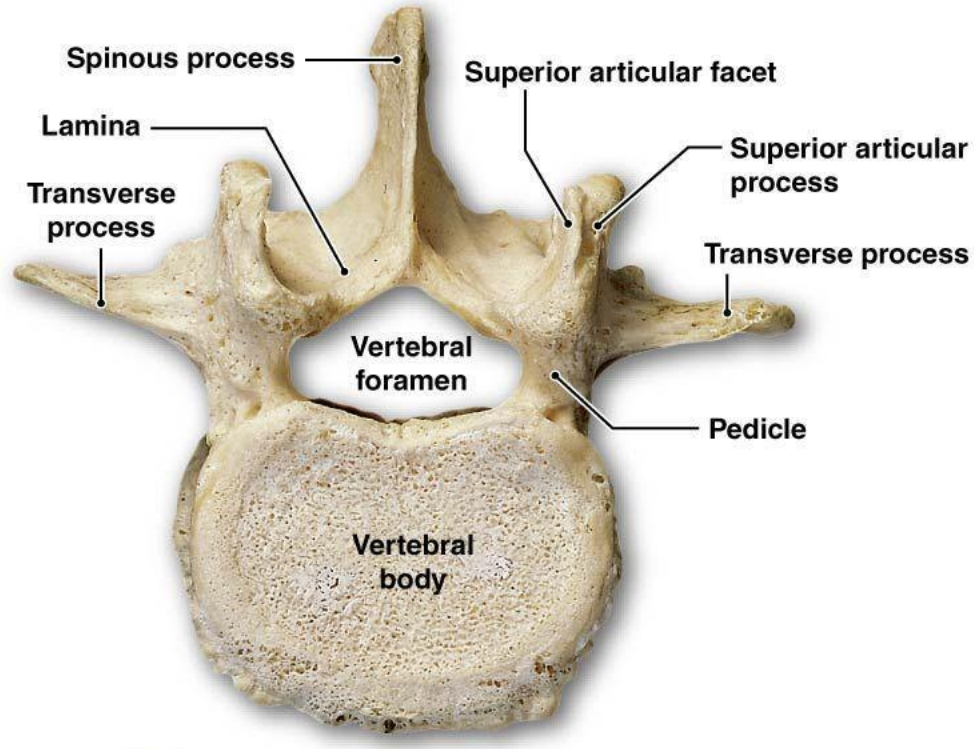




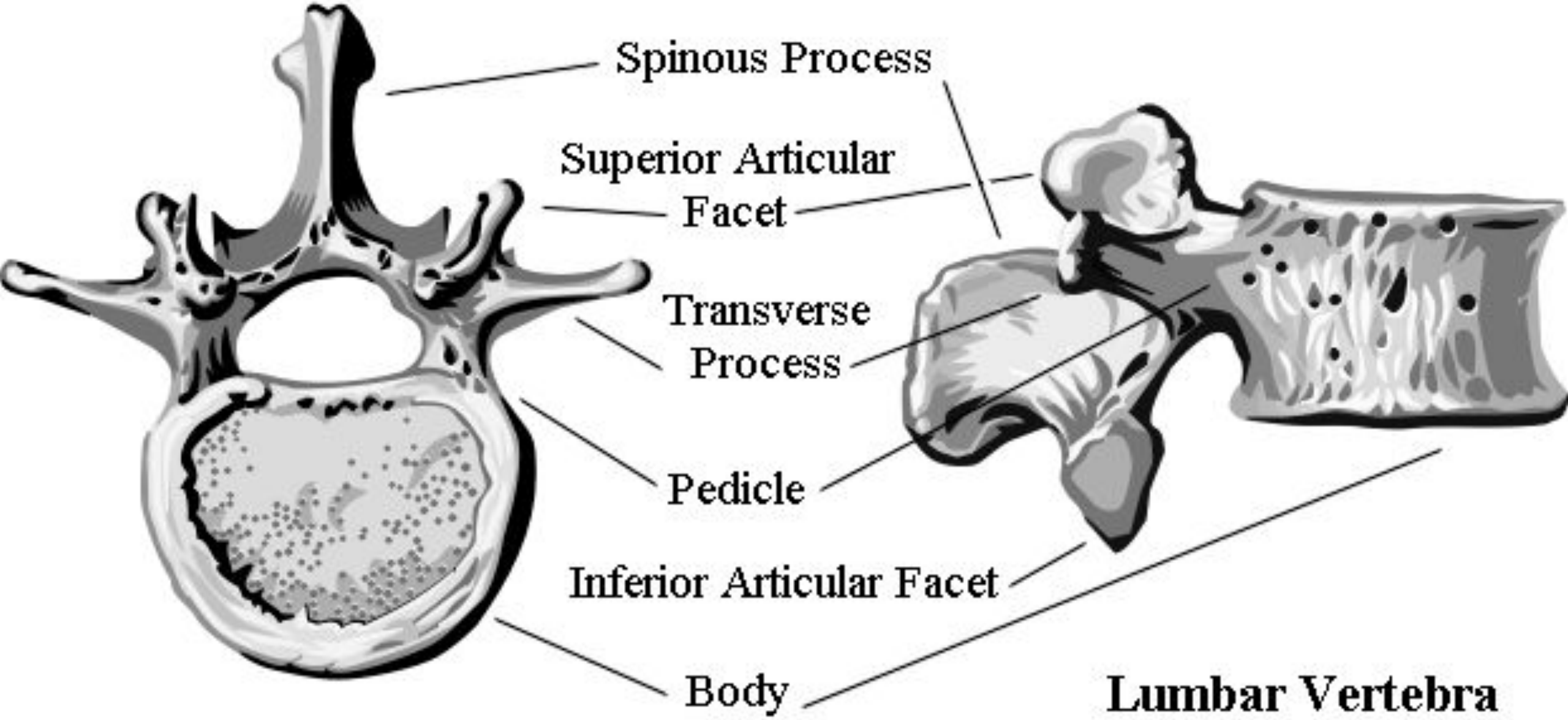
a A lateral view of the lumbar vertebrae, sacrum, and coccyx



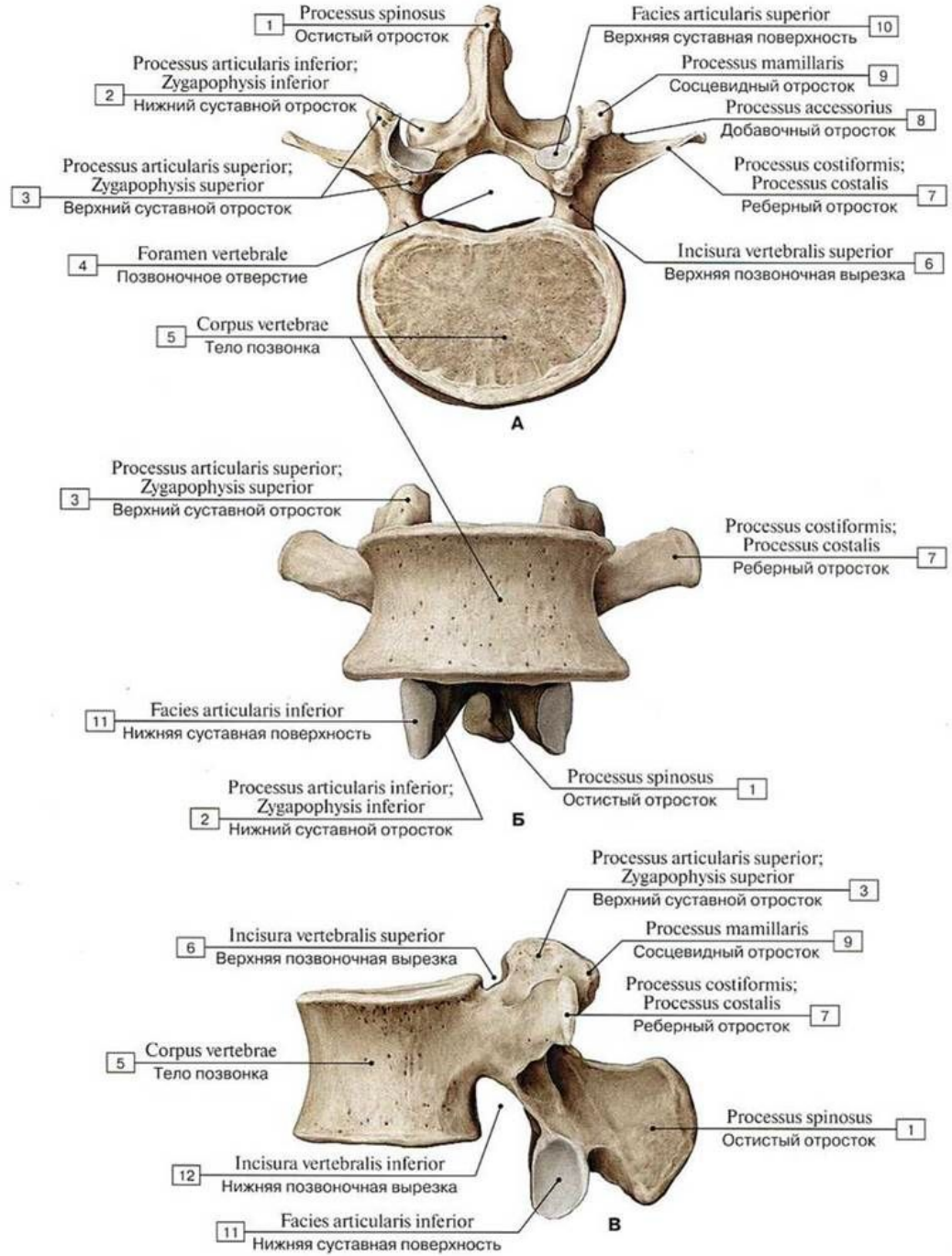
b A lateral view of a typical lumbar vertebra



c A superior view of the same vertebra shown in part b



Lumbar Vertebra


1 Processus spinosus
Остистый отросток
2 Processus articularis inferior; Zygapophysis inferior
Нижний суставной отросток
3 Processus articularis superior; Zygapophysis superior
Верхний суставной отросток
4 Foramen vertebrale
Позвоночное отверстие
5 Corpus vertebrae
Тело позвонка
10 Facies articularis superior
Верхняя суставная поверхность
9 Processus mamillaris
Сосцевидный отросток
8 Processus accessorius
Добавочный отросток
7 Processus costiformis; Processus costalis
Реберный отросток
6 Incisura vertebralis superior
Верхняя позвоночная вырезка
А
3 Processus articularis superior; Zygapophysis superior
Верхний суставной отросток
7 Processus costiformis; Processus costalis
Реберный отросток
11 Facies articularis inferior
Нижняя суставная поверхность
1 Processus spinosus
Остистый отросток
2 Processus articularis inferior; Zygapophysis inferior
Нижний суставной отросток
Б
3 Processus articularis superior; Zygapophysis superior
Верхний суставной отросток
6 Incisura vertebralis superior
Верхняя позвоночная вырезка
9 Processus mamillaris
Сосцевидный отросток
7 Processus costiformis; Processus costalis
Реберный отросток
5 Corpus vertebrae
Тело позвонка
1 Processus spinosus
Остистый отросток
12 Incisura vertebralis inferior
Нижняя позвоночная вырезка
11 Facies articularis inferior
Нижняя суставная поверхность
В

load carried by the sacrum because of the upright posture of the human.The sacrum is triangular in shape, and its **base** (*basis ossis sacri*) faces upward, while the **apex** (*apex ossis sacri*) faces downward. The anterior border of the base together with the body of the last lumbar vertebra forms an angle projecting forward, a *prominence* (*promontorium*). The ventral or *pelvic surface* of the sacrum (*facies pelvina*) is concave. The sites of the fusion of the vertebral bodies are seen on it as *transverse lines* (*lineae transversae*) with the *anterior sacral foramina* (*foramina sacralia pelvina*) at their ends. On the dorsal surface there are, correspondingly, the *posterior sacral foramina* (*foramina sacralia dorsalia*). Five crests formed by fusion of different parts of the vertebrae stretch lengthwise on the dorsal surface: an unpaired *spinous tubercles of the sacrum* on the median line (*crista sacralis mediana*) formed as the result of fusion of the spinous processes; the *articular tubercles of the sacrum* (*cristae sacrales intermediae*) (from fusion of the articular processes); and, lateral to these, the *transverse tubercles of the sacrum* (*cristae sacrales laterales*) (sites of fusion of the transverse processes). Lateral to the sacral foramina are the *lateral parts* of the sacrum (*partes laterales*) formed by fusion of the transverse processes and the sacral ribs. They have on their lateral aspect an auricular surface curved like the auricle, which is called the *auricular surface* (*facies auriculares*). It serves for joining with the iliac bone. At the back of each auricular surface is the *sacral tuberosity* (*tuberositas sacralis*) (the site of attachment of muscles and ligaments). The *sacral canal* (*canalis sacralis*) passes in the sacrum. It is a continuation of the vertebral canal. As a consequence

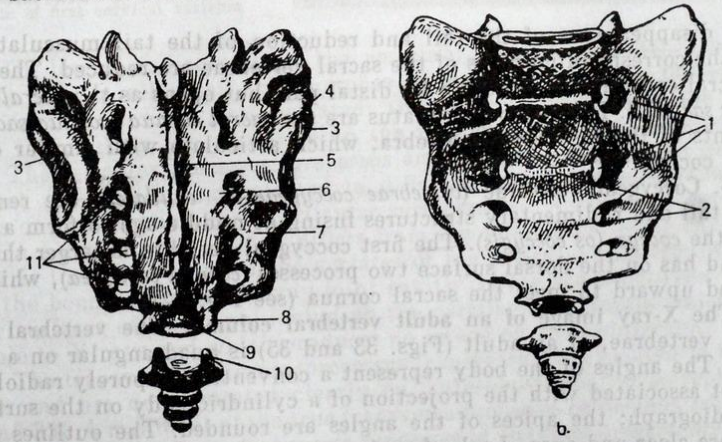


Fig. 32. Sacrum and coccyx.

a, posterior aspect;
b, anterior aspect;
1, foramina sacralia pelvina;
2, lineae transversae;
3, facies auricularis;
4, tuberositas sacralis;
5, crista sacralis mediana;
6, crista sacralis intermedia;
7, crista sacralis lateralis;
8, cornu sacrale;
9, hiatus sacralis;
10, cornu coccygeum;
11, foramina sacralia dorsalia

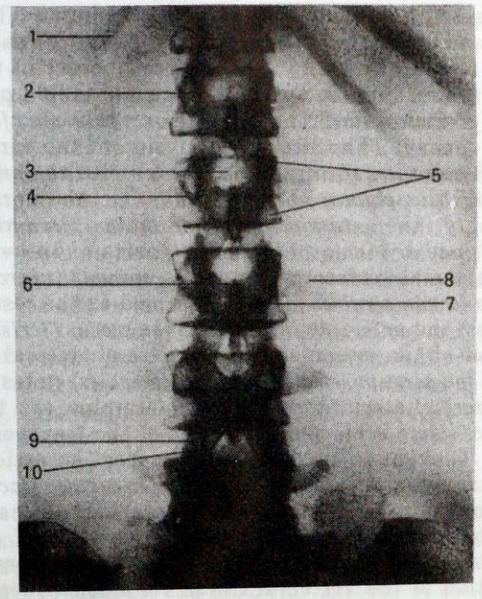


Fig. 33. Radiograph of the lumbar vertebral column in a 32-year-old male (anteroposterior view).

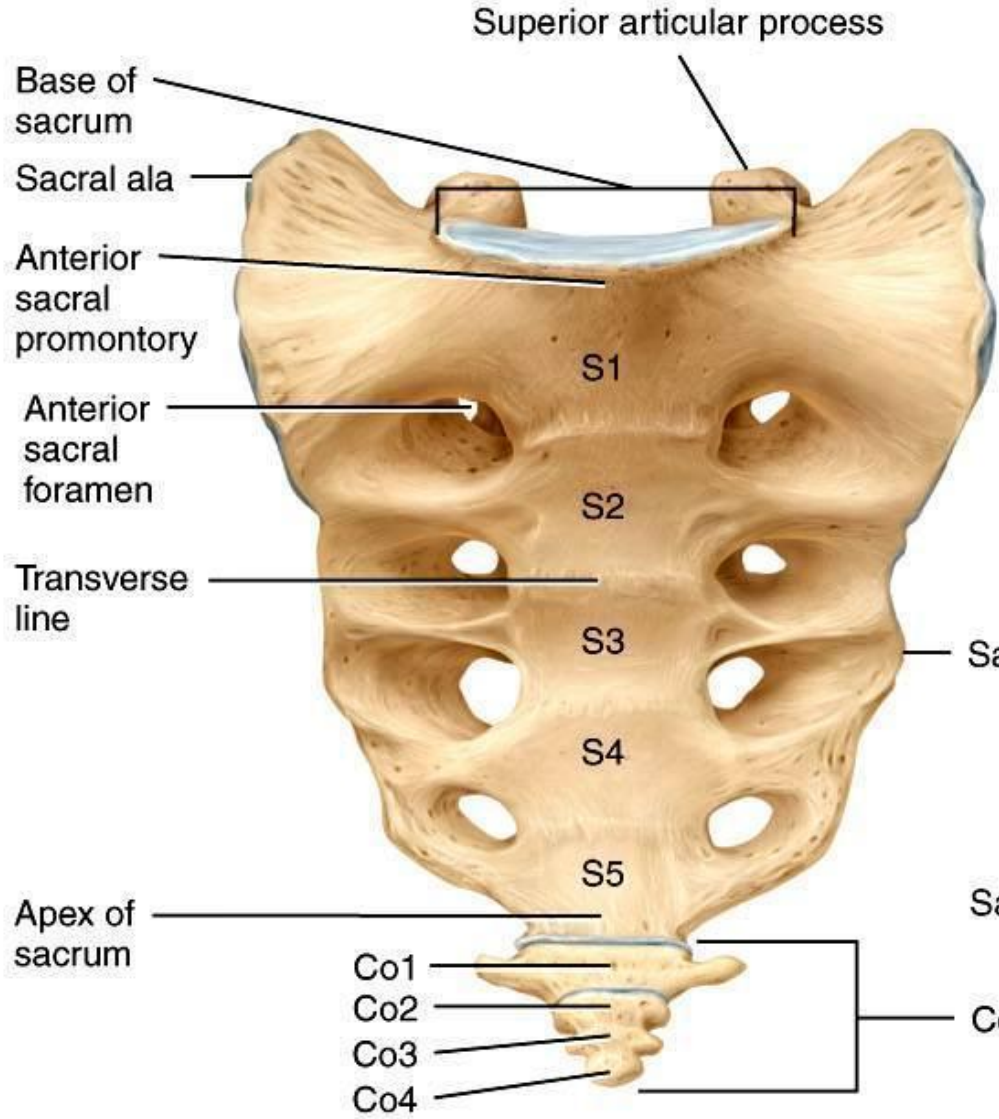
1, twelfth rib;
2, first lumbar vertebra;
3, vertebral body;
4, vertebral 'waist';
5, vertebral 'angles';
6, arch;
7, spinous process;
8, transverse process;
9, superior articular process;
10, inferior articular process

of the disappearance of the tail and reduction of the tail musculature in man, the corresponding parts of the sacral vertebrae are reduced. Therefore, the sacral canal is not closed in its distal part but opens as the *sacral hiatus* (*hiatus sacralis*). Lateral to this hiatus are the *sacral cornua* (*cornua sacralia*), remnants of the last sacral vertebra, which articulate with similar cornua of the coccyx.

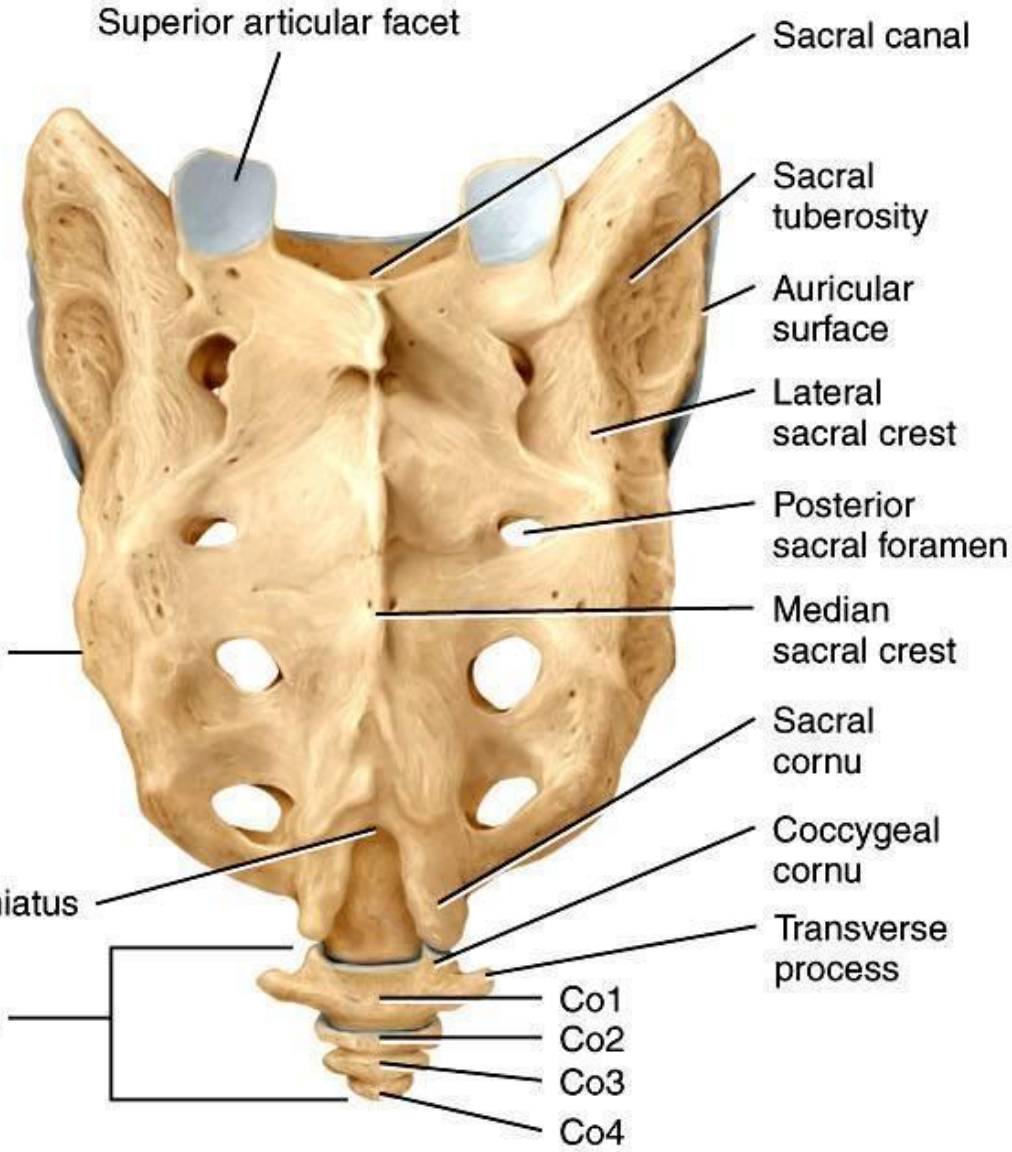
5. **Coccygeal vertebrae** (*vertebrae coccygeae* s. *caudales*) are remnants of the tail and rudimentary structures fusing at middle age to form a single bone, the *coccyx* (*os coccygis*). The first coccygeal vertebra is larger than the rest and has on the dorsal surface two processes (*cornua coccygea*), which are directed upward to meet the sacral cornua (see Fig. 32).

The X-ray image of an adult vertebral column. The vertebral body, corpus vertebrae, of an adult (Figs. 33 and 35) is quadrangular on a radiograph. The angles of the body represent a conventional, purely radiological concept associated with the projection of a cylindric body on the surface of the radiograph; the apices of the angles are rounded. The outlines of the body are clear and even. Lack of an increase in the height of the body from vertebra to vertebra in the caudal direction is a pathological phenomenon. The bodies of the lumbar vertebrae resemble a "reel" with a narrow "waist" (see Fig. 33). The *pedicle of the arch* (*pediculus arcus*) is demonstrated on an anteroposterior radiograph as a circular or oval contrast shadow superimposed on the shadow of the body. The arch in this case is projected as if in a transverse section.

Location of sacrum and coccyx

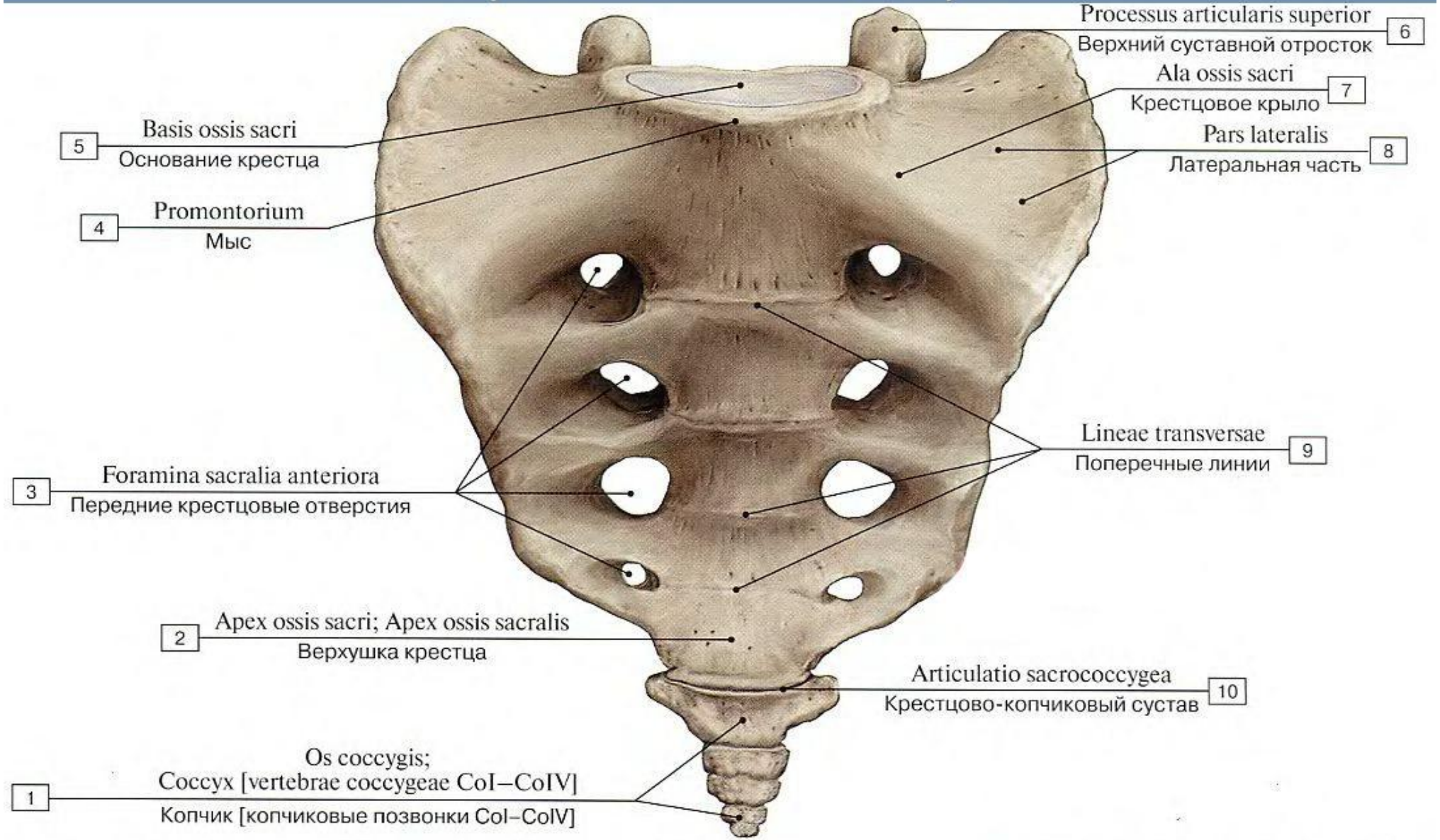


(a) Anterior view



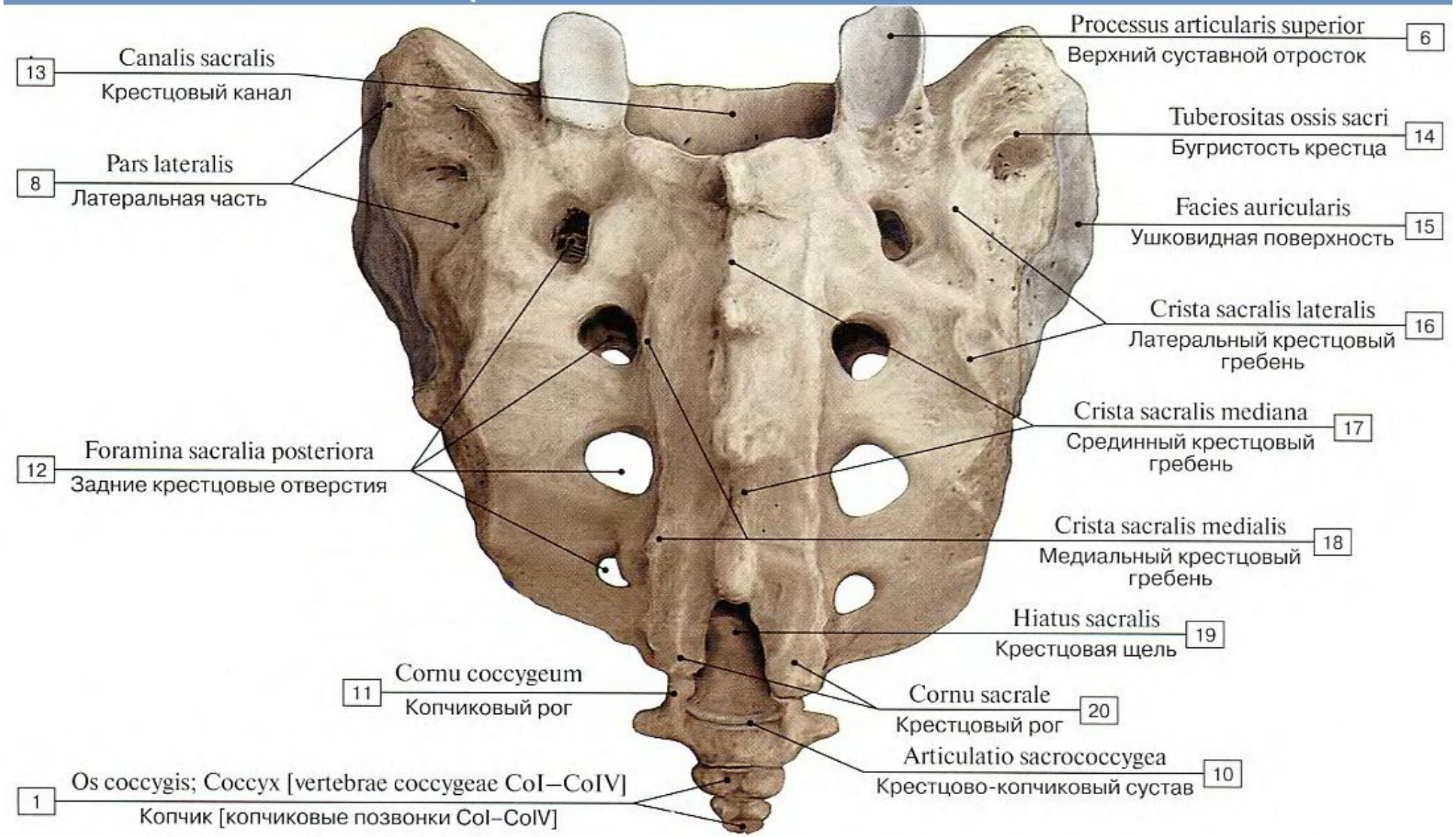
(b) Posterior view

Крестец и копчик, вид спереди



1 – Coccyx [coccygeal vertebrae CoI–CoIV]; *2* – Apex; *3* – Anterior sacral foramina; *4* – Promontory; *5* — Base of sacrum; *6* — Superior articular process; *7* — Ala; Wing; *8* — Lateral part; *9* — Transverse ridges; *10* — Sacrococcygeal joint; *11* — Coccygeal cornu; *12* – Posterior sacral foramina; *13* – Sacral canal; *14* – Sacral tuberosity; *15* – Auricular surface; *16* – Lateral sacral crest; *17* – Median sacral crest; *18* – Intermediate sacral crest; *19* – Sacral hiatus; *20* – Sacral cornu; Sacral horn

Крестец и копчик, вид сзади



1 – Coccyx [coccygeal vertebrae CoI–CoIV]; *2* – Apex; *3* – Anterior sacral foramina; *4* – Promontory; *5* — Base of sacrum; *6* — Superior articular process; *7* — Ala; Wing; *8* — Lateral part; *9* — Transverse ridges; *10* — Sacrococcygeal joint; *11* — Coccygeal cornu; *12* – Posterior sacral foramina; *13* – Sacral canal; *14* – Sacral tuberosity; *15* – Auricular surface; *16* – Lateral sacral crest; *17* – Median sacral crest; *18* – Intermediate sacral crest; *19* – Sacral hiatus; *20* – Sacral cornu; Sacral horn