NERVOUS SYSTEM

The **nervous system** (NS) is the mechanism concerned with the correlation and integration of various bodily processes, the reactions and adjustments of the organism to its environment, and with conscious life. It may be divided into two parts, central and peripheral.

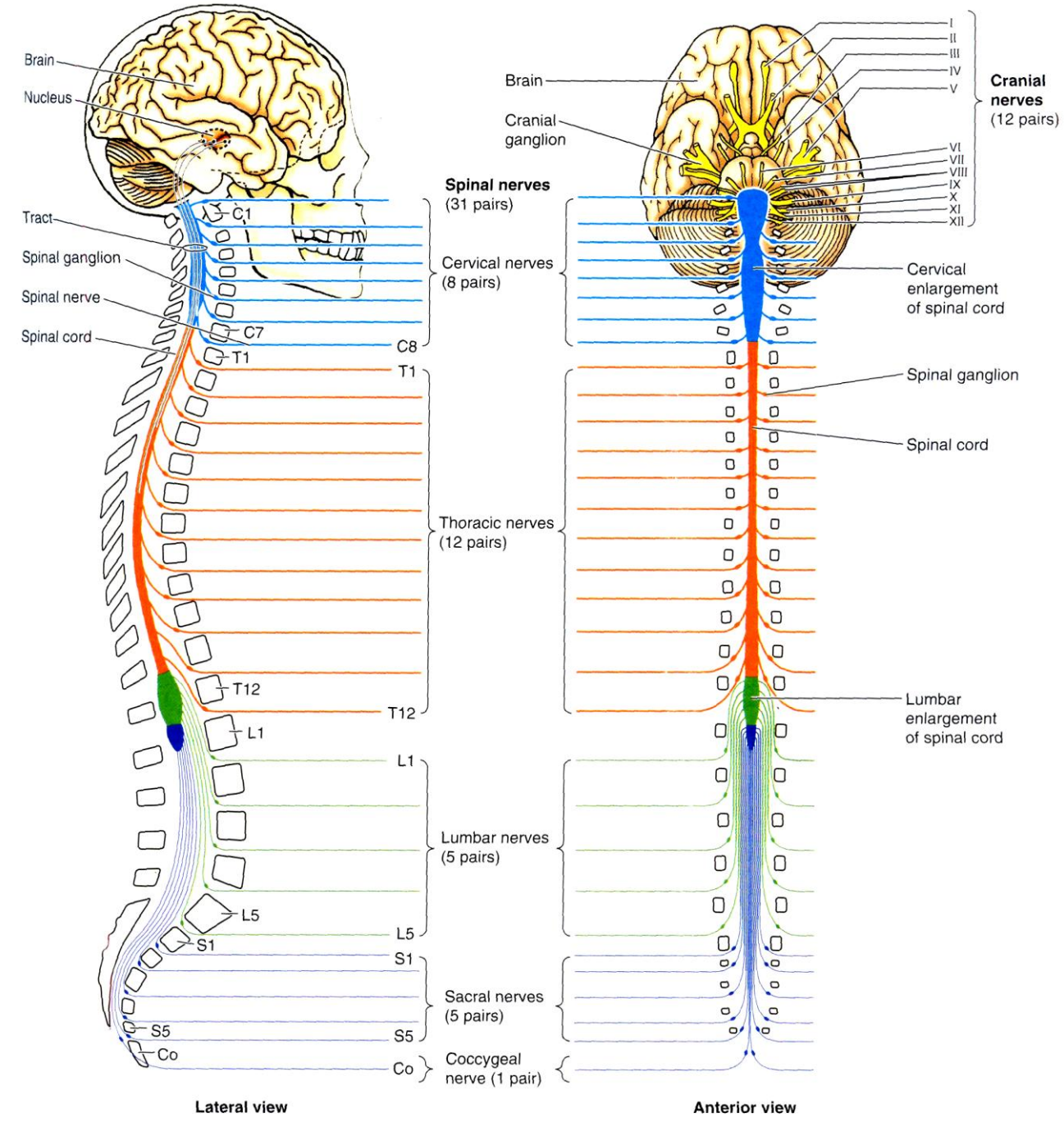
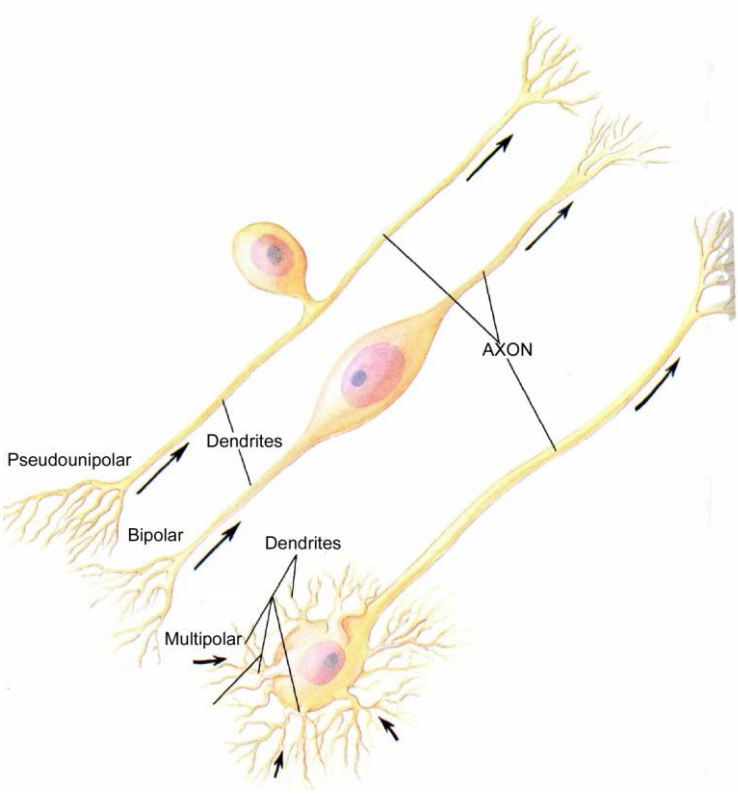


Figure **Basic organization of the nervous system.** The peripheral nervous system consists of nerve fibers and ganglia. Peripheral nerves are either cranial nerves or spinal nerves. Except in the cervical region, each spinal nerve bears the same letter–numeral designation as the vertebra forming the superior boundary of its exit from the vertebral column. In the cervical region, each spinal nerve bears the same letter–numeral designation as the vertebra forming its inferior boundary. Spinal nerve C8 exits between vertebrae C7 and T1. The cervical and lumbar enlargements of the spinal cord occur in relationship to the innervation of the limbs.

The **central nervous system** (CNS) consists of the encephalon or brain, contained within the cranium, and the medulla spinalis or spinal cord, lodged in the vertebral canal.

The **peripheral nervous system** (PNS) consists of a series of nerves by which the central nervous system is connected with the various tissues of the body. These nerves may be arranged in two groups, ***cranial (12 pairs)*** and ***spinal (31 pairs).*** The two groups are intimately connected and closely intermingled.
Gray substance (Gray matter) (substantia grisea, L.) of nervous tissue consists for a most part of groups of the bodies of nerve cells.
White substance(White matter) (substantia alba, L.) of nervous tissue is due to presence of large numbers of nerve fibers.

The **neurons** are the functional units of the NS according to the neuron theory which was formulated by Waldeyer. The NS contains about 100 billion nerve cells. Neurons have two important properties: (1) excitability, or ability to respond to stimuli, and (2) conductivity, or the ability to conduct a signal.
Neurons have two types of processes, ***dendrites*** and ***axons.*** Dendrites conduct nerve impulses toward the cell body. A neuron may have 4 - 200 dendrites. A nerve cell generally has just one axon, which carries nerve impulses away from the cell body to the next nerve cell, or muscle cell. The axon ends by a ***synapse*** (synapsis, G.; connection, E.). The dendrites end by the ***sensory receptors.***



Types of neurons which are based on function:

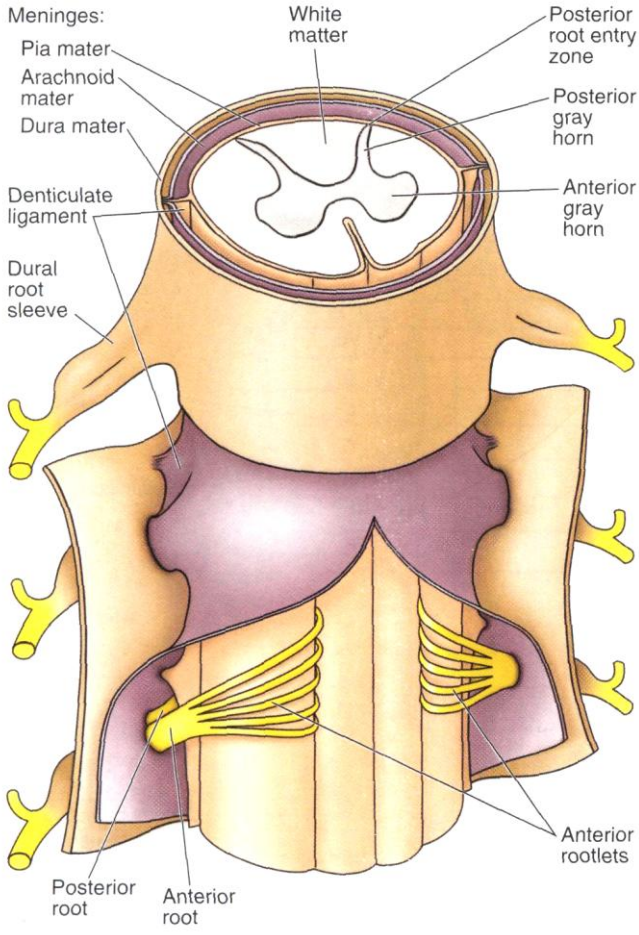
- neurons and nerve fibers conveying information from sensory receptors in the body to the CNS are called ***afferent, sensory neurons,*** or ***protoneurons;*** their cell bodies lie in the ganglia (spinal or cranial) of the PNS; the distal endings of these afferent neurons (dentrites) are connected to the sensory receptors;
- ***efferent***, ***motor neurons,*** or ***motoneurons*** and fibers convey nerve impulses away from the CNS to the effectors (in the muscles); their cell bodies are in the CNS: anterior horn of the spinal cord (5 motor nucles), and motor nucles of the cranial nerves; the distal endings of these efferent neurons (axons) are connected to the effectors;
- ***interneurons***, also called ***association neurons*** lie within the CNS; their functions are to carry impulses from sensory neurons to motor neurons, and to process incoming neural information.

MEDULA SPINALIS

The **medulla spinalis** or **spinal cord** (myelos, G.) forms the elongated, nearly cylindrical part of the CNS which occupies the upper two-thirds of the vertebral canal. Its average length is about 45 cm, while its weight ammounts to about 30 g. Its extends from the level of the upper border of the atlas to that of the lower border of the first, or upper border of the second lumbar vertebra. Above, it is continuous with the brain; below, it ends in a conical extremity, the conus medullaris, from the apex of which a delicate filament, the filum terminale, descends to the coccyx. The lumbar and sacral roots of the spinal cord are collectively called the ***cauda equina*** (L.), which means "horse's tail". The medulla spinalis presents two enlargements, an upper or cervical, and a lower or lumbosacral. The cervical enlargement corresponds with the attachments of the large nerves which supply the upper limbs. It extends from about the third cervical to the second thoracic vertebra. The lumbosacral enlargement corresponds with the attachments of the large nerves which supply the lower limbs. It commences about the level of the ninth thoracic vertebra.

External structure

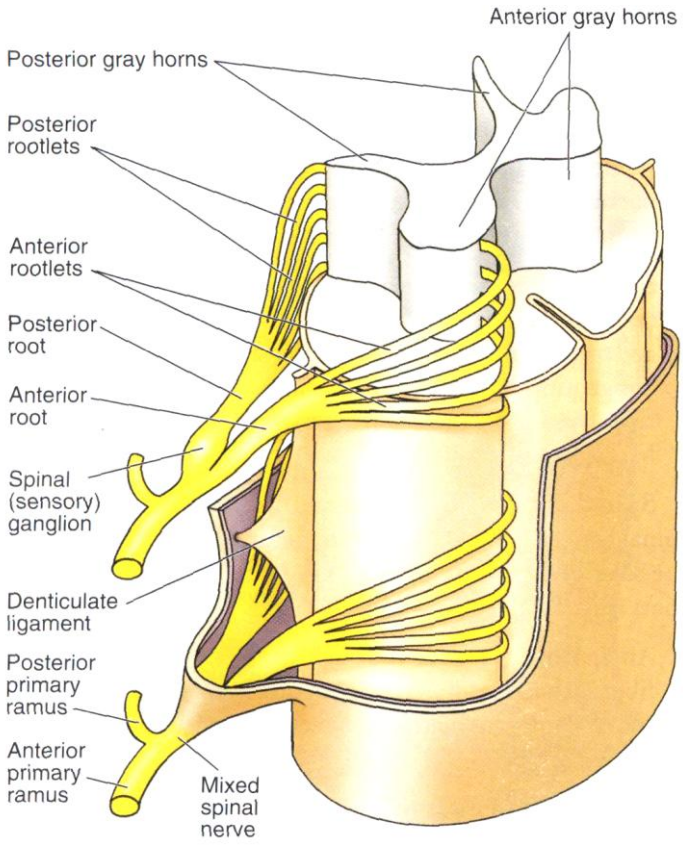
An anterior median fissure (fissura mediana anterior, L.) and a posterior median sulcus (sulcus medianus posterior, L.) incompletely divide the medulla spinalis into two symmetrical parts. On either side of posterior median sulcus, the posterior nerve roots are attached along a vertical furrow named the posterolateral or dorsolateral sulcus. The portion of the medulla spinalis which lies between this and the posterior median sulcus is named the posterior funiculus. The posterior funiculus is sudivided into two fasciculi - a medial named the fasciculus gracilis (tract of Goll); and a lateral, the fasciculus cuneatus (tract of Burdach). The anterior funiculus is between fissura mediana anterior and the ventrolateral sulcus. The anterior nerve roots are in the ventrolateral sulci. Between the exit of two roots (anterior and posterior) is lateral funiculus.



Anterolateral view

The medulla spinalis is ensheased by three protective membranes: ***dura mater spinalis, arachnoid spinalis,*** and the ***pia mater spinalis.*** The sheath of the dura mater spinalis ends at the level of the lower border of the second sacral vertebra. The dura mater spinalis is separated from the periosteum of the vertabrae by the epidural cavity, which contains a quantity of loose areolar tissue, and a plexus of veins. Between the dura mater spinalis and the arachnoid is the subdural cavity. The arachnoid is a thin, transparent sheath, separated from the pia mater by the subarachnoid cavity, which is filled with cerebrospinal fluid. The pia mater closely invests the medulla spinalis and sends delicate septa into it substance, the ligamentum denticulatum, extends along each of its lateral surfaces and is attached by a series of pointed processes to the inner surface of the dura mater.

The internal structure of the medulla spinalis. On examing a transverse section of the medulla spinalis it is seen to consist of gray and white nervous substance. The gray substance forms three gray columns. The anterior column (columna anterior, L.) contains many motor cells.



The lateral column (columna lateralis, L.) contains many preganglionis cells of the autonomic nervous system. This column presents in the C8 - L3 segments. The posterior column (columna posterior, L.) cells are concerned with the reception and conduction of sensory impulses entering through the dorsal roots. The pairs of columns form horns (cornu, L.) at the horizontal section of the medulla spinalis.

The nucles of the ***anterior horn*** (cornu anterius, L.), motor neurons:

1) nucleus anterolateralis;
2) nucleus anteromedialis;
3) nucleus centralis;
4) nucleus dorsolateralis;
5) nucleus dorsomedialis.

The nucles of the ***posterior horn*** (cornu posterius, L.), sensory neurons:

1) nucleus proprius cornu posterior;
2) nucleus thoracicus;
3) nucleus intermediomedialis;
4) substantia gelatinosa;
5) zona spongiosa;
6) cellulae disseminatae.

The nucles of the ***lateral horn*** (cornu lateralis, L.):

1) nucleus intermediolateralis (autonomic sympathetic);
2) formatio reticularis;
3) nuclei parasympathetici sacrales.

The central canal (canalis centralis, L.) runs throught the entire length of the medulla spinalis. The portion of gray substance in front of the canal is named the anterior gray commissure; that behind it, the posterior gray commissure.

The white substance forms three white columns or funiculi, the proper fibers (fasciculi proprii, L.), and the white commissure (commissura alba, L.). The bundles of fibers within each funiculus are subdivided into tracts.

The ***anterior funiculus*** (funiculus anterior, L.) contains such tracts:
1) fasciculi proprii anteriores;
2) tractus corticospinalis (pyramidalis) anterior;
3) tractus vestibulospinalis;
4) tractus reticulospinalis;
5) tractus spinothalamicus anterior.

The tracts of the ***lateral funiculus*** (funiculus lateralis, L.):
1) fasciculi proprii laterales;
2) tractus corticospinalis (pyramidalis) lateralis;
3) tractus rubrospinalis;
4) tractus tectospinalis;
5) tractus olivospinalis;
6) tractus spinothalamicus lateralis;
7) tractus spinocerebellaris anterior (Gower's);
8) tractus spinocerebellaris posterior (Flechsing's).

The tracts of the ***posterior funiculus*** (funiculus posterior, L.):
1) fasciculi proprii posteriores;
2) fasciculus gracilis (tract of Goll);
3) fasciculus cuneatus (tract of Burdach).

Ascending tracts are made up of sensory fibers that carry impulses up the spinal cord to the brain. Descending tracts of fibers transmit impulses from the brain down the spinal cord to the efferent neurons. The short tracts convey impulses from one level of the spinal cord to another.
The ***anterior root*** (radix anterior, L.) consists of efferent fibers (axons) of the efferent, motor neurons, which are situated in the anterior horn and of efferent fibers of the preganglionis cells in the lateral horn of the spinal cord. The ***posterior root*** (radix posterior, L.) consists of afferent fibers which arise from the afferent, sensory neurons in a spinal ganglion.
In the vicinity of an intervertebral foramen, a dorsal root and a ventral root meet to form a spinal nerve. In all, there are 31 pairs of spinal nerves and 31 segments of the spinal cord:
(1) cervical: C1-C8;
(2) thoracic: T1-T12;
(3) lumbar: L1-L5;
(4) sacral: S1-S5;
(5) coccygeal: Co1.

Somatic reflex arc. Afferent, sensory neurons with cell bodies in the spinal ganglia convey sensory information from the periphery to the spinal cord. The information is passed through small internuncial neurons to the motor neuron. The efferent neurons with cell bodies located in the ventral horn of the spinal cord pass along the spinal nerve to contact effector organs.

In the nervous system, the word **nucleus** means a collection of nerve cells inside the CNS. A similar collection of nerve cells outside the CNS is a ganglion.

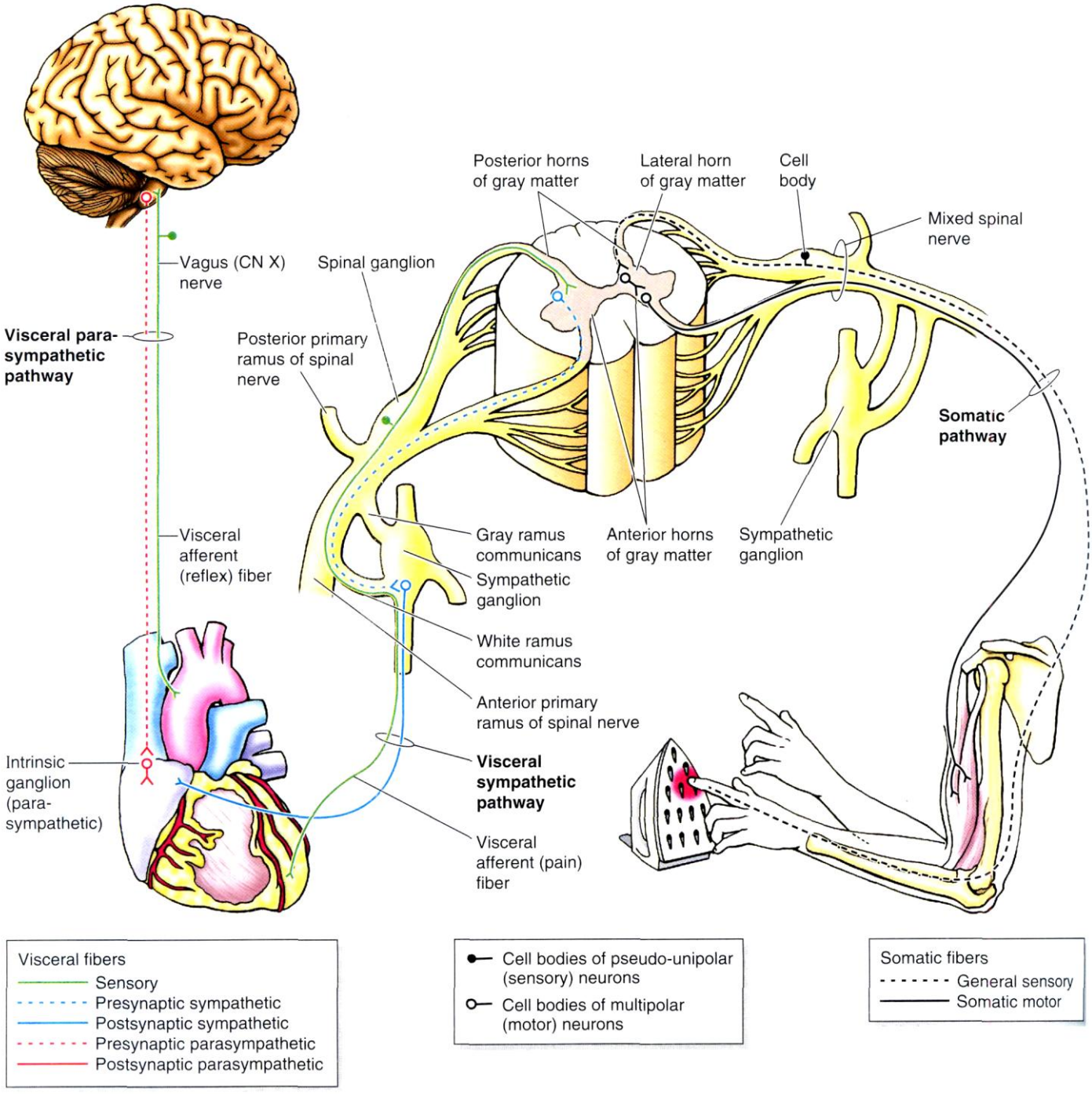


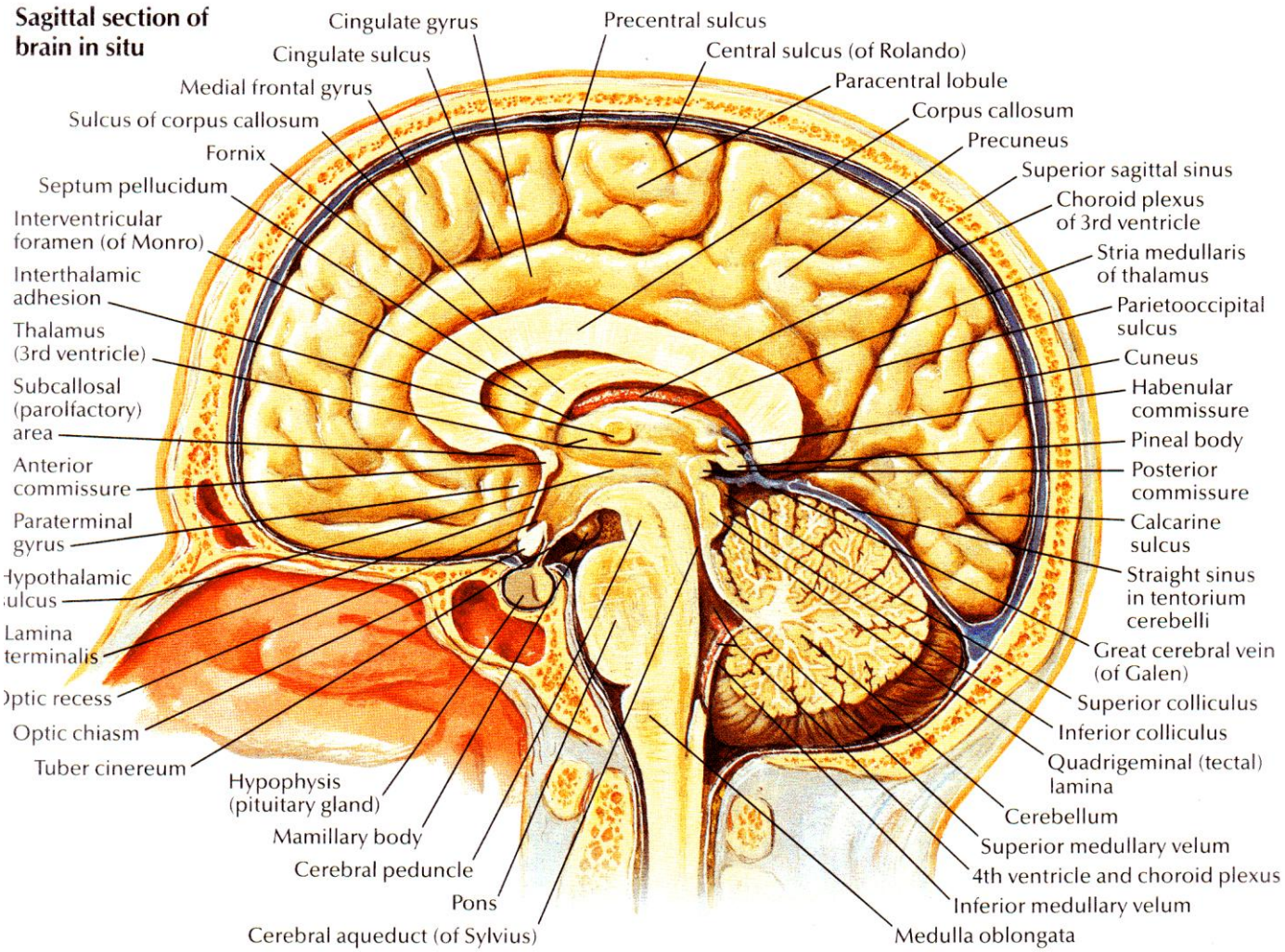
Figure **Somatic and visceral innervation via spinal, splanchnic, and cranial nerves.** The somatic motor system permits voluntary and reflexive movement caused by contraction of skeletal muscles, such as occurs when one touches a hot iron.

BRAIN

The brain (encephalon) during the fourth week develops from three primary cerebral vesicles: *prosencephalon*, *mesencephalon* and *rhombencephalon*. Prosencephalon forms two secondary cerebral vesicles: telencephalon and diencephalon. Rhomboencephalon gives origin for medulla oblongata and metencephalon. Mesencephalon separates from rhomboencephalon by isthmus.

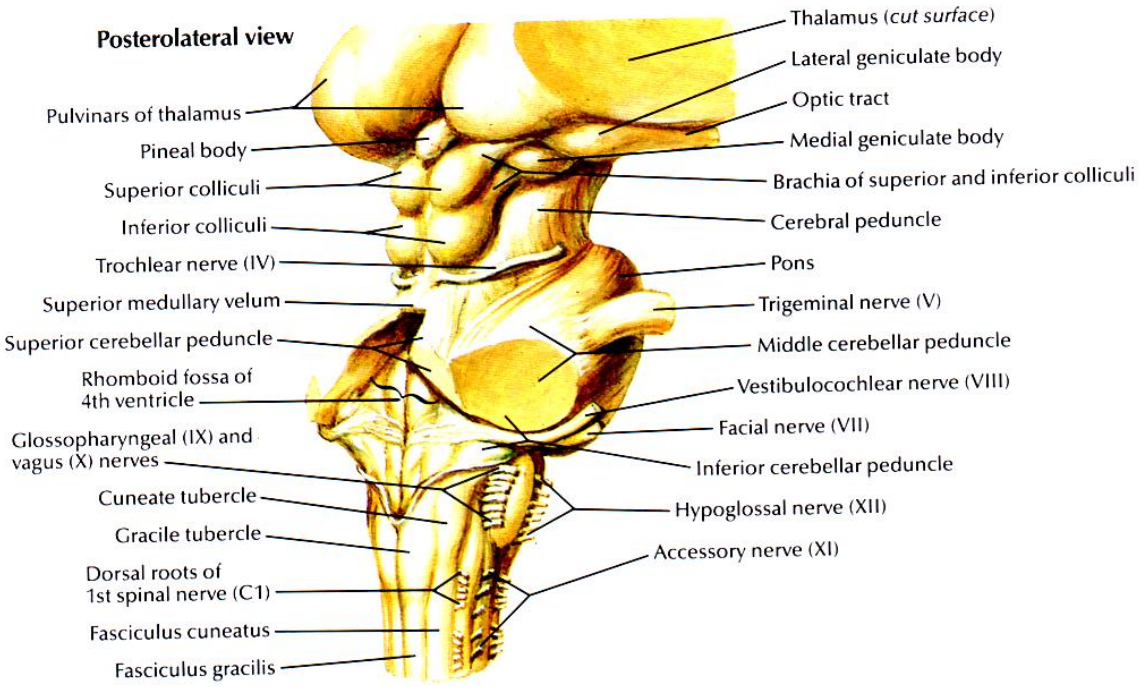
Metencephalon developes into *pons* and *cerebellum*. Midbrain comprises *tectum and pedunculi cerebri*. Diencephalon contains *thalamus* and *hypothalamus*. Telencephalon (forebrain) gives origin for rhinencephalon, basal nuclei of gray matter, pallium of hemispheres, corpus callosum and fornix.

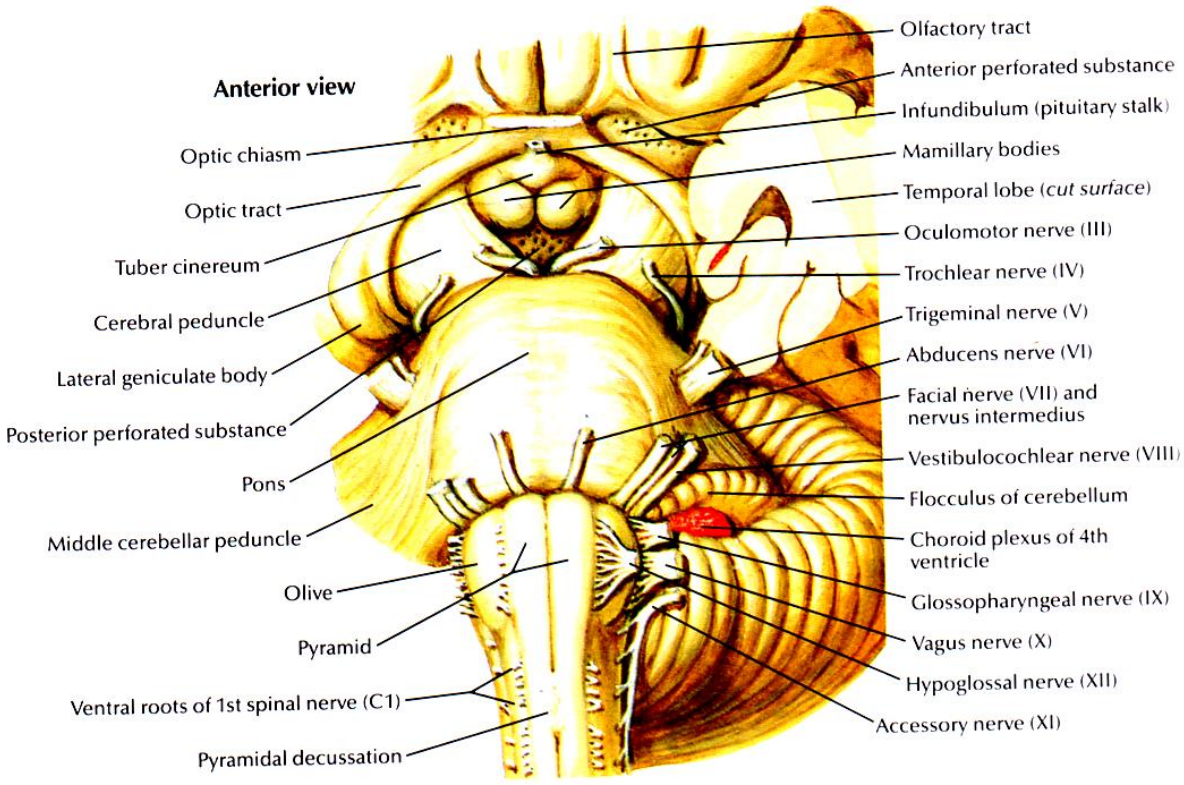
The brain can be divided into two cerebral hemispheres, brainstem and cerebellum. A hemisphere has a base, dorsolateral and medial surfaces. 12 pairs of the cranial nerves exit from the encephalon base.



MEDULLA OBLONGATA

The medulla oblongata also called as *cerebral bulb,* located bet the *pyramidal decussation* and the lower margin of the *pons,* form transition from the spinal cord to the brain. The **anterior median fissure** separates the **pyramids.** The *anterior* and *posterior lateral sulcus* boundary the **olives.** On the posterior surface funiculus cuneatus and funiculus gracilis (see spinal cord) thicken to form the *tuberculum nuclei cuneati* and the *tuberculum nuclei gracilis,* which are bordered in the midline by the **posterior median sulcus.** Posterior surface of the medulla oblongata form a lower part of the rhomboid fossa.





Gray substance of the medulla oblongata is presented by:
• Olivar nuclei
• gracilis and cuneatus nuclei
• cardiac, vasomotor and respiratory centers
• nuclei of the IX-XII cranial nerves
• nuclei of the reticular formation
White substance of the medulla oblongata consists of ascending tracts that form *medial lemniscus* and descending tracts .
Nuclei of the V-XII Cranial Nerves

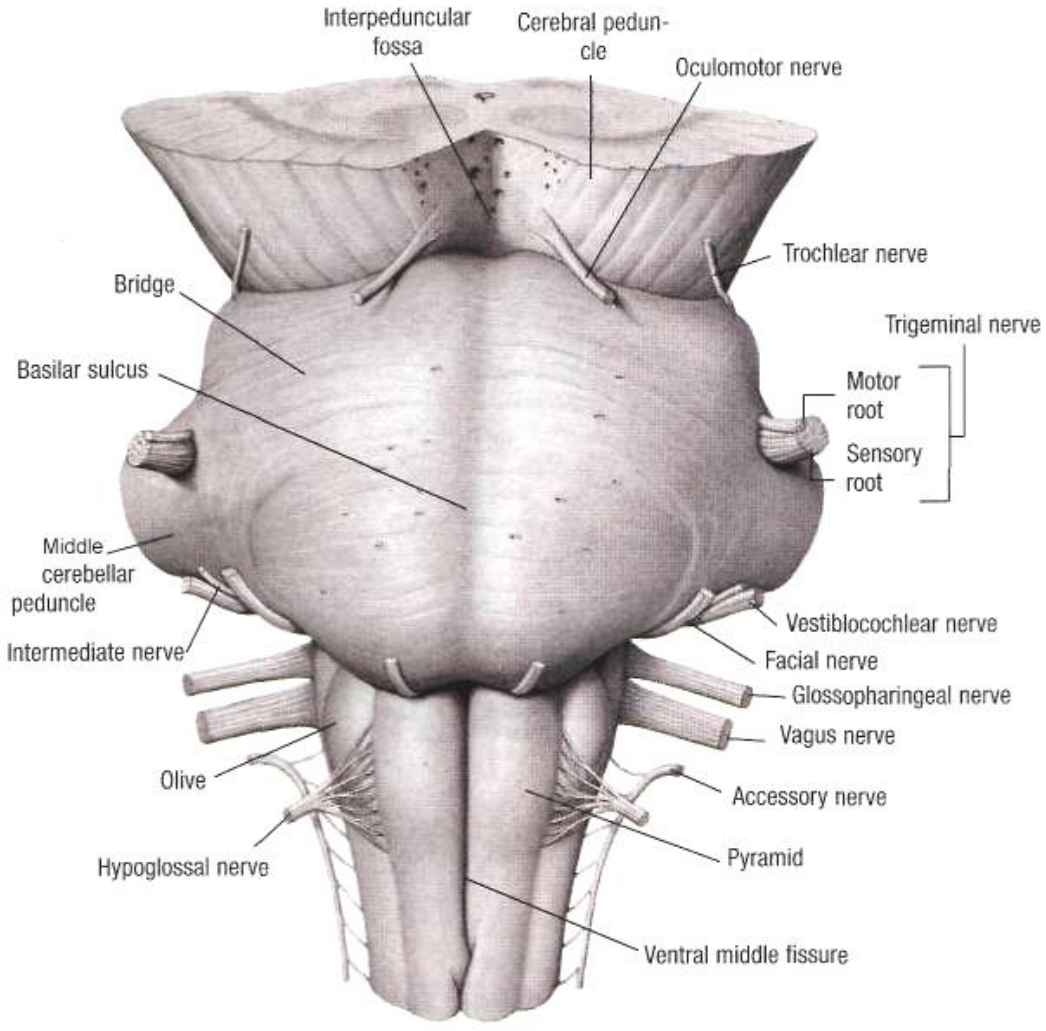
№	Name	Nucleus	Function	Location
V	**Trigeminal**	Motor nucleus mesencephalic, pontine, spinal nuclei	Motor sensory	Pons, mesencephalon, pons, spinal cord
VI	**Abducent**	Abducent	Motor	Colliculus facialis (superficially)
VII	**Facial**	Facial (forms genu) nucleus of the tractus solitarius superior salivatory	Motor Sensory parasympathetic	Colliculus facialis (deep), Pons
VIII	**Vestibulocochlear**	Superior, inferior, medial and lateral vestibular (4), Ventral and dorsal cochlear (2)	All sensory	Vestibular area lateral recess
IX	**Glossopharyngeal**	Ambiguus nucleus of the tractus solitarius Inferior salivatory	Motor Sensory parasympathetic	Medial eminence Medulla oblongata
X	**Vagus**	Ambiguus nucleus of the tractus solitarius dorsal nucleus	Motor Sensory parasympathetic	Medial eminence Medulla oblongata Trigone of the vagus nerve
XI	**Accessory**	Cranial nucleus, spinal nucleus	Motor Motor	Medial eminence spinal cord
XII	**Hypoglossal**	hypoglossal	Motor	Trigone of the hypoglossal nerve

Reticular Formation

The neurons of the brainstem and their **network** of communicating processes are known as the **reticular formation.** It lies in the midpart of the tegmentum and extends from the spinal cord to the midbrain. In the medial region there are large-celled nuclei from which arise long ascending and descending tracts. Groups of nerve cells regulate respiration, heartbeat and blood pressure (changes due to physical work or emotion). The reticular formation influences on the motor system. Through its connections with the nonspecific nuclei of the thalamus, the reticular formation influences the state of consciousness (ascending activation system).

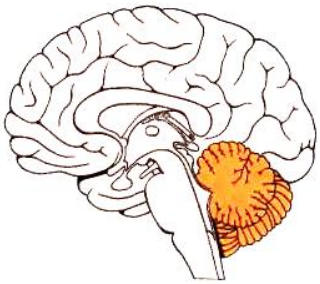
PONS

Pons is positioned front from the medulla oblongata and communicates with cerebellum by *median cerebellar peduncle*. Pons has an anterior and posterior surfaces. *Basilar* sulcus located on the anterior surface. Dorsal surface of the pons form the upper part of the rhomboid fossa. *Striae medullares* separate the pons from the medulla oblongata jn the ventral surface. **Gray substance** of the pons is presented by the proper pontine nuclei and nuclei of the V-VIII cranial nerves (posterior part) On the border between anterior and posterior parts of the pons (tegmentum and base of the pons) the **trapezoid body** lies with the dorsal and ventral nuclei of the trapezoid body in the base. **White substance** of the pons consists *of medial lemniscus (*ascending tracts*),* descending pyramidal tracts and corticopontocerebellar tracts.

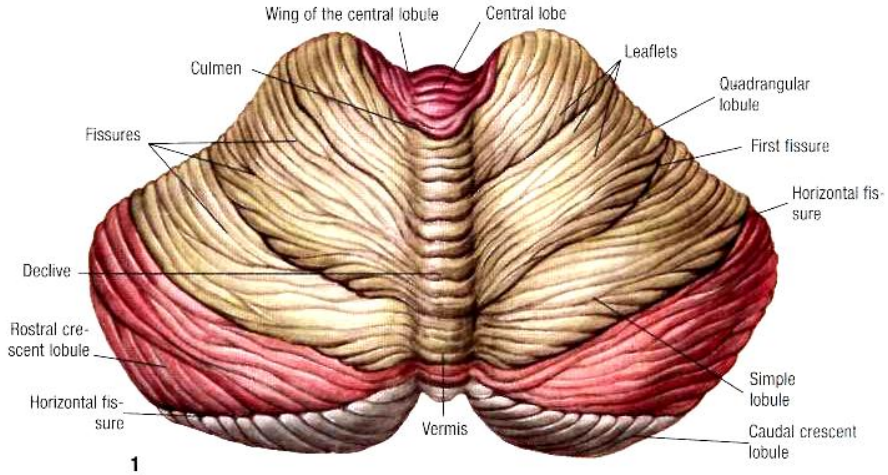


CEREBELLUM

The cerebellum is the integrative organ for coordination and fine synchronization of body movements and for regulation of muscle tone. It forms the roof of the IVth ventricle. Its superior surface is covered by the cerebrum. The medulla oblongata is imbedded in its inferior surface. There is an unpaired central part, the **vermis** of the cerebellum, and two *cerebellar hemispheres. T*he outer surface of the cerebellum exhibits a number of small, almost parallel convolutions, the **cerebellar folia,** separated by **sulci.** Flocculus located laterally from the brainstem.

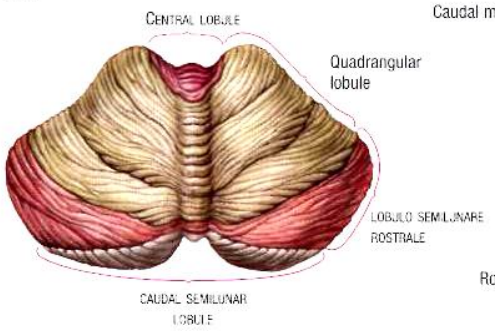


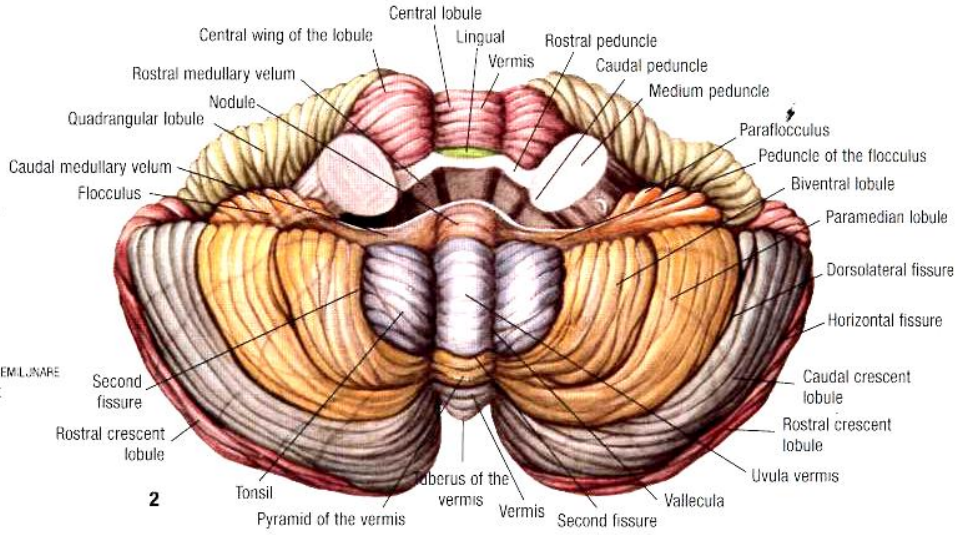
▲ Inside the encephalon
Inside the encephalon, the cerebellum is colored in orange.



► Cerebellum
1. Dorsal view
2. Ventral view

▼ Cervelletto
Vista dorsale: compartimentazione.





On both sides the cerebellum is connected with the brainstem by the cerebellar peduncles, through which pass all the afferent and efferent pathways. Between the two cerebellar peduncles lies the roof of the IVth ventricle with the *superior medullary velum* and the *inferior medullary velum.*

A transverse section reveals the cortex and nuclei of the cerebellum. In a sagittal section the configuration of a tree appears, the so-called ***arbor** vitae.* The *cerebellar nuclei* lie deep in the white matter:The **fastigial nucleus** (roof nucleus) near the midline in the white matter of the vermis.

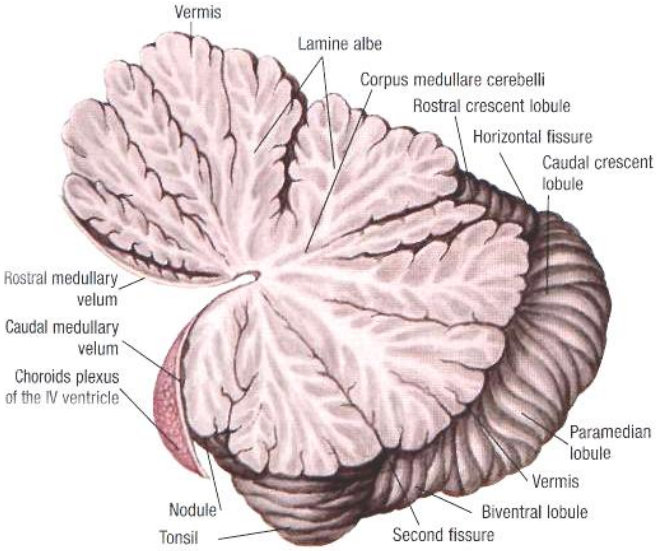
Cerebellar nuclei:

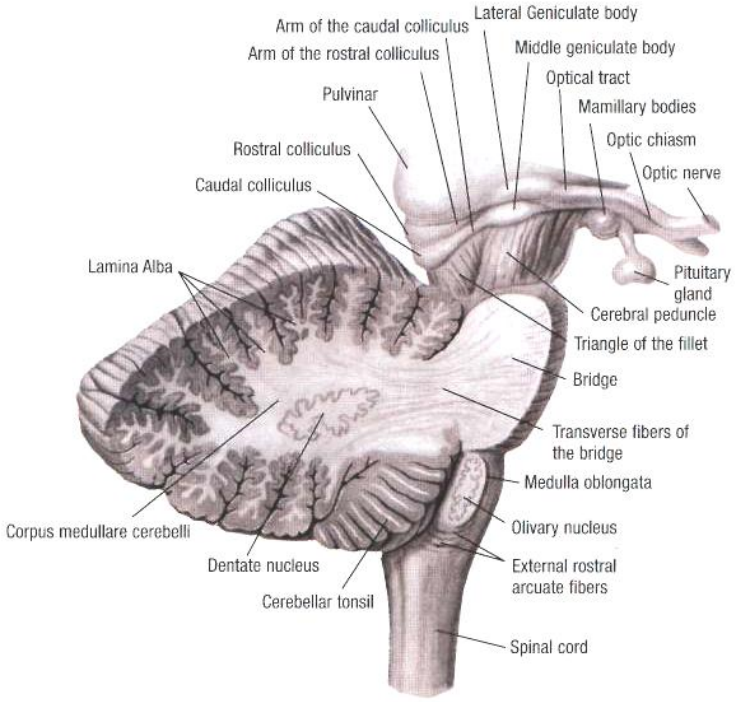
1. The fastigial nucleus

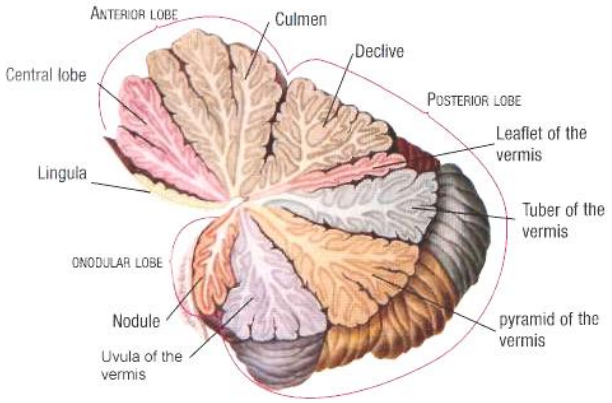
2.The nucleus globosus.

3.Nucleus emboliformis

4.Dentate nucleus

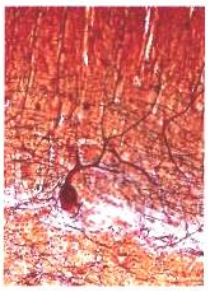






▲ Longitudinal section of the cerebellum
Right side.

◀ Cerebellum
Sectional view from the top.



◀ Purkinje cell
This makes up the intermediate layer of the cerebellum. It branches into the molecular layer in a "headboard" like ramification. A large neurite exits from the opposite cellular pole, crosses the granules and moves through the deep white substance.

The efferent and afferent tracts of the cerebellum run through the three cerebellar peduncles:

1) through the **inferior cerebellar peduncle,** which contains the spinocerebellar tracts and the connections with the vestibular nuclei.

2) through the **middle cerebellar peduncle** with fibers from the pons. These arise from the pontine nuclei and form the continuation of the corticopontine tracts.

3) through the **superior (cranial) cerebellar peduncle,** which constitutes the afferent fiber system to the red nucleus and the thalamus.

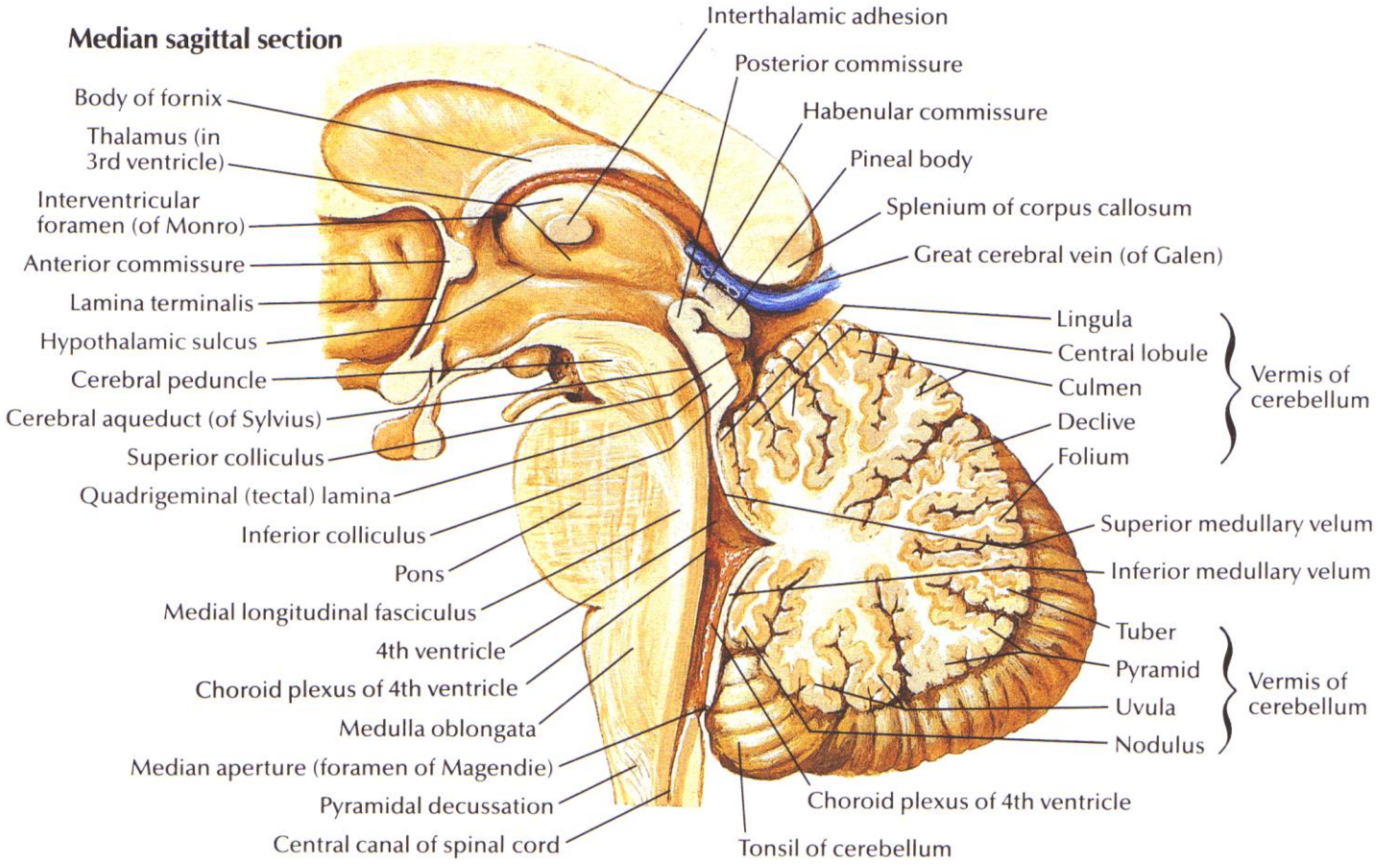
ISTHMUS RHOMBOENCEPHALI

Isthmus rhomboencephali develops between the rhomboencephalon and mesencephalon and comprises three main parts:

1. the **superior cerebellar peduncle**
2. the **superior medullary velum**
3. **the trigonum of the lemniscus**, wich is bordered by cerebral peduncle, superior cerebellar peduncle and inferior brachii of the quadrigeminal plate.

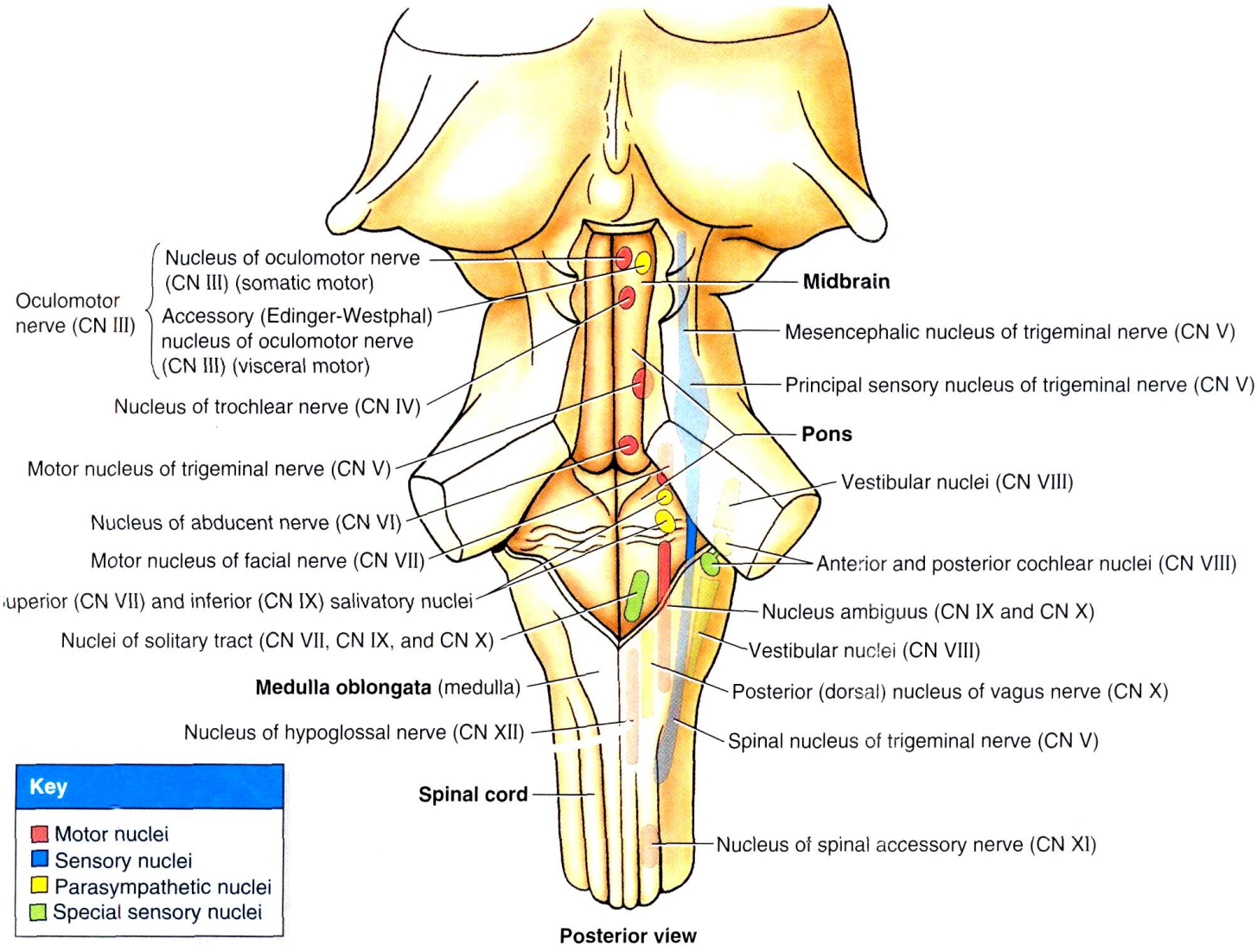
FOURTH VENTRICLE

Fourth ventricle is a cavity of the rhomboencephalon. Its *roof* is formed by the superior medullary velum with the *tela choroidea* and the inferior medullary velum. The *tela choroidea* contains the choroid plexus, its vessels secrets the cerebrospinal fluid. The floor of the fourth ventricle is formed by rhomboid fossa (dorsal surface of the pons and medulla oblongata). Fourth ventricle communicates with the third ventricle by cerebral aqueduct (Sylvius), also with the subarachnoid space by *median aperture (foramen of Magendie)* and 2 *lateral aperture (Luschka's foramen)*



RHOMBOID FOSSA

Rhomboid fossa positioned on the dorsal surface of the pons and medulla oblongata and forms the floor of the IVth ventricle. The inferior cerebellar peduncle, medial cerebellar peduncle and the superior cerebellar peduncle border rhomboid fossa. The floor of the rhomboid fossa shows bulges near the *median sulcus* over the nuclei of the cranial nerves: *medial eminence, facial colliculus, trigonum of the hypoglossal nerve, trigonum of the vagus nerve* and the *vestibular area.*



The rhomboid fossa is crossed by myelinated nerve fibers, the *striae medullares,* which appear at the *lateral recess.* There are processes of the dorsal acoustic nucleus. Rhomboid fossa contains nuclei of the V-XII cranial nerves.

MESENCEPHALON

Mesencephalon ventrally is formed by the *cerebral peduncles* and dorsally by *lamina tecti.* The *cerebral aqueduct* (Sylvius) is a cavity of the mesencephalon. On the dorsal surface of the mesencephalon lies the *quadrigeminal plate,* with two upper and two lower hillocks, the ***superior*** (subcortical visual centre) and ***inferior colliculi*** (subcortical hearing centre). *Brachii from* the superior colliculi extend to the *lateral geniculate body, brachii* from the inferior colliculi extend to the *medial geniculate body.*

Cerebral peduncles are the thick cords that extend from pons to the cerebral hemispheres. The *interpeduncular fossa* lies between the two peduncles (cruses). Its floor is perforated by large numbers of blood vessels, the *posterior perforated substance.* In sulcus on the medial surface of the peduncles there is the exit of the **oculomotor nerve**. In section of the peduncles *substantia nigra* separates the **tegmentum** and the **base.** The base is formed by conducting tracts that pass from cortex cerebri to the spinal cord, medulla oblongata and pons. There are **nucleus ruber** (red) in the tegmentum, on the level of superior colliculi **oculomotor** (motor) and **accessory** (Yakubovycha, Edinger-Westphal /parasympathetic/) nuclei are located. On the level of inferior colliculi motor **nucleus of trochlear nerve**[IV] is located.

Cerebral aqueduct (Sylvius) is a narrow canal that connects III and IV ventricles and surrounded by gray substance.

DIENCEPHALON

Diencephalon comprises the thalamencephalon and hypothalamus. Thalamencephalon consists of **thalamus opticus, epithalamus** and **metathalamus. Hypothalamus** formed by front optic part and back (olfactory) part.

Thalamus opticus is a paired body, which consists of gray substance. In the front it carries the *anterior tubercle.* The posterior extremity *pulvinar* is expanded, directed backward and lateralward, and overlaps the superior colliculus. Each thalamus about 4 cm. in length, and presents two extremities, an anterior and a posterior, and four surfaces, superior, inferior, medial, and lateral. Medial surfaces of the right and left thalamus communicated by *interthalamic adhesion.* Upper surfaces of the thalamus are bordered by *stria medullaris* (medial) and *stria terminalis* (lateral). Gray substance forms *the anterior, medial, dorsal and ventrolateral groups* of nuclei, which are separated each from other by white substance.

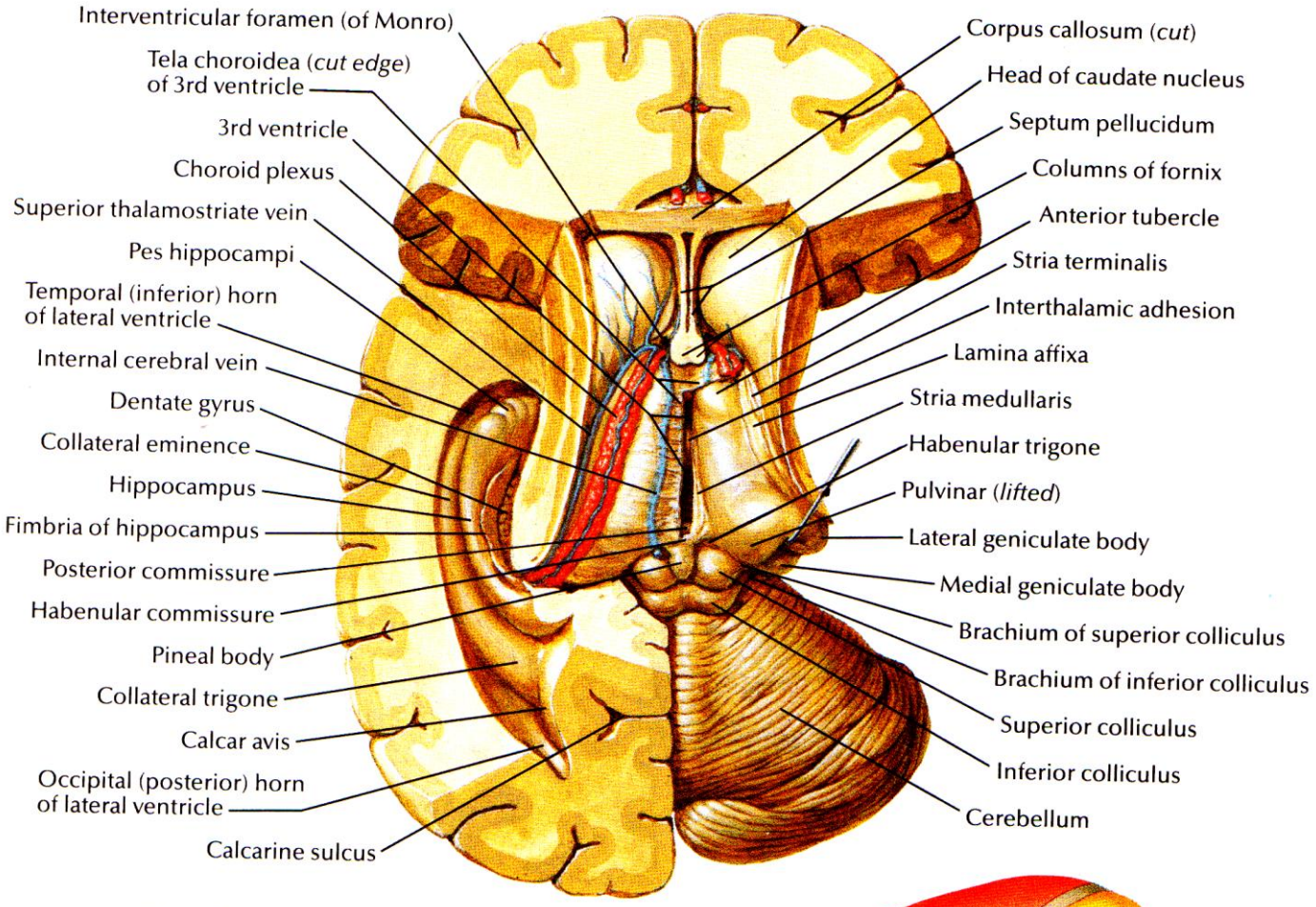
Epithalamus consists of the **pineal body (Epiphysis),** and *the habenulae* with *trigonum habenulae,* the *posterior commissure.* Pineal body is connected with thalamus by the habenulae.

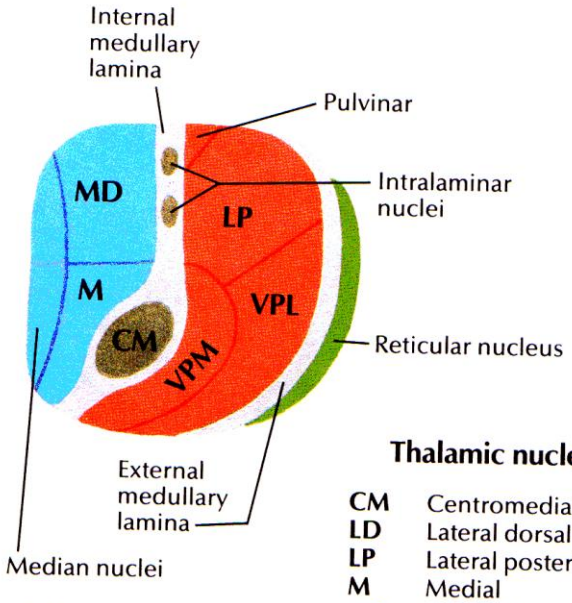
Metathalamus comprises the geniculate bodies, a medial and a lateral. The **medial geniculate body** *(corpus geniculatum mediate)* lies under cover of the pulvinar of the thalamus. The **inferior brachium** from the *inferior colliculus* attaches to the medial geniculate bodies. The **lateral geniculate body** *(corpus geniculatum laterale)* is an oval elevation on the lateral part of the pulvinar. The **superior brachium** from the *superior colliculus* attaches to the lateral geniculate bodies.

Anterior part of the **Hypothalamus** consists of the optic chiasm and *tuber cinereum* with *infundibulum* that carries the *hypophysis.* Posterior part consists of the *mammillary bodies* and *subthalamic region* that carries the *corpus subthalamicum* (nucleus of Luis). The **third ventricle,** the cavity of the diencephalon has 6 walls:

- the lateral walls formed by medial surface of the thalamus;
- the lower wall (floor) formed by hypothalamic region;
- the anterior wall formed by terminal lamina, columna fornicis and anterior cerebral commissural;
- the anterior wall is formed by the habenular commissure and posterior commissure;
- the upper wall (roof) formed by tela choroidea of the III ventricle with plexus choroideus.

There is *interventricular foramen* (of Monro) between anterior thalamic tubercle and columna fornicis. Foramen communicates the III ventricle with the lateral ventricles of cerebrum.

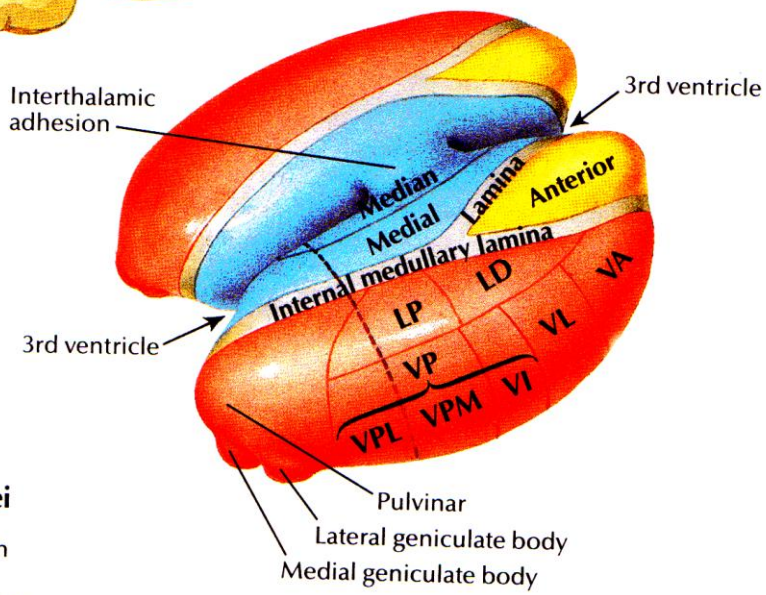




Schematic section through thalamus
(at level of broken line shown in figure at right)

Thalamic nuclei

CM	Centromedian
LD	Lateral dorsal
LP	Lateral posterior
M	Medial
MD	Medial dorsal
VA	Ventral anterior
VI	Ventral intermedial
VL	Ventral lateral
VP	Ventral posterior
VPL	Ventral posterolateral
VPM	Ventral posteromedial



Schematic representation of thalamus
(external medullary lamina and reticular nuclei removed)

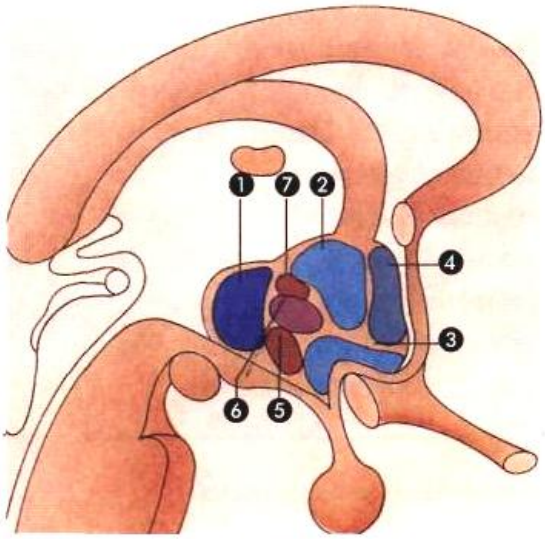
Lateral nuclei
Medial nuclei
Anterior nuclei

PINEAL BODY

The pineal body (corpus pineale; epiphysis) is a small, conical, reddish-gray body lies in the depression between the superior colliculi and has an endocrine role. *Habenulae* extend from the epiphysis to the right and left thalamus. The pineal recess of the third ventricle is located near base of the epiphysis. The epiphysis covered by capsule externally, the septa separate glandular parenchyma into lobuli. Special glandular pinealocytes and gliocytes are the cells of the epiphysis. Often there is "sand" in the gland of adults. The epiphysis produces hormone which inhibits the hypophysis activity until puberty age and takes part in regulation of the metabolism.

HYPOPHYSIS

The hypophysis (pituitary endocrine gland) is a reddish-gray, somewhat oval mass. It is attached to the end of the infundibulum, and is situated in the hypophyseal fossa of the sphenoidal bone, where it is retained by a circular fold of dura mater, the diaphragma sellae. The hypophysis consists of anterior (adenohypophysis) part and posterior (neuorohypophysis) part. **Adenohypophysis** has three portions: anterior (or *pars distalis),* pars *intermedia* and pars *tuberalis.* **Neuorohypophysis** has pars *nervosa* and *infundibulum.* Adenohypophysis *(pars distalis)* secretes somatotropin, adrenocorticotropin. thyrotropin, folliculotropin, prolactin and luteotropin. Pars intermedia produces melanocytestimulating hormone. Neuorohypophysis secretes vasopressin and oxytocyn both of which are produced in the hypothalamus.



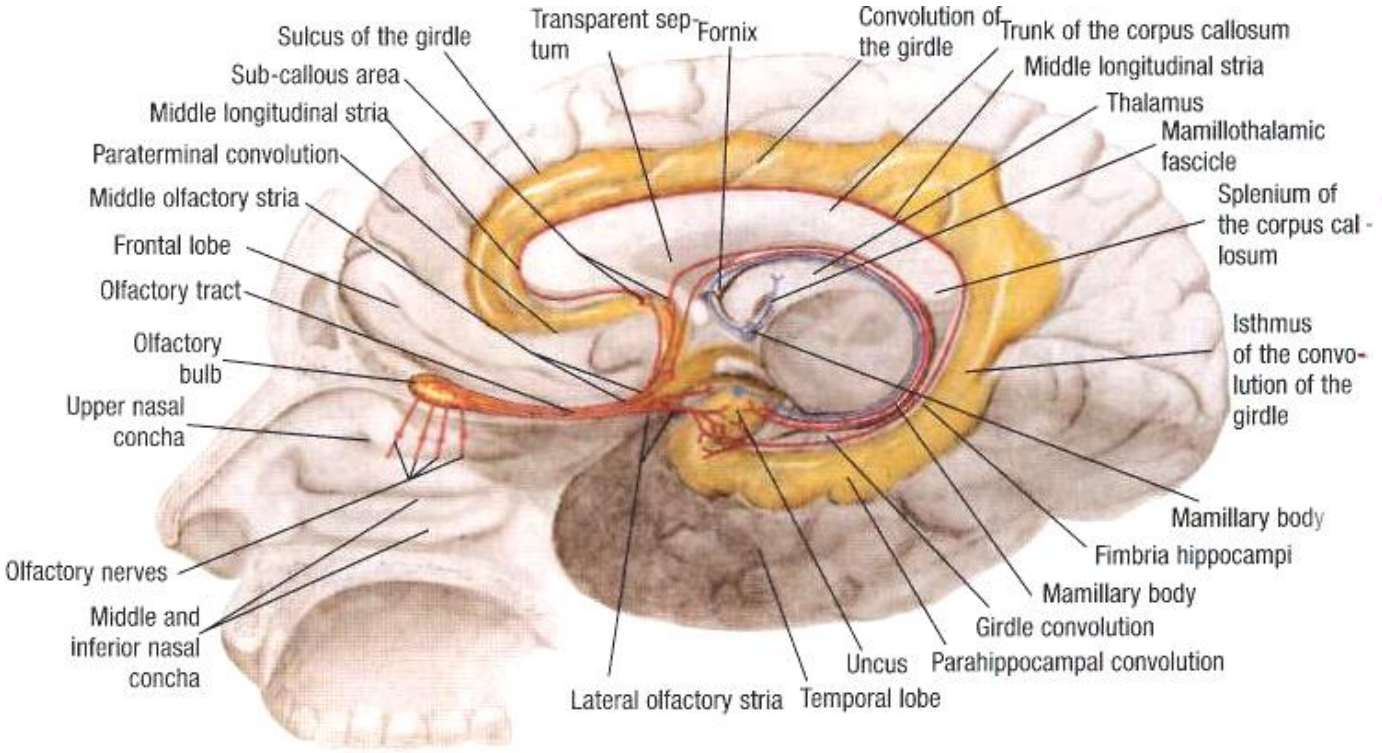
▲ Structure and functions
The hypothalamus is divided into different areas, which regulate the body's different activities; the posterior area ❶ controls the sexual urges; the anterior area ❷ is in charge of thirst sensations, and, along with the supra-optical nuclei ❸, it regulates the use of water; the preoptical nucleus ❹ regulates temperature inside the body. The ventromedial nucleus (also known as "appetistato") ❺ controls the hunger stimulus; the dorsomedial nucleus ❻ controls aggressive behavior, and the dorsal area ❼ is probably the center for "pleasure".

▶ Cerebral centre and endocrine center
The hypothalamus is connected to the brain and the spinal cord. It is the most important meeting point between the central nervous system and the endocrine system, thanks to the direct control it has on the hormonal production of the anterior pituitary. It functions automatically, and it presides over the autonomic nervous system, the metabolism of the organism, the defensive reactions in case of an emergency, and the menstrual cycle.

TELENCEPHALON

The telencephalon includes the cerebral hemispheres with their cavities, the lateral ventricles. Each cerebral hemisphere may be divided into three fundamental parts: the pallium, the rhinencephalon, and basal nuclei, also fornix and corpus callosum.

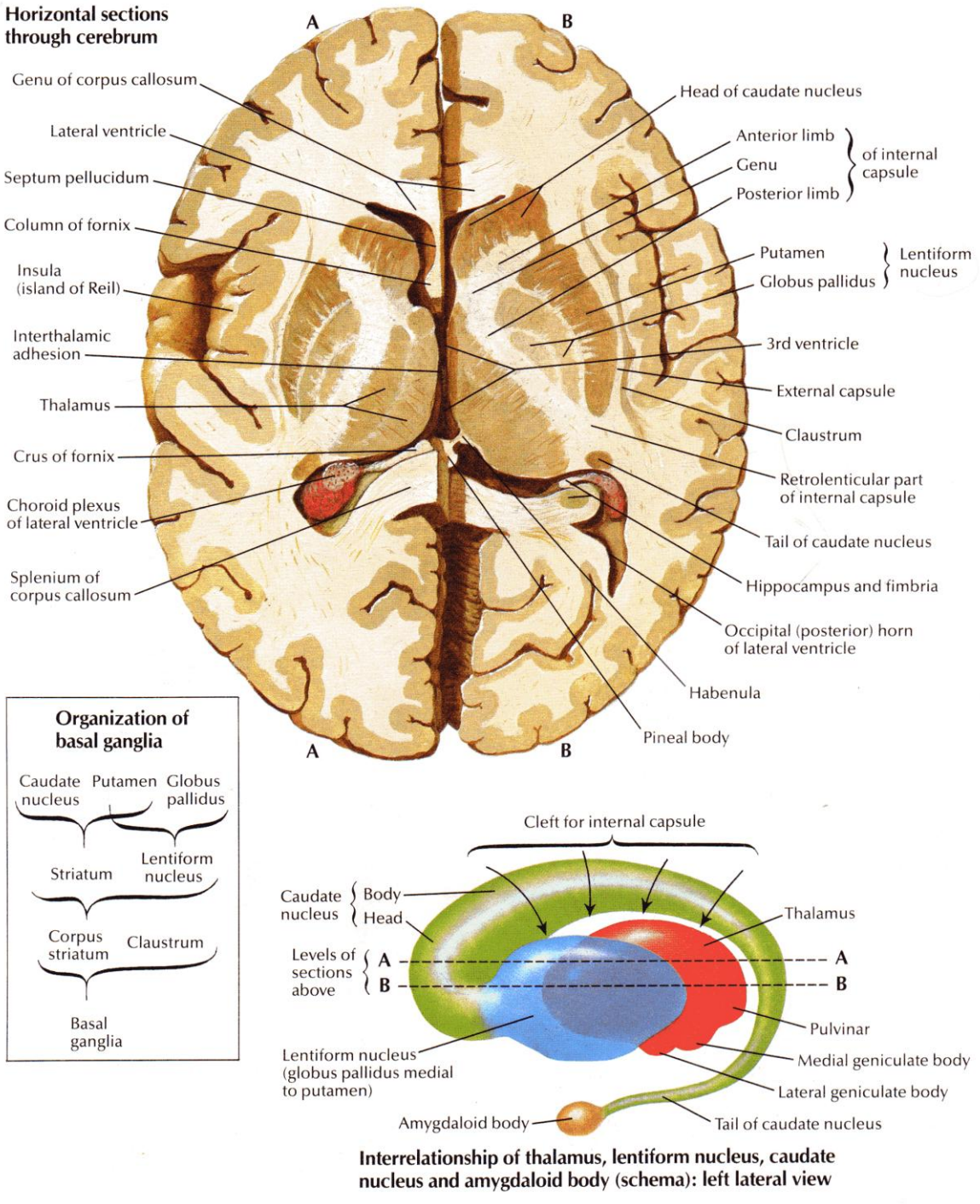
The **Rhinencephalon** associated with the sense of smell, is the oldest part of the telencephalon, and forms almost the whole of the hemisphere in some of the lower animals, e. g., fishes, amphibians, and reptiles. In man it is rudimentary. It divides into *central* and *peripheral* parts. The central part includes the hippocampus, gyrus fornicatus (gyrus cinguli + gyrus hyppocampi), gyrus dentatus, septum pellucidum and uncus. The peripheral part includes the olfactory bulb, olfactory tract, olfactory trigone and anterior perforated substance. Cortical smell analyzer located in the *uncus.* Rhinencephalon is a center of emotional colouring of sensible perception of external environment **(Limbic system).** Together from all subcortical centers it is by energy source for cortex and answers for vitally important man reactions regulates activity of internal organs: hunger feeling and thirst, sounds perceptions and smells. Here are the memory mechanisms.



Basal nuclei are the paired masses of gray matter located deep within the white matter in base of the forebrain. Basal nuclei include 1) corpus striatum, 2) claustrum and 3) nucleus amygdaloideus.

Corpus striatum is composed of **caudate nucleus** (it has a head, body and tail) and **lentiform nucleus** (it consists of medial and lateral globus pallidus and putamen). There is a thick lamina of white substance, the *internal capsule* between caudate nucleus and globus pallidus. It has the prominence of the curve is called the *genu, the frontal crus* and the *occipital crus.* The occipital crus separates the lentiform nucleus from the thalamus and carries *optic and acoustic radiation.*

The **nucleus amygdaloideus** is an ovoid gray mass situated at the lower end of the inferior cornu of the lateral ventricle (in temporal lobe).



Interrelationship of thalamus, lentiform nucleus, caudate nucleus and amygdaloid body (schema): left lateral view

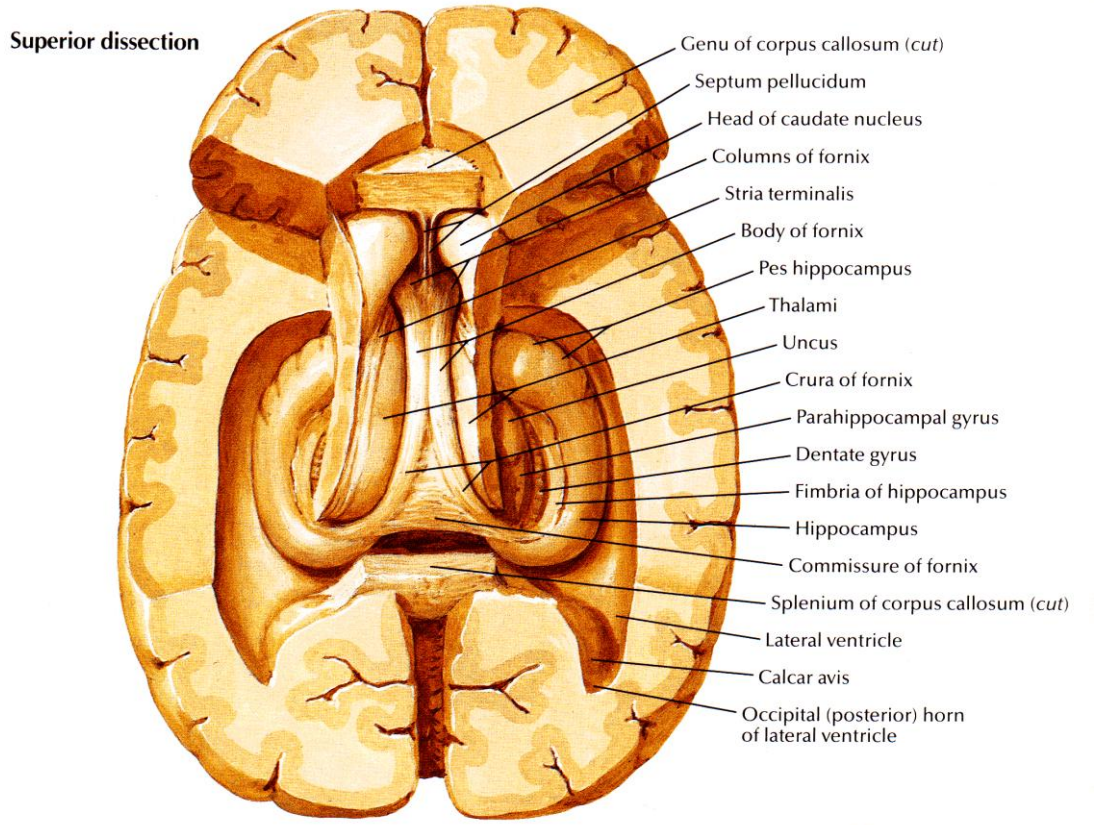
White Matter of the Cerebrum.

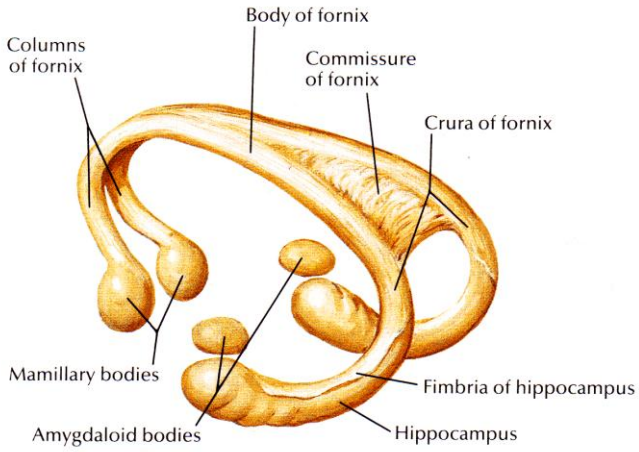
The external capsule located between putamen and claustrum. The extrema capsule separates the claustrum and cortex of the insula.

The **corpus callosum** connects right and left cerebral hemispheres. Corpus callosum anteriorly carries a genu that passes into rostrum. Last continue as a lamina rostralis and lamina terminalis. Back part of the corpus callosum called splenium.

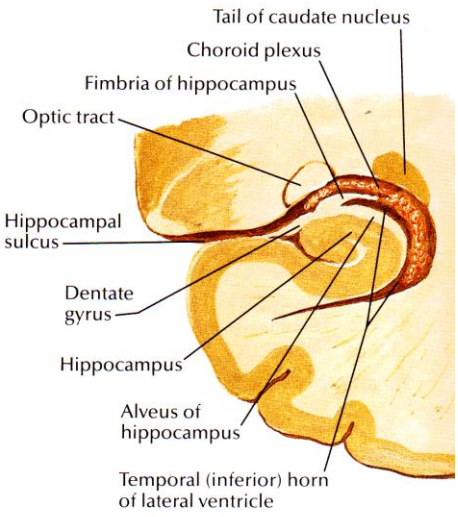
The **fornix cerebri** located under corpus callosum and has a body, columna fornicis (anteriorly) and crura fornicis (posteriorly). Crus fused with the hippocampus and form the fimbria hippocampi. **Anterior commissura** positioned closely to the columna fornicis.

The **septum pellucidum** is tightened between corpus callosum and fornix. It consists of the *2* laminae and cavity between them.





Fornix: schema



Coronal section: posterior view

Cortex of the Cerebrum

A hemisphere is covered by **cortex** and has inferior, dorsolateral and medial surfaces. The anterior end of the hemisphere is named the frontal pole; the posterior, the occipital pole; and the anterior end of the temporal lobe, the temporal pole. The right and left hemispheres are separated medially by a deep cleft, named the **longitudinal cerebral fissure.** The surfaces of the hemispheres are molded into a number of irregular eminencies, named **gyri** or convolutions, and separated by furrows termed **fissures** and **sulci.** The hemispheres consist of 5 lobes: frontal, parietal, occipital, temporal and insula (located in depth of lateral sulcus).
On the dorsolateral surface of the hemisphere can be finding the **Central sulcus** [Rolandi] that separates frontal and parietal lobes. The **Lateral sulcus** [Sylvii] that separates temporal lobe from the frontal and parietal lobes. **Parietooccipital** sulcus passes between parietal and occipital lobes on the medial surface.

There are some sulci on the ***dorsolateral*** surface of the **frontal** lobe: precentral sulcus, superior frontal sulcus, and inferior frontal sulcus. They separate: precentral gyrus, superior frontal gyrus, middle frontal gyrus, and inferior frontal gyrus. The inferior frontal gyrus is divided into opercular, triangular and orbital parts by anterior and ascending rami.

The lateral surface of the **parietal lobe** is cleft by a well-marked furrow, the intraparietal sulcus and the postcentral sulcus. There are postcentral gyrus, superior parietal lobule and inferior parietal lobule. The last contains the supramarginal and angular gyri.

The **temporal lobe** is divided into superior, middle, and inferior gyri by the superior and middle temporal sulci. Three or four gyri will be seen springing from the depth of the hinder end of the lateral sulcus, these are named the *transverse temporal gyri* (Heschl).

The **occipital lobe** is small and pyramidal in shape. It is traversed by the transverse occipital sulci that border occipital gyri.

On the **insula** (it is located in depth of lateral sulcus) they distinguish circular and central sulci which border longi and breve gyri.

There are some sulci on the ***medial*** surface of the hemisphere: sulcus corporis callosi, cingulate sulcus, hippocampal sulcus, parietooccipital and calcarine sulcus. They separte corporus callosum from gyrus cinguli, superior frontal gyri, gyrus parahippocampalis, dentate gyrus, paracentral lobule (of Bets), precuneus and cuneus. Gyrus cinguli and gyrus parahippocampalis with isthmus form fornicate gyrus that it is the central part of the rhinencephalon.

On the **inferior** surface of the hemisphere can be finding: collateral sulcus, occipitotemporal sulcus, rhinal sulcus and orbital sulcus. They separate the lateral occipitotemporal gyrus, medial occipitotemporal gyrus, lingual gyrus, gyrus rectus and orbital gyri.

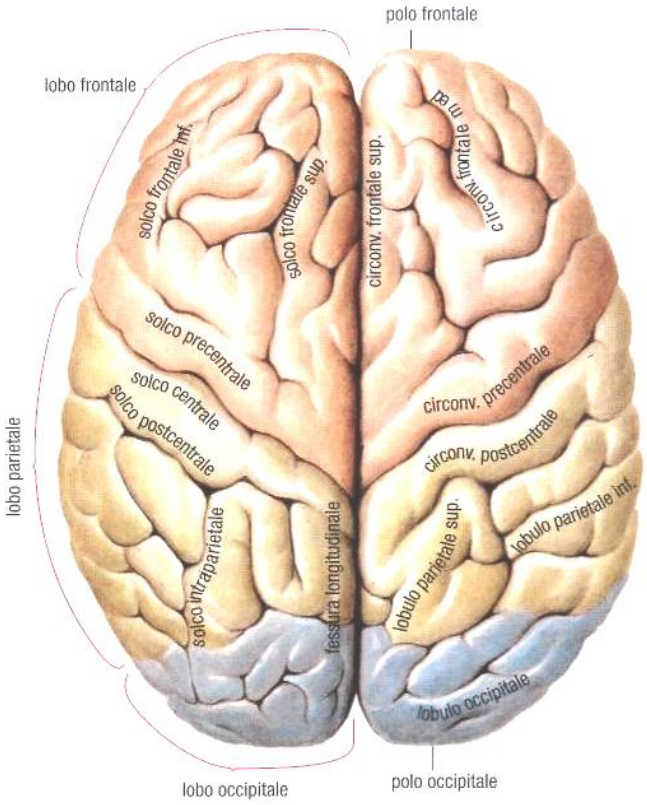
Cortical Fields

We distinguish some specific cortical fields that control motor, sensory, language and others functions. They can be divided into more general motor area, sensory area and also some specific sensory centers.

Motor area involved with the control of voluntary muscles. It is located in precentral gyrus and paracentral lobule (motor homunculus).

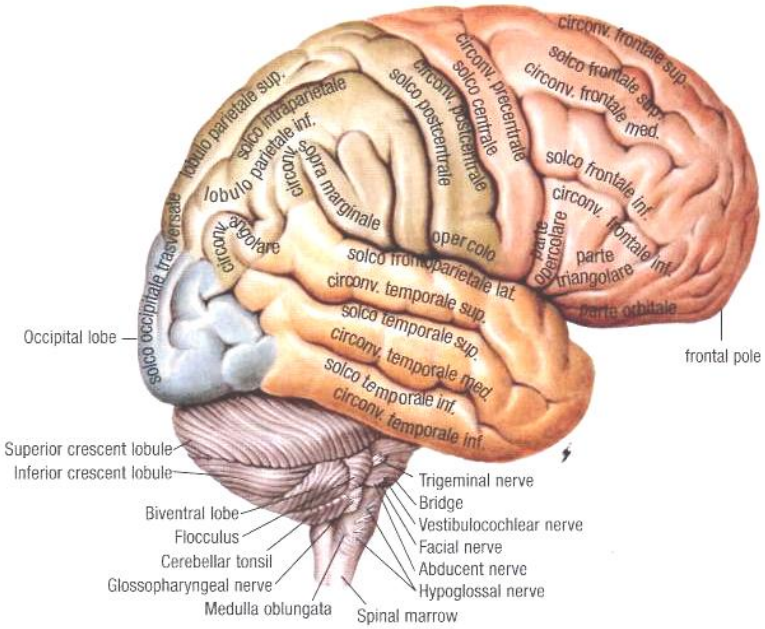
Sensory area responsible for cutaneous and muscular sensations (temperature, pain and touch), located in postcentral gyrus and paracentral lobule (sensory homunculus).

Centre of stereognosia is located in superior parietal lobule closely to intraparietal sulcus.



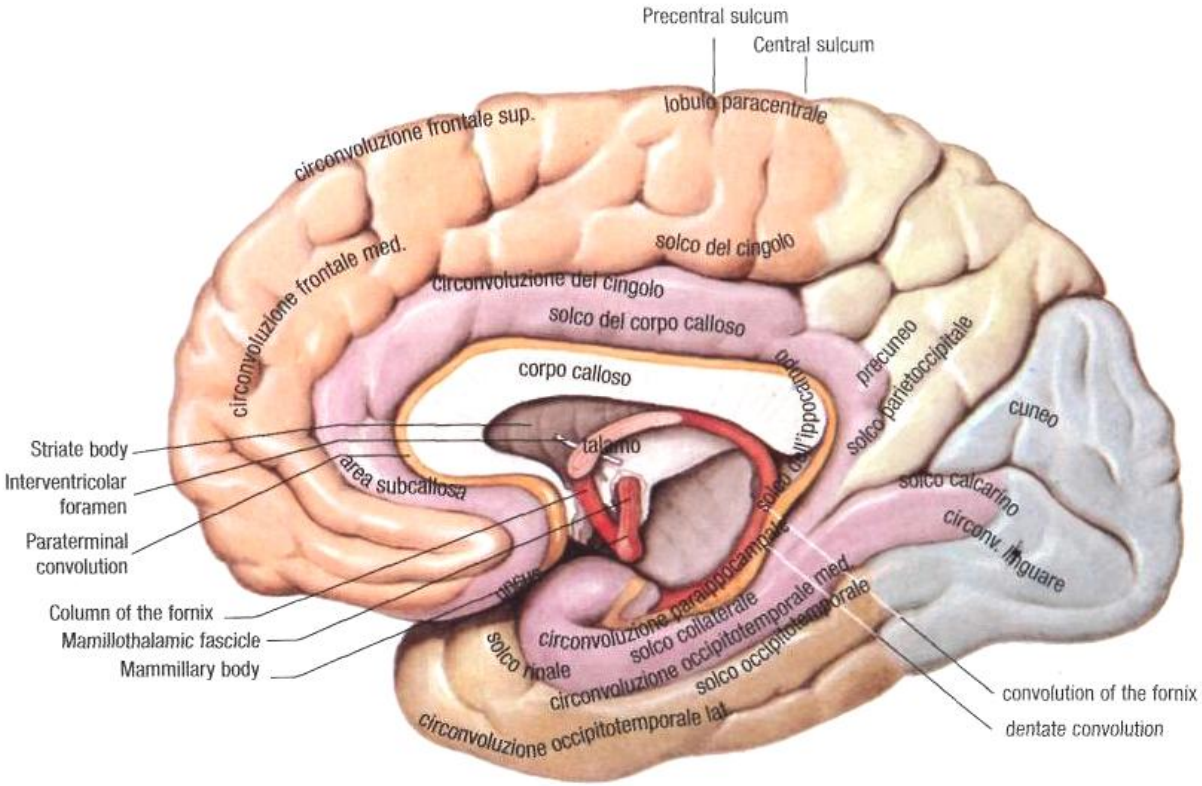
▲ **The cerebral hemispheres**
Top view

- Frontal lobe
- Parietal lobe
- Occipital lobe
- Temporal lobe
- Cerebellum

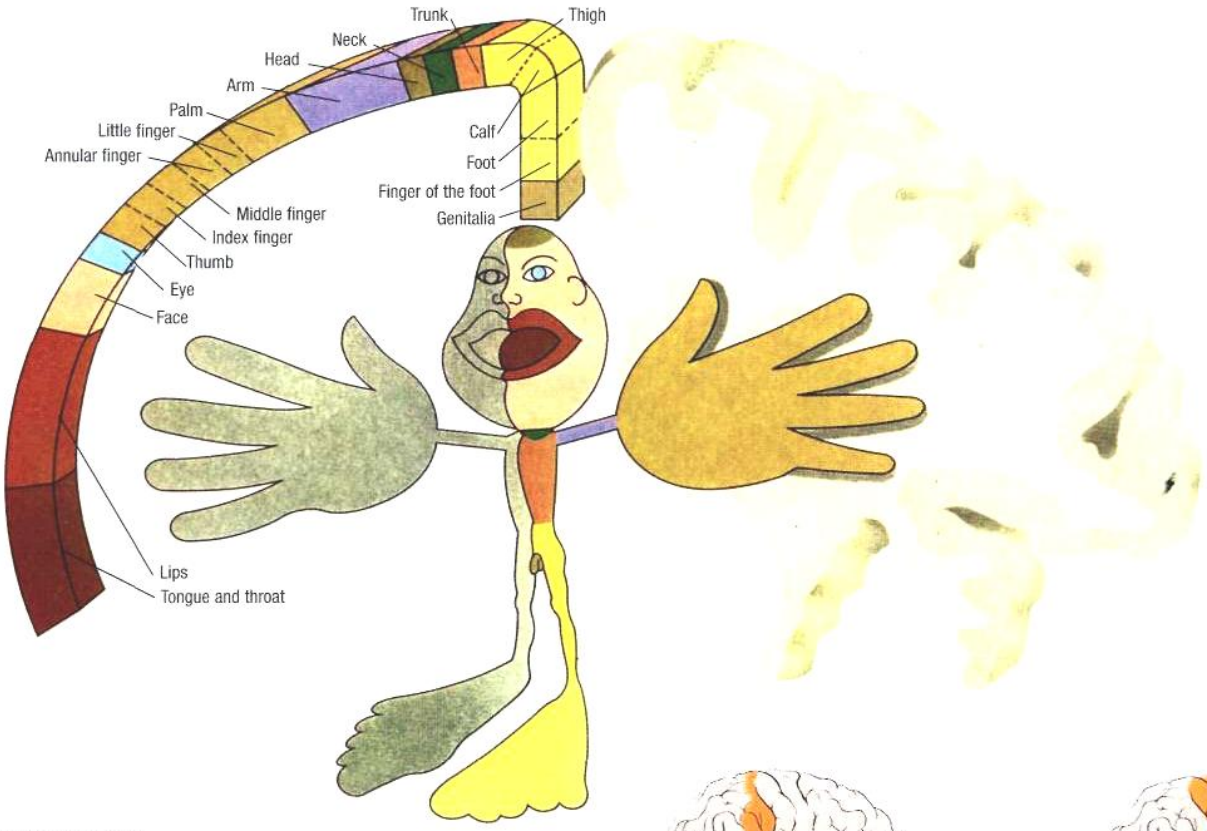


▲ **Brain**
Right side.

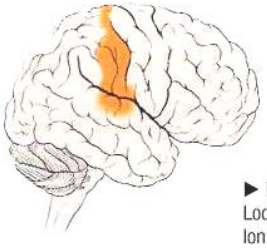
▶ **Inside the encephalon**
In this right section of the encephalon, the brain is orange.



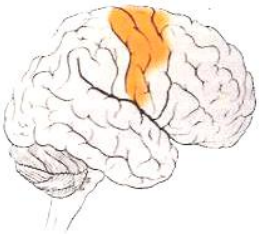
Auditory centre located in the transverse temporal gyri (Heschl). Function is interpretation of auditory sensations.
Visual cortical centre situated in calcarine sulcus. Function of the occipital lobe is' conscious perception of vision.
Smell and tasting centre located in part of limbic system - uncus.
Centre of praxia is located supramarginal gyrus.



▲ **Map of the "tactile" cortex**
The various parts of the body are drawn proportionally to the number of neurons inside the relative projection areas.



► **Sensory cortex**
Location of the encephalon.



► **Motor cortex**
Location of the encephalon.

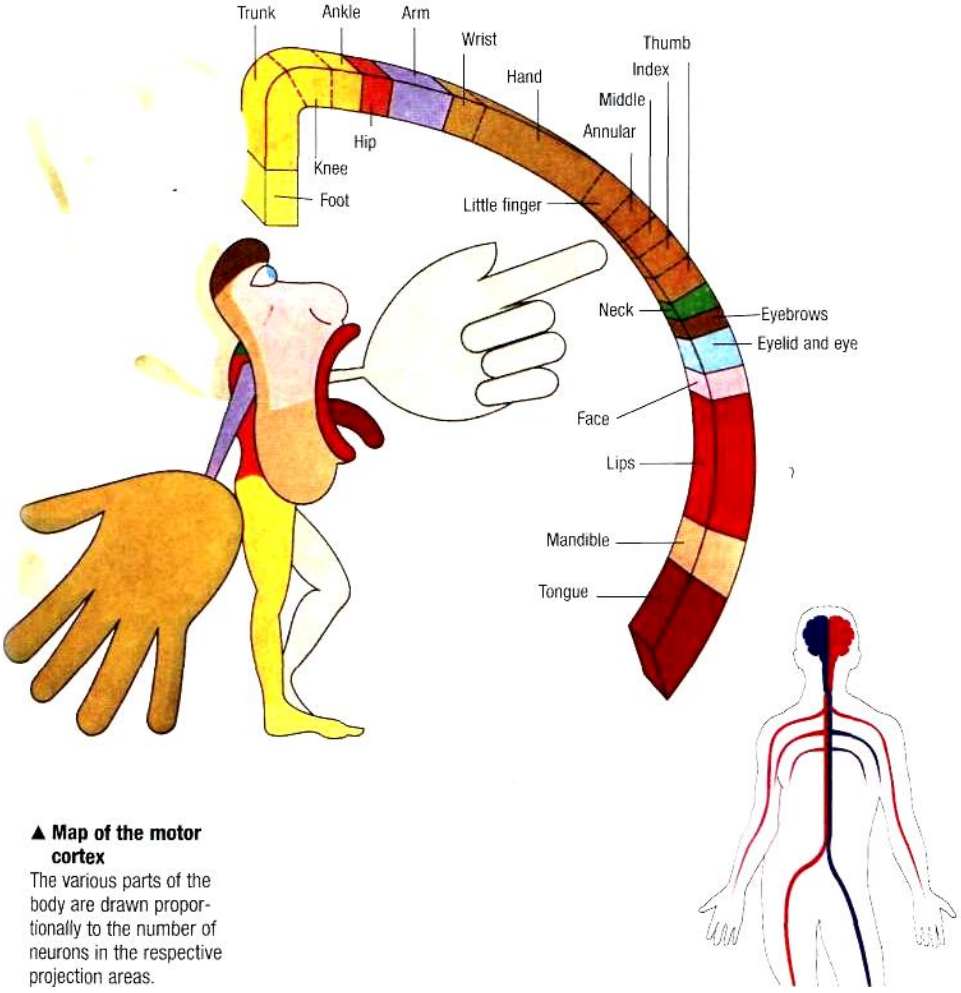
Language areas: motor -

1.Motor speech area (Broca's centre) is located in lower frontal gyrus

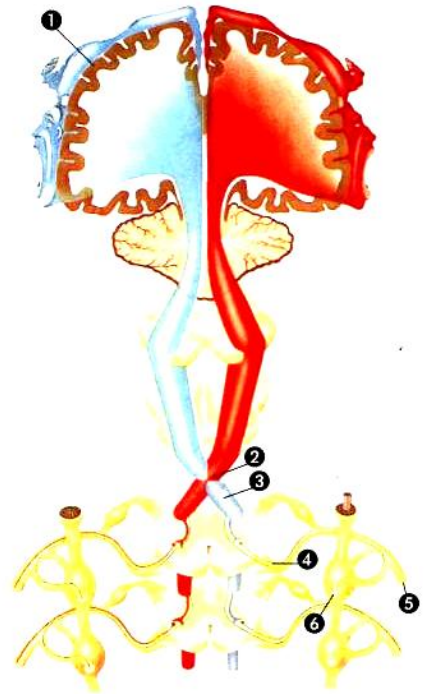
2. Writing (graphic) area is located in middle frontal gyrus-

3.Auditory language centre (Wernicke's area) located in superior temporal gyrus. It responsible for understanding of spoken language.

4.Reading centre situated in angular gyrus (responsible also for reading, writing, counting and calculating).



▲ Map of the motor cortex
The various parts of the body are drawn proportionally to the number of neurons in the respective projection areas.



◄▲ Crossing of fibers
Motor areas: left **in red**, right **in blue**. The nerve impulses produced by the cortex ❶ go through those fibers that criss-cross in the medulla oblongata ❷, reach the fibers of the spinal marrow ❸), and reach the muscle, through the spinal motor roots ❹ and the spinal nerves ❺ The movements of the involuntary muscles are controlled by the fibers of the autonomous nervous system (**in green**). From there, they reach the chain of nervous ganglia ❻ located adjacent to the spinal column.

Lateral ventricles

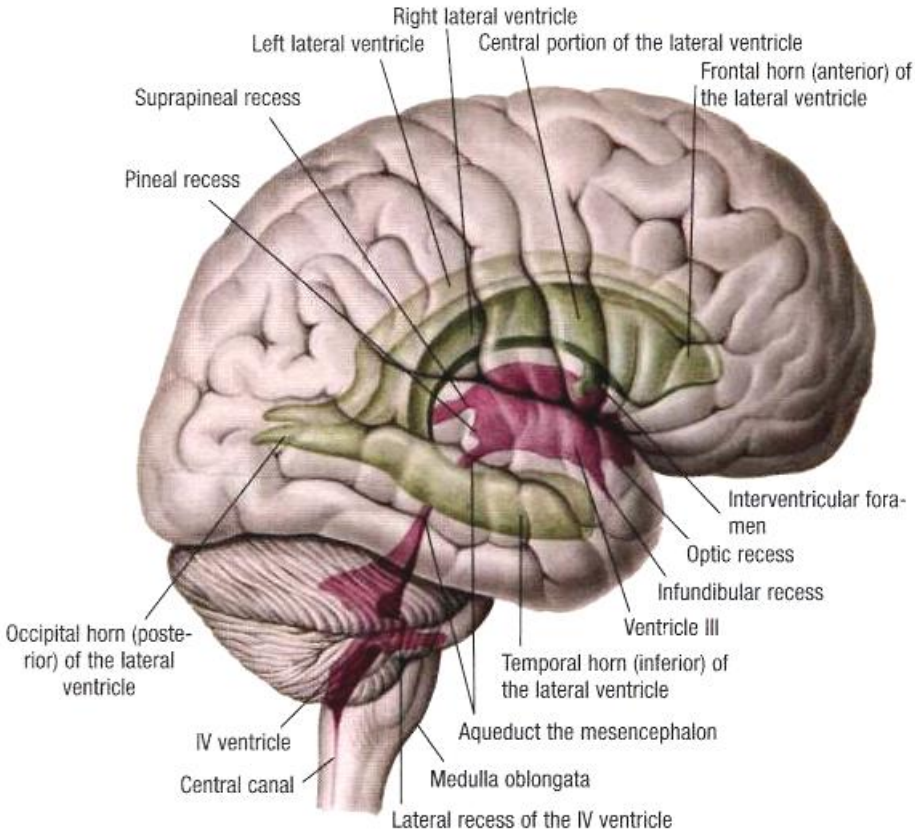
The two lateral ventricles are cavities situated in the lower and medial parts of the cerebral hemispheres. They are separated from each other by a median vertical partition, the **septum pellucidum,** but communicate with the third ventricle and indirectly with each other through the **interventricular foramen.** Each lateral ventricle consists of a central part, and three prolongations from it, termed anterior, posterior and inferior cornua (horn).

The anterior horn passes forward into the frontal lobe. It bordered:
• medially - by lamina of septum pellucidum
• laterally - by head of caudate nucleus
• anteriorly and roof- by corpus callosum.
Central part is found in parietal lobe. It is limited:
• below - by body of caudate nucleus and dorsal surface of the thalamus;
• upwards and laterally - by fibers of corpus callosum, which form a roof.

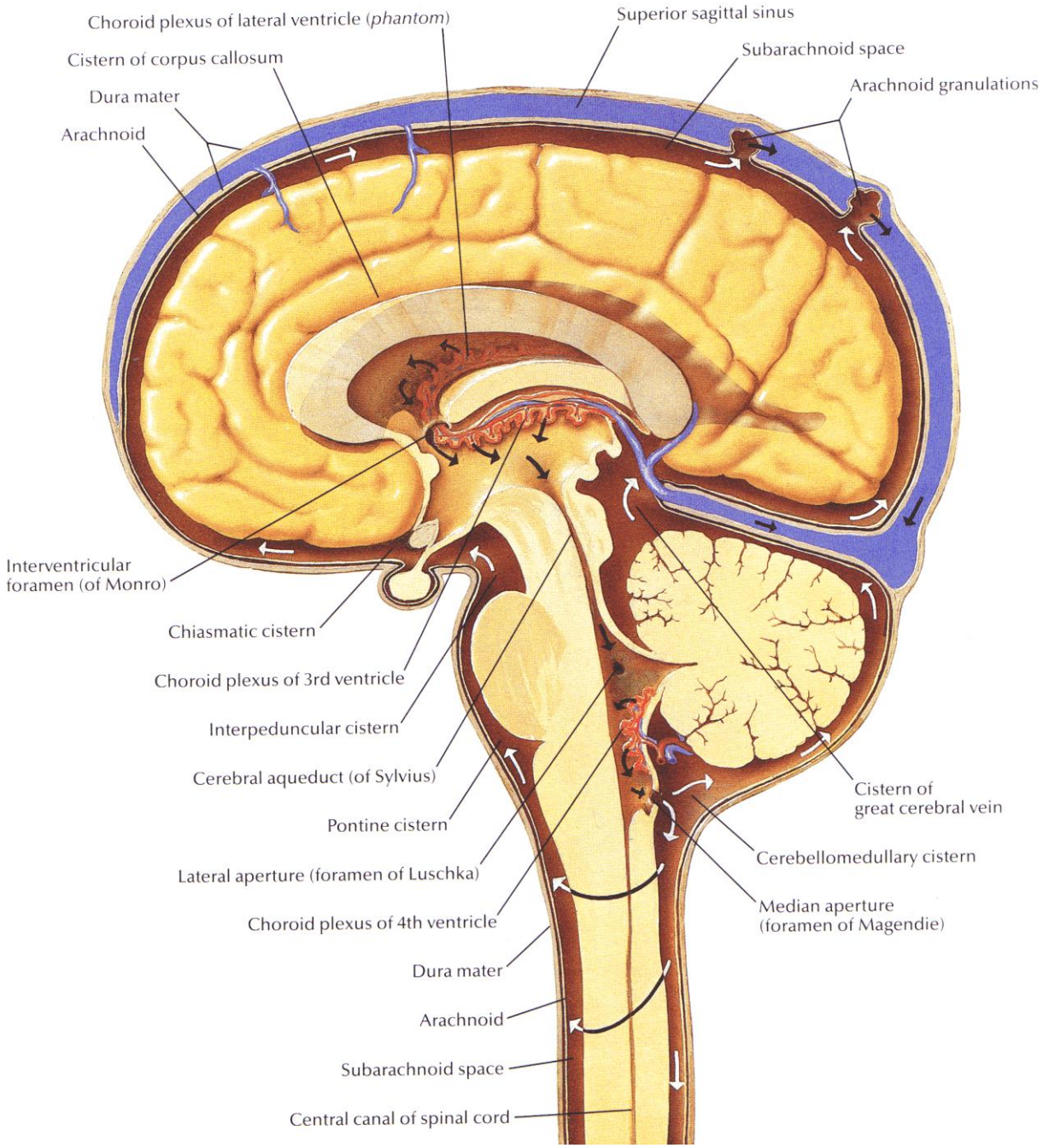
The posterior horns localised in occipital lobes and cover by white matter 'tapetum'. They carry the bulb and the calcar avis on medial wall, and a collateral triangle on the floor.

The inferior horns are found in temporal lobe. They are boundered:
• medially - by hippocampus;
• below - by white matter, which forms collateral eminence;
• superolaterally - by white matter;
• superomedially - by a tail of caudate nucleus.

The central part and inferior horn of lateral ventricle contain choroid plexus of lateral ventricle generated of penetration pie mater by vessels. Choroid plexus passes to the III ventricle through interventricular foramen. Choroid plexus takes part in formation of larger half of cerebrospinal fluid.



A **cerebrospinal fluid** passes from lateral ventricles through the interventricular foramen into third ventricle, where its amount increases. Then it flows from third ventricle through the cerebral aqueduct into fourth ventricle. In the fourth ventricle a cerebrospinal fluid passes the subarachnoid space through the median (of Magendie) and lateral (of Luschka) aperture and also to the central canal of the spinal cord. Cerebrospinal fluid of the subarachnoid space returns to the venous blood in the venous sinuses through the Pachioni's arachnoid granulation.



Meninges of the brain

The brain is enclosed by in 3 meninges: **dura mater, arachnoid** and **pia mater.** Dura mater is the periosteum for internal surface of the skull bones and there is no space between dura mater and bones. There is **subarachnoid space** between choroid and pia mater, which is filled in by cerebrospinal fluid. This space has expansions, which are called 'cisterns':

- cerebellomedullary cistern;
- chiasmatic cistern;
- interpeduncular cistern;
- cistern of the lateral fossa;
- pontocerebellar cistern;
- superior cistern.

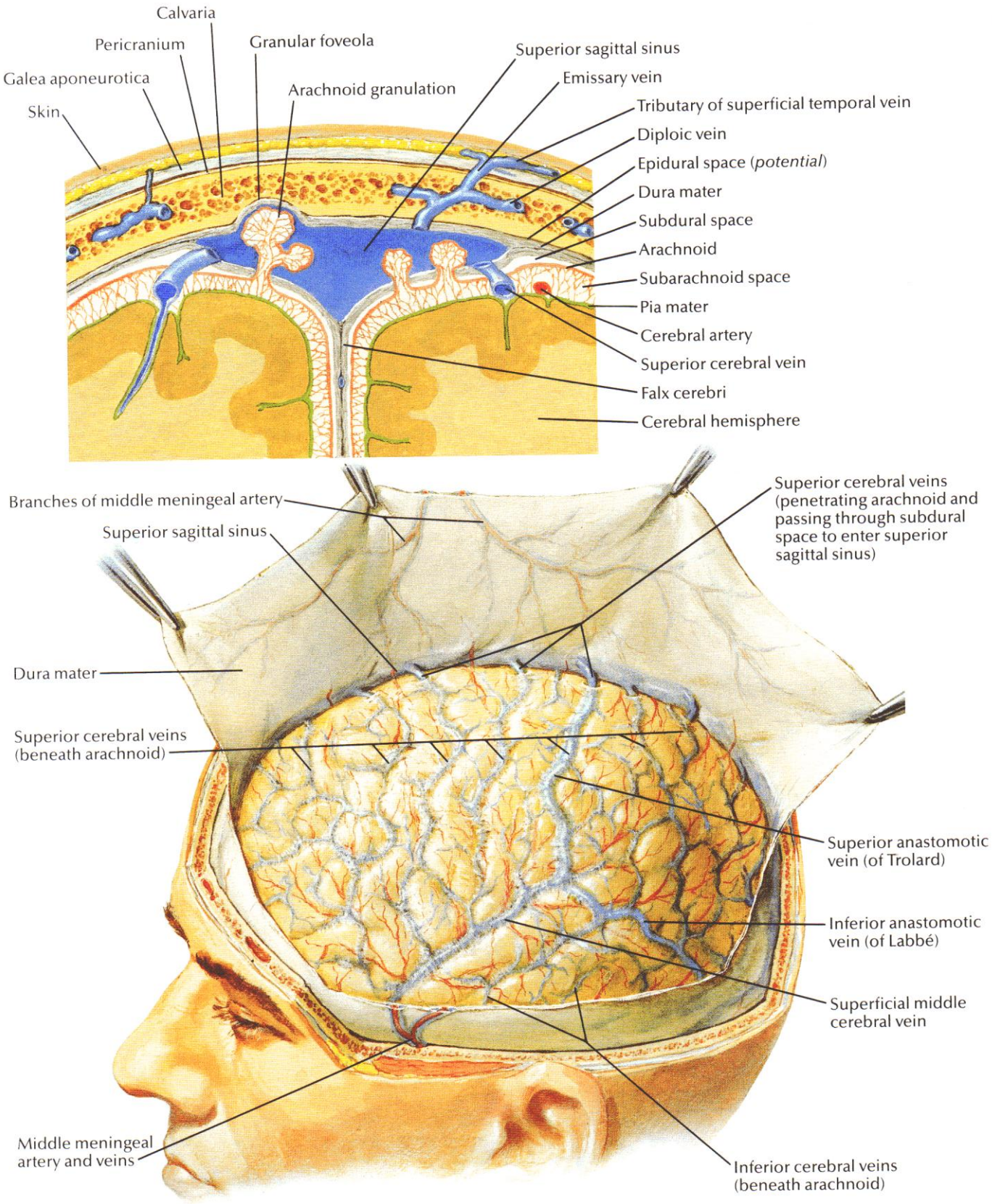
Dura mater has some processes extend into the cavity of the scull and separating the brain parts:

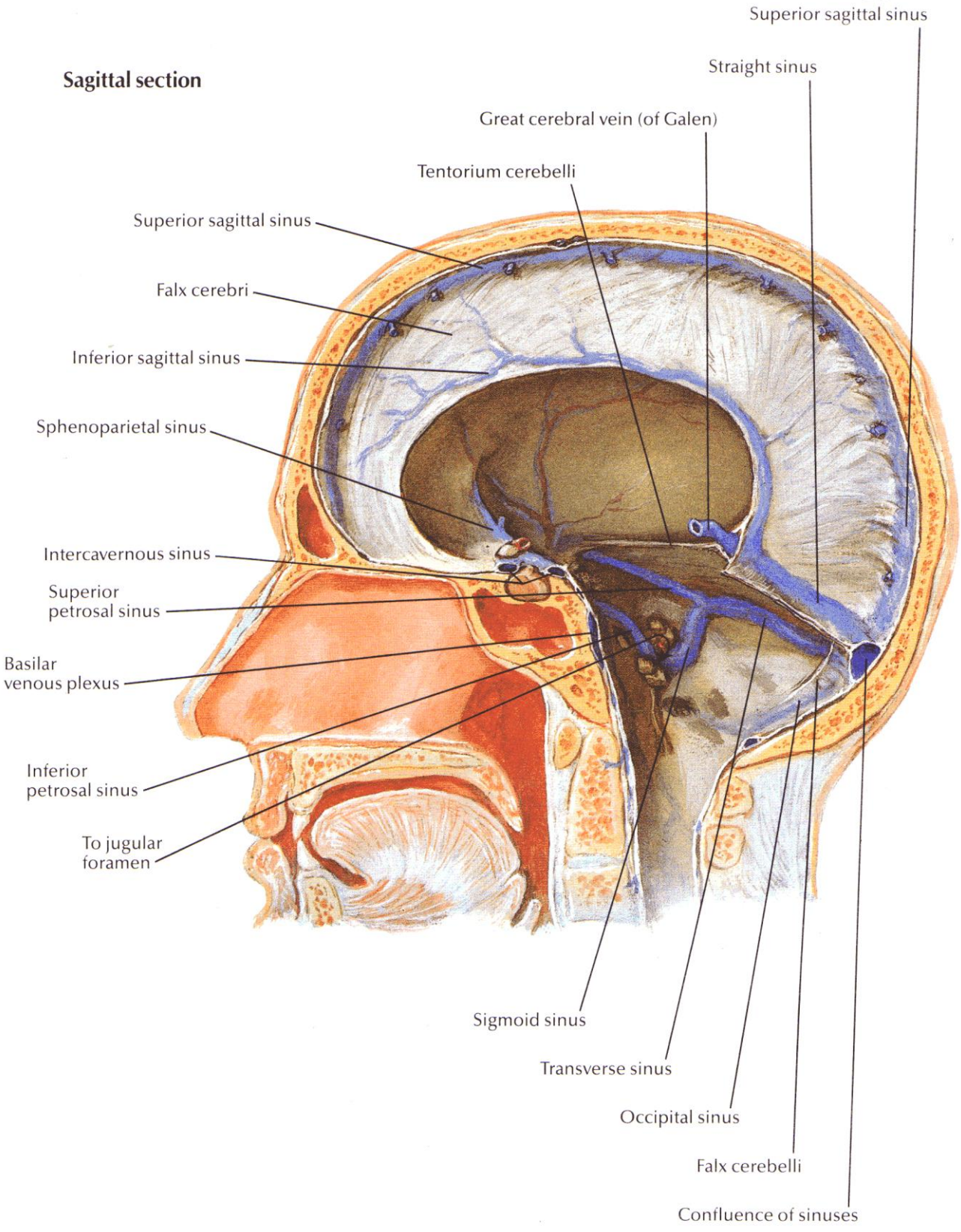
- Falx cerebri occupies a longitudinal fissura cerebri and separates the brain to right and left hemispheres;
- Falx cerebelli lies in longitudinal cerebellum furrow and separates it into right and left cerebellum hemispheres;
- Diaphragma sellae closes hypophysial fossa, separating a hypophysis from diencephalon.
- Tentorium cerebelli occupies a tranverse fissura cerebri and separates the cerebellum from the occipital lobe of the telencephalon.
- Dura mater forms a *trigeminal cavity* on anterior surface of the temporal pyramide.

The processes of dura mater approaching sulcuses on the skull bones slit and fasten to sulcus edges, forming the **venous sinuses** where venous blood flows:

- superior sagittal sinus;
- inferior sagittal sinus;
- straight [rectus] sinus;
- occipital sinus;
- inferior petrosal sinus;
- superior petrosal sinus;
- transverse sinus;
- cavernous sinus;
- intercavernous sinus;
- sphenoparietal sinus;
- sigmoid sinus.

These sinuses flow together in confluence sinuum. Venous blood from all sinuses passes into sygmoid sinus, and then - into internal jugular vein. The arachnoid forms the Pachioni's arachnoid granulation. They extend from venous sinuses in internal surface skull vault bone and form foveoli granulares. Arachnoid granulations provide a cerebrospinal fluid flow from subarachnoid space into venous blood. Emissary veins and diploic veins communicate the sinuses of dura mater with the superficial head veins.


Calvaria
Pericranium
Granular foveola
Superior sagittal sinus
Galea aponeurotica
Emissary vein
Arachnoid granulation
Skin
Tributary of superficial temporal vein
Diploic vein
Epidural space (*potential*)
Dura mater
Subdural space
Arachnoid
Subarachnoid space
Pia mater
Cerebral artery
Superior cerebral vein
Falx cerebri
Cerebral hemisphere
Branches of middle meningeal artery
Superior sagittal sinus
Superior cerebral veins (penetrating arachnoid and passing through subdural space to enter superior sagittal sinus)
Dura mater
Superior cerebral veins (beneath arachnoid)
Superior anastomotic vein (of Trolard)
Inferior anastomotic vein (of Labbé)
Superficial middle cerebral vein
Middle meningeal artery and veins
Inferior cerebral veins (beneath arachnoid)


Sagittal section
Superior sagittal sinus
Straight sinus
Great cerebral vein (of Galen)
Tentorium cerebelli
Superior sagittal sinus
Falx cerebri
Inferior sagittal sinus
Sphenoparietal sinus
Intercavernous sinus
Superior petrosal sinus
Basilar venous plexus
Inferior petrosal sinus
To jugular foramen
Sigmoid sinus
Transverse sinus
Occipital sinus
Falx cerebelli
Confluence of sinuses

Pathways of the brain and spinal cord subdivide into: associative, commissural and projection fibers.

Associative pathways are the tracts communicating functional areas of one hemisphere. They can be divided into long associative fibers and short associative fibers. The long associative pathways include:

1. Superior longitudinal fascicle communicates frontal, parietal and occipital lobes;
2. Inferior longitudinal fascicle communicates parietal, occipital, temporal lobes;
3. Uncinate fascicle - communicates frontal, parietal and temporal lobes;
4. Fornicate fascicle - communicates central areas of rhinencephalon;

To short associative tracts are arcuate fibres of the cerebrum, which communicate neighbouring convolutions within hemisphere.

The **Commissural pathways** communicate symmetric areas of both hemispheres of cerebrum and both halves of spinal cord for co-ordination of their activity. There are:

1. corpus callosum;
2. anterior cerebral commissura;
3. posterior cerebral commissura;
4. habenular commissura;
5. fornicate commissura;
6. interthalamic adhesion;
7. posterior white commissura of spinal cord.

The **Projecting pathways** are the tracts, which communicate the cerebrum and spinal cord with working organs. They subdivided into ascending (sensible) and descending (motor). The sensible projecting tracts into its turn subdivide into exteroreceptive, interoceptive and proprio-receptive. The motor projecting fibers tracts are pyramidali and extrapyramidal.

To exteroreceptive tracts belong the tracts temperatural, palpable, pain sensivity, also vision, hearing, olfaction. The proprioreceptive tracts are subdivided into tracts of cortical direction (Goll tracts and Burdach) and cerebellar directions (Flechsig and Gowers tracts). Anterior and lateral corticospinal tracts and also corticonuclear tract belong to pyramidal pathways. The extrapyramidal tracts include rubrospinal, vestibulospinal, reticulospinal, olivospinal pathways.

Pain and temperature sensation pathway **(Lateral spinothalamic tract).**

1. Body of first neuron is found in spinal ganglion. The peripheral process of this neuron terminates by exteroreceptor in skin, and central -on the strength of posterior rootlets into posterior horns of spinal cord, where contacts with second neuron.
2. The second neuron localised in proper nucleus of posterior horns of spinal cord. Its axons make a crossing in grey commissura of spinal cord and pass in lateral funiculus (lateral spinothalamic tract). Axons within the medial of lemniscus reach the thalamus, where terminate by synapse with body of third neuron.
3. The third neuron is in lateral nucleus of thalamus, and its axons 'thalamocortical tract' pass to postcentral gyrus (cortical analyser of skin sensation) through the back third of internal capsule.

Pressure and touch sensation pathway **(Anterior spinothalamic tract).**

1. Body of first neuron is found in spinal ganglion. The peripheral process of this neuron terminates by exteroreceptor in skin, and central -in the gelatinose substance of spinal cord, where contacts with second neuron.
2. The second neuron axons make a crossing in grey commissura of spinal cord and pass in lateral funiculus (anterior spinothalamic tract). Axons reach the thalamus, where terminate by synapse with body of third neuron.

3. The third neuron is in thalamus, it passes to postcentral gyrus (cortical analyser of skin sensation) through the back third of internal capsule.

Proprioreceptive pathway (cortical direction) - Bulbothalamic tract.

1. The first neuron of this tract lies in spinal ganglion. Its peripheral process terminates by proprioreceptor in muscles, tendoms, jonts capsules and ligaments. The central process passeswith posterior rootlets into spinal cord and form in white matter Goll tract - fascicle (upper 11 segments). The process passes to medulla oblongata, where terminate by synapse with second neuron.
2. The second neurons are in gracilis and cuneate nuclei of medulla oblongata. Axons this neuron form bulbothalamic tract, which composes a base of medial lemniscus. Axons of second neuron cross (deccusation of lemniscus) and reach the thalamus, where terminate by synapse with third neuron.
3. The third neurons pass through the internal capsule and form the thalamocortical tract.

Proprioreceptive pathways with cerebellar direction (Spinocerebellar tracts).

Posterior spinocerebellar tract (Flechsig tract)

1. The first neuron is in spinal ganglion. Its peripheral process terminates by proprioreceptor and central with the posterior rootlets of spinal cord passes to the grey matter.
2. The second neuron lies in thoracic nucleus of posterior horns . Its axons pass in lateral funiculus. Then it reaches the cortex of the cerebellar vermis through the inferior cerebellar pedunculi and dentate nucleus. Nervous impulse passes to the ruber nucleus.

Anterior spinocerebellar tract (Gowers tract). Two-neurons way. This tract differs from previous by its second neuron, a body of which is found in medial intermediate nucleus of spinal cord. Axons of the second neuron get across and pass into lateral funiculus, reaching the superior cerebral velum. They cross here and pass to the vermis and dentate nucleus. Nervous impulse also passes to the ruber nucleus.

Descending (motor) pathways are subdivided into pyramidal and extrapyramidal pathways.

Pyramidal system:

Lateral corticospinal (pyramidal) tract

1. A Body of first neuron is found in gigantic pyramidal cells (Bets) of top and middle third of precentral gyrus of the cortex. Axons pass through anterior third part of internal capsule, pons, medulla oblongata; part of fibres gets across forming the pyramids. The crossed fibres of first neuron pass in lateral funiculus of the spinal cord 'lateral corticospinal (pyramidal) tract' and terminate in anterior horns of spinal cord.
2. The second neuron lies in motor nucleus of anterior horns, and its axons pass with the anterior rootlets and spinal nerves as far as skeletal muscles of the trunk and extremities.

Anterior corticospinal (pyramidal) tract

1. Major part of fibres of first neurons of anterior corticospinal tract does not cross in pyramids of medulla oblongata, and passes in anterior funiculus of the spinal cord. Axons cross in grey commissura terminate by synapse with bodies of second neurons.first
2. The second neuron lies in motor nucleus of anterior horns, and its axons pass within the anterior rootlets and spinal nerves as far as skeletal muscles of the trunk and extremities.

Corticonuclear tract

1. The first neuron of this tract is found in gigantic pyramidal cells of cortex in lower third of precentral gyrus. Axons pass through the genu of internal capsule, base of cerebral peduncles and terminate in motor nucleus of rhomboid fossa and midbrain, previously passing across partially on opposite side.
2. The second neuron lies in motor nucleus of rhomboid fossa and midbrain of opposite side, and its axons with cranial nerves pass as far as stripped muscles of the head and superficial neck muscles.

Extrapyramidal pathways transmit impulses providing muscles tone and reflexes of equilibrium and execution of automated motions. They include rubrospinal, tectospinal, vestibulospinal, reticulospinal and olivospinal tracts.

Rubrospinal tract

1. The first neuron is found in red nucleus (n. ruber). Its axons make tegmental deccusation and pass through the base of cerebral peduncles, pons, and medulla oblongata. They form tract in lateral funiculus and reach motor nuclei in anterior horns of spinal cord.
2. The second neuron lies in motor nucleus of anterior horns of spinal cord, and its axons on the strength of anterior rootlets and spinal nerves reach trunk and extremities muscles.

This 2-neuron tract is descending link for reflex link of unconscious motion coordination. Spinocerebellar tracts (Flechsig and Gowers tracts) are the ascending links for this regulation. Spinocerebellar tracts send impulses for rubrospinal tracts through the intermediate link (from cerebellar vermis and dentate nuclei to the ruber nuclei).

Corticopontocerebellar tract (way of cortical correction of the cerebellum)

This 2-neuron tract starts from all lobes of cerebral hemispheres. Axons run through the internal capsula to the proper pontini nuclei. Second neurons cross and pass to the cerebellar vermis through the middle cerebellar pedunculi. Some links directed also to dentate and ruber nuclei. This pathway materializes cortical correction of unconscious motion coordination.

AUTONOMIC NERVOUS SYSTEM

Autonomic (vegetative) nervous system - this is part of nervous system, which provides innervation of all vessels, internal organs, smooth muscles and glandular epithelium including. It coordinates work of all internal organs, regulates the metabolic and trophic processes in all organs and walls, supports organism homeostasis.

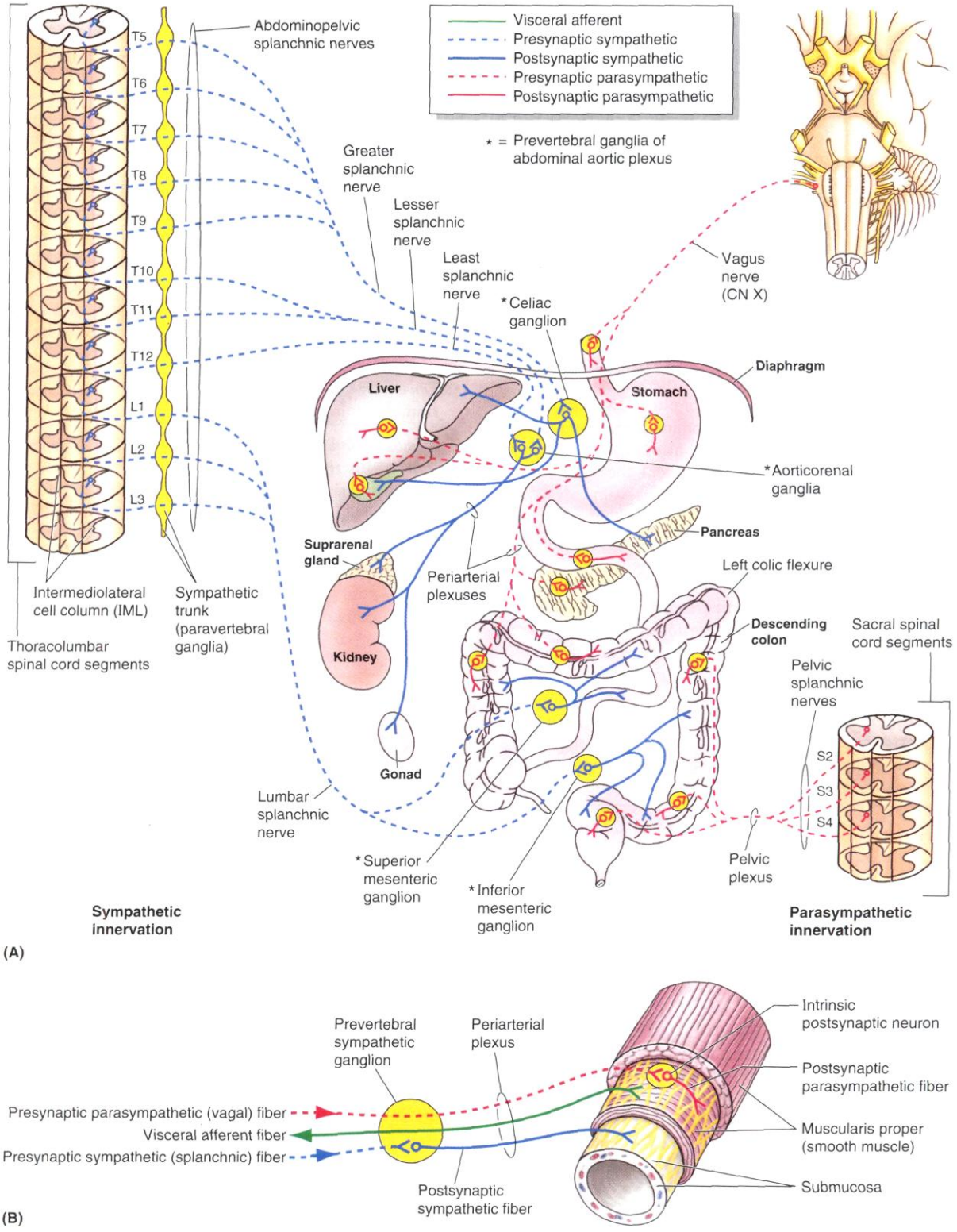
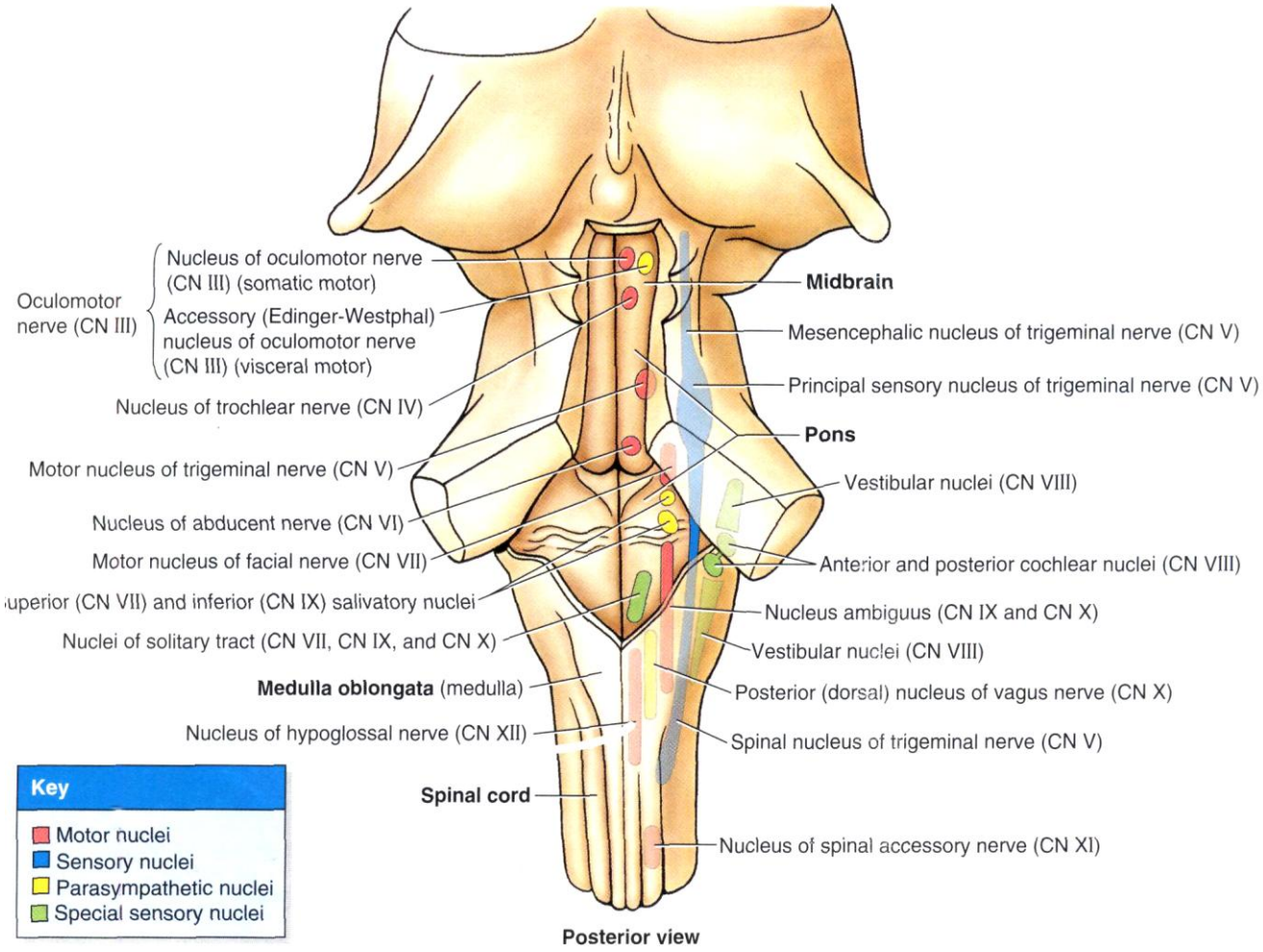


Figure **Autonomic nerves of posterior abdominal wall. A.** Origin and distribution of presynapatic and postsynaptic sympathetic and parasympathetic fibers, and the ganglia involved in supplying abdominal viscera are shown. **B.** The fibers supplying the intrinsic plexuses of abdominal viscera are demonstrated.

Function of autonomous department controlled by influence of higher autonomous (vegetative) centres, which are contained in cerebellum, hypothalamus, and basal nuclei of forebrain and in cortex of cerebrum.

This department has a row of peculiarities, which distinguish it from somatic nervous system:

- group localization of autonomic (vegetative) nuclei in central nervous system:
  - higher autonomic center - **hypothalamus,** frontal cortex of the hemisphere, cerebellum
  - midbrain
  - rhomboid fossa

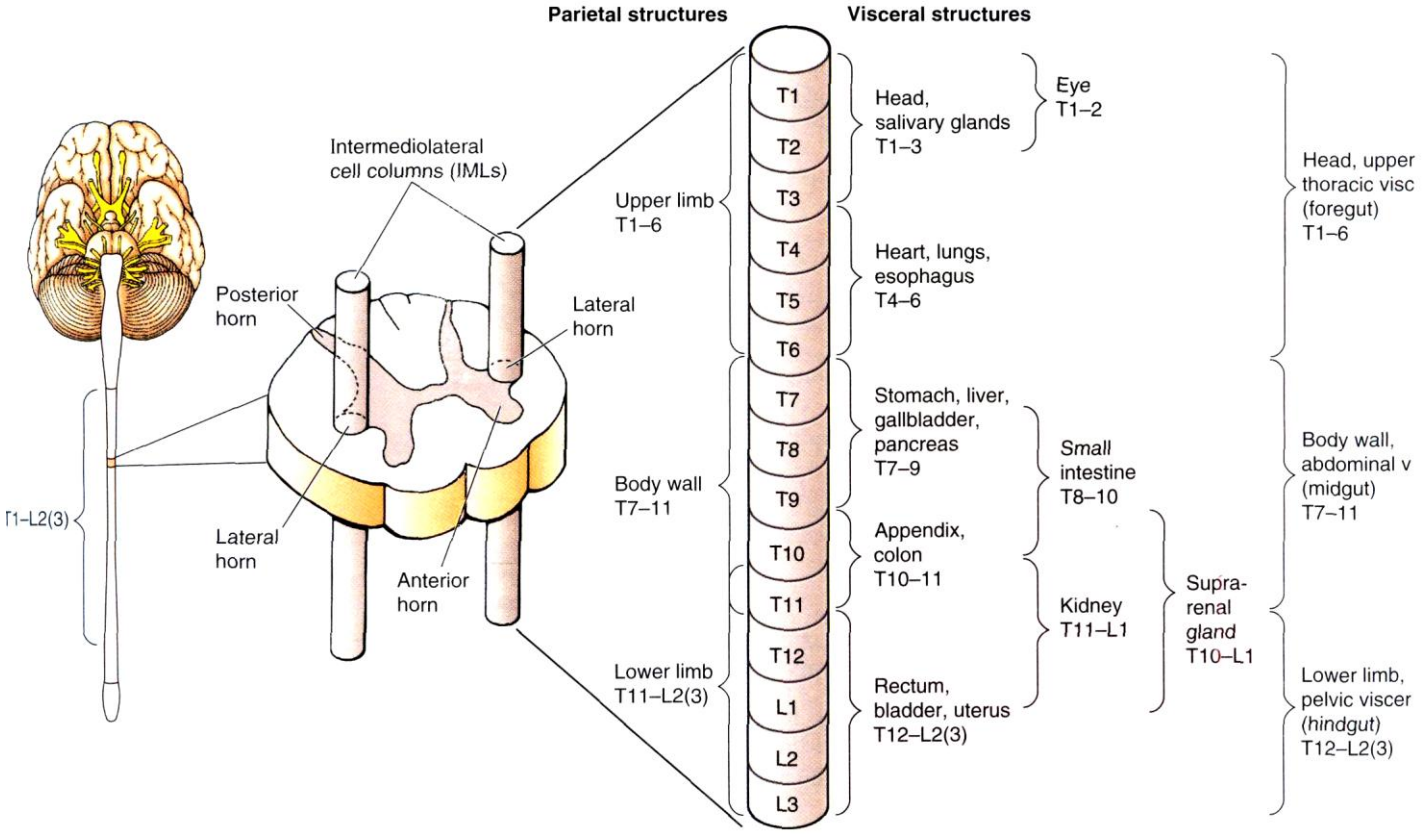


- spinal cord
- congestion of effectory neuron bodies in ganglia;
- 2 neurons tract from central autonomicc (vegetative) system to organ:
- 1st neuron - preganglionic, 2nd neuron - postganglionic;
- major part of peripheral fibers of autonomous part does not have myelin coat;
- speed of nervous impulse on autonomous part is lesser, than in somatic nervous system;

Autonomic nervous system has sympathetic and parasympathetic divisions.

• **SYMPATHETIC (THORACOLUMBAR) DIVISION**

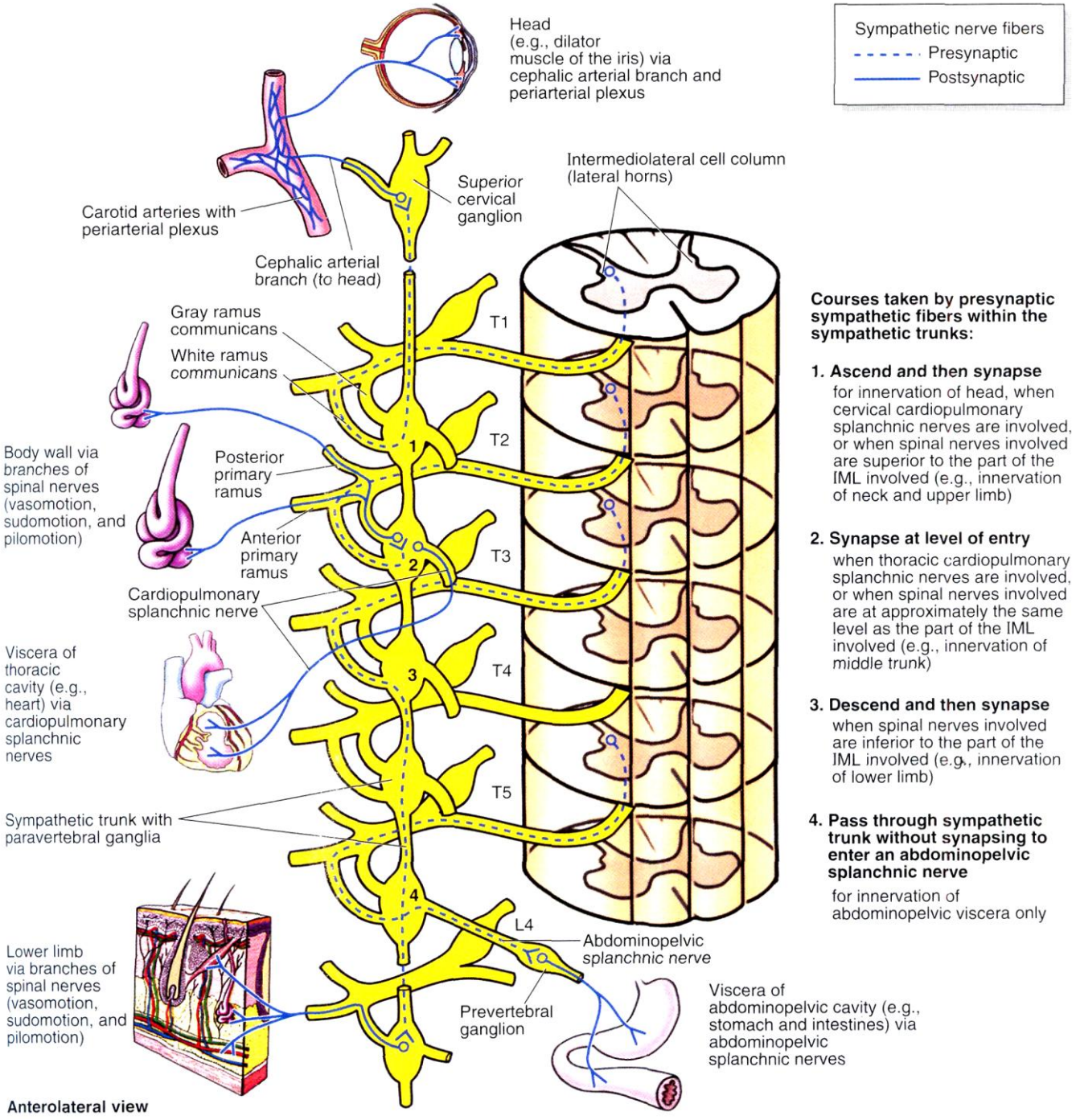
• Sympathetic centres are located in lateral intermediate nuclei of lateral horns (spinal cord segments Cg-TryTh-L -L).



• Peripheral sympathetic division includes right and left sympathetic trunks, communicating branches, prevertebral sympathetic ganglia, plexuses and fibbers, which pass to organs and tissues.

Sympathetic trunk is a paired formation, which is found on sides from vertebral column and consists of 20-25 paravertebral sympathetic ganglia, joint between each other by interganglionic rami. The whitecommunicating branches from spinal nerves approach to sympathetic trunk. They are preganglionic fiber (passes from lateral intermediate nucleus in composition of anterior rootlets and spinal nerve to nearest paravertebral sympathetic ganglion). The white communicating branches pass to eighth cervical, all thoracic and two top lumbar spinal ganglion.

Sympathetic trunk consists of 3 cervical, 10-12 thoracic, 4-5 lumbar, 4-5 sacral and one unpaired coccigeal ganglia. White communicating branches (preganglionic fibers) approach to upper cervical, lower sacral and coccigeal ganglia by the interganglionic branches. Ganglia of sympathetic trunk give off the gray communicating branches, which direct to nearest spinal nerve and contain postganglionic fibers.



Superior cervical ganglion is a largest ganglion of sympathetic trunk, is located in the level of transversal processes of 2-3 cervical vertebrae.

Superior cervical ganglion gives off the following branches:

gray communicating rami for I-IV cervical spinal nerves;

internal carotid nerve passes to carotid artery and forms internal carotid plexus, which passes into cranial cavity. Sympathetic rootlet for pterygopalatine ganglion (radix sympathica-deep petrosal nerve) separates from internal carotid plexus. Deep petrosal nerve passes through the pterygoid canal get the pterygopalatine fossa, transitory passing through the ganglion and realize innervation of the vessels and glands of mucous membrane of the nose cavity and mouth, conjuctive and face skin;

jugular nerve is passes on wall of internal jugular vein, where divides into branches passing to the 9^{th}, 10^{th} and 11^{th} cranial nerves;

laryngo-pharyngei nerves take hand in formation laryngo-pharyngeus plexus, innervating mucous membrane and vessels of the pharynx and larynx;

superior cervical cardiac nerve passes down parallelly with sympathetic trunk, to deep part of cardiac plexus.

Middle cervical ganglion, inconstant, located anteriorly from transversal process of 6th cervical vertebra. This ganglion is connected with superior and inferior ganglia by interganglionic rami. They form subclavian loop around subclavian artery.

Middle cervical ganglion gives off such branches:

- gray communicating branches to V-VI cervical spinal nerves;
- common carotid nerves, which take hand in formation of external carotid plexus and plexus of inferior thyroid artery;
- middle cervical cardiac nerve passes alongside of superior cervical cardiac nerve and enters into deep part of cardiac plexus.

Inferior cervical ganglion frequently flows together with first thoracic ganglion and forms a cervicothoracic ganglion (stellate ganglion). It lies on neck of first rib, behind subclavian artery.

Ganglion gives off the following branches:

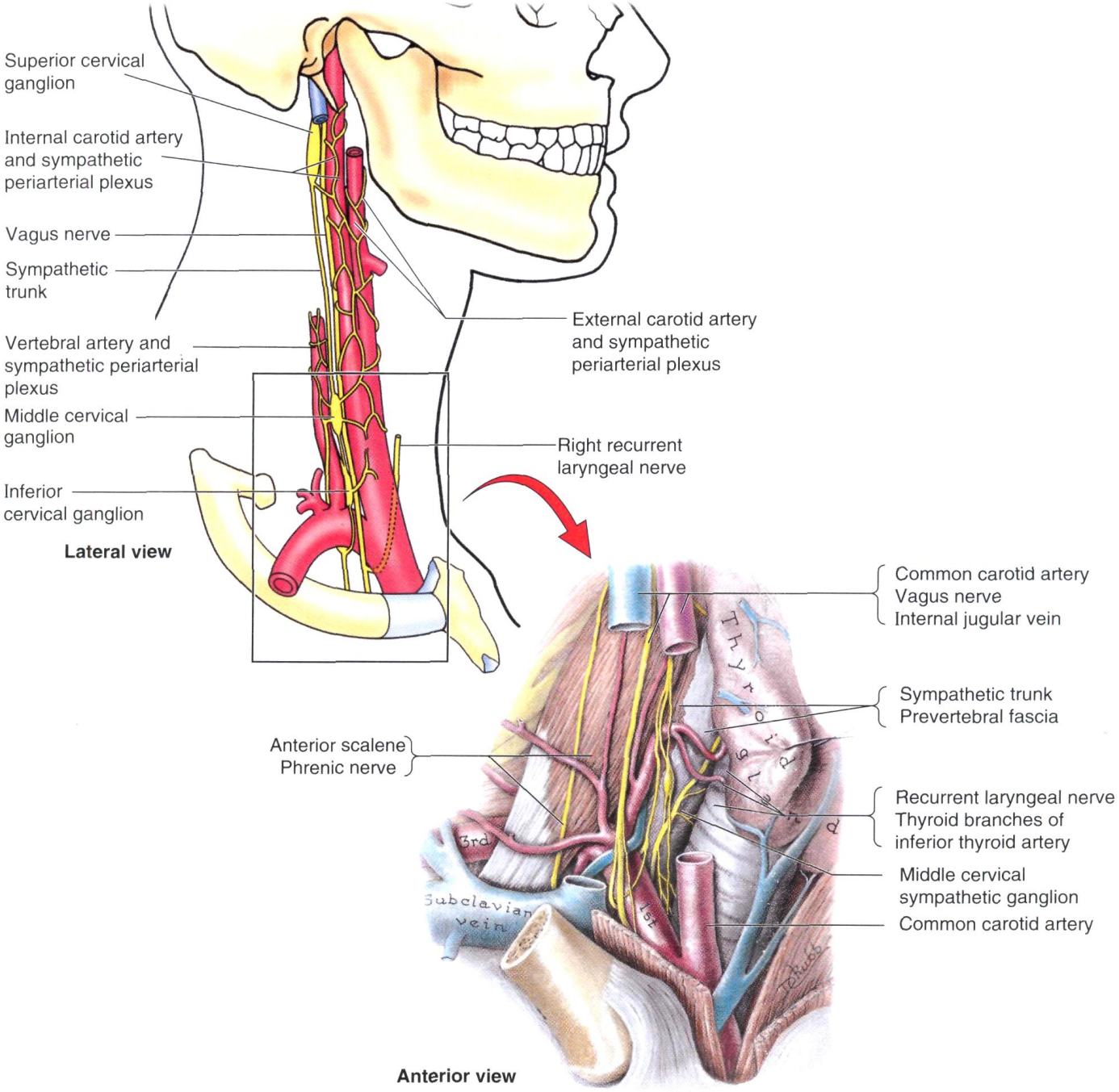
gray communicating branches to VI-VIII cervical spinal nerves;

subclavian nerves, which form subclavian plexus, that ramifies on branches of this artery;

branches to vagus and phrenic nerves;

vertebral nerve, which forms vertebral plexus round vertebral artery. This plexus spreads with branches of vertebral artery to spinal cord and brain meninges;

inferior cervical cardiac nerve is passes to deep part of cardiac plexus.


Superior cervical ganglion
Internal carotid artery and sympathetic periarterial plexus
Vagus nerve
Sympathetic trunk
Vertebral artery and sympathetic periarterial plexus
Middle cervical ganglion
Inferior cervical ganglion
Lateral view
External carotid artery and sympathetic periarterial plexus
Right recurrent laryngeal nerve
Common carotid artery
Vagus nerve
Internal jugular vein
Sympathetic trunk
Prevertebral fascia
Anterior scalene
Phrenic nerve
Recurrent laryngeal nerve
Thyroid branches of inferior thyroid artery
Middle cervical sympathetic ganglion
Common carotid artery
Thyroid gland
3rd
Subclavian vein
1st
Anterior view

Thoracic ganglia of sympathetic trunk (10-12), which are contained near caput of ribs laterally from vertebral bodies. Thoracic ganglia receive the communicating white branches containing preganglionic fibers. Thoracic ganglia give off the following branches:

gray communicating branches, which approach to intercostal nerves;

thoracic cardiac nerves being a party to forming of cardiac plexus;

thoracic pulmonary branches passing to bronchi and lungs, forming pulmonary plexus;

- thoracic aortic rami, which form thoracic aortic plexus;

major splanchnic nerve, formed by branches from VI-IX thoracic ganglia and consist overwhelmingly of preganglionic fibers. This nerve passes through the lumbar part of diaphragm into abdominal cavity and terminates in ganglia of abdominal plexus;

- minor splanchnic nerve starts from X-XI thoracic sympathetic ganglia and also has preganglionic fibers. It passes down into abdominal cavity (through the lumbar part of diaphragm) and enters into ganglia of abdominal plexus.

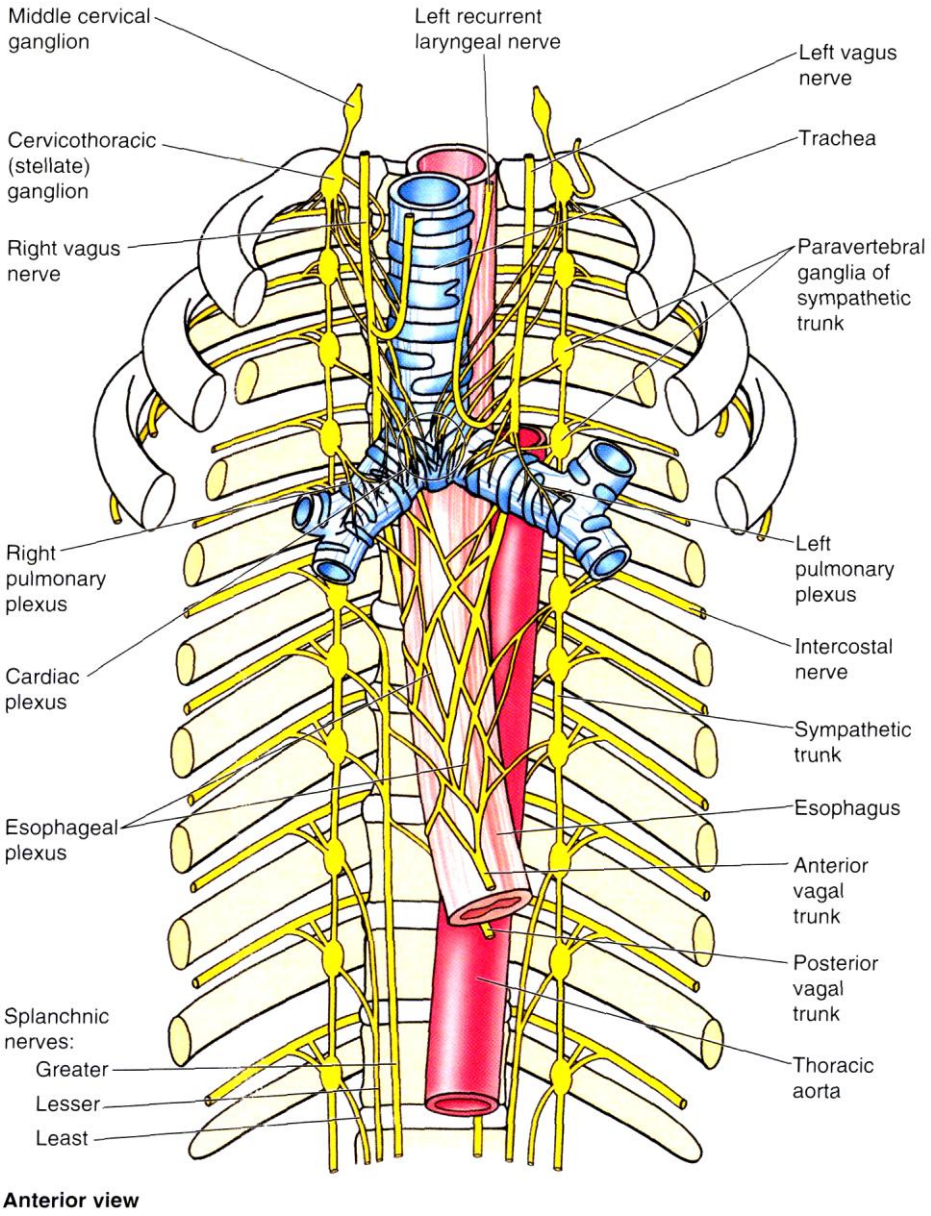
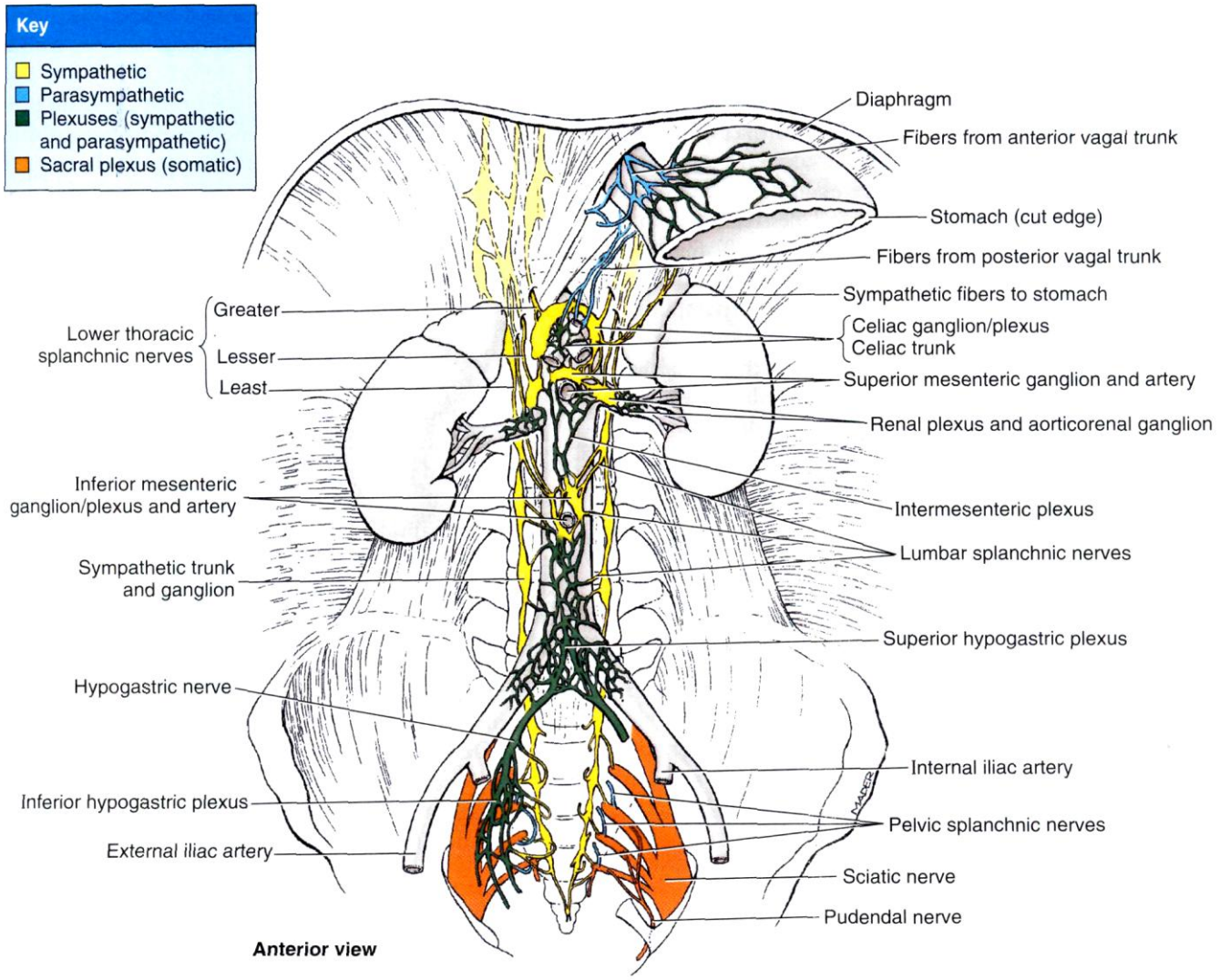


Table **Autonomic Innervation of the Abdominal Viscera (Splanchnic Nerves)**



Splanchnic Nerves	Autonomic Fiber Type[a]	System	Origin	Destination
A. ***Cardiopulmonary*** (Cervical and upper thoracic)	*Postsynaptic*	Sympathetic	*Cervical and upper thoracic* sympathetic trunk	*Thoracic cavity (viscera superior* to level of diaphragm)
B. **Abdominopelvic**			Lower thoracic and abdominopelvic sympathetic trunk:	Abdominopelvic cavity (prevertebral ganglia serving viscera and suprarenal glands *inferior to level of diaphragm*)
1. Lower thoracic a. Greater b. Lesser c. Least 2. Lumbar 3. Sacral	Presynaptic		1. Thoracic sympathetic trunk: a. T5–T9 or T10 level b. T10–T11 level c. T12 level 2. Abdominal sympathetic trunk 3. Pelvic (sacral) sympathetic trunk	1. Abdominal prevertebral ganglia: a. Celia ganglia b. Aorticorenal ganglia c. & 2. Other abdominal prevertebral ganglia (superior and inferior mesenteric, and of intermesenteric/hypogastric plexuses 3. Pelvic prevertebral ganglia
C. **Pelvic**	Presynaptic	Parasympathetic	Anterior rami of S2–S4 spinal nerves	Intrinsic ganglia of descending and sigmoid colon, rectum, and pelvic viscera

[a]Splanchnic nerves also convey visceral afferent fibers, which are not part of the autonomic nervous system.

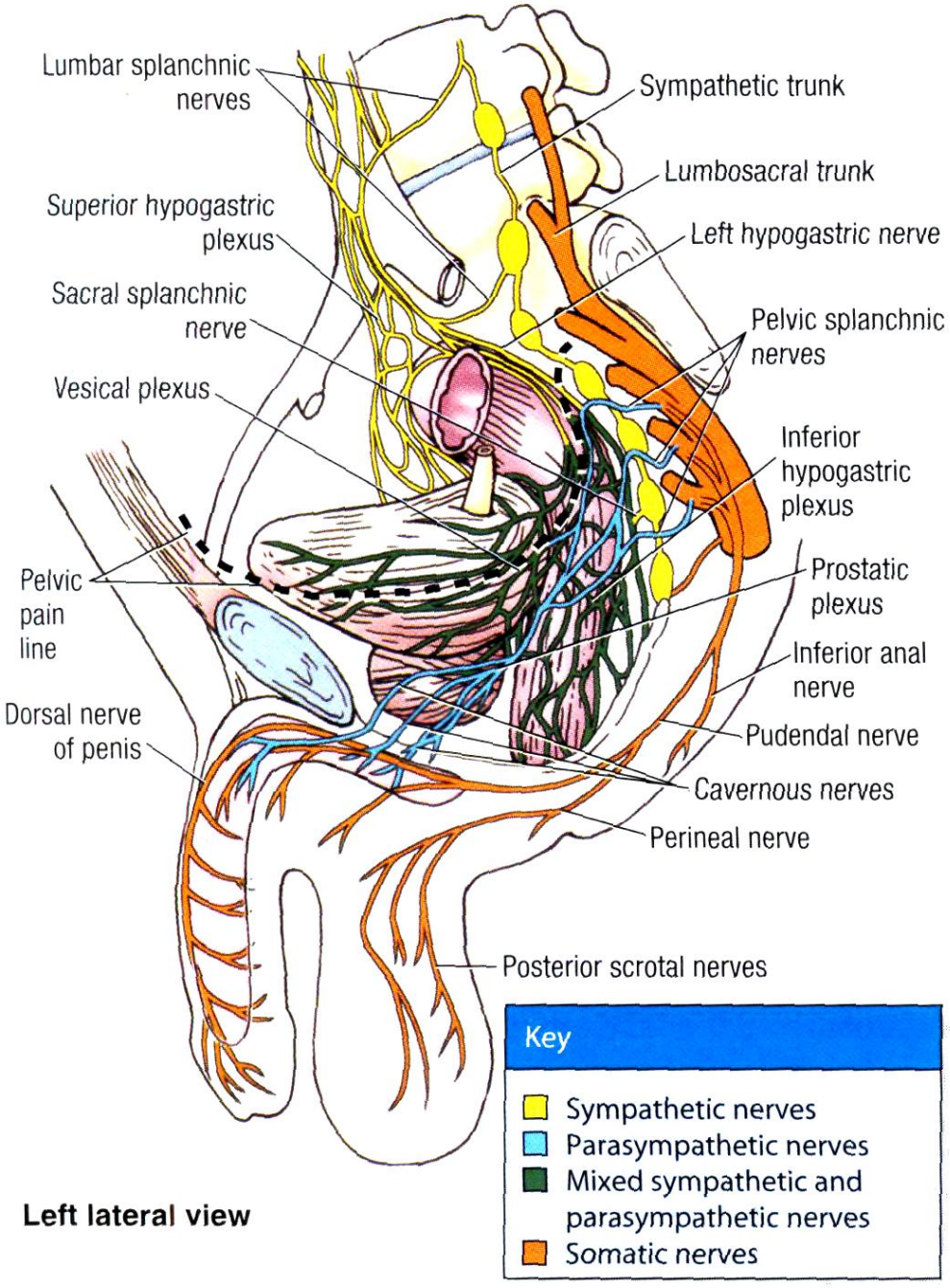
The lumbar ganglia of lumbar department of sympathetic trunk are represented by 4-5 ganglia and interganglionic branches. These ganglia are found on anterior-lateral surface of lumbar vertebrae bodies. The lumbar ganglia of right and left sympathetic trunk unite between oneself by communicating branches. The first and second lumbar ganglia approach the communicating white branches. Each ganglion gives off the gray communicating branches to lumbar spinal nerves and lumbar splanchnic nerves, which pass to abdominal plexus and have both preganglionic and postganglionic nervous fibers.

Sacral ganglia of sympathetic trunk formed by 4 ganglia, which lie on pelvic surface of sacrum, medially from pelvic sacral foramen. The right and left sympathetic trunks terminate in unpaired (coccigeal) ganglion. The sacral ganglia of right and left side unite each other by transversal branches. They give off communicating gray branches for sacral spinal nerves and sacral splanchnic nerves, which pass to superior and inferior hypogastric autonomic (vegetative) plexus.

Preganglionic fibers in composition of major and minor splanchnic nerves, and also lumbar splanchnic nerves approach to the prevertebral sympathetic ganglia, which lie at the anterior surface of backbone closely to celiac trunk and superior mesenteric artery. This semilunar-shaped celiac ganglia, superior mesenteric ganglion, aortorenal ganglia, phrenic ganglia, renal ganglia and some other. Postganglionic fibres from them pass to organs together with blood vessels and form same name plexus. Celiac plexus (the biggest) supplies a liver, spleen, stomach, pancreas, small intestine and large intestine (to descending colon).

Celiac plexus continues around abdominal aorta, form abdominal aortic plexus. It innervates kidney, suprarenal glands, ureters and testicles (ovaries).

Inferior mesenteric plexus starts closely to inferior mesenteric artery. It innervates descending and sigmoid colon, superior part of the rectum. Superior hypogastric plexus located in point of aortic bifurcation. It receives splanchnic nerves from lower lumbar and upper sacral sympathetic ganglia. Superior hypogastric plexus divides into right and left inferior hypogastric plexuses lower then promontorium. Inferior hypogastric plexus reaches the organs and tissues of lesser pelvis with arterial branches from internal iliac artery. It innervates seminal vesicles, prostate (male) uterus, Fallopian tubes, vagina (female), also rectum, urinary bladder.



Left lateral view

PARASYMPATHETIC (CRANIOSACRAL) DIVISION

Central part of parasympathetic division consists of the cranial part and pelvic part. Cranial part located in midbrain and rhomboid fossa. Mesencephalic portion contains accessory oculomotor (Yakubovych-Edinger-Westphal) nucleus, and bulbar portion contains superior salivary nucleus and inferior salivary nucleus and dorsal nucleus of vagus nerve. Pelvic part carries the parasympathetic nuclei, which lie in gray matter of sacral segments S_{II} S_{IV} of spinal cord.

Peripheral part consists of the ganglia, nerves and fibers.

Ciliary ganglion is formed by bodies of second /postganglionic/ neurons. It positioned in orbite near the optic nerve. The preganglionic fibres start from accessory oculomotor (Yakubovych-Edinger-Westphal) nucleus in composition of oculomotor nerve and separate from inferior branch as a radix oculomotorius, terminate by synapse with cells in ciliary ganglion. The postganglionic nervous fibres in composition of short ciliary nerves (nervi ciliares breves) pass to sphincter muscle of pupil and ciliary muscle. Sensory branches of nasociliary nerve and sympathetic postganglionic fibres from cavernous plexus pass through the ganglion.

Pterygopalatine ganglion lies in pterygopalatine fossa. It receives parasympathetic preganglionic fibres from superior salivary nucleus (with greater petrosal nerve). Last forms n. canalis pterygoidei (Vidian nerve) with sympathetic rootlet (from internal carotid plexus), sympathetic neurons innervate blood vessels. The postganglionic fibres join the ganglionic (sensory) nerves from maxillary nerve. Zygomatic nerve carries parasympathetic fibres to the lacrimal nerve (through the communicating branch) for innervating lacrimal gland. Nasal and palatine nerves provide complete innervating of the mucous membrane (and glands) in nasal cavity and palate.

Submandibular ganglion lies on medial surface same name salivary gland. Preganglionic parasympathetic fibres start from superior salivary nucleus in composition of chorda tympani. Last joins the lingual nerve that gives off sensory twigs for ganglion. Postganglionici fibres from this ganglion together with sensory and sympathetic fibres (from facial plexus) innervate submandibular salivary gland (often also sublingual gland).
Sublingual ganglion /inconstant/ located on external surface of sublingual salivary glands. It receives and gives off the same branches as submandibular parasympathetic ganglion.

Otic ganglion adjoins with mandibular of nerve under ovale foramen. This ganglion obtains parasympathetic innervation from inferior salivary nucleus (lesser petrosal nrerve). Postganglionic fibres in composition of auriculotemporal nerve innervate parotid salivary gland. Postganglionic sympathetic fibres (from middle meningeal plexus) which innervate the vessels of parotid salivary glands.

Parasympathetic part of X vagus nerve commences in dorsal nucleus of vagus nerve and contains a numerous of intramural ganglia. These ganglia enter to composition of cardiac, esophageal, pulmonary, gastric, intestinal, and others splanchnic plexus. Postganglionic neurons supply smooth muscles, glands and vessels of internal ogans in neck, thoracic and abdominal regions.

SENSORY ORGANS
VISUAL ORGANS

Eye consists of eyeball, auxiliary eye organs and the optic nerve. Eyeball has nucleus and wall.

Auxiliary eye apparatus includes eyelids, muscles of eyeball, lacrimal apparatus, orbital fasciae, vessels and nerves.

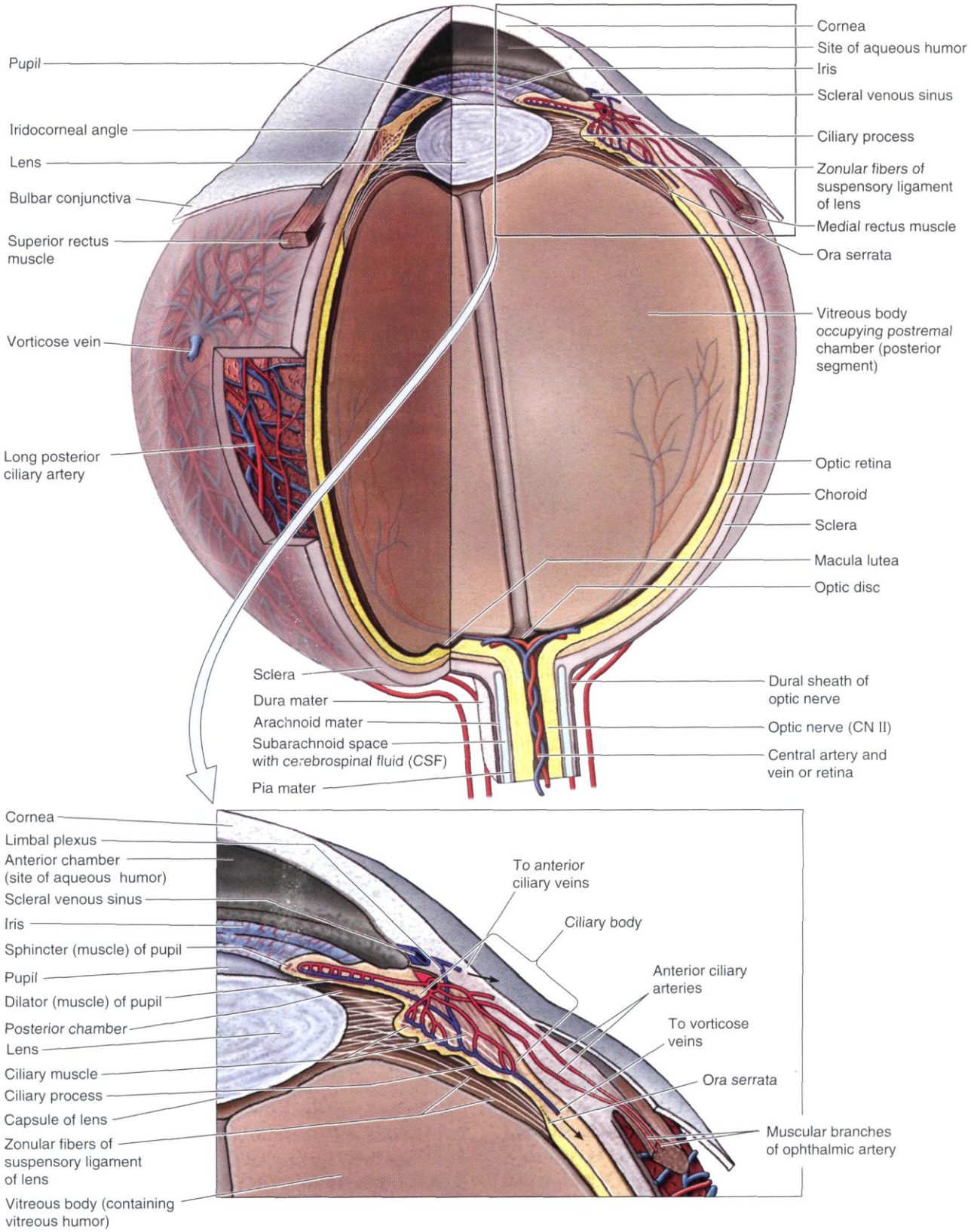
Eyeball is serrounded by adiposal body of orbite, muscles of eyeball and orbital fascia. Bony orbit is covered by periorbita. It has an anterior pole, posterior pole, and axis. Axis courses between poles. Optic axis starts from anterior pole to central fossa of the retina. Line that is found transversal on surface of eyeball and is found in the middle to distance between poles is called equator, and line passing perpendicularly to equator is called meridian.
Eyeball wall consists of three coats: fibrous (external), vascular (middle) and internal (retina).

Fibrous coat of eyeball subdivides into transparent ***cornea*** (anteriorly) and ***sclera*** .
Vascular coat has:
1. proper vascular coat **"*choroidea"***, which connects with sclera and delimited by perivascular space.
2.***Ciliary body*** consists of ciliary corona and by 70 ciliary processes. There is ciliary muscle in ciliary body, its contraction provides eye accommodation.
3. ***Iris*** carries the round oriface in centre -*pupilla*. Smooth muscles, which form a pupil muscle-sphincter and pupil muscle-dilator are round the pupil.

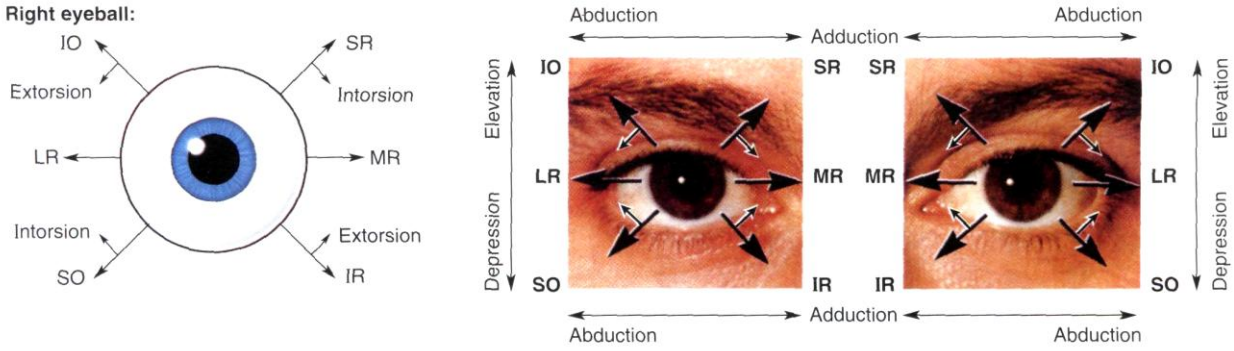
Internal coat of eyeball - 'retina'. There are external pigmental layer and internal nervous layer in visual part of the retina. According to function they distinguish posterior larger visual part of retina, which contains rods and cones, and lesser blind part of retina. There are neither rods nor cones in blind part. Ora serrata is the boundary between optic and blind parts, which accords with transition of choroid into ciliary body. In posterior part of retina is found a disc of the optic nerve that has a small concavity. Macula is located in the centre of retina. Central fossa is the place of best sight sharpness, where is observed most rods and cones.

Nucleus of eyeball consists of vitreous body, lens, and aqueous humor in anterior and posterior chambers.
Vitreous body represents by transparent mass without any vessels. It occupies largest portion of eyeball behind lens.
The transparent **lens** consists of tight layers of proteins. The thin, clear lens **capsule** encloses the lens and provides attachment for the **suspensory ligament (zonular fibers).**

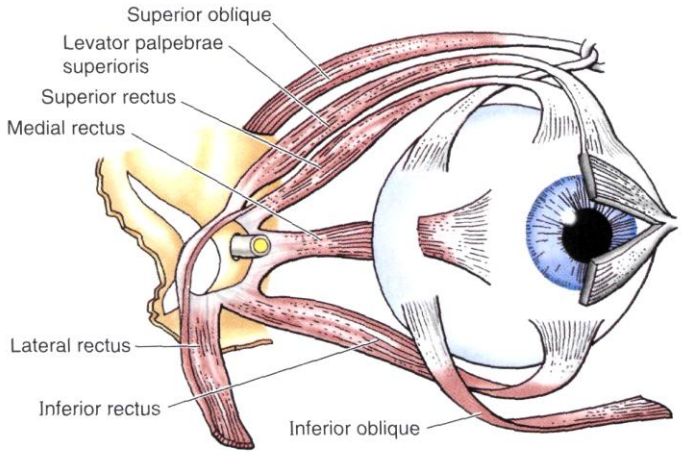
Anterior chamber of eyeball placed between posterior surface of cornea surface and anterior surface of the iris.
Posterior chamber is found between posterior surface by iris and anterior surface of lens. The anterior and posterior chambers are filled by *aqueous humor,* which produced by ciliary processes of ciliary body and unite each other by the medium of pupil. Between cornea and iris is found iridocorneal corner, which is filled by pectinate ligament with the Fontana's spaces. Aqueous humor draines from anterior chamber through fountain spaces to the Schlemm's canal (venous sinus of sclera).


Pupil
Iridocorneal angle
Lens
Bulbar conjunctiva
Superior rectus muscle
Vorticose vein
Long posterior ciliary artery
Cornea
Site of aqueous humor
Iris
Scleral venous sinus
Ciliary process
Zonular fibers of suspensory ligament of lens
Medial rectus muscle
Ora serrata
Vitreous body occupying postremal chamber (posterior segment)
Optic retina
Choroid
Sclera
Macula lutea
Optic disc
Sclera
Dura mater
Arachnoid mater
Subarachnoid space with cerebrospinal fluid (CSF)
Pia mater
Dural sheath of optic nerve
Optic nerve (CN II)
Central artery and vein or retina
Cornea
Limbal plexus
Anterior chamber (site of aqueous humor)
Scleral venous sinus
Iris
Sphincter (muscle) of pupil
Pupil
Dilator (muscle) of pupil
Posterior chamber
Lens
Ciliary muscle
Ciliary process
Capsule of lens
Zonular fibers of suspensory ligament of lens
Vitreous body (containing vitreous humor)
To anterior ciliary veins
Ciliary body
Anterior ciliary arteries
To vorticose veins
Ora serrata
Muscular branches of ophthalmic artery

Additional eye structures include: extrinsic muscles of eyeball, eyebrows, eyelids, conjuctiva, lacrimal apparatus.
They originate in common annular tendom and insert into sclera and can rotate eyeball on frontal and vertical axis. As result pupilla moves up, down laterally and medially.



(A) Arrows, direction pupil moves when the indicated muscle acts[a]



(B) Anterolateral view from right

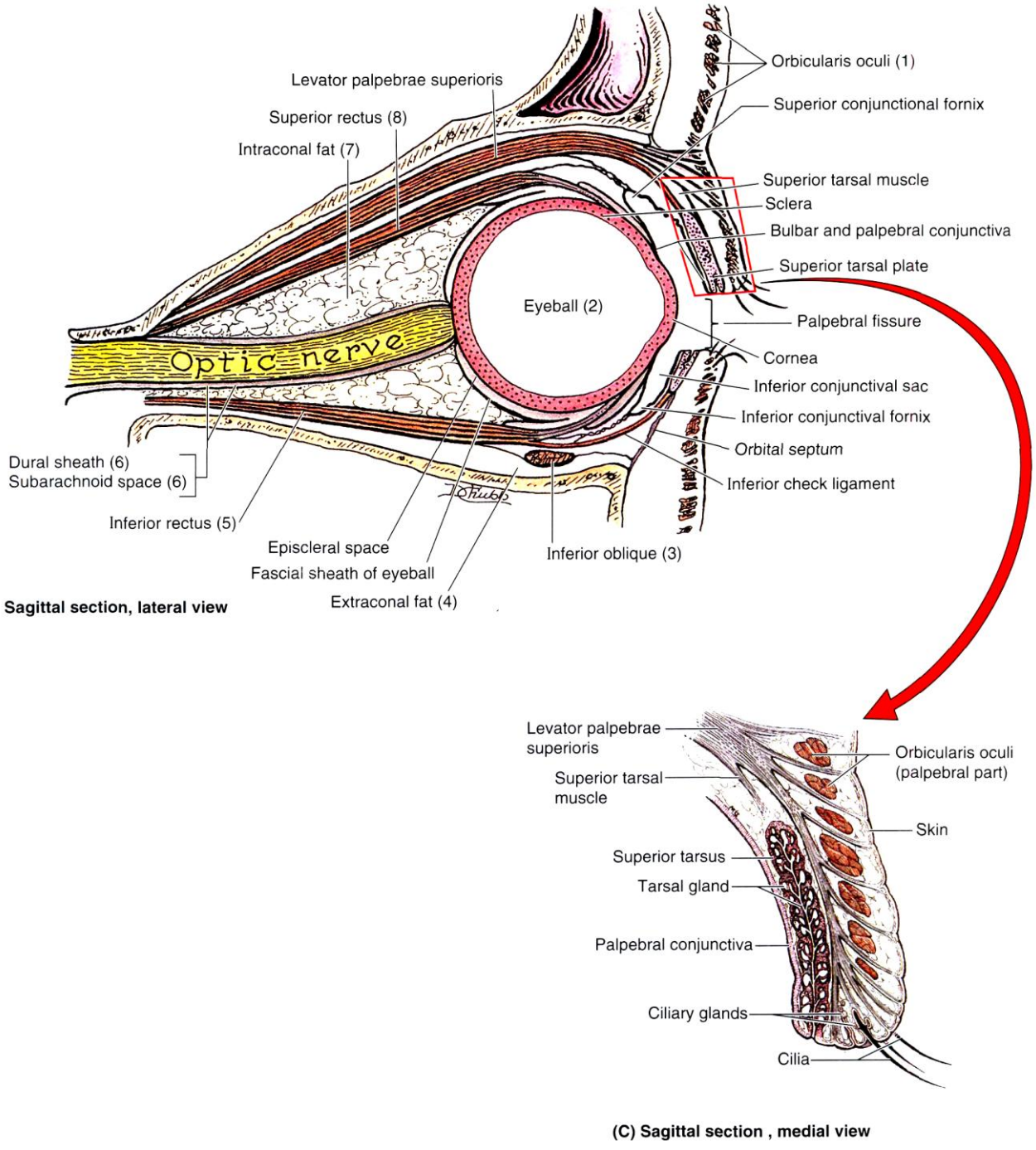
Individual anatomical actions of muscles as studied anatomically

Table **Extraocular Muscles of the Orbit**

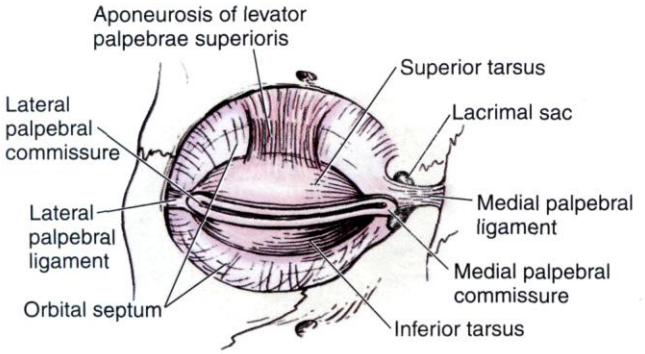
Muscle	Origin	Insertion	Innervation	Main Action[a]
Levator palpebrae superioris	Lesser wing of sphenoid bone, superior and anterior to optic canal	Superior tarsus and skin of superior eyelid	Oculomotor nerve; deep layer (superior tarsal muscle) is supplied by sympathetic fibers	Elevates superior eyelid
Superior oblique	Body of sphenoid bone	Its tendon passes through a fibrous ring or trochlea, changes its direction, and inserts into sclera deep to superior rectus muscle	Trochlear nerve (CN IV)	Abducts, depresses, and medially rotates eyeball
Inferior oblique	Anterior part of floor of orbit	Sclera deep to lateral rectus muscle	Oculomotor nerve (CN III)	Abducts, elevates, and laterally rotates eyeball
Superior rectus	Common tendinous ring	Sclera just posterior to corneoscleral junction		Elevates, adducts, and rotates eyeball medially
Inferior rectus				Depresses, adducts, and rotates eyeball medially
Medial rectus				Adducts eyeball
Lateral rectus			Abducent nerve (CN VI)	Abducts eyeball

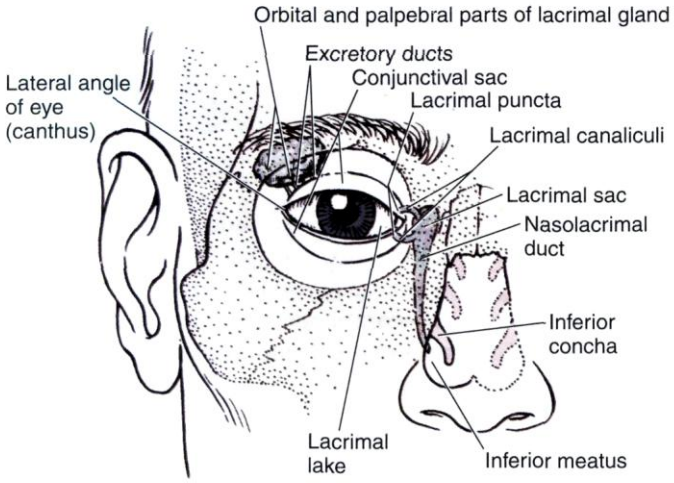
[a]It is essential to appreciate that all muscles are continuously involved in eyeball movements; thus the individual actions are not usually tested clinically. *SR*, superior rectus (CN III); *LR*, lateral rectus (CN VI); *IR*, inferior rectus (CN III); *IO*, inferior oblique (CN III); *MR*, medial rectus (CN III); *SO*, superior oblique (CN IV).

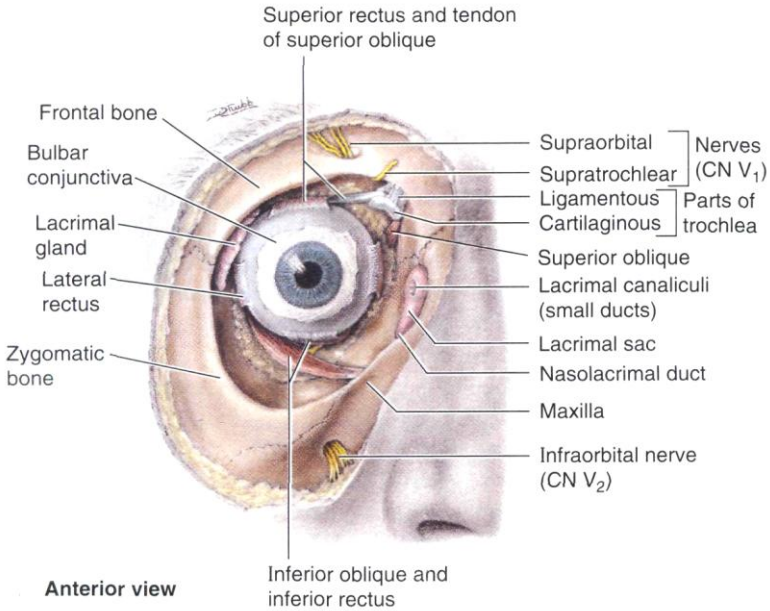
Levator palpebrae superioris muscle elevates upper eyelid.
Periosteum of orbit is *'periorbita'* forming the cover of bones and passes through the optic canal into dura mater encephali. Eyeball is enveloped by *vagina of eyeball* (Tenon's capsule). *Adiposal body* of orbit localised between vagina of eyeball and periorbita, which formes elastic pillow for eyeball.
Superior and inferior **eyelids** cover and protect eyeball. Front surface of eyelids is covered by skin. Posterior surface of the eyelids and anterior free surface of eyeball are covered by thin conjuctiva**.** Last forms superior and inferior sac of conjuctiva.
Yeybrows (supercilium) consist of short, sick hair positioned transversally above both eyes along the superior orbital ridges of the scull.



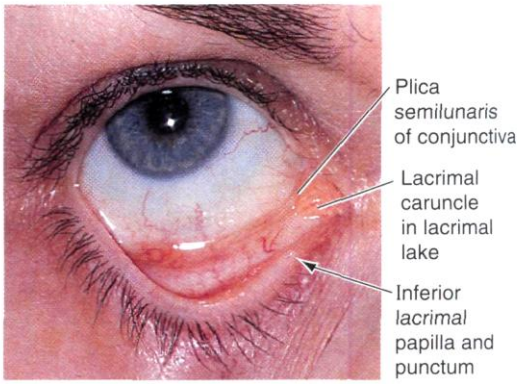
Lacrimal apparatus consists of **lacrimal gland** lying in superolateral portion of the orbit and a series of lacrimal ducts that drain the secretion into the nasal cavity. The *excretory ductuli* of lacrimal gland (10-15) open into conjunctive sac of upper eyelid . With each blink of the eyelids, tears passe medially and downward and drains into *lake* and two small openings, called **lacrimal puncta** on both sides of the *lacrimal caruncle.* From here, tears drains through the *lacrimal canaliculus* into the *lacrimal sac* and continious through the *nasolacrimal duct* to the inferior meatus of the nasal cavity.





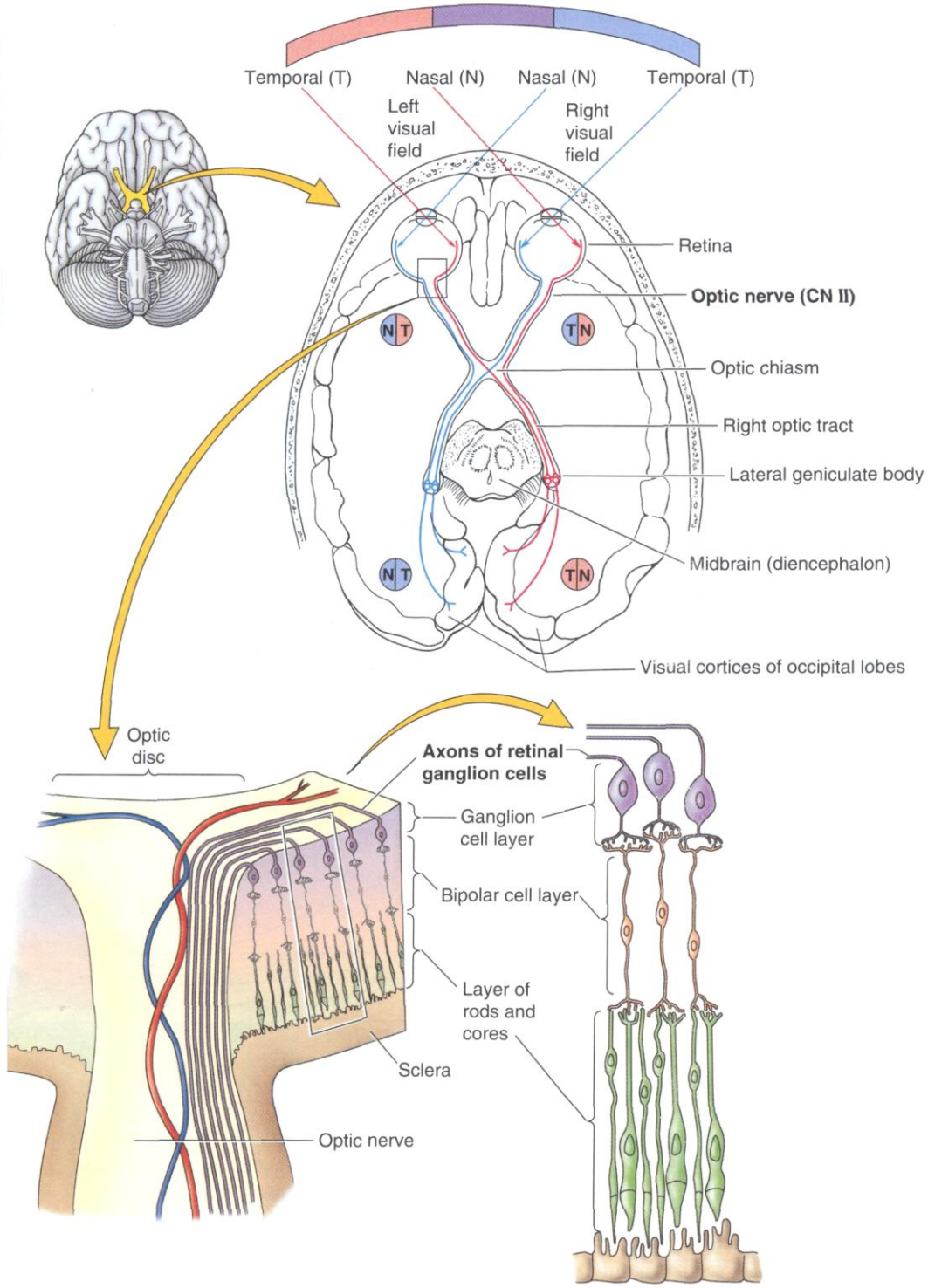


Anterior view



Anterior view

The nerve elements of the retina form a chain of three neurons . The first link of this chain consists of the light-sensitive cells of the retina (rods and cones) which constitute the receptor of the visual analyser. The second link is made up of the bipolar cells, and the third of multipolar cells (ganglion n. optici), whose processes continue into the nerve fibres of the optic nerve.As an extension of the brain the nerve is covered by all three meninges forming a sheath for it which fuses intimately with the sclera at the eyeball. Spaces called intervaginal are preserved between the sheaths (spatia intervaginalia) corresponding to the spaces in the brain formed betweeii the meninges. On passing out of the orbit through the optic canal, the optic nerve approaches the inferior surface of the brain, where it partly decussates in the region of the optic chiasma.



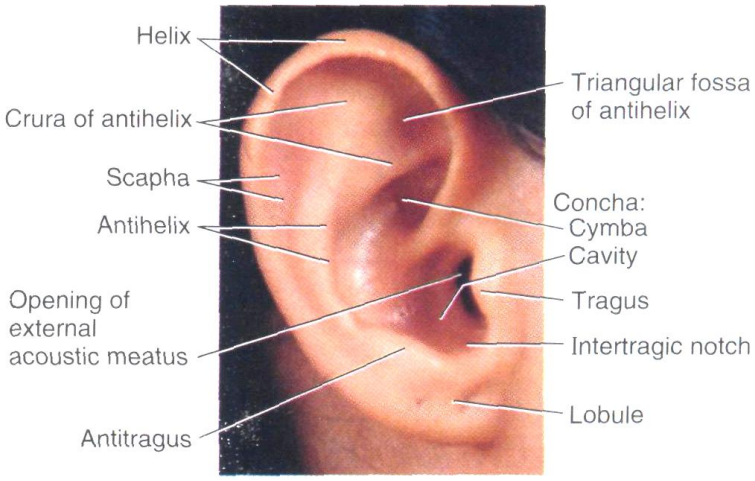
Only the medial parts of the nerves running from the medial halves of the retina decussate; the lateral parts running from the lateral halves of the retina remain uncrossed. This is why every optic tract (tractus n. optici) arising from the chiasma contains fibres in its lateral part running from the lateral half of the retina of the eye located on its own side, and fibres in the medial part running from the medial half of the contralateral eye. Knowing the character of the chiasma the site of the lesion of the visual tract can be determined by the character of the loss of vision. Thus,for example, when the left optic nerve is affected, the left eye will become blind; in a lesion of the left optic tract or optic centre of each hemisphere, vision is lost in the left halves of the retinae of both eyes, i.e. half-blindness of both flyes (hemianopsia) occurs; in a lesion of the chiasma there is a loss of vision in the medial half of both eyes (in central localization of the lesion) or complete blindness of both eyes (in extensive lesion of the chiasma). Both the crossed and uncrossed fibres of the visual tracts end in two bundles in the subcortical visual centres: (1) in the superior quadrigeminal bodies, and (2) in the thalamus pulvinar and lateral geniculate body. The first bundle ends in the superior quadrigeminal body lodging the visual centres which are connected with mesencephalic nerve nuclei innervating the striated muscles of the eyeball and the smooth muscles of the iris. It is due to this connection that in response to certain light stimuli a corresponding convergence and accommodation (pupillary reflex) of the visual apparatus occurs.

The other bundle ends in the pulvinar of the thalamus and in the lateral geniculate body where the bodies of the hew (fourth) neurons are located. The axons of the latter pass through the dorsal part of the posterior genu of the internal capsule and then form the optic radiation (radiato optica) in the white matter of the cerebral hemispheres, which reaches the cortex of the occipital lobe of the brain.

It should be borne in mind that chiasma opticum is not merely the crossing of optic fibres, but a considerably more complicated formation. A detailed study of the structure of the chiasma revealed that there are also commissural fibres in it, which are not axons of the retinal ganglionic cells. The fibres of the commissures intertwine with the optic fibres of the chiasma.

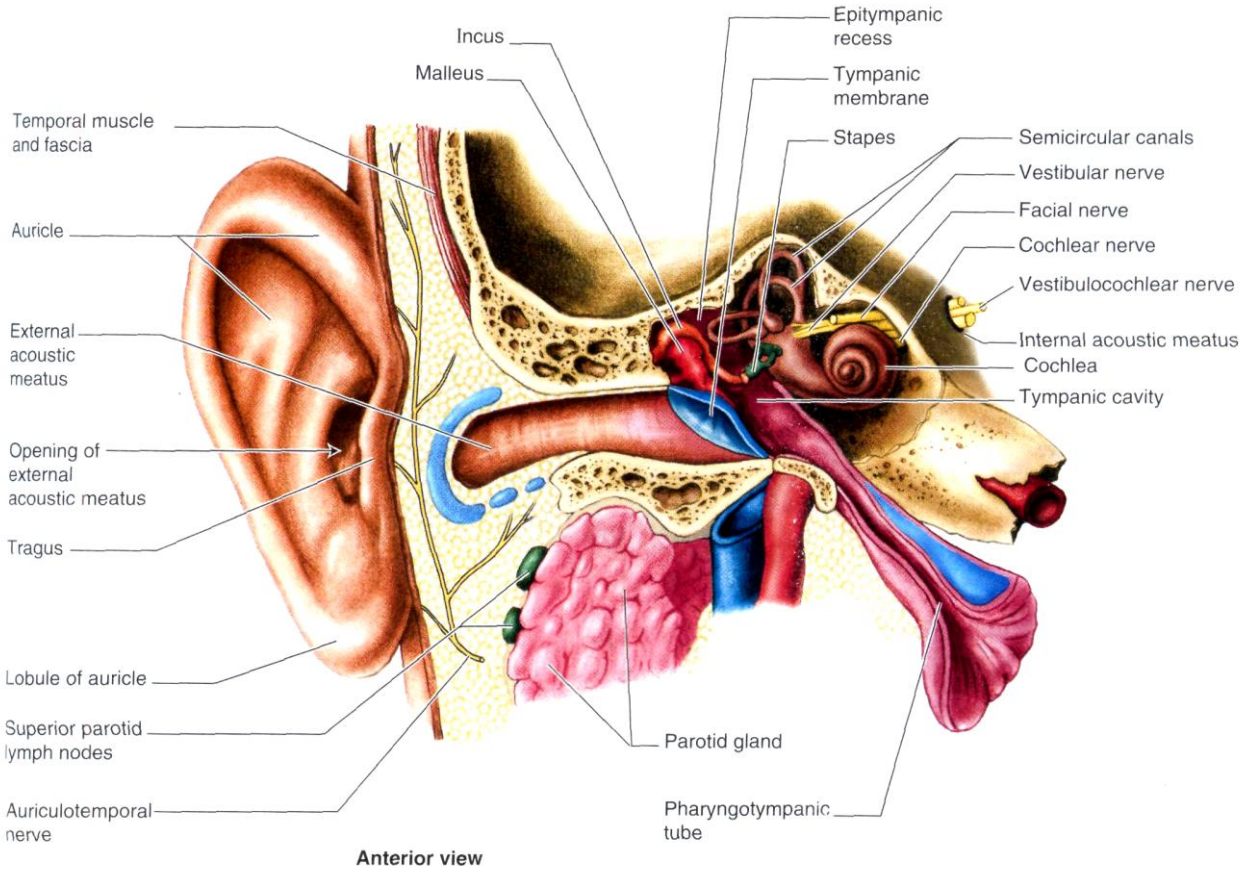
EAR (HEARING AND EQUILIBRIUM ORGAN)

Ear subdivides on auricle (outer ear), middle ear and internal ear. Auricle and external auditory meatus belong to outer ear. Middle ear contains a tympanic cavity and auditory tube (Eustachian). Internal ear composes an osseous labyrinth and membranous labyrinth.

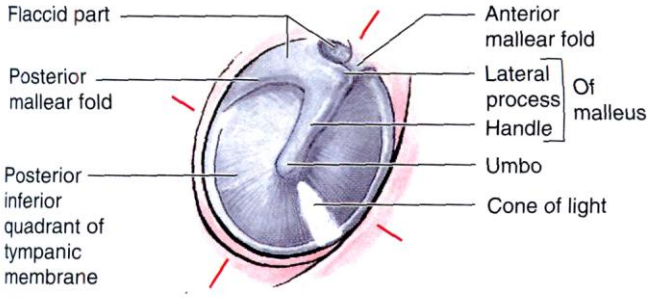


<u>AURICLE</u> contains a cartilage covered by skin. In inferior part a cartilage is absent there is auricular *lobule* (earlobe). Also auricle has a *helix, triangular fossa, antihelix, concha, tragus, antitragus.*

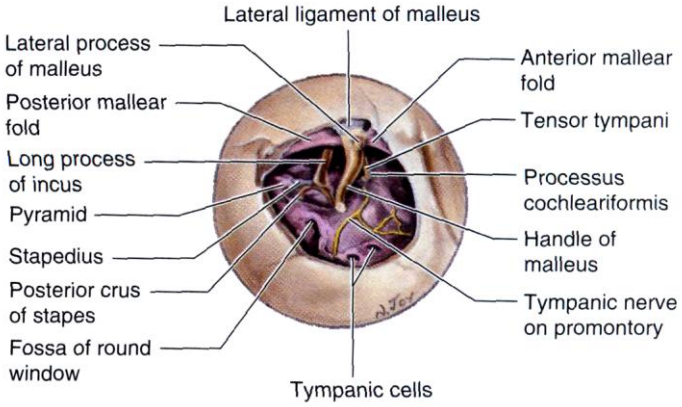
External auditory meatus is open outside, in depth from cavity of middle ear it dissociates by tympanic membrane. External auditory meatus has cartilaginous part and inner osseous part. Cartilaginous part composes one-third length of auditory meatus. Osseous part occupies two thirds of auditory meatus. Auditory meatus is curved S-like and for its straightening attached to examination of tympanic membrane necessary to draw off auricle posterior, up and outside.



The tympanic membrane or ear drum *(membrana tympani)* is located at the junctions of the external and middle ears. Its edge fits into the sulcus tympanicus at the end of the external auditory meatus as into a frame. The tympanic membrane is secured in the sulcus tympanicus by a *fibrocartilaginous ring (anulus fibrocartilagineus).* The membrane is inclined because of the oblique position of the medial end of the auditory meatus, but in newborns it is almost horizontal. The tympanic membrane in an adult is oval in shape and measures 11 mm in length and 9 mm in breadth. It is a thin semitransparent sheet in which the centre, called the *umbo (umbo membranae tympani)* is drawn in like a shallow funnel. Its external surface is covered by a thinned-out continuation of the skin covering the auditory meatus (stratum cutaneum), the internal surface by the mucous lining of the tympanic cavity (stratum mucosum).



Auriscopic view of right tympanic membrane



Inferolateral view, right side

THE MIDDLE EAR

The middle ear consists of the tympanic cavity and the auditory tube through which it communicates with the nasopharynx.

The tympanic cavity *(cauitas tympani)* is situated in the base of the pyramid of the temporal bone between the external auditory meatus and the labyrinth (internal ear). It contains a chain of three small ossicles transmitting sound vibrations from the tympanic membrane to the labyrinth. The tympanic cavity is very small (volume of about 1 cm^3) and resembles a tambourine propped up on its side and greatly inclined toward the external auditory meatus. Six walls are distinguished in the tympanic cavity.

The lateral, or **membranous wall** *(paries membranaceus)*

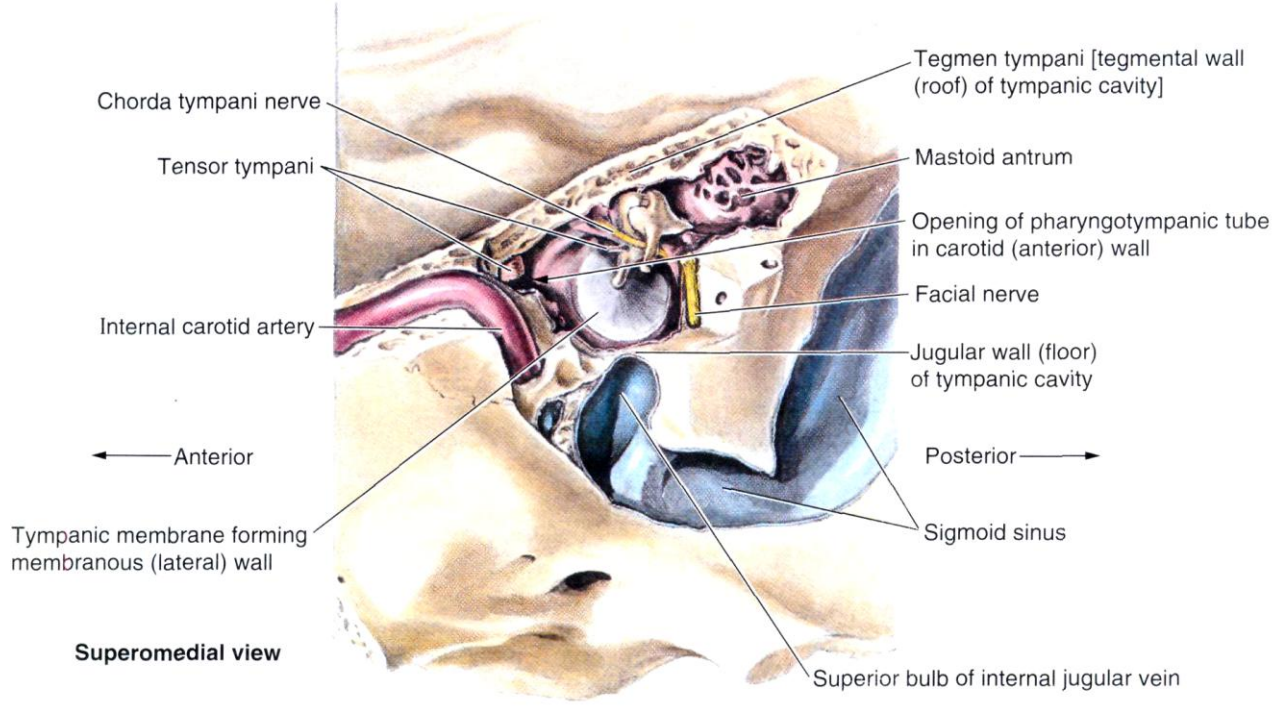
The medial wall of the tympanic cavity belongs to the labyrinth and is therefore called **the labyrinthine wall** *{paries labyrinthicus).*

The posterior, or **mastoid, wall of the tympanic cavity** *(parties mastoideus)*

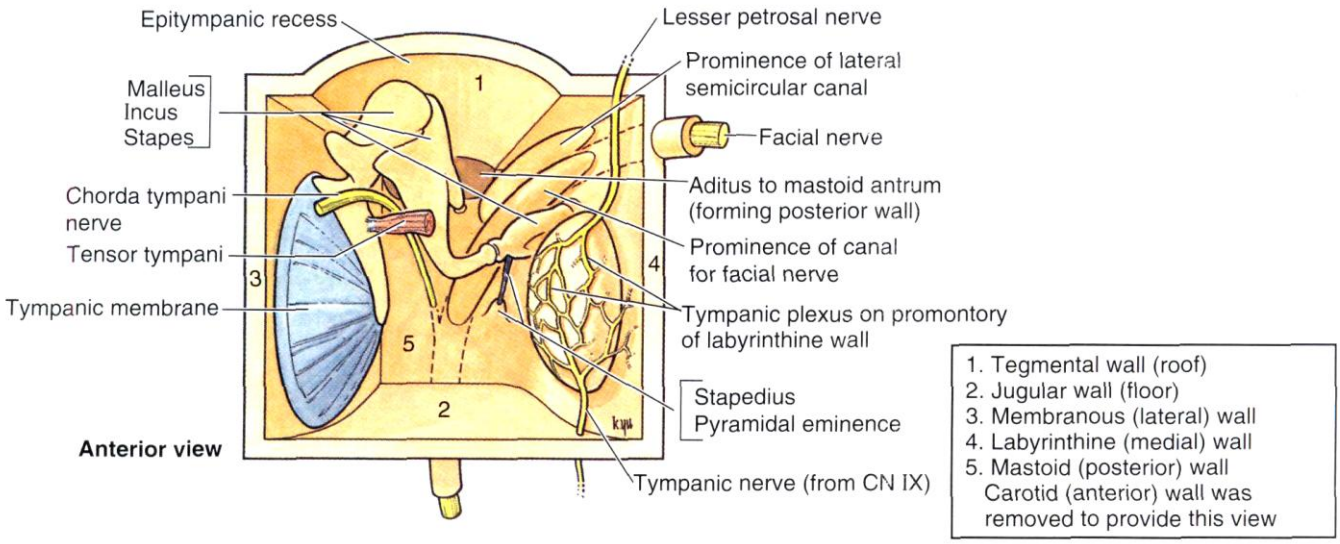
The anterior, or **carotid, wall of the tympanic cavity** *(paries caroticus)* **The roof, or tegmental wall *oi* the tympanic cavity** *(paries tegmentalis)* corresponds on the anterior surface of the pyramid to the tegmen tympany and separates the tympanic cavity from the cranial cavity.

The floor, or jugular wall of the tympanic cavity *(paries jugularis)* faces the base of the skull in close proximity to the jugular fossa. The three tiny *auditory ossicles* in the tympanic cavity are called the **malleus, incus, and stapes,** the Latin for hammer, anvil and stirrup, respectively, which they resemble in shape.

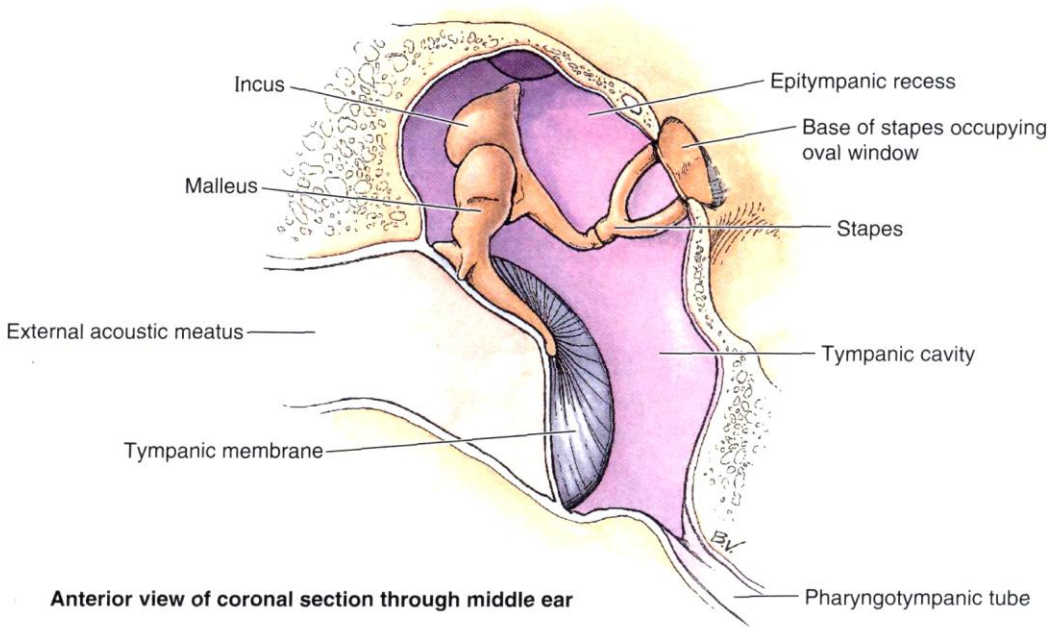
The chain of ossicles performs two *functions:* (1) the conduction of sound through the bones and (2) the mechanical transmission of sound vibrations to the fenestra cochlea. The latter function is accomplished by two small muscles connected with the auditory ossicles and located in the tympanic cavity; they regulate the movement of the chain of ossicles. One of them, the **tensor tympani muscle**, lies in the canal for the tensor tympany (semicanalis m. tensoris) constituting the upper part of the musculotubal canal of the temporal bone.



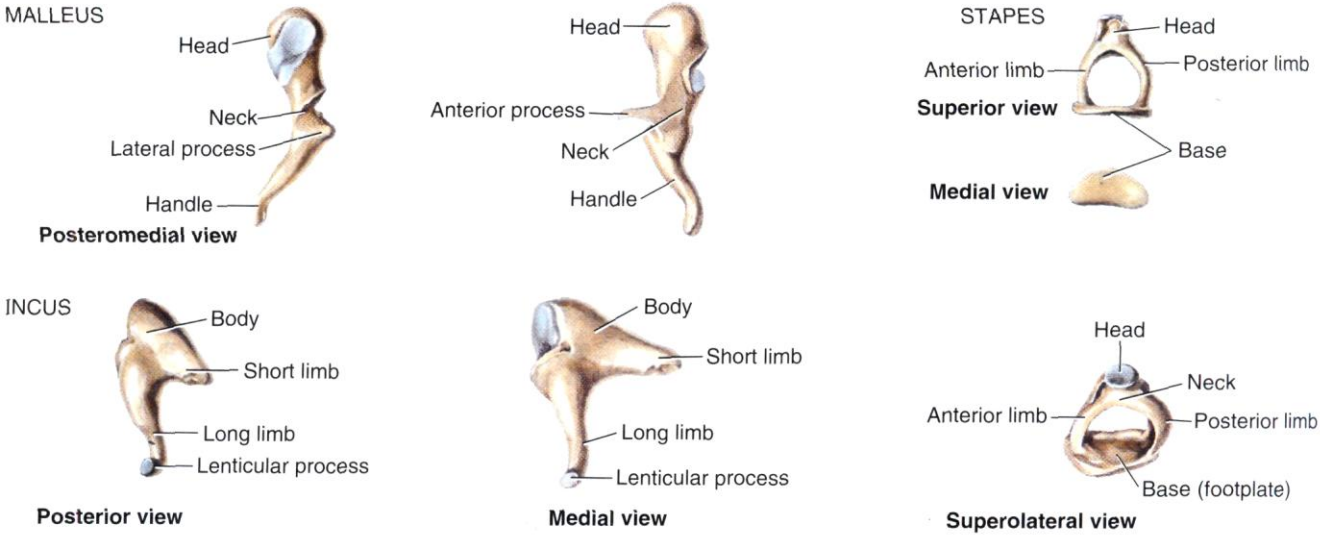
Superomedial view



Anterior view



Anterior view of coronal section through middle ear



The other muscle, the stapedius muscle, is lodged in the pyramid of the tympanum and fastened to the posterior limb of the stapes at the head. In function this muscle is an antagonist of the pre ceding one and accomplishes a reverse movement of the ossicle in the middle ear in the direction of the fenestra cochlea. The stapedius muscle is innervated from the facial nerve, which, passing nearby, sends small branch to the muscle.

The auditory, or Eustachian, or pharyngotympanic tube *(tuba auditiva [Eustachii])* which lends the name "eustachitis" to inflammation of the tube, lets the air pass from the pharynx into the tympanic cavity, thus equalizing the pressure in this cavity with the atmospheric pressure, which is essential for the proper conduction to the labyrinth of the vibrations of the tympanic membrane. The auditory tube consists of osseous and cartilaginous parts, which are joined with each other. At the site of their junction, called the isthmus of the tube (isthmus tubae), the canal of the tube is narrowest. The *bony part* of the tube, beginning with its tympanic opening *(ostium tympanicum tubae auditivae),* occupies the large inferior portion of the muscular-tube canal (semicanalis tubae auditivae) of the temporal bone. The *cartilaginous part*, which is a continuation of the bony part, is formed of elastic cartilage.

THE INTERNAL EAR

The **internal ear**, or the **labyrinth**, is located in the depth of the pyramid of the temporal bone between the tympanic cavity and the internal auditory meatus, through which the auditory nerve emerges from the labyrinth.

Osseous labyrinth consists of cochlea, vestibulum and semicircular canals.

Vestibulum represents by cavity, its lateral wall carries vestibular and cochlear fenestrae (windows). *Vestibular (oval) fenestra* containes a base of stapes, and a *cochlear (round)* window is closed by the secondary tympanic membrane. There are 5 foramens of the semicircle canals in posterior wall of vestibulum, anterior wall has a big foramen conducting into cochlear canal. Crest of internal wall separates a *spherical recess* from *elliptic recess.* Internal foramen of vestibular canalicule opens in elliptic recess.

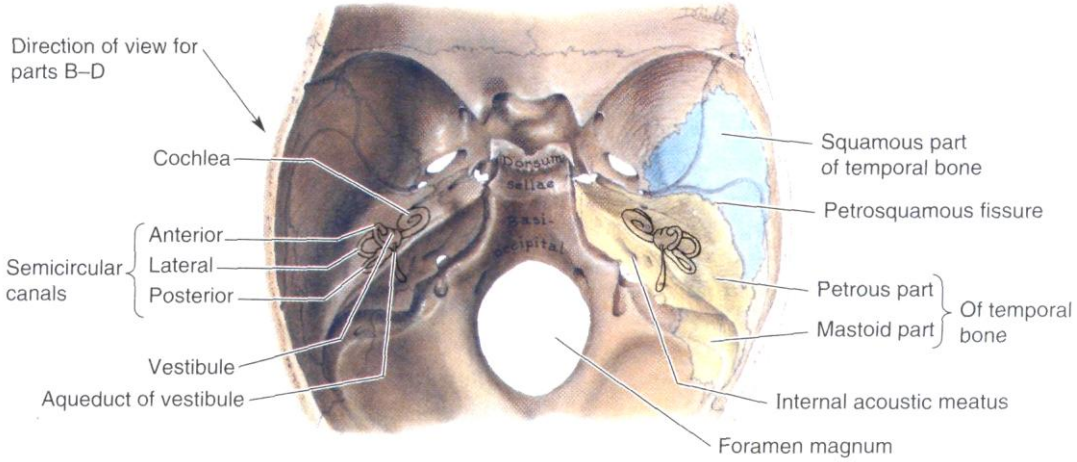
Osseous **semicircular canals** represented by three arched tubes lying in three mutually perpendicular planes. There are *anterior, posterior and lateral* semicircular canals. Each semicircular canal has broadened part in its base anterior, posterior and lateral osseous *ampule.* Semicircle canals join the vestibulum by the medium of osseous legs. Those legs containing ampule are called ampular legs. The legs of the anterior and posterior semicircular canal fuse together into one. As result the semicircle osseous canals unite with vestibulum by five foramina.

Cochlea lies anteriorly from vestibulum, represented by osseous tube forming two and half turns round cochlear axis *(modiolus).* There is osseous *spiral plate* inside the cochlea, apex of the cochlea called **cupula.** In cochlear base internal foramen of cochlear canaliculi is found.

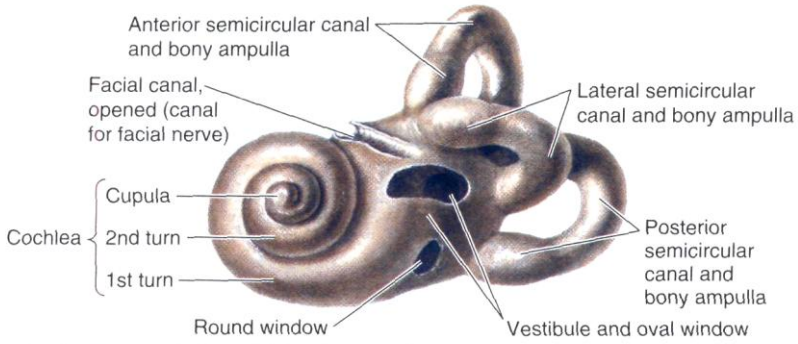
Membranouse labyrinth in vestibulum consists of **utriculus** and **sacculus.** Utriculus lies in elliptic recess of osseous labyrinth and connects with semicircular ducts, and a sacculus lies in spherical recess of osseous labyrinth and connects with cochlear duct by communicating duct. Utriculus and saccule communicate each other by the medium of utriculosaccular duct. From last endolymphatic duct starts that passes in vestibular canalicule. Endolymphatic duct passing from external foramen of vestibular canaliculus on posterior surface of pyramid of temporal bone, reaches endolymphatic sacculus placed under cerebral dura mater.

` Semicircular ducts are inserted in osseous semicircular canals. So there are *anterior, posterior and lateral semicircular ducts.* They carry anterior, posterior and lateral membranous ampulae. Receptors of balance of rotating located in *cristae ampullares.* Receptors of balance located in *static maculae* in utriculus and sacculus.

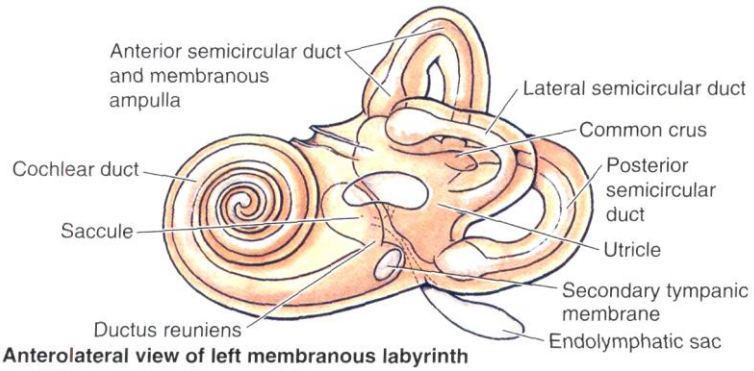
Cochlear duct positioned in spiral canal and starts from vestibular osseous labyrinth and finishes in blind end. On transversal cut a cochlear duct has triangle shape and enclosed by external, superior and inferior walls. External wall fused together with periosteum of spiral canal; an inferior wall is a tympanic wall, it supplementes the spiral plate; superior wall is vestibular wall. Cochlear duct occupies middle part of osseous spiral canal and separates *tympanic scala* from *vestibular scala.* Spiral organ (Corti) localised in cochlear duct on spiral membrane, which belongs to peripheral part of auditory analyser. **Sound** waves are received by tympanic membrane from *auricle* and *external acoustic meatus.* Oscillation of *tympanic membrane* is transfered to auditory ossicles - *malleus, incus* and *stapes.* Base of stapes, which covers a window of vestibula, begins oscillates *the perilymph.* Oscillation passes through *vestibular scala, helicotrema* and *tympanic scala.* Then *vestibular wall* starts to vibrate. Last forces the oscillation of the *endolymph* in cochlear duct. This vibration is received by sensory *haircells* of spiral (Korti) organ.



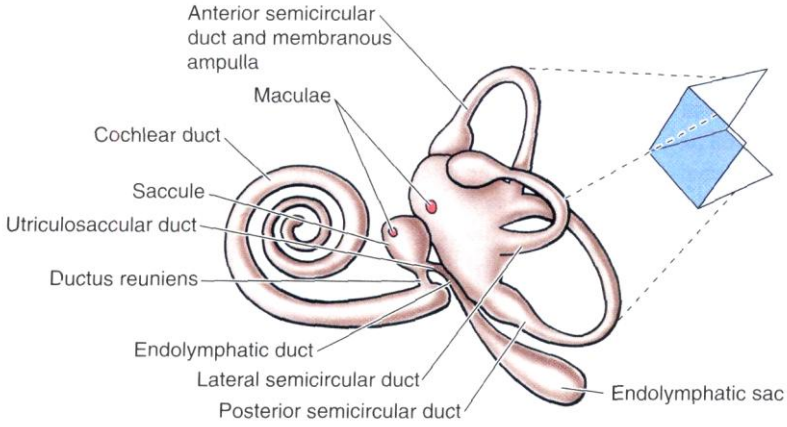
Superior view of internal surface of cranial base



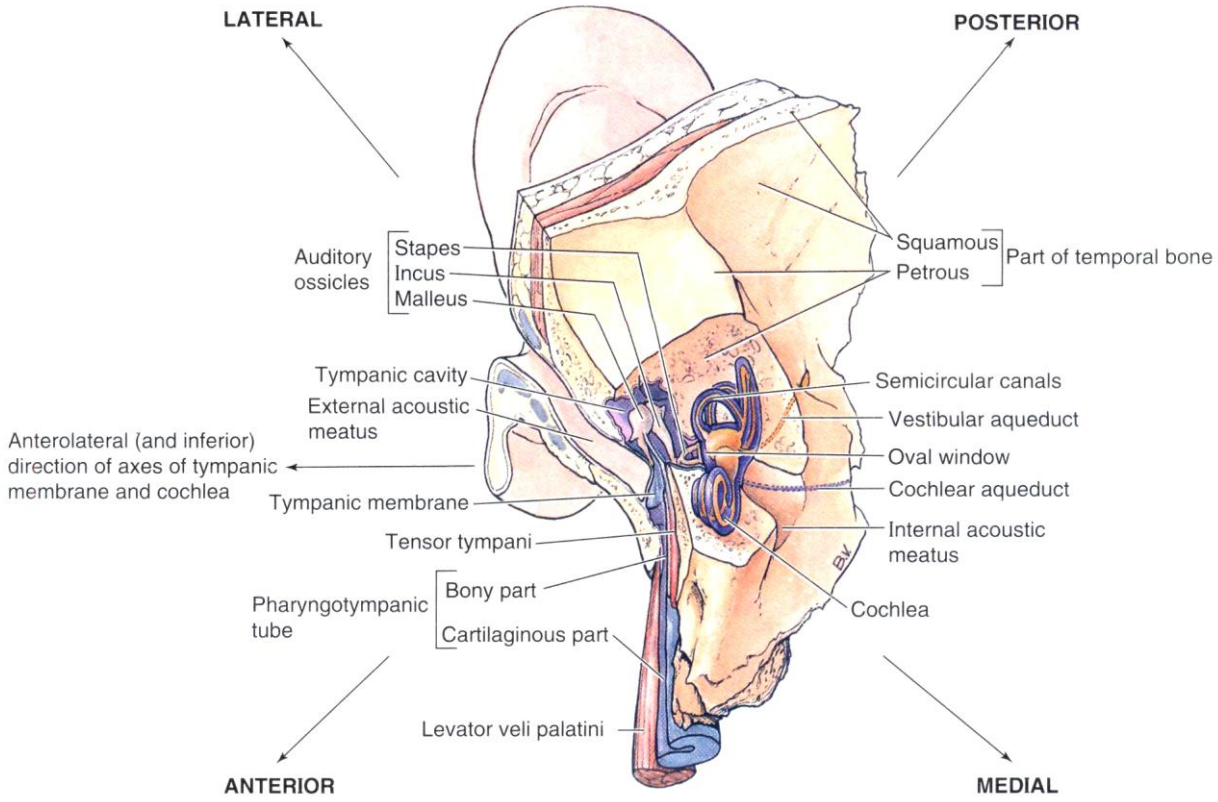
Anterolateral view of left otic capsule



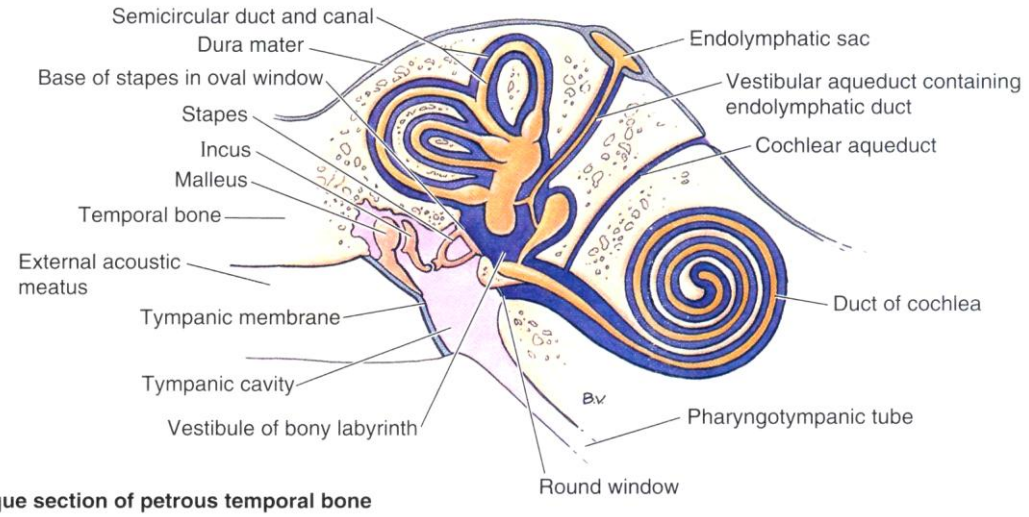
Anterolateral view of left membranous labyrinth (through transparent otic capsule)



Anterolateral view of left membranous labyrinth



Superomedial view

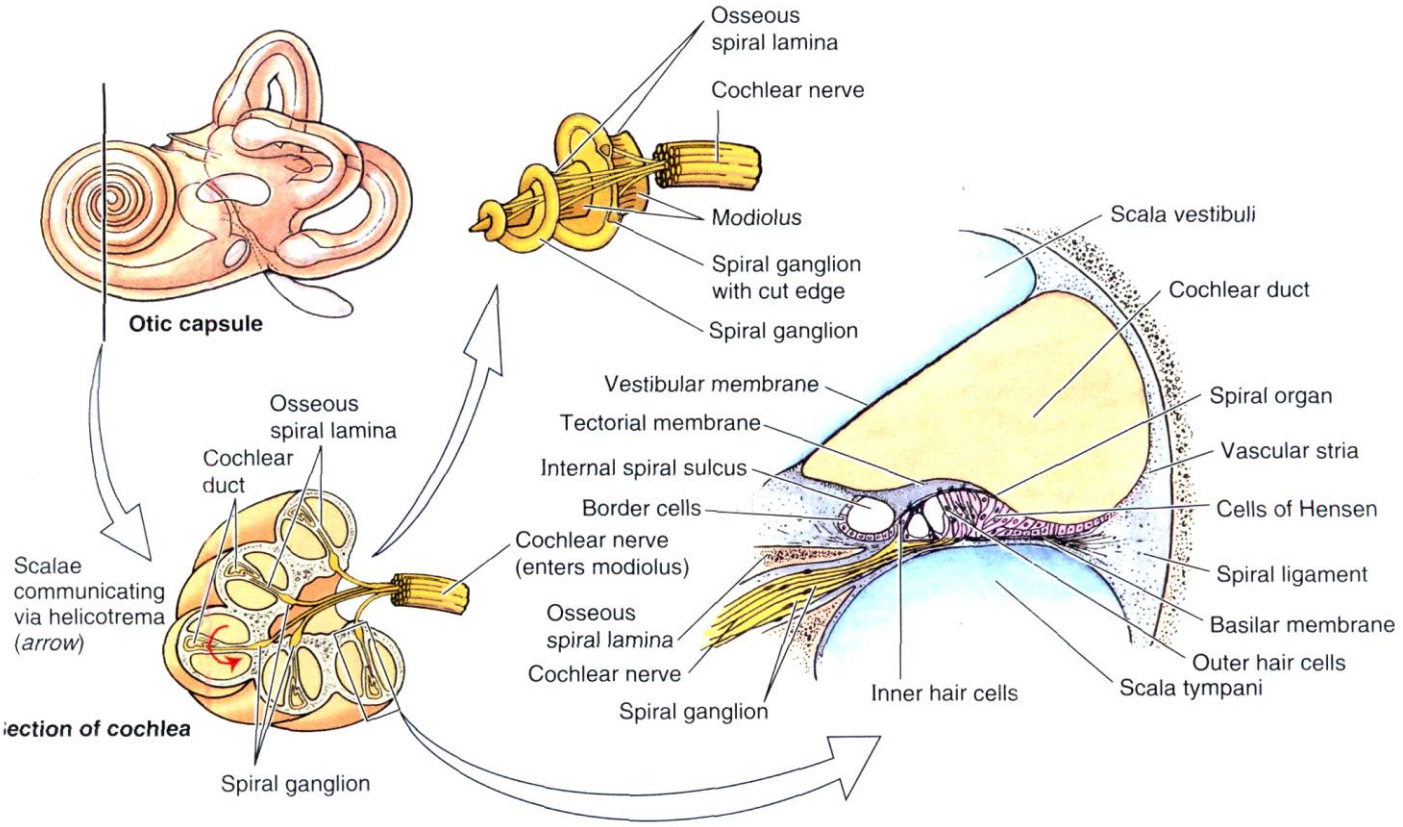


Oblique section of petrous temporal bone

THE AUDITORY (8th) NERVE

The auditory nerve *(n. vestibulocochlearis* s. *statoacusticus*, BNA), an efferent nerve which separated away from the facial nerve, contains somatic-sensory fibres running from the organ of hearing and balance . It consists of two parts—the vestibular nerve *{pars vestibularis)* and lie cochlear nerve *(pars cochlearis),* which differ in their functions: the vestibular nerve conducts impulses from the static apparatus laid out in the vestibule and the semicircular canals of the labyrinth of the internal ear, rhile the cochlear nerve conducts acoustic impulses from the organ of Corti *a* the cochlea which receives acoustic stimuli.

Since these are all sensory nerves, each of them has its own nerve ganglion containing bipolar nerve cells. The ganglion of the vestibular nerve ailed the *vestibular ganglion (ganglion vestibulare)* lies on the floor of the internal acoustic meatus, while the ganglion of the cochlear nerve, *spiral g'anglion of the cochlea (ganglion spirale)* is located in the cochlea.



The peripheral processes of the bipolar cells of the ganglia terminate in the receptors of the above mentioned parts of the labyrinth; this will be discussed in detail in the chapter on sensory organs . The central processes that emerge from the internal ear through the porus acusticus internus pass as components of the corresponding part of the nerve to the brain. They enter it lateral to the facial nerve reaching their nuclei: the vestibular nerve—four nuclei and the cochlear nerve two nuclei.

The anterior part of the membranous labyrinth, the **duct of the cochlea,** *(ductus cocklearis),* enclosed in the bony cochlea, is the most vital component of the **organ of hearing**. The duct of the cochlea begins with a blind end in the cochlear recess of the vestibule somewhat posteriorly of the ductus reuniens that connects the duct with the saccule. Then it passes along the entire spiral canal of the bony cochlea and ends blindly at its apex. On cross section the duct of the cochlea is triangular in shape . One of its three walls is fused with the external wall of the bony canal of the cochlea; another wall, termed the *spiral membrane (membrana spiralis),* is a continuation of the osse ous spiral lamina which stretches between the free edge of the latter and the outer wall. The third, a very thin wall of the duct of the cochlea *(paries vestibularis ductus cochlearis)* stretches obliquely from the spiral lamina to the outer wall.

The basilar membrane (membrana spiralis) encloses the basilar lamina which carries the apparatus appreciating sounds: the organ of Corti, or the spiral organ. The duct of the cochlea separates the scala vestibuli from the scala tympani except for a place in the dome of the cochlea where they communicate through an opening called *helicotrema.* Scala vestibuli communicates with the perilymphatic space of the vestibule and scala tympani ends blindly at the fenestra cochlea.

OLFACTORY ORGAN

Olfactory receptors placed in *olfactory region* of nasal cavity (in superior nasal meatus). Receptors (1^{st} neuron) associated with epithelial supporting cells. The peripheral process of olfactory cells carry the olfactory cilia and the central process form 15-20 olfactory nerves **(1^{st} cranial nerve),** which pass through the foramens in cribriform plate and reach the *olfactory bulb.* The axons of 2^{d} neurons runs through the olfactory tract terminate in *olfactory triangle and anterior perforating substance,* where the bodies of the 3^{d} neurons lie. Axons of the 3^{d} neurons get the *uncus* and other part of *limbic system,* which is cortical olfactory analyser.

TASTE ORGAN

In man gustatory buds (2000 in number) are situated in mucous membrane of the *tongue,* palatine, pharynx, epiglottis. Most of gustatory buds localised in vallatae,foliatae and fungiform papillae of the tongue. In front 2/3 part of tongue tasting impulses are perceived by fibres of chorda tympani (intermediate nerve), in back 1/3 portion of tongue - by glossopharyngeal ne*rve,* in lingual root and epiglottis by fibres of *vagus, nerve.*

The central process of first neurons, that are situated in mouth cavity, pass in composition of VII, IX, X cranial nerves to tasting sensory nucleus that positioned in medulla oblongata - nucleus tractus solitarius. Axons of second neurons run to the *thalamus,* where the third neuron is situated. Axons of third neurons terminate in *uncus* (cortex of cerebrum), where is situated a cortical taste analyzer.

THE PERIPHERAL PART OF THE NERVOUS SYSTEM
ANIMAL, OR SOMATIC, NERVES

The nerve trunks are divided according to the place where they branch off from the central nervous system: the spinal nerves (nn. spinales) branch off from the spinal cord while the cranial nerves (nn. craniales) arise from the brain.

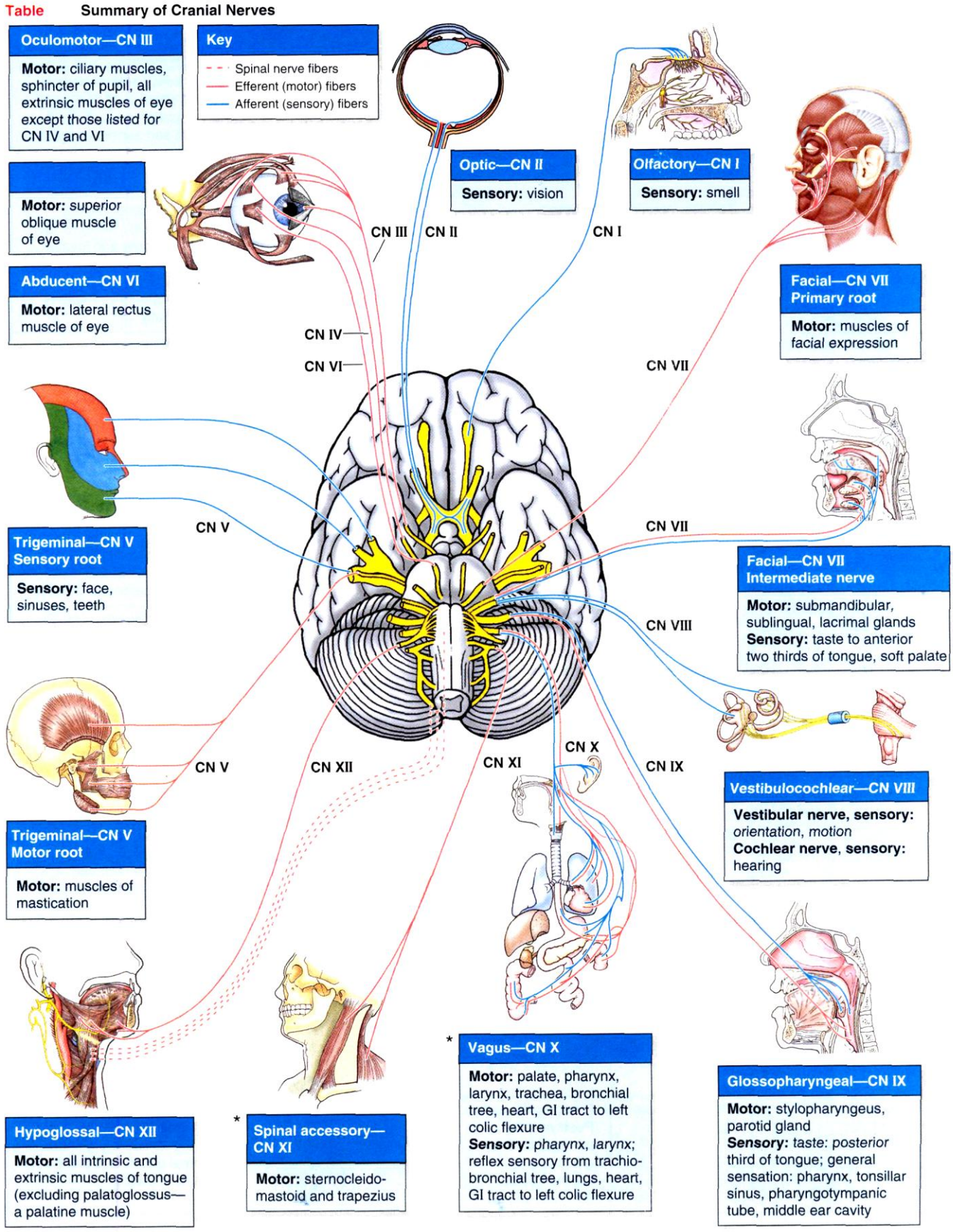
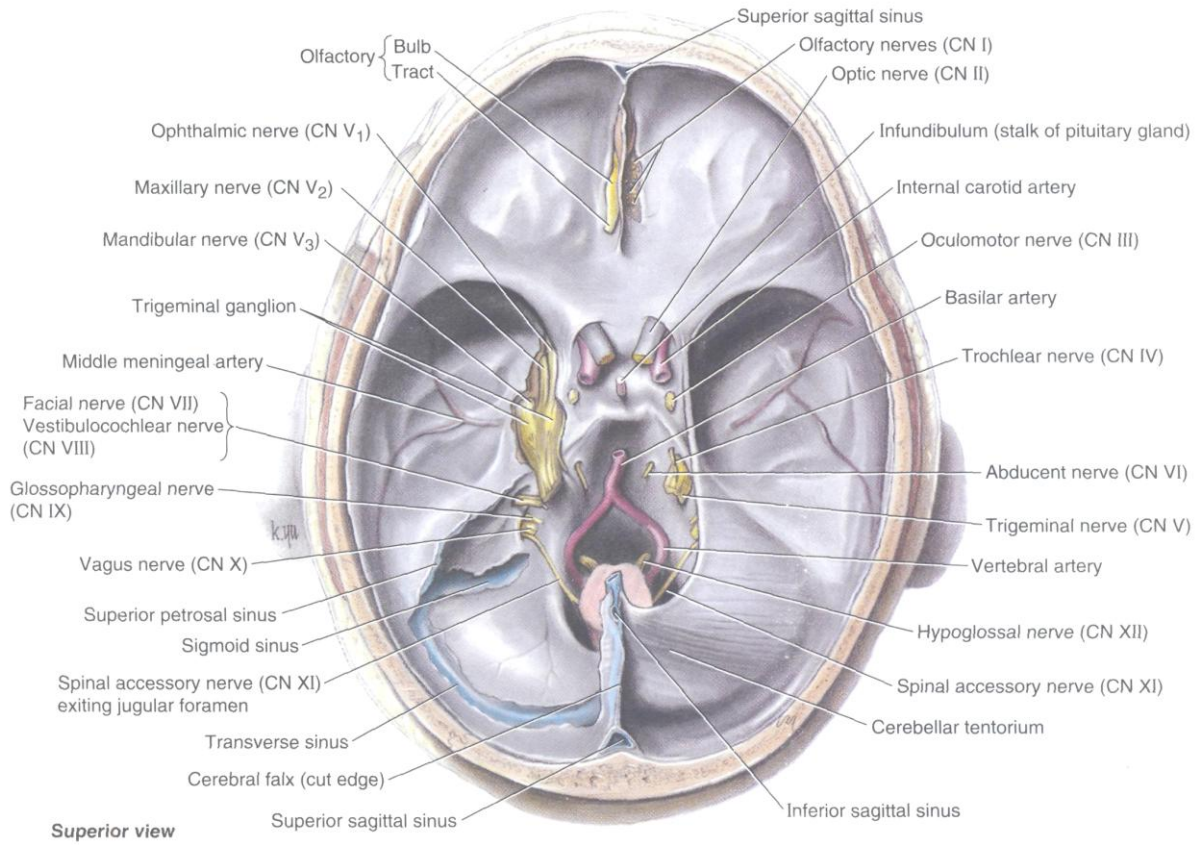


Table **Cranial Nerves: Attachment to Central Nervous System, General Functions, and Distributiona (*continued*)**

Cranial Nerves		Part of Central Nervous System Nerve(s) Enter(s) or Emerge(s) From		General Functional Types of Fibers[b]		General Distribution
Number	Name					
V	Trigeminal	Brainstem	Pons (mesencephalon)	Mixed	Motor root	Derivative of fronto-nasal process and 1st pharyn-geal arch
					Sensory root	
VI	Abducent		*Junction between* pons and medulla	Motor only		One ex-traocular muscle
VII	Facial			Mixed	Motor root	Derivatives of 2nd *pharyngeal* arch
					Intermediate nerve	
VIII	Vestibulocochlear			Special sensory only		Internal (inner) ear
IX	Glossopharyngeal		Medulla (myelencephalon)	Mixed		Derivatives of 3rd pharyngeal arch
X	Vagus[c]					Derivatives of 4th pha-ryngeal arch
XII	Hypoglossal					Muscles of tongue
XI	Spinal accessory[d]	Superior spinal cord		Motor only		Superficial layer of neck

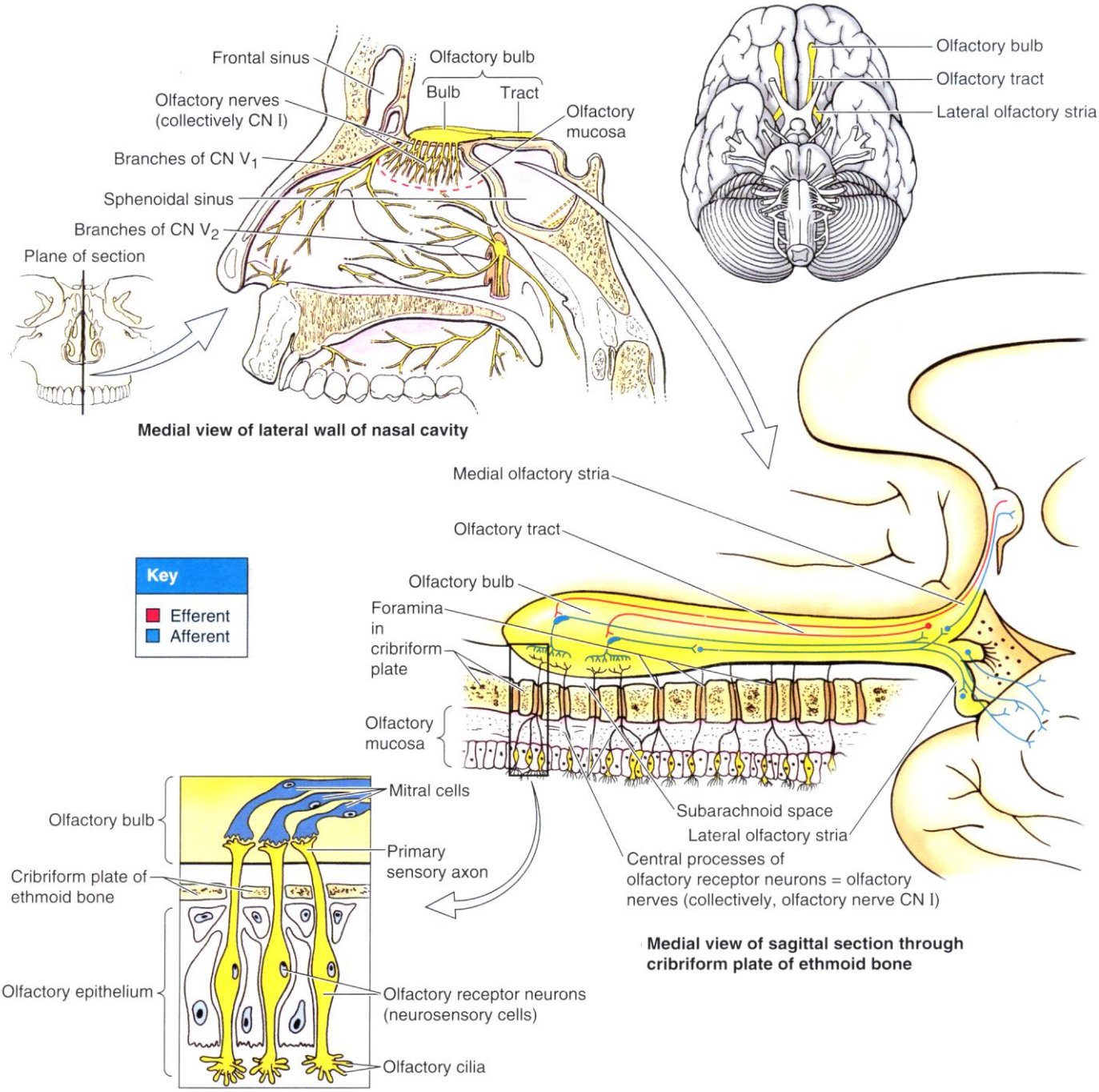
[a]The superficial origins of the cranial nerves from the central nervous system (except for CN IV, which arises from the posterior aspect of the midbrain).
[b]Note that the colors in this column match those of the nerves in the figure.
[c]The traditional "cranial root of the accessory nerve" is considered here as part of the vagus nerve.
[d]The spinal accessory nerve as listed here refers to only the traditional "spinal root of the accessory nerve."



Superior view

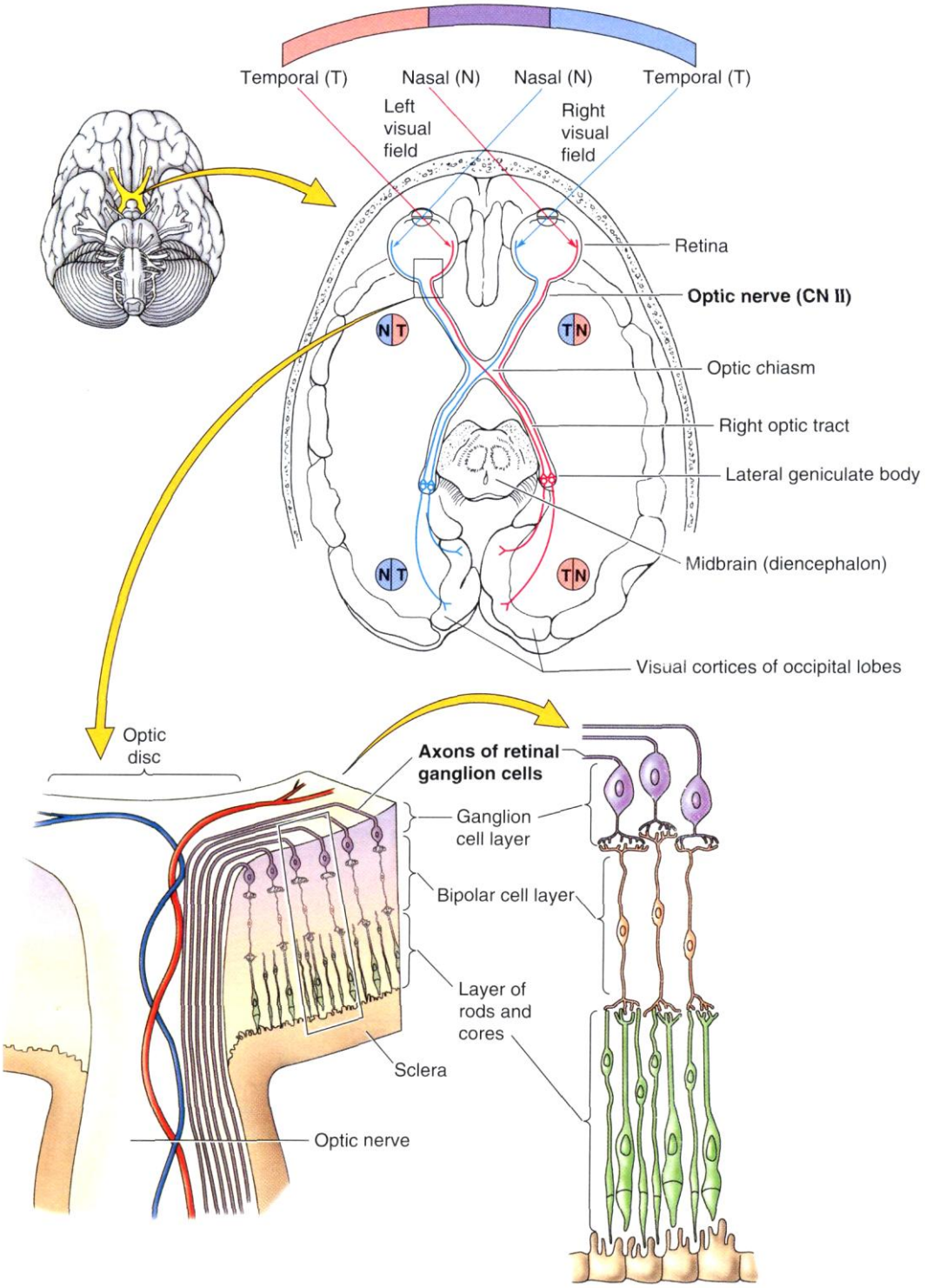
Olfactory nerve (I pair)

Olfactory receptors placed in *olfactory region* of nasal cavity (in superior nasal meatus). Receptors (1st neuron) associated with epithelial supporting cells. The peripheral process of olfactory cells carry the olfactory cilia and the central process form 15-20 olfactory nerves **(1st cranial nerve),** which pass through the foramens in cribriform plate and reach the *olfactory bulb.* The axons of 2d neurons runs through the olfactory tract terminate in *olfactory triangle and anterior perforating substance*, where the bodies of the 3d neurons lie. Axons of the 3d neurons get the *uncus* and other part of *limbic system*, which is cortical olfactory analyser.



Optic nerve (II pair)

Optic nerve is a part of visual analyser. Three neurons of visual tract are located in retina: *1* - photoreceptors rods and cones, *2* - bipolar cells and *3* - ganglionic (multipolar) cells. Axons of third neurons form the **Optic nerve (II),** which passes through the *optic canal* and get the cranial cavity. Medial fibres of the optic nerve pass to the opposite side and form the *optic chiasma.* Lateral fibres part do not cross each other and keep their own side. Then fibres of the optic nerve form *optic tract* wich get the *subcortical sight centres({lateral geniculate body* and *superior colliculus* of midbrain). Then 4^{th} neurons are located in pulvinar thalami. Their axons run through the posterior leg of *internal capsule* (visual radiation) and reach *cortical visual analyser* in calcarine sulcus (occipital lobe).



Axons of optic tract contact with cells in accessory oculomotor / parasympathetic/nucleus (Yakubovych-Edinger-Westphal's) by means of intermediate neuron. There are link for realising the ***pupillar reflex*** and ***accomodation.*** Axons of fifth neurons run in composition of oculomotor nerve get a *ciliary ganglion,* where sixth neurons positioned. Their axons pass with short ciliary nerves into eyeball and give innervating *for ciliary and sphincter pupillae muscles.* This reflex does not depend on our will and consciousness.

Oculomotor nerve (III pair)

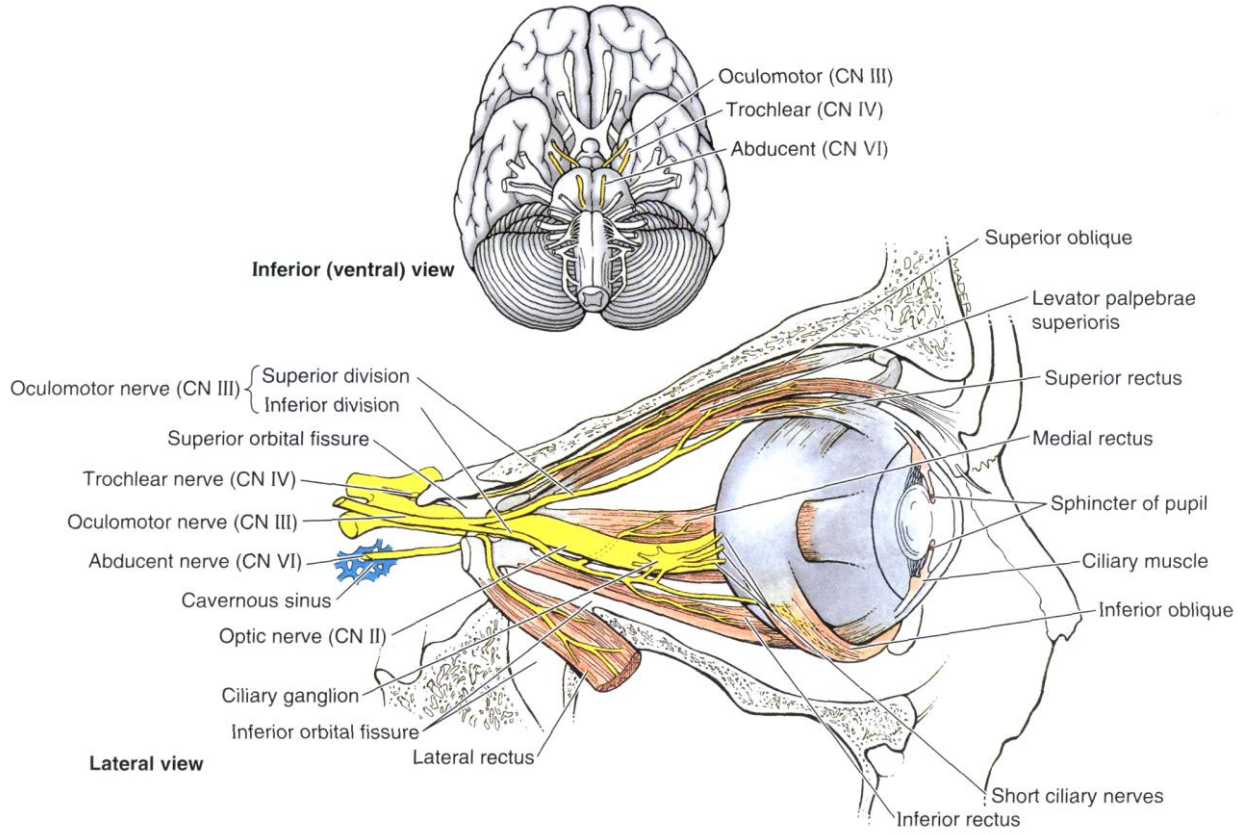
Fibres of oculomotor nerve starts from *motor* nucleus and *accessory* oculomotor /parasympathetic/ nucleus (Edinger-Westphal's). They are found in lamina tecti of midbrain (superior colliculus). Nerve exites from brain in interpeduncular fossa then it passes through the superior orbital fissura. Here it subdivides into *superior and inferior* branches. Nervous fibres from superior branch innervate superior rectus muscle and levator of superior eyelid. Motor fibres from inferior branch innervate inferior and medial rectus muscles and also inferior oblique_muscle. The parasympathetic fibres form *oculomotor radix* and reach the ciliary ganglion. The postganglionic parasympathetic fibres from ganglion pass in composition of short ciliary nerves to ciliary and sphincter pupillae muscles.

Trochlear nerve (IV pair)

Trochlear nerve has an own motor nucleus, which is disposed in quadrigeminal plate on level of inferior colliculus of midbrain. Their axons exite from brain from superior cerebral vellum, then pass laterally from lateral cerebral pedunculi and through the superior orbital fissura. Trochlear nerve supplies superior oblique_muscle.

Abducens nerve (VI pair)

Abducens nerve has a motor nucleus, which is disposed superficially in facial colliculus (rhomboid fossa). Axon exites from brain in fissure between pyramids of medulla oblongata and pons, and from skull - through the superior orbital fissura. Abducens nerve supplies lateral oblique muscle.

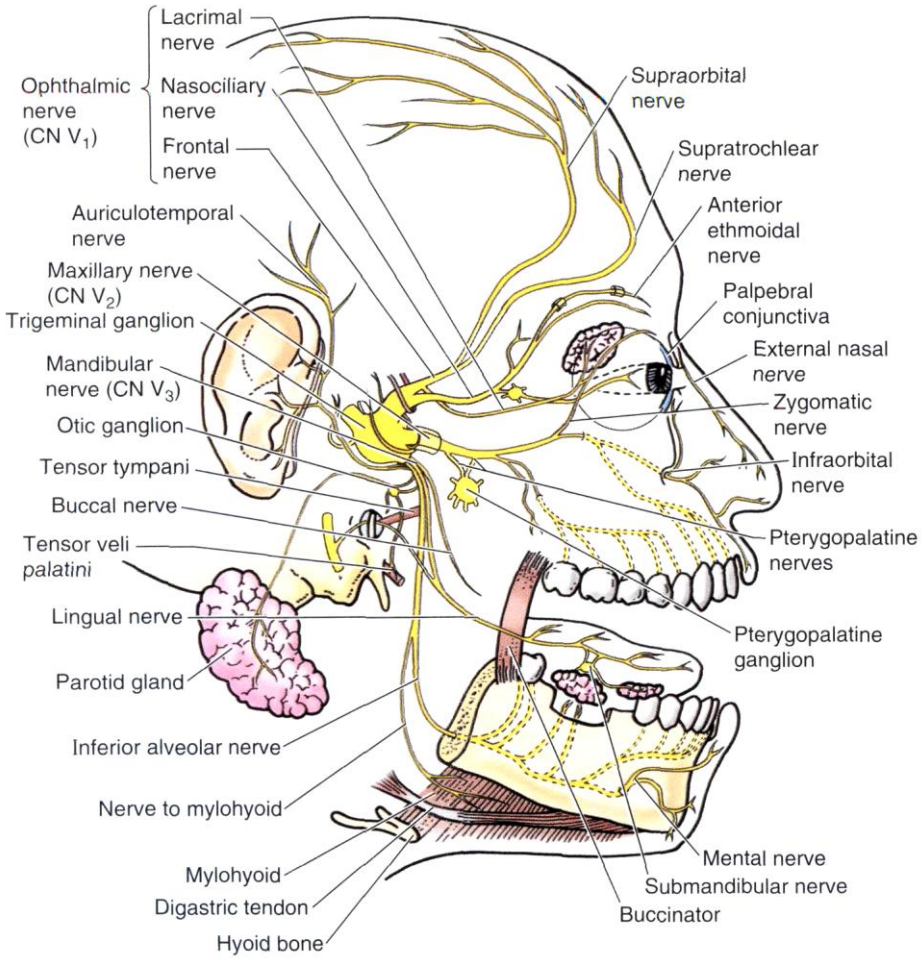


Trigeminal nerve (V)

Trigeminal nerve has one *motor* nucleus and *mesencephalic, pontine and spinal sensory* nuclei. They localised in pons (rhomboid fossa), mesencephalon and spinal cord. Nerve starts from brain by *sensory* rootlet and *motor* rootlet between pons and middle cerebellar pedunculi. Sensory rootlet represents by central process of sensory cells, which lie in *trigeminal ganglion* (Gasser's) on top of pyramid of temporal bone. This ganglion is contained in trigeminal cavity which is formed by dura mater. Motor rootlet represents by axons from motor cells (motor nucleus).

Trigeminal nerve passes from skull by three divisions:

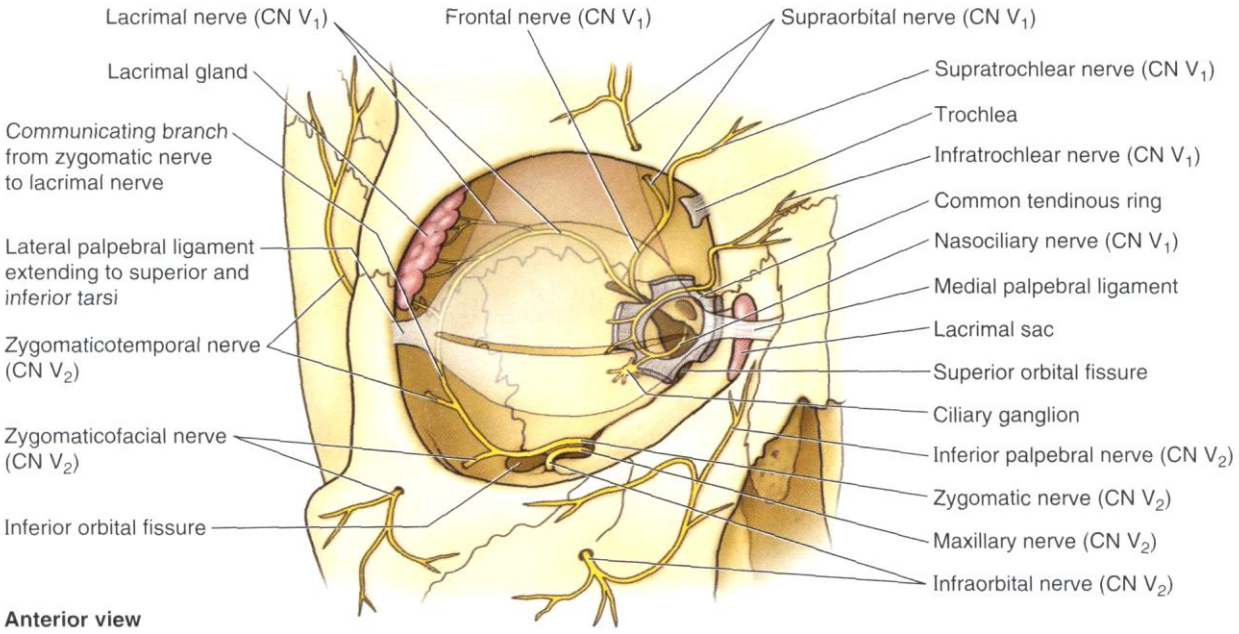
1. Ophthalmic nerve, sensory, exits from skull through the superior orbital fissura;
2. Maxillary nerve, sensory, exits from skull through the rotundum foramen;
3. Mandibular nerve, mixed (sensory, motor), exits from skull through the ovale foramen.



Ophthalmic nerve fossa subdivides in orbital into frontal nerve, lacrimal nerve and nasociliary nerve.

Nasociliary nerve passes on superomedial wall of orbit and innervates medial eye corner and nose. Sensory *long ciliary nerves* pass to the coats of the eyeball, *short ciliary nerves* pass through the ciliary ganglion and carry parasympathetic and sympathetic fibres for eyeball with all its tissues and muscles (sphincter pupillae, dilator pupillae and ciliary muscle). *Posterior and anterior ethmoidal* nerves pass through the posterior and anterior ethmoidal foramen. They innervate mucous membrane of ethmoidal cells (air sinus) and anterior part of nose cavity.

Frontal nerve passes on middle part of upper wall of orbite and passes on forehead skin over *supraorbital* and *frontal* notches by three branches, innervating forehead skin and top eyelid.



Lacrimal nerve passes on upper-lateral wall of the orbit, transfixes a lacrimal gland, innervating it. Passing out from gland, it innervates the skin of lateral eye corner. Postganglionic and parasympathetic fibres from pterygopalatine ganglion (which pass with zygomatic nerve) pass to lacrimal nerve and provide a secretory innervation of the lacrimal gland.

Maxillary nerve passes through the rotundum foramen and reaches the pterygopalatine fossa, where ramifies on three branches: infraorbital nerve, zygomatic nerve and ganglionic branches to pterygopalatine ganglion.

Infraorbital nerve passes through the inferior orbital fissura enters into orbite, where lies on its lower wall, passes in infraorbital fissura and infraorbital sulcus and canal. Nerve passes into canine fossa, forming *'pes anserinus minor'*. There are *inferior palpebral, external nasal* and *superior labial* nerves that innervate skin from medial eye corner to mouth corner. *Superior alveolar nerves (posterior, middle and inferior)* start from infraorbital nerve in maxilla (infraorbital canal.). They innervate mucous membrane of the maxillary sinus and form superior dental plexus. The last gives off the *superior dental nerves* and *superior gingival branches* of the upper jaw.

Zygomatic nerve passes through the inferior orbital fissura entering orbite. Then it passes into zygomaticoorbital foramen and divided into *zygomaticofacial* and *zygomaticotemporal* sensory branches for skin of face and temporal region. Zygomatic nerve carries postganglionic parasympathetic fibres from pterygopalatine ganglion and gives off them to lacrimal nerve. Parasympathetic fibres provide secretory innervation of the lacrimal gland.
The *ganglionic branches* start from maxillary nerve and pass to pterygopalatine ganglion. Postganglionic branches *include greater palatine* nerve and *lesser palatine* nerve that pass through the greater palatine canal and lesser palatine foramens, innervating mucous membrane of the hard and soft palatine. The *posterior nasal* (medial and lateral) nerves pass through the sphenopalatine foramen pass into nasal cavity, where innervate mucous membrane of the nasal cavity. *Nasopalatine* nerve starts from the nasal branches and reaches the mucous membrane of the hard palatine through the incisive canal. Postganglionic parasympathetic fibres from pterygopalatine ganglion are in composition of these nerves.

Mandibular nerve carries both the motor and sensory fibres. After passing out from ovale foramen mandibular nerve gives off the motor branches that innervate all 4 masticatory muscles, olso *velli palatine tensor* muscle and nerve *tensor of tympanic membrane muscle.* Sensory branches of the mandibular nerve: buccal nerve, auriculotemporal nerve, lingual nerve, inferior alveolar nerve and meningeal branches.

Buccal nerve transfixes a buccinator muscle and innervates mucous membrane of the cheek and also mouth corner skin.

Auriculotemporal nerve begins by two rootlets that envelop a middle meningeal artery, and then unite into one trunk, which transfixes parotid gland, innervating it and skin of temporal area, also, the auricle. Postganglionic parasympathetic fibres from **otic ganglion** pass in composition of this nerve, which provide a secretory innervation of parotid gland.

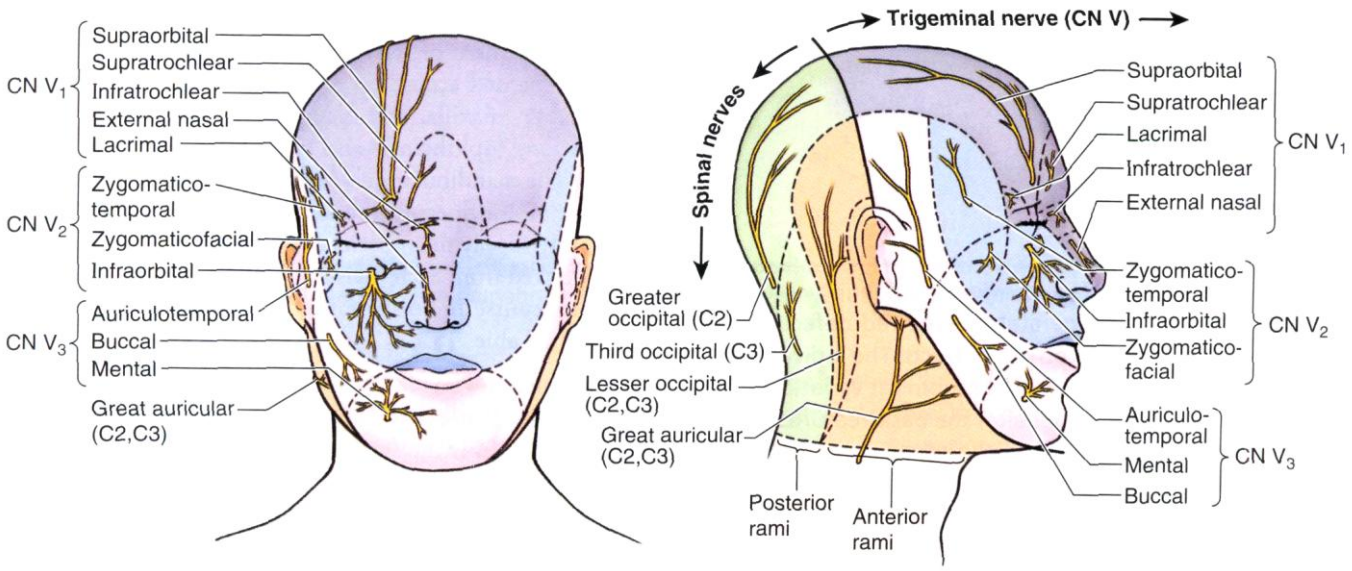
Lingual nerve passes on internal surface of lower jaw under mucous membrane of the mouth cavity and enters into lower part of tongue, providing a general sensory innervation of the anterior 2/3 part and sensory innervation sublingual and submandibular salivary glands.

Chorda tympani (from 7th cranial nerve), which contains the gustatory (tasting) and secretory (parasympathetic) fibres. Gustatory fibres innervate of tasting buds on mucous membrane of the anterior 2/3 part of the tongue, and secretory (parasympathetic) enter in to **submandibular** and sublingual parasympathetic **ganglia.** The postganglionic fibres from these ganglia provide a secretory innervation the same name - submandibular and sublingual salivary glands.

Inferior alveolar nerve (mixed) has a motor branches that supply *mylohyoid muscle* and anterior belly of the *digastric muscle.* The sensory fibres enter into mandibular channel, where form inferior dental plexus, branches innervate the *teeth and gums* of lower jaw. From canal these fibres are passing out from bone as a *mental nerve,* which terminates in skin of lower lip and chin.

Table **Summary of Divisions of Trigeminal Nerve (CN V)**

Divisions/Distributions	Branches
Ophthalmic nerve (CN V_1) Sensory only Passes through superior orbital fissure Supplies cornea, upper conjunctiva, mucosa of anterosuperior nasal cavity, frontal and ethmoidal sinuses, anterior and supratentorial dura mater, skin of dorsum of external nose, superior eyelid, forehead, and scalp	Tentorial nerve (a meningeal branch) Lacrimal nerve Communicating branch from zygomatic nerve Frontal nerve Supraorbital nerve Supratrochlear nerve Nasociliary nerve Sensory root of ciliary ganglion Short ciliary nerves Long ciliary nerves Infratrochlear nerves Anterior and posterior ethmoidal nerves
Maxillary nerve (CN V_2) Sensory only Passes through foramen rotundum Supplies dura mater of anterior part of middle cranial fossa; conjunctiva of inferior eyelid; mucosa of posteroinferior nasal cavity, maxillary sinus, palate and anterior part of superior oral vestibule; maxillary teeth; and skin of lateral external nose, inferior eyelid, anterior cheek, and upper lip	Meningeal branch Zygomatic nerve Zygomaticofacial branch Zygomaticotemporal branch Communicating branch to lacrimal nerve Ganglionic branches to (sensory root of) pterygopalatine ganglion Posterior superior alveolar branches Infraorbital nerve Anterior and middle superior alveolar branches Superior labial branches Inferior palpebral branches External nasal branches Greater palatine nerves Posterior inferior lateral nasal nerves Lesser palatine nerves Posterior superior lateral nasal branches Nasopalatine nerve Pharyngeal nerve
Mandibular nerve (CN V_3) Sensory and motor Passes through foramen ovale Supplies sensory innervation to mucosa of anterior two thirds of tongue, floor of mouth, and posterior and anterior inferior oral vestibule; mandibular teeth; and skin of lower lip, buccal, parotid, and temporal regions of face; and external ear (auricle, upper external auditory meatus, and tympanic membrane)	General sensory branches Meningeal branch (nervus spinosum) Buccal nerve Auriculotemporal nerve Lingual nerve Inferior alveolar nerve Nerve to mylohyoid Inferior dental plexus Mental nerve Branchiomotor branches Masseter Temporal Medial and lateral pterygoids Mylohyoid Anterior belly of digastric Tensor tympani



Anterior view **Lateral view**

Table Cutaneous Nerves of the Face and Scalp

Nerve	Origin	Course	Distribution
Cutaneous nerves derived from ophthalmic nerve (CN V_1)			
Supraorbital	Largest branch from bifurcation of *frontal nerve,* approximately in middle of orbital roof	Continues anteriorly along roof of orbit, emerging via supraorbital notch or foramen; ascends forehead, breaking into branches	Mucosa of *frontal sinus;* skin and conjunctiva of middle of *superior eyelid;* skin and pericranium of *anterolateral forehead and scalp* to vertex (interauricular line)
Supratrochlear	Smaller branch from bifurcation of *frontal nerve,* approximately in middle of orbital roof	Continues anteromedially along roof of orbit, passing lateral to trochlea and ascending forehead	Skin and conjunctive of medial aspect of *superior eyelid;* skin and pericranium of *anteromedial forehead*
Lacrimal	Smallest branch from trifurcation of *CN V_1* proximal to superior orbital fissure	Runs superolaterally through orbit, receiving secretomotor fibers via a communicating branch from the zygomaticotemporal nerve	*Lacrimal gland* (secretomotor fibers); small area of skin and conjunctiva of *lateral part of superior eyelid*
Infratrochlear	Terminal branch (with anterior ethmoidal nerve) of *nasociliary nerve*	Follows medial wall of orbit, passing inferior to trochlea	Skin lateral to *root of nose;* skin and conjunctiva of *eyelids adjacent to medial canthus, lacrimal sac,* and *lacrimal caruncle*
External nasal	Terminal branch of *anterior ethmoidal nerve*	Emerges from nasal cavity by passing between nasal bone and lateral nasal cartilage	Skin of nasal *ala, vestibule, and dorsum of nose,* including *apex*
Cutaneous nerves derived from maxillary nerve (CN V_2)			
Infraorbital	Continuation of *CN V_2* distal to its entrance into the orbit via the inferior orbital fissure	Traverses infraorbital groove and canal in orbital floor, giving rise to superior alveolar branches; then emerges via infraorbital foramen, immediately dividing into inferior palpebral, internal and external nasal, and superior labial branches	Mucosa of *maxillary sinus;* premolar, canine, and incisor *maxillary teeth;* skin and conjunctiva of *inferior eyelid;* skin of *cheek, lateral nose,* and anteroinferior *nasal septum;* skin and oral mucosa of *superior lip*

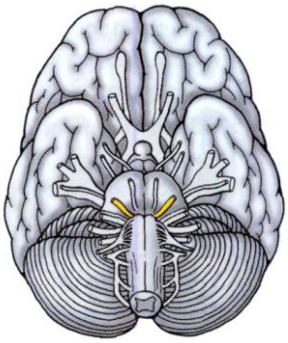
Table **Cutaneous Nerves of the Face and Scalp *(continued)***

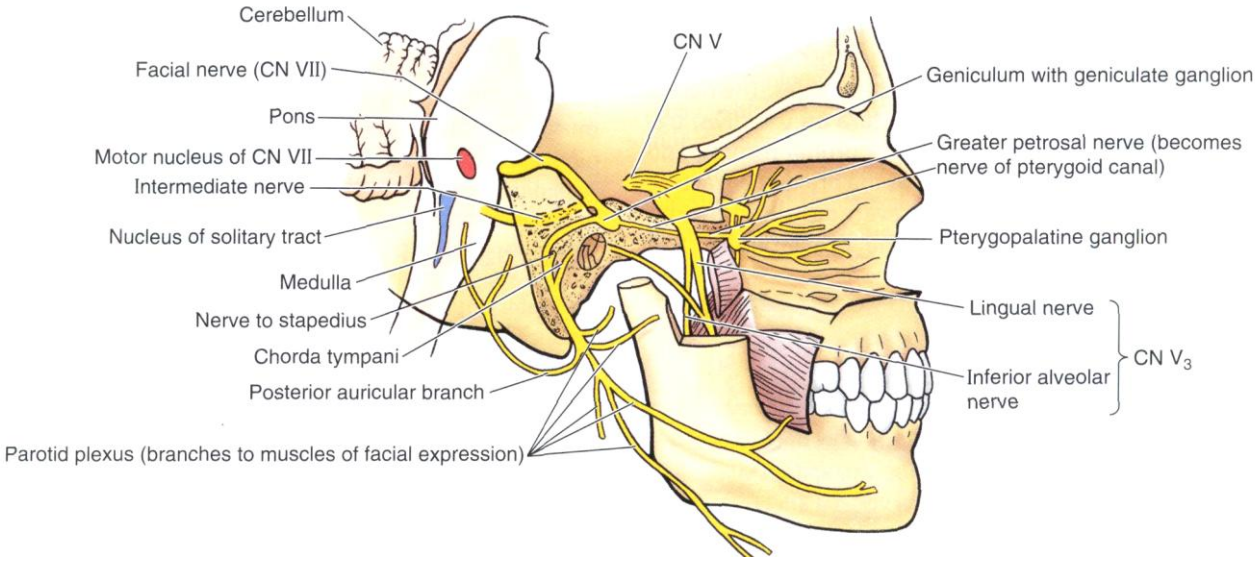
Nerve	Origin	Course	Distribution
Zygomaticofacial	Smaller terminal branch (with zygomaticotemporal nerve) of *zygomatic nerve*	Traverses zygomaticofacial canal in zygomatic bone at inferolateral angle of orbit	Skin on prominence of *cheek*
Zygomaticotemporal	Larger terminal branch (with zygomaticofacial nerve) of *zygomatic nerve*	Sends communicating branch to lacrimal nerve in orbit; then passes to temporal fossa via zygomaticotemporal canal in zygomatic bone	Hairless skin *anterior part of temporal fossa*
Cutaneous nerves derived from mandibular nerve (CN V_3)			
Auriculotemporal	In infratemporal fossa via two roots from *posterior trunk of CN V_3* that encircle middle meningeal artery	Passes posteriorly deep to ramus of mandible and superior deep part of parotid gland, emerging posterior to temporomandibular joint	Skin anterior to auricle and posterior two thirds of *temporal region;* skin of tragus and adjacent helix of *auricle;* skin of roof of *external acoustic meatus;* and skin of superior *tympanic membrane*
Buccal	In infratemporal fossa as sensory branch of *anterior trunk of CN V_3*	Passes between two parts of lateral pterygoid muscle, emerging anteriorly from cover of ramus of mandible and masseter, uniting with buccal branches of facial nerve	Skin and oral mucosa of *cheek* (overlying and deep to anterior part of buccinator); *buccal gingivae* (gums) adjacent to second and third molars
Mental	Terminal branch of *inferior alveolar nerve* (CN V_3)	Emerges from mandibular canal via mental foramen in anterolateral aspect of body of mandible	Skin of *chin* and skin; oral mucosa of *inferior lip*
Cutaneous nerves derived from anterior rami of cervical spinal nerves			
Greater auricular	Spinal nerves C2 and C3 via cervical plexus	Ascends vertically across sternocleidomastoid, posterior to external jugular vein	Skin overlying angle of mandible and inferior lobe of auricle; parotid sheath
Lesser occipital		Follows posterior border of sternocleidomastoid; then ascends posterior to auricle	Scalp posterior to auricle
Cutaneous nerves derived from posterior rami of cervical spinal nerves			
Greater occipital nerve	As medial branch of posterior ramus of spinal nerve C2	Emerges between axis and obliquus capitis inferior; then pierces trapezius	Scalp of occipital region
Third occipital nerve	As lateral branch of posterior ramus of spinal nerve C3	Pierces trapezius	Scalp of lower occipital and suboccipital regions

Facial nerve (VII pair)

Facial nerve consists of: *1- proper facial nerve,* which has fibers starting from motor nucleus in depth of facial colliculus in rhomboid fossa, and *2- intermediate nerve,* which has a fibers of sensory nucleus of solitarius tract and parasympathetic - superior salivatory nucleus.

Facial nerve passes through facial canal, gives off motor branch for *stapedius muscle,* then exits from skull through the stylomastoid foramen and in*nervates posterior auricular, stylohyoid* muscles and posterior belly of *digastric* muscle.

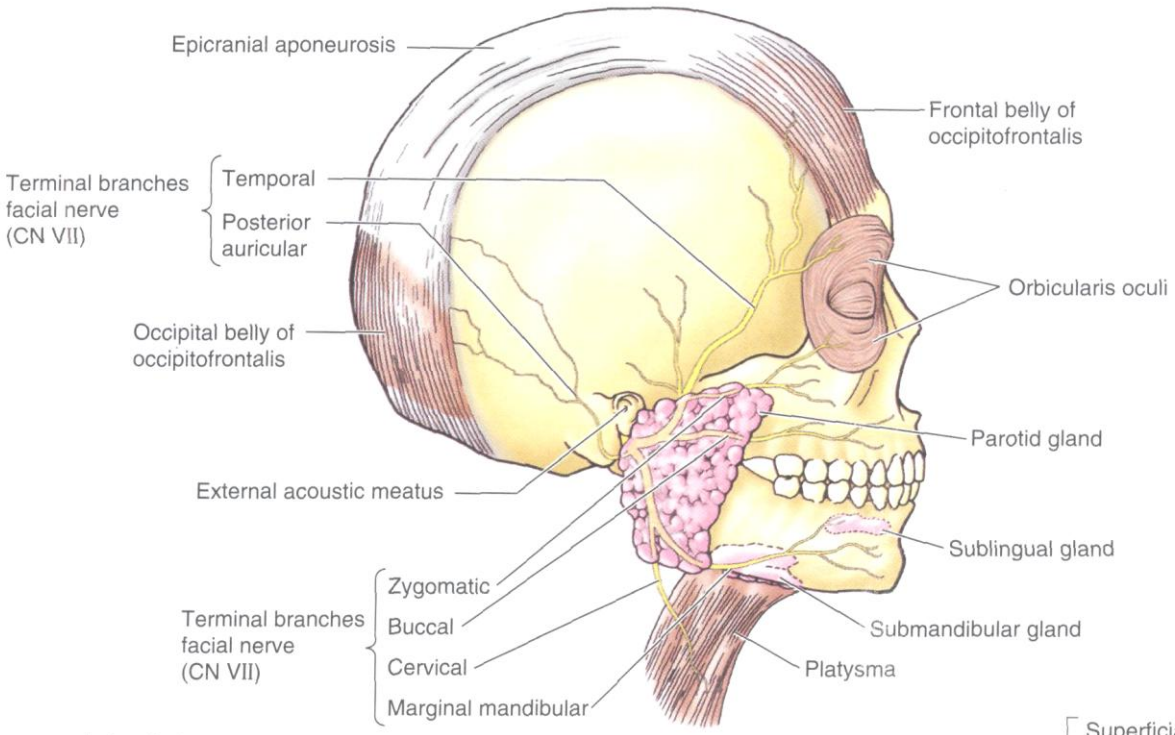




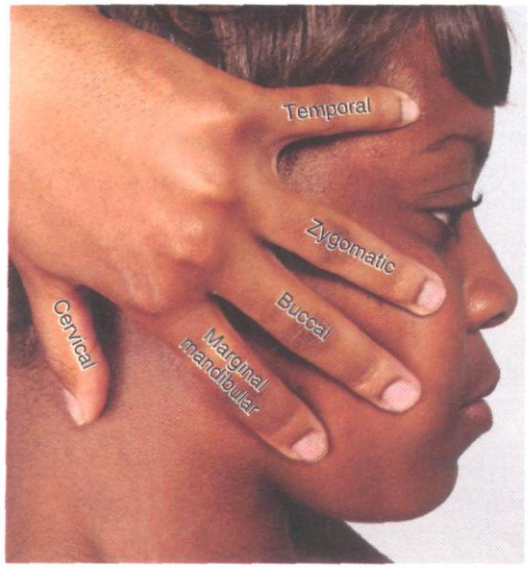
Facial nerve enters into thickness of parotid salivary glands (but does not innervate it!) and forms there parotid plexus. Last gives off the motor branches which innervate *expression (mimetic) muscles.* There are: temporal branches (supply auricular, orbicularis oculi and occipitofrontalis muscles), zygomatic branches (they supply zygomatic major and orbicularis oculi muscles), buccal branches (supply zygomatic major and minor, levator labii superioris, buccinator, orbicularis oris, nasalis, and risorius muscles), marginal mandibulae branch (supplies depressor anguli oris and depressor labii inferioris, mentalis muscles) and cervical branch (for the platisma).

Intermediate nerve has two divisions: Nervus petrosus major and Chorda tympani.

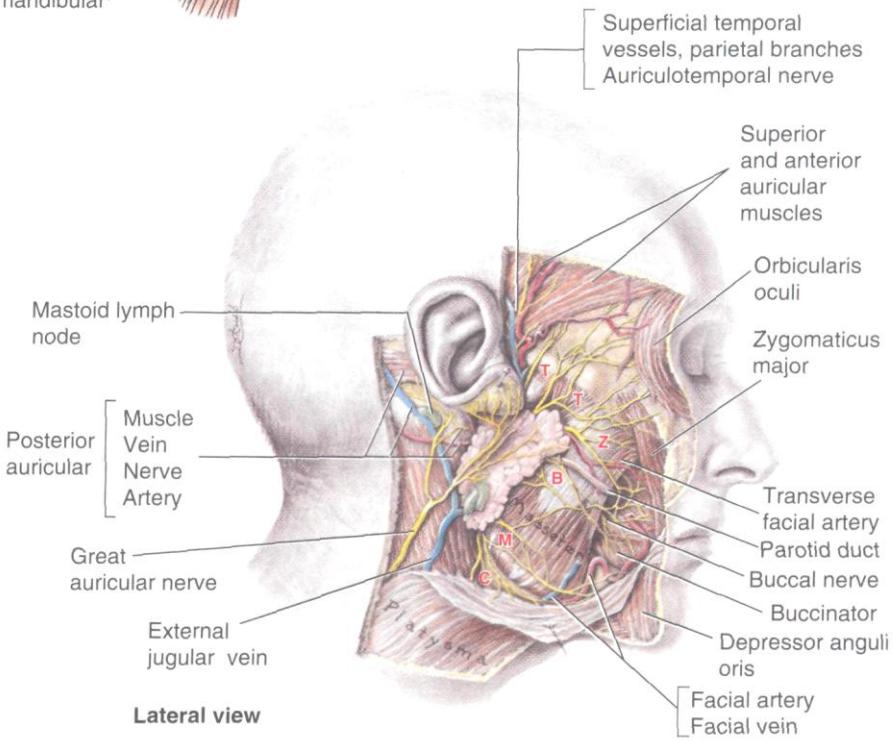
Greater petrosal nerve (preganglionic secretory fibers to the lacrimal glands, nasal glands and palatine glands) separates off from the geniculate ganglion, extends through the hiatus of the canal for the greater petrosal nerve, across the foramen lacerum and finally through the pterygoid canal to the *pterygopalatine ganglion.*



Lateral view



Lateral view



Lateral view

Chorda tympani carries preganglionic secretory fibers to the submandibular and sublingual glands and taste fibers to the anterior two third of the tongue. Taste (sensory) fibers contain peripheral axons of cells localized in geniculate ganglion. The central process of neurocytes of this ganglion terminate in nucleus of solitarius tract. Chorda tympani passes through the petrotympanic fissura and joints the *lingual nerve* (from the V^{th} cranial nerve), then its branches reach the tongue and *parasympathetic* submandibular and sublingual ganglia for innervating the same names salivary glands.

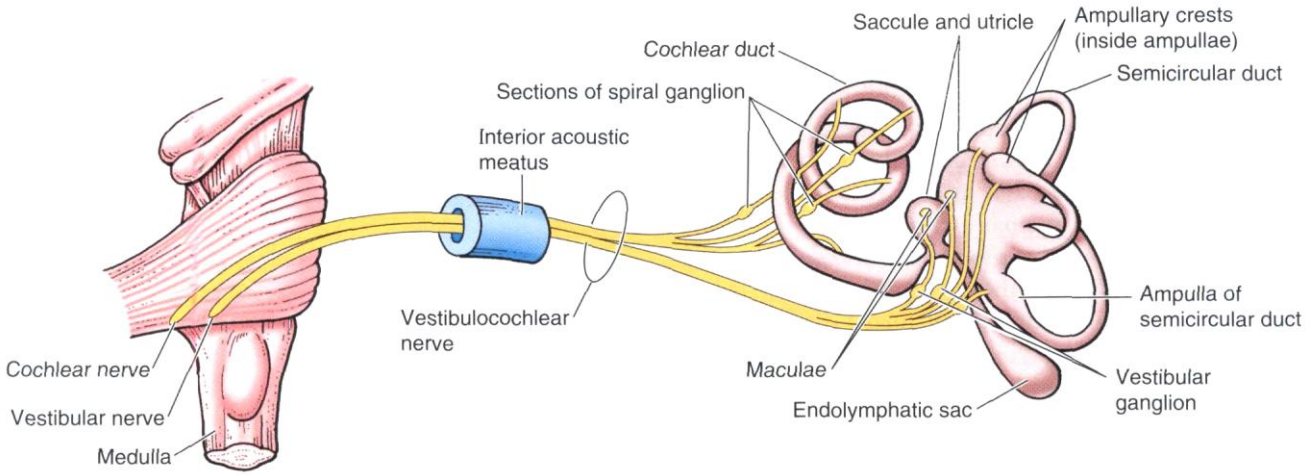
Vestibulo-cochlear nerve (VIII nerve)

1. Body of first neuron of auditory tract positioned in cochlear ganglion (spiral cochlear ganglion). The peripheral process of first neurons terminates in spiral organ and the central process neurons form **cochlear part of VIII cranial nerve.** It passes through the internal auditory meatus into cranial cavity, where terminates by synapse with second neuron.

2. The bodies of second neurons of cochlear nerve are found in anterior and posterior cochlear nucleus in lateral recess of rhomboid fossa. Axons of second neurons form fascicles having a name *trapezoid body.* These fibres terminate partly in superior olivar nucleus. One from posterior cochlear nucleus form *striae medullaris* of fourth ventricle.

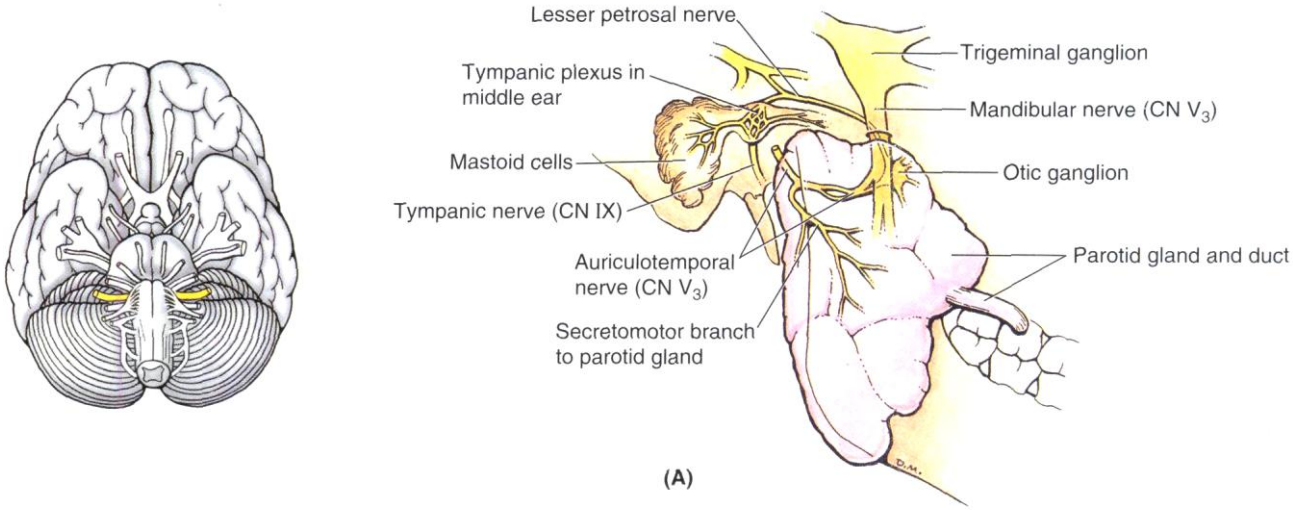
3. The third neuron of auditory tract positioned in superior olivar nucleus. Their axons a lateral lemniscus, which runs through the isthmus of rhombencephalon (triangle of lemniscus) and reach the subcortical hearing centres.

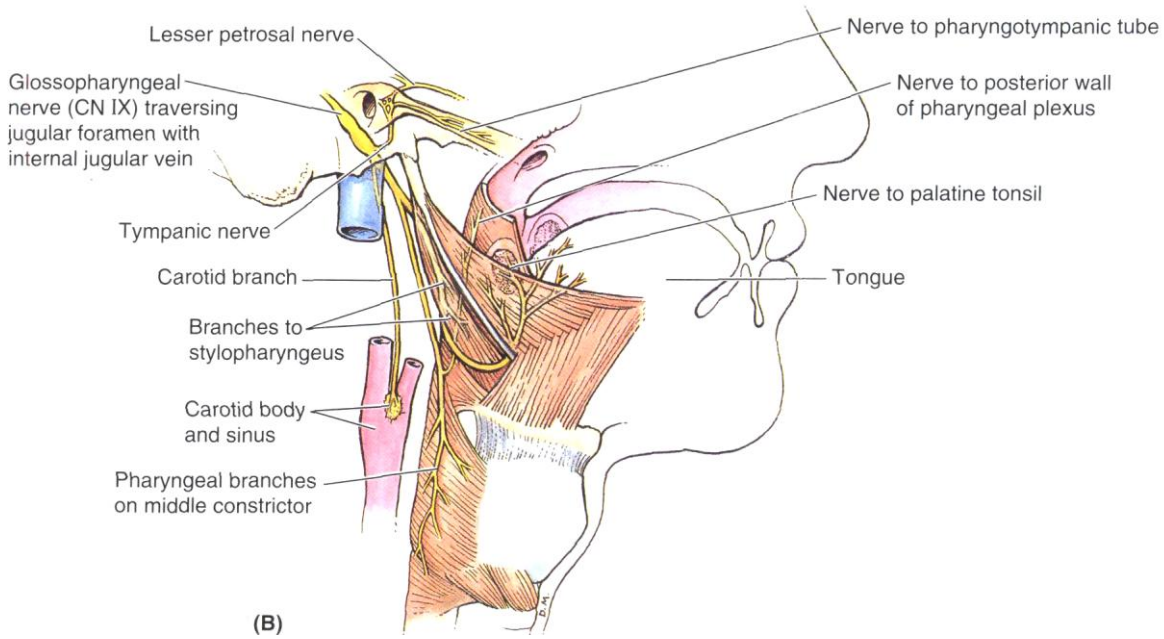
4. The bodies of fourth neurons of auditory tract located in *medial geniculate body* and *inferior colliculus* of midbrain. Then axons run through the posterior third of posterior leg of *internal capsule* and reach Geshla gyrus (*cortical hearing analyser* in superior temporal gyrus). Axons of the fourth neurons also pass from inferior colliculus to the anterior funiculus of spinal cord as *vestibulospinal tract.* Instantaneous reaction in response to sound (protective reflex) realises by means of this pathway.



Glossopharyngeal nerve (IX)

Glossopharyngeal nerve is mixed nerve, which has a nucleus ambiguous (motor), nucleus of the tractus solitarius (sensory) and inferior salivatory nucleus (parasympathetic) in rhomboid fossa. Sensory fibers start from a superior and inferior *ganglia* in region of the jugular foramen. Glossopharyngeal nerve reaches the tongue root, where divides by final branches *rr. linguales*, that innervating mucous membrane the posterior third of the tongue.





Glossopharyngeal nerve gives off the following branches:

1. *Tympanic nerve* (mixed) passes through tympanic canalicule and enters into tympanic cavity. Here its sensory branches together with caroticotympanic nerves (sympathetic) form *tympanic plexus* which innervate mucous membrane of the tympanic cavity and auditory tube *(r. tubarius).* The parasympathetic preganglionic fibers start from inferior salivatory nucleus, exite from tympanic cavity through hyatus nervi petrosi minoris as *lesser petrosal nerve.* Last passes in sulcus and enters into *otic ganglion.* Postganglionic fibres provide a secretory innervation of parotid salivary glands.

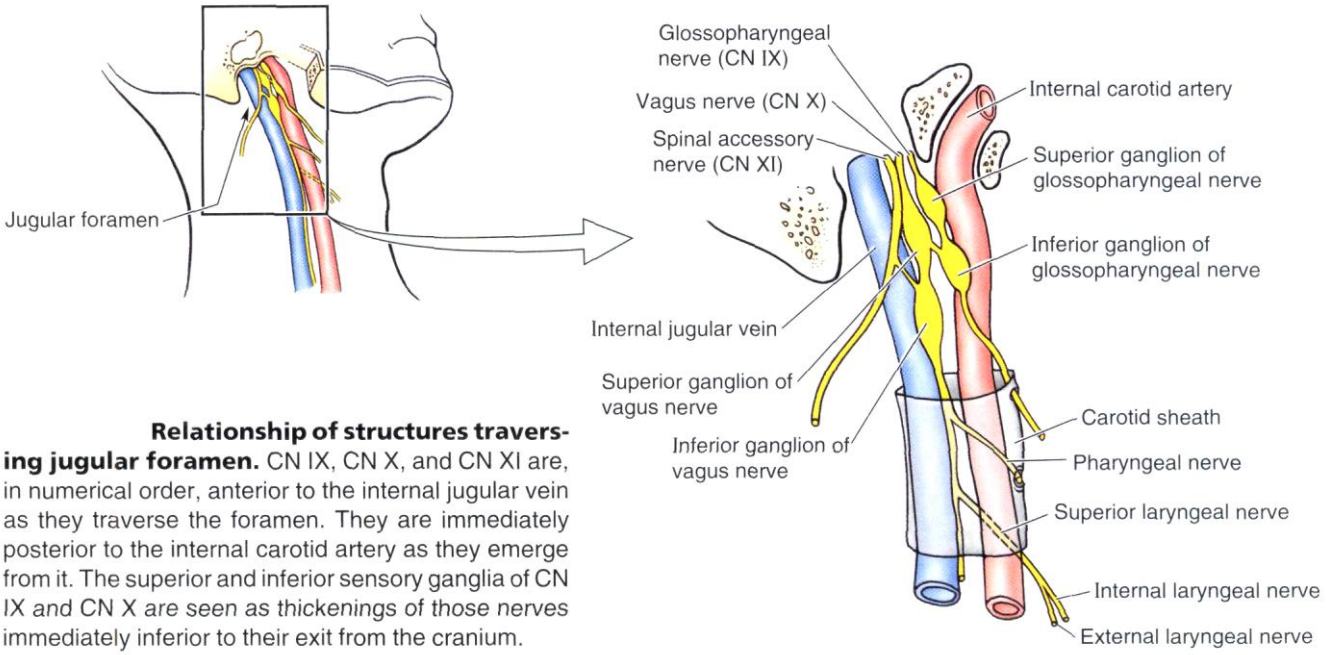
2. Pharyngeal branches pass to lateral wall of the pharynx, where together with branches of vagus nerve and sympathetic trunk form *pharyngeal plexus.* Last provides innervating of the muscles and mucous membrane of the throat.

3. Tonsillar branches pass to mucous membrane of the palatine tonsils and palatine arches.

4. Branch of stylopharyngeal muscle.

5. Branch of carotid sinus, innervating the receptors of carotid glomus and sinus.

6. Communicating branch with the auricular branch of vagus nerve.



Relationship of structures traversing jugular foramen. CN IX, CN X, and CN XI are, in numerical order, anterior to the internal jugular vein as they traverse the foramen. They are immediately posterior to the internal carotid artery as they emerge from it. The superior and inferior sensory ganglia of CN IX and CN X are seen as thickenings of those nerves immediately inferior to their exit from the cranium.

Vagus nerve (X)

Vagus nerve (mixed) contains *motor* fibers which start from nucleus ambiguus, *parasympathetic* (preganglionic) fibers form dorsal nucleus and *sensory* fibers from superior and inferior ganglia in jugular foramen.

- ***Cranial part of vagus nerve*** gives off the following branches: Meningeal branch which starts from superior ganglion and passes to cranial dura mater in posterior cranial fossa;

Auricular branch, which starts from superior ganglion, passes over mastoid canalicule of temporal bone and innervates the skin of external surface of auricle and posterior wall of external acoustic meatus.

- ***Cervical part of vagus nerve*** gives off:

Pharyngeal branches with branches of Glossopharyngeal nerve and sympathetic trunk form *pharyngeal plexus*, that innervates throat (superior and middle constrictors; levator veli palatini, palatopharyngeus and palatoglossus, uvulae muscles).

Superior cervical cardiac branches pass downward along common carotid artery and communicate with sympathetic nerves, enter into cardiac plexus and supply the heart (sensory and parasympathetic innervating).

Superior laryngeal nerve originate from inferior ganglion and carry sensory, motor and parasympathetic preganglionic fibers. Motor fibers of the *external branch* innervate cricothyroid and inferior constrictor muscles, sensory fibers *(internal branch)* supply mucous membrane of the larynx over vocal fold, mucous membrane of the epiglottis and tongue root.

Recurrent laryngeal nerve passes upward between esophagus and trachea and sends a numerous twigs. *Inferior laryngeal nerve* supplies mucous membrane of the larynx below vocal fold and the rest of muscles (thyroarytenoid, lateral and posterior cricoarytenoid, transverse and oblique arytenoid, vocalis). *Tracheal*, *esophageal* and *inferior cervical cardiac branches* supply internal organs.

• ***Thoracic part of vagus nerve*** gives off:

Thoracic cardiac branches which pass to cardiac plexus;

Bronchial branches with sympathetic nerves form pulmonary plexus. Last enters in lungs with bronchi.

Esophageal branches form *esophageal plexus* round this organ.

`***Abdominal part of vagus nerve*** is represented by anterior and posterior vagal trunks, which originate from esophageal plexus. *Anterior vagal trunk* located on front surface of the stomach and gives branches gives off the anterior gastric and hepatic branches. Posterior vagal trunk supplies back gastric wall, and gives off coeliac branches to reach celiac plexus. Then fibers of vagus nerve with sympathetic fibers supply the liver, spleen, pancreas, kidneys, small and large intestine (including a upper department of descending colon).

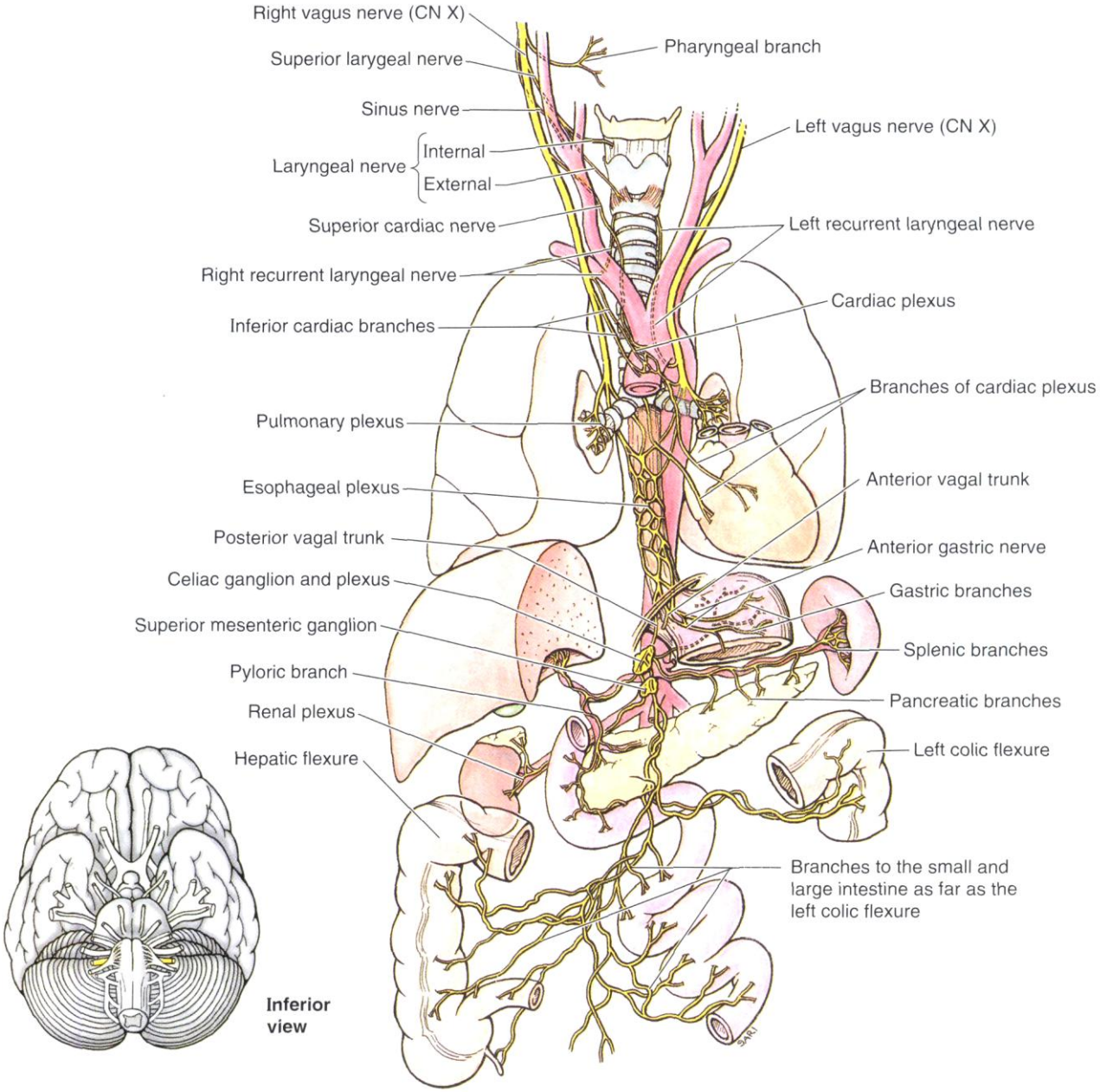
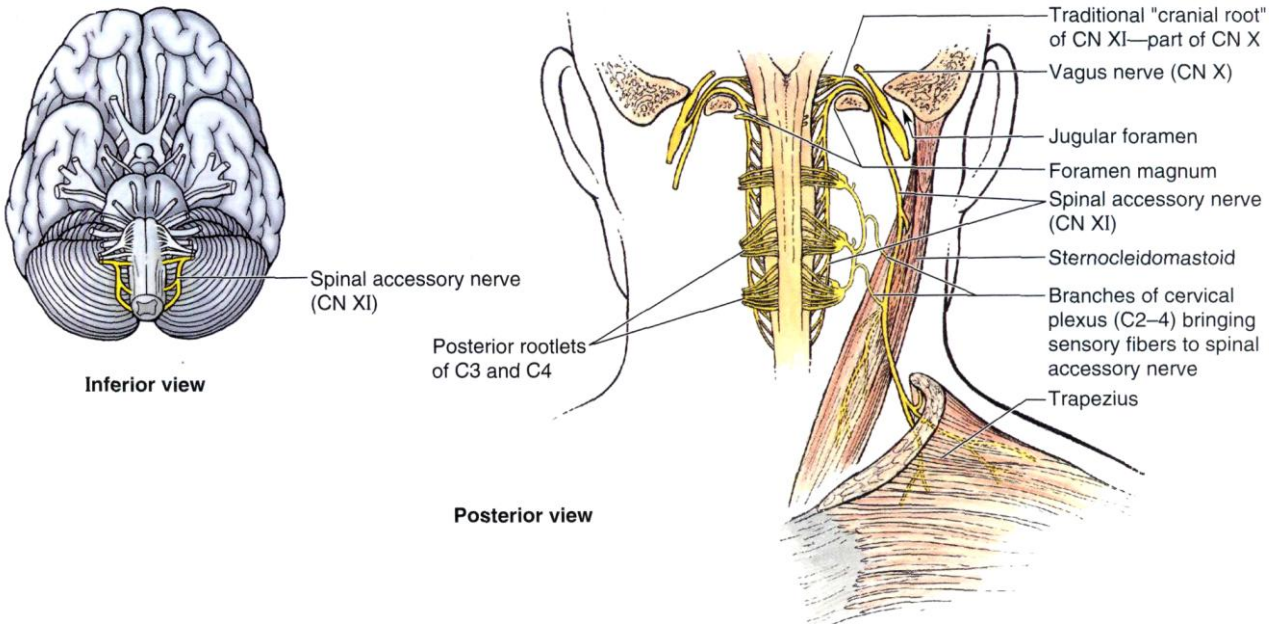


Table Summary of Vagus Nerve (CN X)

Divisions (Parts)	Branches
Cranial Vagi arise by a series of rootlets from medulla (includes traditional cranial root of CN XI)	Meningeal branch to dura mater (sensory; actually fibers of C2 spinal ganglion neurons that hitch a ride with vagus nerve) Auricular branch
Cervical Exit cranium/enter neck through jugular foramen; right and left vagus nerves enter carotid sheaths and continue to root of neck	Pharyngeal branches to pharyngeal plexus (motor) Cervical cardiac branches (parasympathetic, visceral afferent) Superior laryngeal nerve (mixed) internal (sensory) and external (motor) branches Right recurrent laryngeal nerve (mixed)
Thoracic Vagi enter thorax through superior thoracic aperture; left vagus contributes to anterior esophageal plexus; right vagus to posterior plexus; form anterior and posterior trunks	Left recurrent laryngeal nerve (mixed; all distal branches convey parasympathetic and visceral afferent fibers for reflex stimuli) Thoracic cardiac branches Pulmonary branches Esophageal plexus
Abdominal Anterior and posterior vagal trunks enter abdomen through esophageal hiatus in diaphragm; distribute asymmetrically	Esophageal branches Gastric branches Hepatic branches Celiac branches (from posterior trunk) Pyloric branch (from anterior trunk) Renal branches Intestinal branches (to left colic flexure)

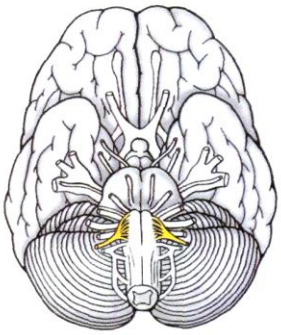
Accessory nerve (XI pair)

Accessory nerve is a motor nerve, which has a ambiguus nucleus (cranial) and nucleus of accessory nerve (spinal nucleus). The accessory rootlets pass through the jugular and magnum foramen. Trunk of accessory nerve divides into internal branch and external branch. Internal branch joints vagus nerve, and an external branch reaches the sternocleidomastoid and trapezius muscles (innervating them).

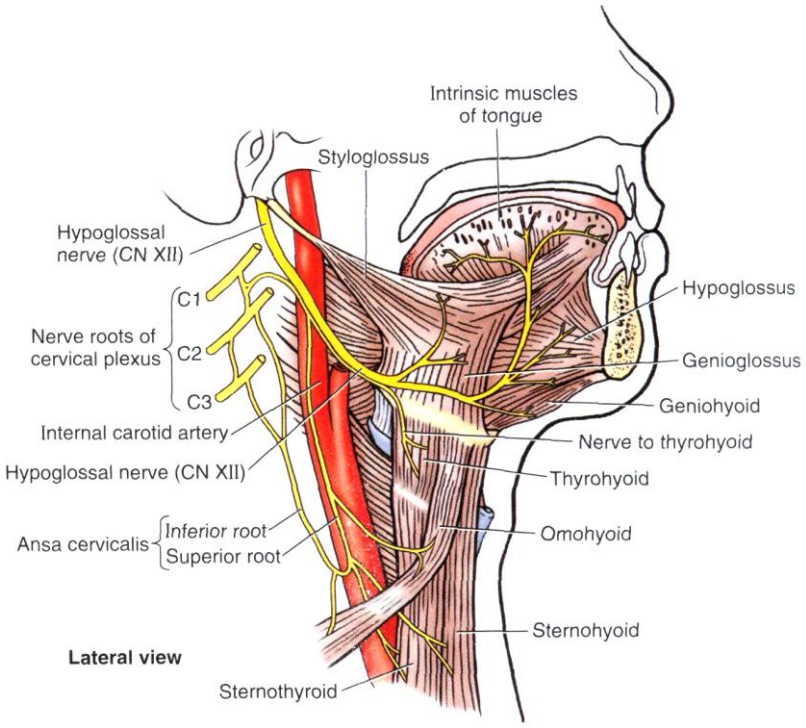


Hypoglossal nerve (XII pair)

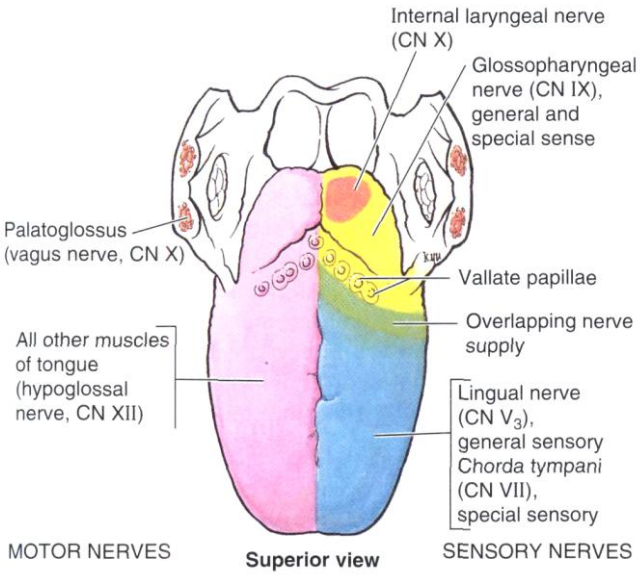
Hypoglossal nerve is a motor nerve, which has an motor nucleus in hypoglossall triangle of the rhomboid fossa. Nerve exits from myelencephalon (medulla oblongata) by numerous rootlets in furrow between pyramid and olive, and passes through the of hypoglossal canal.



Inferior view

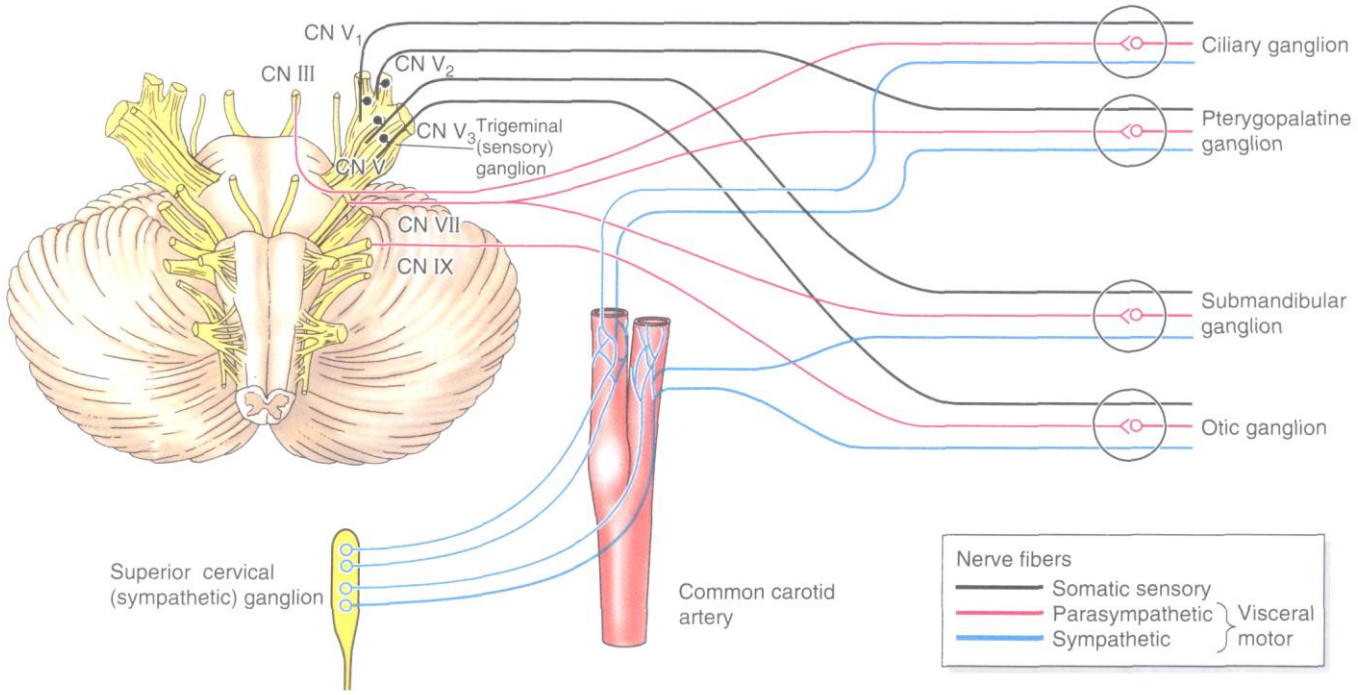


Hypoglossal nerve runs into submandibular triangle (it borders lingual triangle here) and enters into tongue thickness, where disintegrates on lingual branches, that innervate all tongue muscles (Extrinsic: genioglossus, hyoglossus and styloglossus muscles: and intrinsic: superior longitudinal, inferior longitudinal, transverse and vertical muscles).



Hypoglossal nerve gives off the descending ramus which joins with descending branch from cervical plexus forming **ansa cervicalis.** It gives off the motor branches innervating infrahyoid muscles: sternohyoid, sternothyroid, omothyroid and thyrohyoid.

Table **Summary of Cranial Parasympathetic Ganglia**



Ganglion	Location	Parasympathetic Root	Sympathetic Root	Main Distribution
Ciliary	Between optic nerve and lateral rectus, close to apex of orbit	Inferior branch of oculomotor nerve (CN III)	Branches from internal carotid plexus in cavernous sinus	Parasympathetic postsynaptic fibers from ciliary ganglion pass to ciliary muscle and sphincter pupillae of iris; sympathetic postganglionic fibers from superior cervical ganglion pass to dilator of pupil and blood vessels of eye
Pterygopalatine	In pterygopalatine fossa, where it is suspended by ganglionic branches of maxillary nerve (sensory roots of pterygopalatine ganglion); just anterior to opening of pterygoid canal and inferior to CN V_2	Greater petrosal nerve from facial nerve (CN VII) via nerve of pterygoid canal	Deep petrosal nerve, a branch of internal carotid plexus that is a continuation of postsynaptic fibers of cervical sympathetic trunk; fibers from superior cervical ganglion pass through pterygopalatine ganglion and enter branches of CN V_2	Parasympathetic postganglionic (secretomotor) fibers from pterygopalatine ganglion innervate lacrimal gland via zygomatic branch of CN V_2; sympathetic postsynaptic fibers from superior cervical ganglion accompany branches of pterygopalatine nerve that are distributed to blood vessels of nasal cavity, palate, and superior parts of pharynx
Otic	Between tensor veli palatini and mandibular nerve (CN V_3); lies inferior to foramen ovale of sphenoid bone	Tympanic nerve from glossopharyngeal nerve (CN IX); continues from the tympanic plexus as the lesser petrosal nerve	Fibers from superior cervical ganglion come from plexus on middle meningeal artery	Parasympathetic postsynaptic fibers from otic ganglion are distributed to parotid gland via auriculotemporal nerve (branch of CN V_3); sympathetic postsynaptic fibers from superior cervical ganglion pass to parotid gland and supply its blood vessels
Submandibular	Suspended from lingual nerve by two ganglionic branches (sensory roots); lies on surface of hyoglossus muscle inferior to submandibular duct	Parasympathetic fibers join facial nerve (CN VII) and leave it in its chorda tympani branch, which unites with lingual nerve	Sympathetic fibers from superior cervical ganglion via plexus on facial artery	Parasympathetic postsynaptic (secretomotor) fibers from submandibular ganglion are distributed to sublingual and submandibular glands; sympathetic fibers supply sublingual and submandibular glands

Table **Summary of Cranial Nerves (*continued*)**

Nerve	Components	Location of Nerve Cell Bodies	Cranial Exit	Main Action(s)
Olfactory (CN I)	Special sensory	Olfactory epithelium (olfactory cells)	Foramina in cribriform plate of ethmoid bone	Smell from nasal mucosa of roof of each nasal cavity and superior sides of nasal septum and superior concha
Optic (CN II)	Special sensory	Retina (ganglion cells)	Optic canal	Vision from retina
Oculomotor (CN III)	Somatic motor	Midbrain	Superior orbital fissure	Motor to superior rectus, inferior rectus, medial rectus, inferior oblique, and levator palpebrae superioris muscles; raises superior eyelid; turns eyeball superiorly, inferiorly, and medially
	Visceral motor	Presynaptic: midbrain Postsynaptic: ciliary ganglion		Parasympathetic innervation to sphincter of pupil and ciliary muscle; constricts pupil and accommodates lens of eye
Trochlear (CN IV)	Somatic motor	Midbrain		Motor to superior oblique that assists in turning eye infero-laterally (or inferiorly when adducted)
Trigeminal (CN V)				
Ophthalmic (CN V_1)	General sensory	Trigeminal ganglion	Superior orbital fissure	Sensation from cornea, skin of forehead, scalp, eyelids, nose, and mucosa of nasal cavity and paranasal sinuses
Maxillary (CN V_2)			Foramen rotundum	Sensation from skin of face over maxilla, including upper lip, maxillary teeth, mucosa of nose, maxillary sinuses, and palate
Mandibular (CN V_3)			Foramen ovale	Sensation from skin and over side of head mandible including lower lip, mandibular teeth, temporomandibular joint, mucosa of mouth and anterior two thirds of tongue
	Branchial motor	Pons		Motor to muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, and tensor tympani
Abducent (CN VI)	Somatic motor	Pons	Superior orbital fissure	Motor to lateral rectus that turns eye laterally
Facial (CN VII)	Branchial motor	Pons	Internal acoustic meatus; facial canal; stylomastoid foramen	Motor to muscles of facial expression and scalp; also supplies stapedius of middle ear, stylohyoid, and posterior belly of digastric
	Special sensory	Geniculate ganglion		Taste from anterior two thirds of tongue and the palate
	Visceral motor	Presynaptic: pons Postsynaptic: pterygopalatine ganglion; submandibular ganglion		Parasympathetic innervation to submandibular and sublingual salivary glands, lacrimal gland, and glands of nose and palate

Table **Summary of Cranial Nerves (*continued*)**

Nerve	Components	Location of Nerve Cell Bodies	Cranial Exit	Main Action(s)
Vestibulocochlear (CN VIII)				
Vestibular	Special sensory	Vestibular ganglion	Internal acoustic meatus	Vestibular sensation from semicircular ducts, utricle, and saccule related to position and movement of head
Cochlear	Special sensory	Spiral ganglion		Hearing from spiral organ
Glossopharyngeal (CN IX)	Branchial motor	Medulla	Jugular foramen	Motor to stylopharyngeus to assist with swallowing
	Visceral motor	Presynaptic: medulla Postsynaptic: otic ganglion		Parasympathetic innervation to parotid gland
	Visceral sensory	Superior ganglion		Visceral sensation from parotid gland, carotid body and sinus, pharynx, and middle ear
	Special sensory	Inferior ganglion		Taste from posterior third of tongue
	General sensory	Inferior ganglion		Cutaneous sensation from external ear
Vagus (CN X)	Branchial motor	Medulla		Motor to constrictor muscles of pharynx (except stylopharyngeus), intrinsic muscles of larynx, muscles of palate (except tensor veli palatini), and striated muscle in superior two thirds of esophagus
	Visceral motor	Presynaptic: medulla Postsynaptic: neurons in, on, or near viscera		Parasympathetic innervation to smooth muscle of trachea, bronchi, digestive tract, and cardiac muscle of heart
	Visceral sensory	Superior ganglion		Visceral sensation from base of tongue, pharynx, larynx, trachea, bronchi, heart, esophagus, stomach, and intestine to left colic flexure
	Special sensory	Inferior ganglion		Taste from epiglottis and palate
	General sensory	Superior ganglion		Sensation from auricle, external acoustic meatus, and dura mater of posterior cranial fossa
Spinal accessory (CN XI)	Somatic motor	Spinal cord		Motor to sternocleidomastoid and trapezius
Hypoglossal (CN XII)	Somatic motor	Medulla	Hypoglossal canal	Motor to intrinsic and extrinsic muscles of tongue (except palatoglossus)

*The traditional "cranial root of the accessory nerve" is considered here as part of the vagus nerve (CN X); the spinal accessory nerve (CN XI) as listed here refers only to the traditional "spinal root of the accessory nerve."

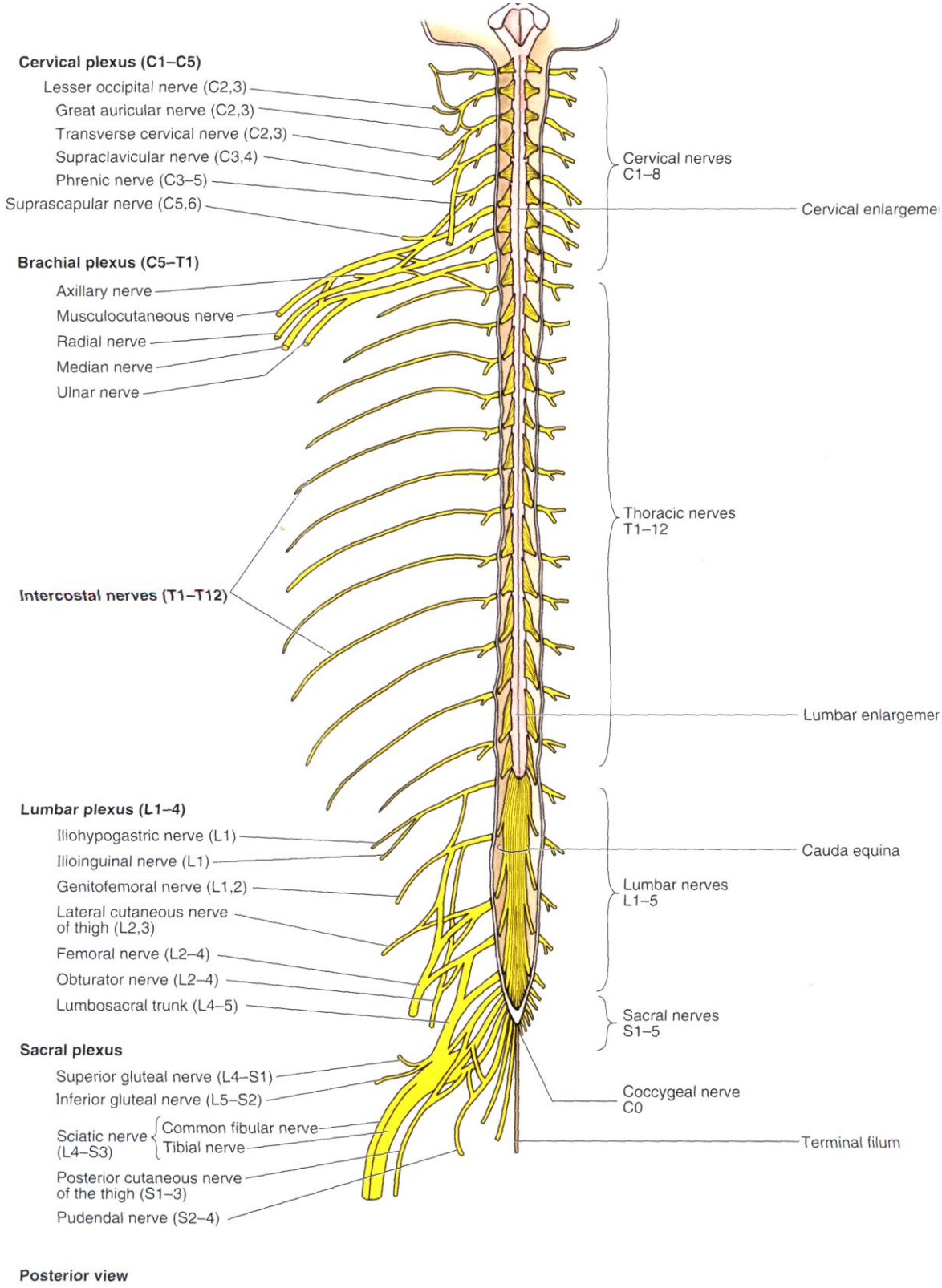
Table **Summary of Cranial Nerve Lesions**

Nerve	Type(s) and/or Site(s) of Lesion	Abnormal Findings
CN I	Fracture of cribiform plate	Anosmia (loss of smell); cerebrospinal fluid rhinorrhea
CN II	Direct trauma to orbit or eyeball; fracture involving optic canal	Loss of pupillary constriction
	Pressure on optic pathway; laceration or intracerebral clot in the temporal, parietal, or occipital lobes of brain	Visual field defects
CN III	Pressure from herniating uncus on nerve; fracture involving cavernous sinus; aneurysms	Dilated pupil; ptosis; eye turns down and out; pupillary reflex on the side of the lesion will be lost
CN IV	Stretching of nerve during its course around brainstem; fracture of orbit	Inability to look down when eye is adducted
CN V	Injury to terminal branches (particularly CN V_2) in roof of maxillary sinus; pathological processes affecting trigeminal ganglion	Loss of pain and touch sensations; paraesthesia; masseter and temporalis muscles do not contract; deviation of mandible to side of lesion when mouth is opened
CN VI	Base of brain or fracture involving cavernous sinus or orbit	Eye falls to move laterally; diplopia on lateral gaze
CN VII	Laceration or contusion in parotid region	Paralysis of facial muscles; eye remains open; angle of mouth droops; forehead does not wrinkle
	Fracture of temporal bone	As above, plus associated involvement of cochlear nerve and chorda tympani; dry cornea; loss of taste on anterior two thirds of tongue
	Intracranial hematoma ("stroke")	Forehead wrinkles because of bilateral innervation of the frontalis muscle; otherwise paralysis of contralateral facial muscles
CN VIII	Tumor of nerve (acoustic neuroma)	Progressive unilateral hearing loss; tinnitus (noises in ear)
CN IX	Brainstem lesion or deep laceration of neck	Loss of taste on posterior third of tongue; loss of sensation on affected side of soft palate
CN X	Brainstem lesion or deep laceration of neck	Sagging of soft palate; deviation of uvula to normal side; hoarseness owing to paralysis of vocal fold
CN XI	Laceration of neck	Paralysis of sternocleidomastoid and superior fibers of trapezius; drooping of shoulder
CN XII	Neck laceration; basal skull fractures	Protruded tongue deviates toward affected side; moderate dysarthria (disturbance of articulation)

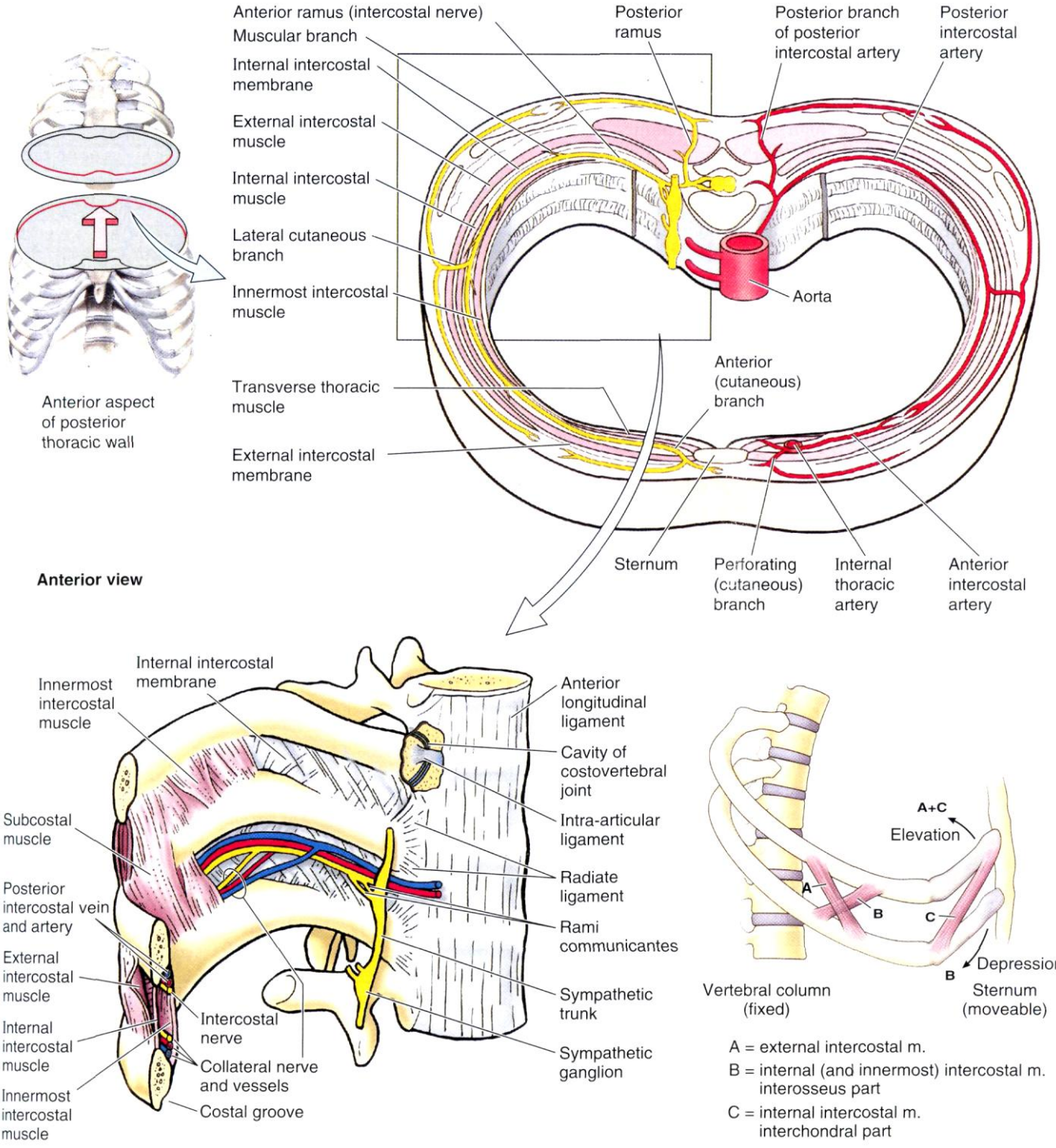
THE SPINAL NERVES

The **spinal nerves** *(nn. spinales)* are located in regular order corresponding to the myotomes (myomeres) of the trunk and alternate with the segments of the spine; every nerve is attended by a corresponding area of skin (dermatome).

Man has 31 pairs of spinal nerves: 8 pairs of **cervical**, 12 pairs of **thoracic**, 5 pairs of **lumbar**, 5 pairs of **sacral** and 1 pair of **coccygeal** nerves .



Every spinal nerve branches off from the spinal cord in two roots: the *dorsal* or *posterior* (sensory) root, and the *ventral* or *anterior* (motor) root. Both roots are joined in one trunk, or *funiculus* which passes from the spine through an intervertebral orifice. Near and somewhat externally of the place where the roots join, the posterior root forms the *ganglion spinale* or *ganglion* in which the anterior motor root does not participate. Since both roots are joined the spinal nerves are mixed nerves; they contain sensory (afferent) fibres from the cells of the spinal ganglia, motor (efferent) fibres from the cells of the anterior horn, and also vegetative fibres from the cells of the lateral horns emerging from the spinal cord as part of the anterior root .



In the opinion of certain authors vegetative fibres are also contained in the posterior root. The vegetative fibres which pass through the roots into the animal nerves, ensure such processes in the soma as trophies, vasculo-motor reactions, etc.

On emerging from the intervertebral orifice every cerebrospinal nerve divides, according to two parts of the myotome (dorsal and ventral), into two branches:
(1) the **posterior, dorsal branch** *(ramus dorsalis)* for the autochthonous muscles of the back developing from the dorsal part of the myotome and the skin covering it;
(2) the **anterior, ventral branch** *(ramus ventralis)* for the ventral wall of the trunk . and the limbs, developing from the ventral parts of the myotomes.
Besides this, another two kinds of branches arise from the cerebrospinal nerve:
(3) the **communicating branches** *(rami communicantes)* to the sympathetic trunk for innervating the internal organs;
(4) the **meningeal branch** *(ramus meningeus)* passing back through the intervertebral orifice for innervating the membranes of the spinal cord.
The **posterior branches** *(rami dorsales)* of all the cerebrospinal nerves pass backward between the transverse processes of the vertebrae, curving around their articular processes. With the exception of the first cervical, fourth and fifth sacral and coccygeal branches, they all divide into the **medial branch** *(ramus medialis)* and **lateral branch** *(ramus lateralis)* which supply the skin of the back of the head, the posterior surface of the neck and back and the deep dorsal muscles.

The posterior branch of the first cervical nerve, n. suboccipital, emerges between the occipital bone and the atlas and then divides into branches supplying **mm.** recti capitis major and minor, m. semispinalis capitis, mm. obliqui capitis. N. suboccipitalis does not give off branches to the skin. The posterior branch of the second cervical nerve, the **greater occipital nerve** *(n. occipitalis major)* coming out between the posterior arch of the atlas and the second vertebra, pierces the muscles and, having become subcutaneous, innervates the occipital part of the head.

Rami dorsales of the thoracic nerves divide into medial and lateral branches giving rise to branches running to the autochthonous muscles; the skin branches of the superior thoracic nerves originate only from rami mediales, while those of the inferior thoracic nerves, from rami laterales.
The cutaneous branches of the three upper lumbar nerves pass to the superior part of the gluteal region under the name of **gluteal branches** (of the posterior primary rami of lumbar nerves) *(nn. clunium superiores);* the cutaneous branches of the sacral nerves are called gluteal branches (of the posterior primary rami of sacral nerves) *(nn. clunium medii).*

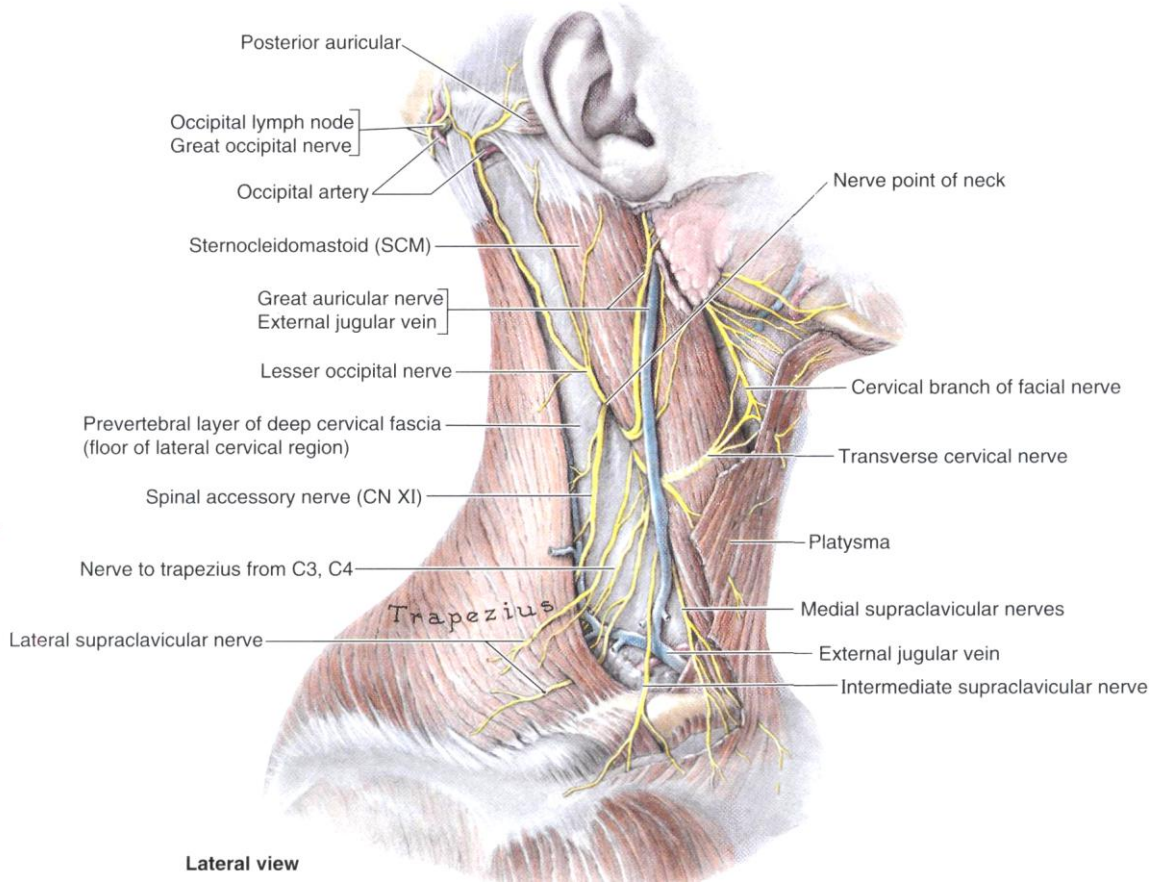
The **anterior branches** *(rami ventrales)* of the spinal nerves innervate the skin and muscles of the ventral wall of the body and both pairs of limbs. Since the skin of the lower abdomen participates in the development of the external sexual organs, the skin covering them is also innervated by the anterior branches. Except for the first two, the anterior branches are much larger than the posterior branches.

The anterior branches of the spinal nerves preserve their original metameric structure only in the thoracic segment (nn. intercostales). In the other segments connected with the limbs in whose development the segmentary character is lost, the nerves arising from the anterior spinal branches intertwine. This is how nervous *plexuses* are formed in which exchange of fibres of different neuromeres takes place. A complex redistribution of fibres occurs in the plexuses: the anterior branch of every spinal nerve sends its fibres into several peripheral nerves and, consequently, each of them contains fibres of several segments of the spinal cord.

Most of the nerves emerging from plexuses are mixed; this is why the clinical picture of the lesion is made up of motor disorders, sensory disorders and vegetative disorders.

Three large plexuses are distinguished: cervical, brachial and lumbosacral.

THE CERVICAL PLEXUS



The **cervical plexus** *(plexus cervicalis)* is formed by the anterior branches of four superior cervical nerves *(CI-CIV)* which are connected by three arching loops and are located laterally of the transverse processes between the prevertebral muscles from the medial side and vertebral (m. scalenus medius, m. levator scapulae and m. splenius cervicis) from the lateral side, anastomosing with n. accessorius, n. hypoglossus and tr. sympathicus. In front the plexus is covered by m. sternocleidomastoideus.

The branches arising from the plexus are divided into cutaneous, muscular and mixed.

The cutaneous branches:

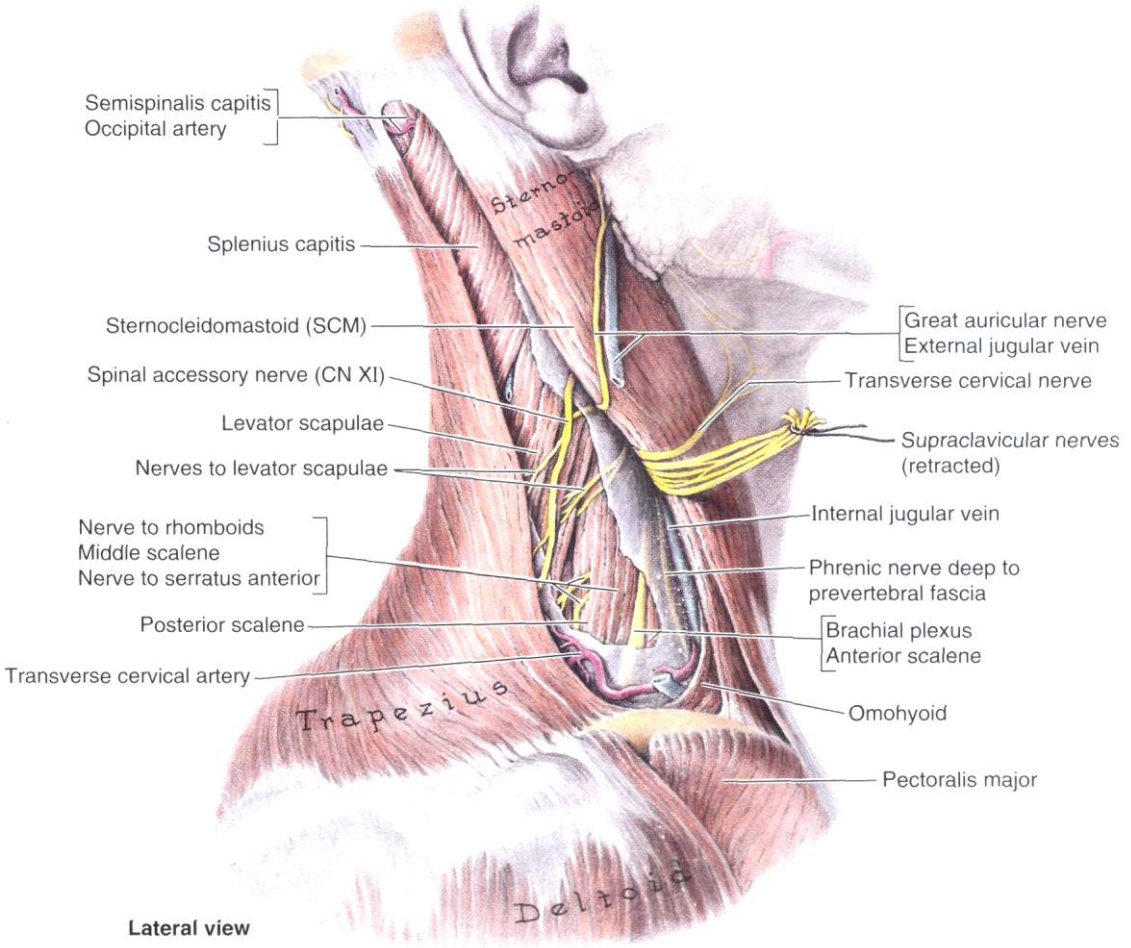
1. The lesser occipital nerve (n. occipitalis minor) runs to the skin of the lateral part of the occipital region.
2. The great auricular nerve (n. auricularis magnus), the thickest nerve of the cutaneous branches of the cervical plexus, passes to the concha auriculae, supplying it and the external acoustic meatus.
3. The anterior cutaneous nerve of the neck (n. transversus colli) arises, like the preceding two nerves, from the middle of the posterior edge of m. sternocleidomastoideus and divides into branches which curve around the posterior edge of the sternocleidomastoid muscle and pass over its external surface forward and down under the m. platysma, supplying the skin of the neck.
4. The supraclavicular nerves (nn. supraclaviculares) descend under the platysma nearly perpendicularly along the supraclavicular fossa into the skin above the pectoralis major and deltoideus.

The muscular branches:

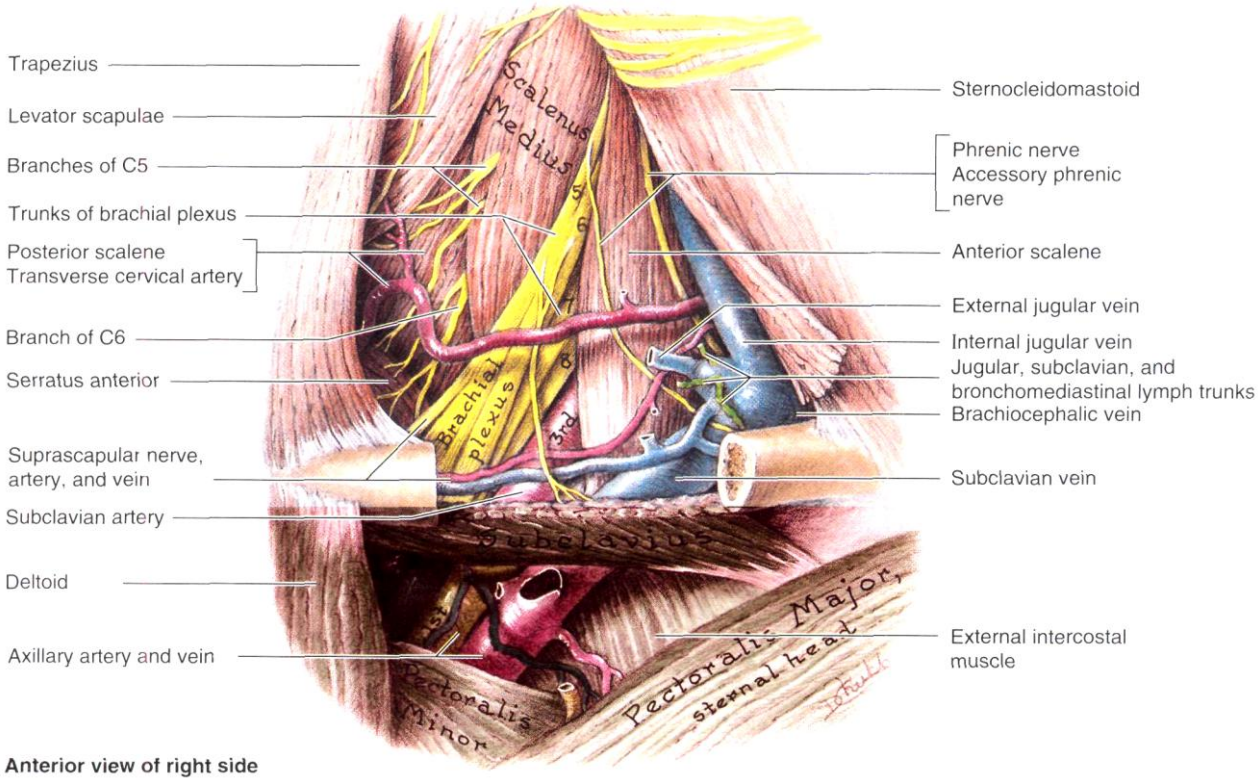
1. Branches to the mm. recti capitis anterior and lateralis, mm. longus capitis and colli, mm. scaleni, m. levator scapulae and, finally, to mm. intertransversarii anteriores.

2. **Radix inferior,** , passes in front of the v. jugularis interna under the sternocleidomastoid muscle and at the intermediary tendon of the m. omohyoideus joins with radix superior (hypoglosus n.) forming a ***cervical loop*** *(ansa cervicalis)* . By means of the branches arising from the ansa, the fibres of the cervical plexus innervate the m. sternohyoideus, m. sternothyreoideus and m. omohyoideus.

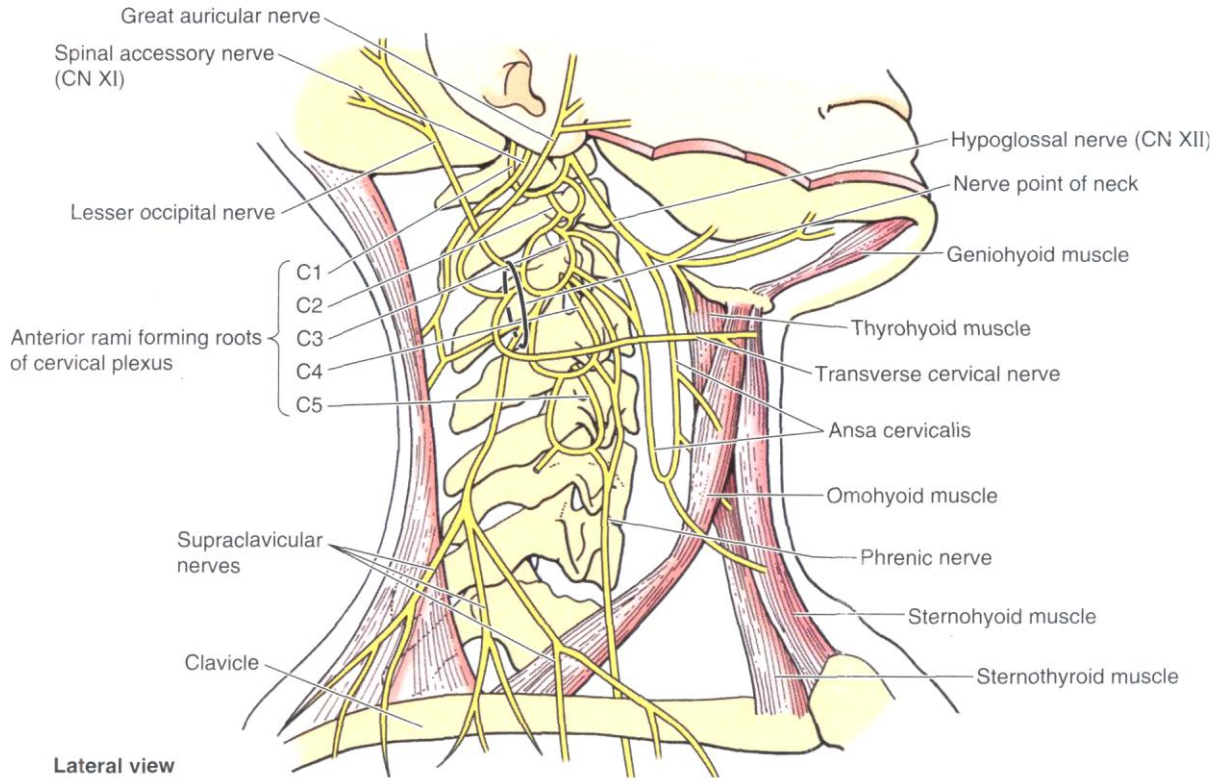
3. Branches to the m. sternocleidomastoideus and m. trapezius which participate in the innervation of these muscles together with the accessory nerve.



Lateral view

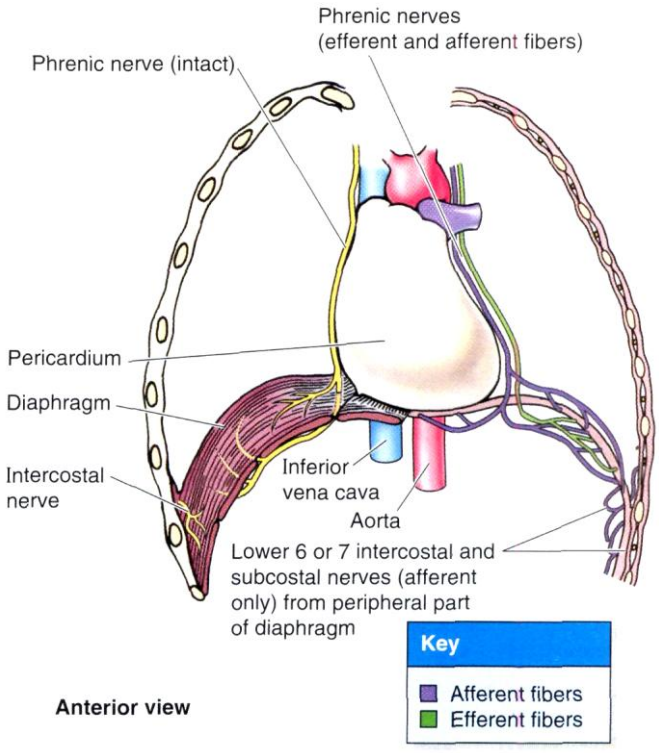


Anterior view of right side



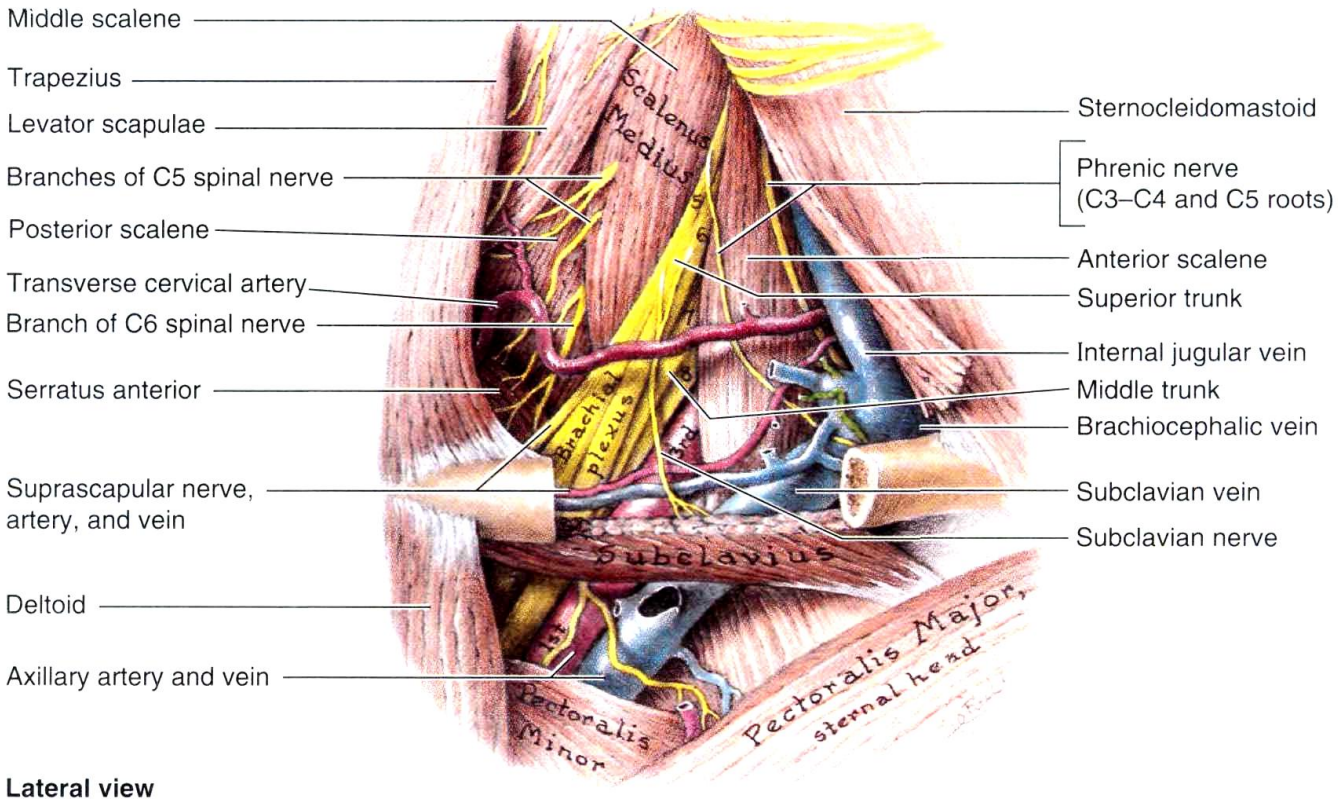
The mixed branches:

The **phrenic nerve** *(n. phrenicus)* descends along m. scalenus anterior into the thoracic cavity where it passes between the subclavian artery and vein. Further the right phrenic nerve descends nearly vertically in front of the root of the right lung and passes along the lateral surface of the pericardium to the diaphragm. The left phrenic nerve crosses the anterior surface of the aortic arch and passes in front of the root of the left lung along the left lateral surface of the pericardium to the diaphragm. Both nerves pass in the anterior mediastinum between the pericardium and pleura. The phrenic nerve receives fibres from two inferior cervical ganglia of the sympathetic trunk. The phrenic nerve is a mixed nerve: its motor branches innervate the diaphragm thus functioning as a nerve that is responsible for respiration; it sends sensory nerves to the pleura and pericardium. Some of the terminal branches of the nerve pass through the diaphragm into the abdominal cavity *(nn. phrenicoabdominales)* and anastomose with the sympathetic plexus of the diaphragm, sending small branches to the peritoneum, the hepatic ligaments and to the liver itself; as a result, when liver is affected, a special phrenicus-symptom may arise. There is information pointing to more extensive innervation by the phrenic nerve; it is presumed that with its fibres in the thoracic cavity it supplies the heart, lungs, the thymus gland, and in the peritoneal cavity it is connected with the solar plexus through which it innervates certain internal organs.

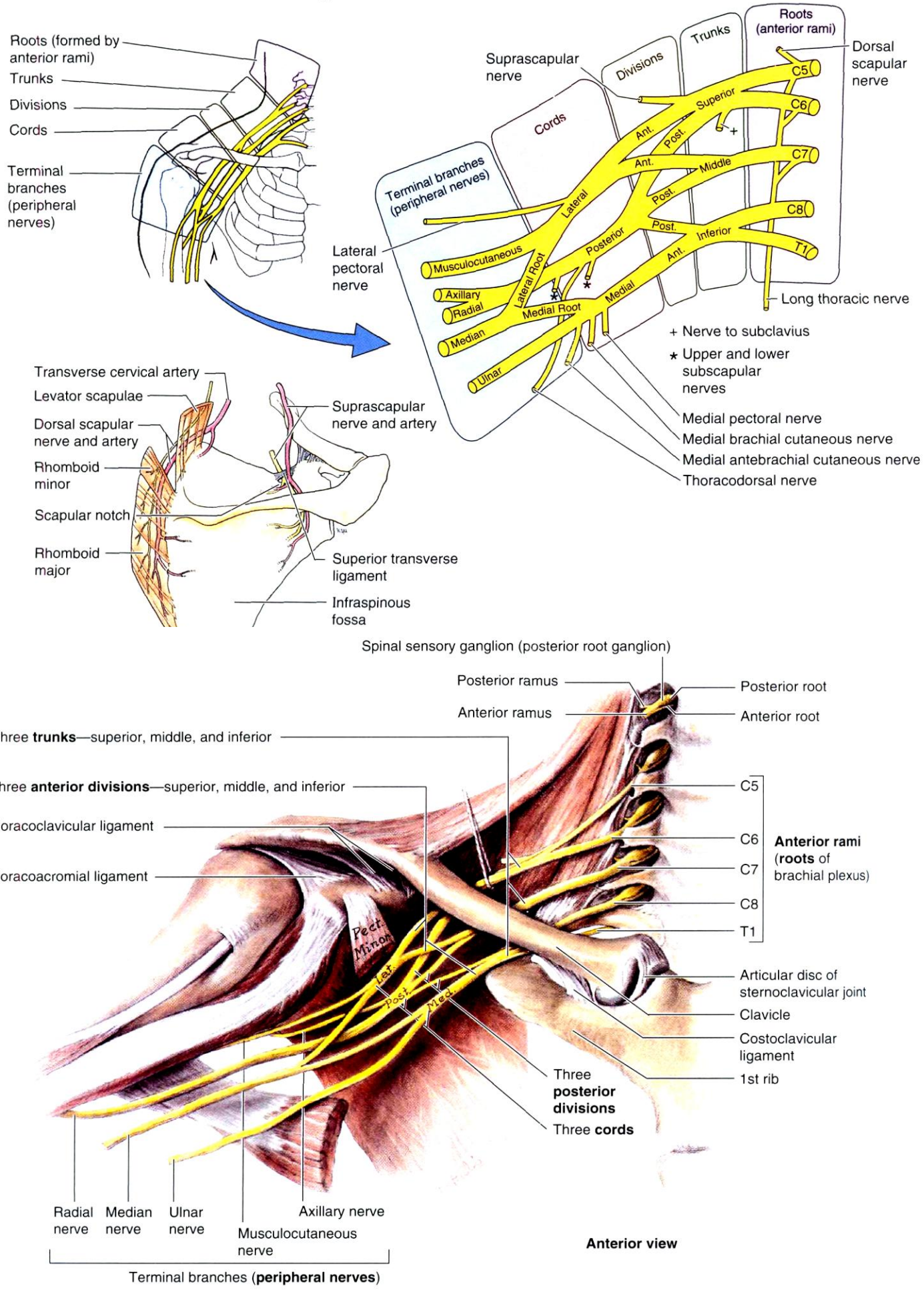


THE BRACHIAL PLEXUS

The **brachial plexus** *(plexus brachialis)* is composed of the anterior branches of four inferior cervical nerves *(CV-CVIII)* and the greater part of first thoracic nerve *{ThI).* The brachial plexus passes through the space between the scalenus anterior and scalenus medius into the supraclavicular fossa higher and behind the subclavian artery. Three thick nerve trunks arise from it; they pass into the axillary fossa and surround a.axillaris from three sides: from the lateral (lateral trunk) and medial (medial trunk) sides and posteriorly of the artery (posterior trunk). Pars supraclaviculars and pars infraclavicularis are usually distinguished in the brachial plexus. There are short and long peripheral branches. The short branches arise from various points in the supraclavicular part of the plexus and supply the cervical muscles partially, as well as the muscles of the shoulder girdle (with the exception of m. trapezius) and the shoulder joint. The long branches arise from the abovementioned three trunks and run the length of the upper limb, innervating its muscles and skin.



Lateral view


Roots (formed by anterior rami)
Trunks
Divisions
Cords
Terminal branches (peripheral nerves)
Roots (anterior rami)
Trunks
Divisions
Cords
Suprascapular nerve
Dorsal scapular nerve
C5
C6
C7
C8
T1
Superior
Middle
Inferior
Ant.
Post.
Terminal branches (peripheral nerves)
Lateral pectoral nerve
Musculocutaneous
Axillary
Radial
Median
Ulnar
Lateral Root
Medial Root
Lateral
Posterior
Medial
Long thoracic nerve
+ Nerve to subclavius
* Upper and lower subscapular nerves
Medial pectoral nerve
Medial brachial cutaneous nerve
Medial antebrachial cutaneous nerve
Thoracodorsal nerve
Transverse cervical artery
Levator scapulae
Dorsal scapular nerve and artery
Rhomboid minor
Scapular notch
Rhomboid major
Suprascapular nerve and artery
Superior transverse ligament
Infraspinous fossa
Spinal sensory ganglion (posterior root ganglion)
Posterior ramus
Anterior ramus
Posterior root
Anterior root
Three trunks—superior, middle, and inferior
Three anterior divisions—superior, middle, and inferior
Coracoclavicular ligament
Coracoacromial ligament
C5
C6
C7
C8
T1
Anterior rami (roots of brachial plexus)
Pect. Minor
Lat.
Post.
Med.
Articular disc of sternoclavicular joint
Clavicle
Costoclavicular ligament
1st rib
Three posterior divisions
Three cords
Radial nerve
Median nerve
Ulnar nerve
Axillary nerve
Musculocutaneous nerve
Terminal branches (peripheral nerves)
Anterior view

The short branches:

1. The **nerve to the rhomboids** *(n. dorsalis scapulae)* innervates m. levator scapulae and mm. rhomboidei.

2. The **nerve to the serratus anterior muscle** *(n. thoracicus longus)* descends along the external surface of m. serratus anterior, which it supplies.

3. The **suprascapular nerve** *(n. suprascapularis)* passes through the incisura scapulae into the fossa supraspinata and together with a. suprascapularis passes under the acromion into the infraspinous fossa. It innervates mm. supra- and infraspinatus and the capsule of the shoulder joint.

4. The **lateral and medial pectoral nerves** *(nn. pectorales medialis and lateralis)* run to m. pectoralis major and minor.

5. The **nerve to the subclavius muscle** *(n. subclavius)* passes to m. subclavius.

6. **Subscapular nerves** *(nn. subscapulares)* supply m. subscapulars, m. teres major and m. latissimus dorsi. The branch running along the axillary edge of the shoulder blade to m. latissimus dorsi is called n. thoracodorsalis.

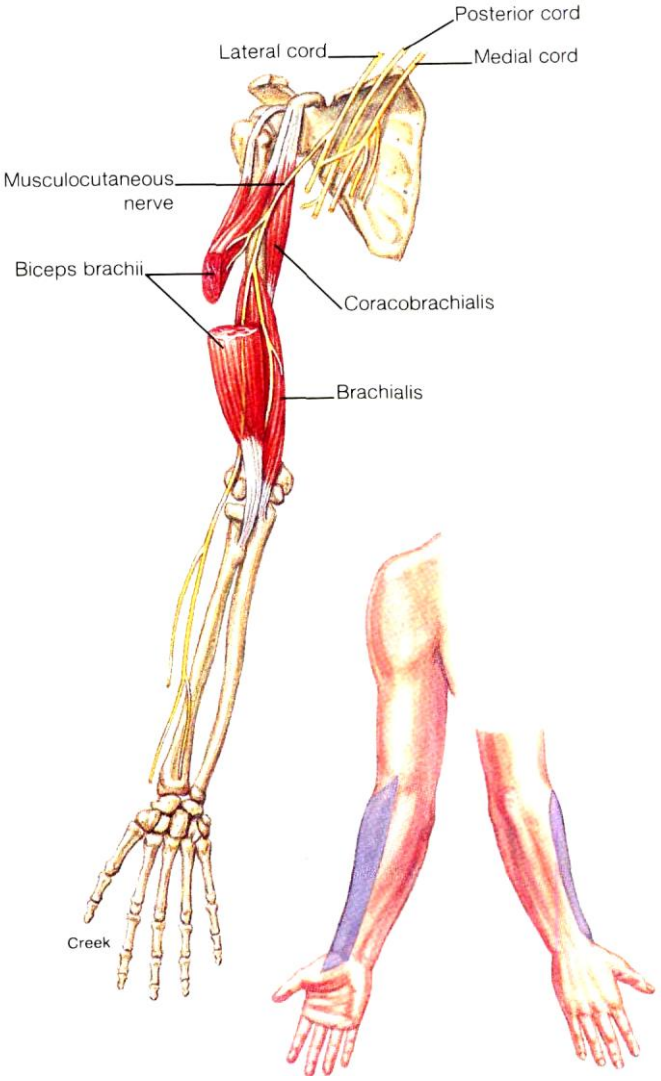
Nerve	Origin[a]	Course	Structures Innervated
Supraclavicular branches			
Dorsal scapular	Posterior aspect of anterior ramus of **C5** with a frequent contribution from C4	Pierces middle scalene; descends deep to levator scapulae and rhomboids	Rhomboids; occasionally supplies levator scapulae
Long thoracic	Posterior aspect of anterior rami of **C5, C6,** C7	Passes through cervicoaxillary canal (Fig. 6.14), descending posterior to C8 and T1 roots of plexus (anterior rami); runs inferiorly on superficial surface of serratus anterior	Serratus anterior
Suprascapular	Superior trunk, receiving fibers from **C5,** C6 and often C4	Passes laterally across lateral cervical region (posterior triangle of neck), superior to brachial plexus; then through scapular notch inferior to superior transverse cervical ligament	Supraspinatus and infraspinatus muscles; glenohumeral (shoulder) joint
Subclavian nerve (nerve to subclavius)	Superior trunk, receiving fibers from C5, **C6** and often C4 (Fig. 6.29)	Descends posterior to clavicle and anterior to brachial plexus and subclavian artery (Fig. 6.29); often giving an *accessory root to phrenic nerve*	Subclavius and sternoclavicular joint (accessory phrenic root innervates diaphragm)
Infraclavicular branches			
Lateral pectoral	Side branch of lateral cord, receiving fibers from C5, **C6,** C7	Pierces costocoracoid membrane to reach deep surface of pectoral muscles; a *communicating branch to the medial pectoral nerve* passes anterior to axillary artery and vein	Primarily pectoralis major; but some lateral pectoral nerve fibers pass to pectoralis minor via branch to medial pectoral nerve (Fig. 6.30*A*)

7. The **circumflex nerve** *(n. axillaris)* is the thickest nerve among the short branches of the brachial plexus. It passes together with a. circumflexa humeri posterior through the foramen quadrilaterum onto the posterior surface of the surgical neck of the humerus and sends branches to mm. deltoideus, teres minor and to the shoulder joint. Along the posterior edge of the deltoid muscle it gives off a cutaneous branch, n. cutaneous brachii lateralis superior, that innervates the skin of the deltoid and the posterolateral region of the upper arm in its upper part.

Nerve	Origin[a]	Course	Structures Innervated
Musculo-cutaneous	Terminal branch of lateral cord, receiving fibers from C5–C7	Exits axilla by piercing coracobrachialis (Fig. 6.28); descends between biceps brachii and *brachialis (Fig. 6.31), supplying both; continues as lateral cutaneous nerve of forearm*	Muscles of anterior compartment of arm *(coracobrachialis, biceps brachii and brachialis)* (Fig. 6.30*B*); skin of lateral aspect of forearm
Median	**Lateral root of median nerve** is a terminal branch of lateral cord (C6, C7); **medial root of median nerve** is a terminal branch of medial cord (C8, T1)	Lateral and medial roots merge to form median nerve lateral to axillary artery; descends through arm adjacent to brachial artery, with nerve gradually crossing anterior to artery to lie medial to artery in cubital fossa (Fig. 6.32*A*)	Muscles of anterior fore-arm compartment (except for flexor carpi ulnaris and ulnar half of flexor digito-rum profundus), five intrin-sic muscles in thenar half of palm and palmar skin (Fig. 6.30*B*)
Medial pectoral	Side branches of medial cord, receiving fibers from C8, T1	Passes between axillary artery and vein; then pierces pectoralis minor and enters deep surface of pectoralis major; although it is called *medial* for its origin from medial cord, it lies lateral to lateral pectoral nerve	Pectoralis minor and ster-nocostal part of pectoralis major
Medial cutaneous nerve of arm		Smallest nerve of plexus; runs along medial side of axillary and brachial veins; communicates with *intercostobrachial nerve*	Skin of medial side of arm, as far distal as medial epi-condyle of humerus and olecranon of ulna
Median cutaneous nerve of forearm		Initially runs with ulnar nerve (with which it may be confused) but pierces deep fascia with basilic vein and enters subcutaneous tissue, dividing into anterior and posterior branches	Skin of medial side of fore-arm, as far distal as wrist
Ulnar	Larger terminal branch of medial cord, receiving fibers from C8, T1 and often C7	Descends medial arm; passes posterior to medial epicondyle of humerus; then descends ulnar aspect of forearm to hand (Figs. 6.30*C* and 6.32*A*)	Flexor carpi ulnaris and ul-nar half of flexor digitorum profundus (forearm); most intrinsic muscles of hand; skin of hand medial to axial line of digit 4
Upper subscapular	Side branch of posterior cord, receiving fibers from **C5**	Passes posteriorly, entering subscapularis directly	Superior portion of subscapularis
Lower subscapular	*Side branch of posterior cord,* receiving fibers from **C6**	*Passes inferolaterally, deep to subscapular artery* and vein	*Inferior portion of sub-*scapularis and teres major
Thoracodorsal	Side branch of posterior cord, receiving fibers from C6, **C7,** C8	Arises between upper and lower subscapular nerves and runs inferolaterally along posterior axillary wall to apical part of latissimus dorsi	Latissimus dorsi
Axillary	Terminal branch of posterior cord, receiving fibers from **C5,** C6	Exits axillary fossa posteriorly, passing through quadrangular space[b] with posterior circumflex humeral artery (Fig. 6.31); gives rise to *superior lateral brachial cutaneous nerve;* then winds *around surgical neck of humerus deep to deltoid* (Fig. 6.30*D*)	Glenohumeral (shoulder) joint; teres minor and del-toid muscles (Fig. 6.30*D*); skin of superolateral arm *(over inferior part of* deltoid)
Radial	Larger terminal branch of posterior cord (largest branch of plexus), receiving fibers from C5–T1	Exits axillary fossa posterior to axillary artery; passes posterior to humerus in radial groove with deep brachial artery, between lateral and medial heads of triceps; perforates lateral intermuscular septum; enters cubital fossa, dividing into *super-ficial* (cutaneous) and *deep* (motor) *radial nerves* (Fig. 6.30*D*)	All muscles of posterior compartments of arm and forearm (Fig.6.30*D*); skin of posterior and inferolat-eral arm, posterior fore-arm, and dorsum of hand lateral to axial line of digit 4

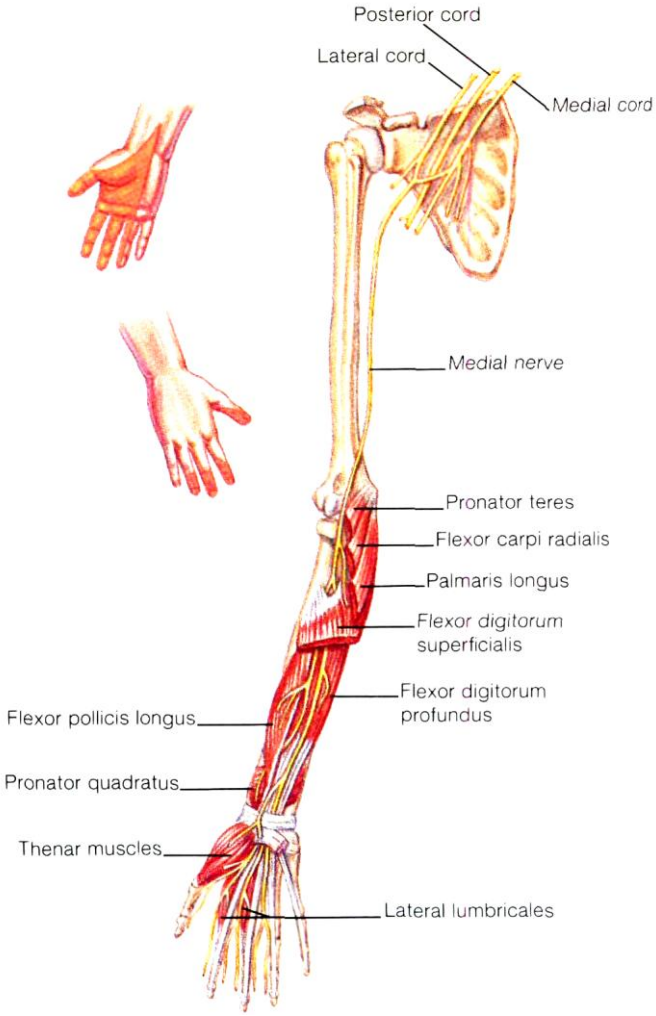
The long branches:

Among the long branches we can distinguish the anterior branches for the flexors and pronators (nn. musculocutaneus, medianus and ulnaris) and the posterior branches for the extensors and supinators (n. radialis).



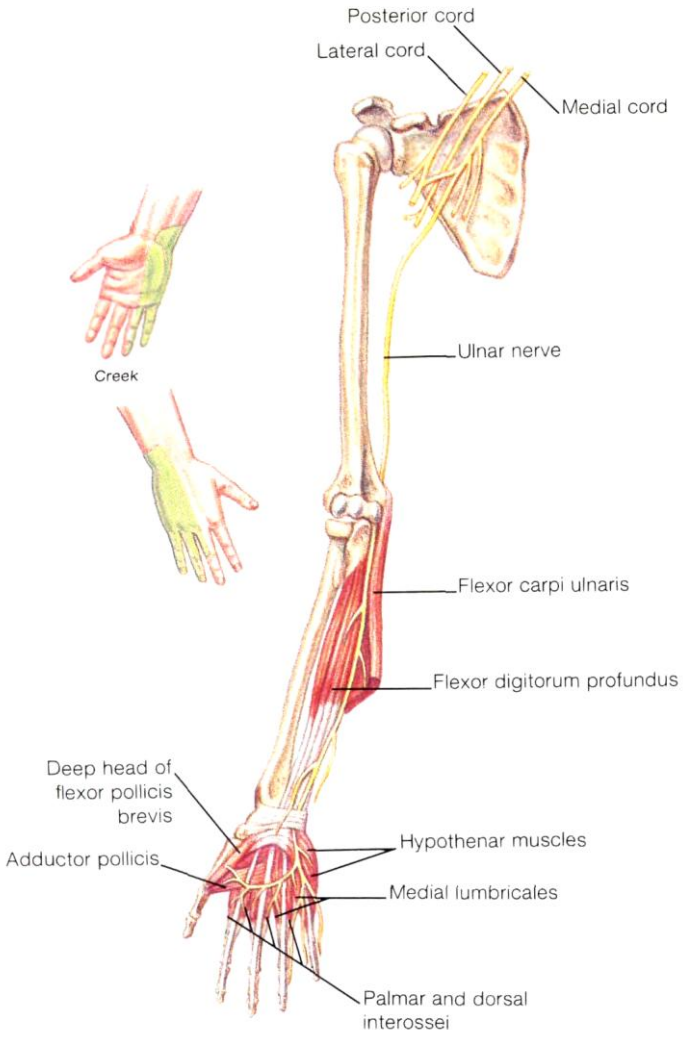
1. The **musculocutaneous nerve** *(n. musculocutaneus)* originates from the lateral trunk of the brachial plexus , pierces m. coracobrachialis and innervates all the anterior muscles of the shoulder: mm. coracobrachialis, biceps and brachialis. On passing between the latter two onto the lateral side of the upper arm, it continues onto the forearm as the *lateral cutaneous nerve of the forearm (n. cutaneus antebrachii lateralis)* supplying the skin of the radial side of the latter and the skin of the thenar.

2. The **median nerve** *(n. medianus)* , arises from the medial and lateral trunks in two roots which embrace the a. axillaris in front. It then passes into the sulcus bicipitalis medialis together with the brachial artery. In the cubital fossa the nerve runs under the m. pronator teres and the superficial flexor of the fingers and then between the latter and the m. flexor digitorum profundus and into the sulcus medianus in the middle of the forearm and to the palm. On the upper arm, the median nerve gives off no branches. On the forearm it gives off rami musculares to all the muscles of the anterior flexor group, with the exception of the m. flexor carpi ulnaris and the part of the deep flexor of the fingers (m.flexor digitorum profundus) nearest to it.



One of the branches, the *posterior interosseous nerve (n. interosseus antebrachii anterior)* accompanies the a. interossea anterior on the interosseous membrane and innervates the deep flexor muscles (m. flexor pollicis longus and part of the flexor digitorum profundus), m. pronator quadratus and the radiocarpal joint. The median nerve gives off a thin cutaneous branch, the *palmar cutaneous branch* (of the median nerve) *(ramus palmaris n. mediani)* over the radiocarpal joint. This branch supplies a small area of skin on the thenar and the palm. The median nerve passes onto the palm through the canalis carpi together with the tendons of the flexors and divides into three branches, the *common plantar digital nerves (nn. digitales palmares communes)* which run along the first, second and third metacarpal spaces under the palmar aponeurosis toward the fingers. The first branch innervates the muscles of the thenar with the exception of the m. adductor pollicis and the deep head of the m. flexor pollicis brevis which are innervated by the ulnar nerve. The common palmar digital nerves, in turn, divide into seven *proper palmar digital nerves (nn. digitales palmares proprii)* which pass to both sides of the thumb, to the index and middle fingers and to the radial side of the ring finger. The same branches also supply the skin on the radial side of the palm; the digital nerves also supply the first and second vermiform muscles.

3. The **ulnar nerve** *(n. ulnaris)* which emerges from the medial trunk of the brachial plexus passes on the medial side of the upper arm to the posterior surface of the medial epicondyle (it lies under the skin here and this is why it gets hurt so often, causing a prickling sensation in the middle zone of the forearm) and then extends in the sulcus ulnaris and further in the canalis carpi ulnaris where it runs, together with the arteries and veins of the same name, to the palm. On the surface of the retinaculum flexorum it transforms into its terminal branch—the ramus palmaris n. ulnaris. Like the median nerve, the ulnar nerve does not give rise to any branches on the upper arm.



The branches of the ulnar nerve on the forearm and hand:

Rami articulares to the elbow joint.

Rami musculares for the m.flexor carpi ulnaris and its neighbouring portion of the m.flexor digitorum profundus.

Ramus cutaneus palmaris to the skin of the hypothenar.

Ramus dorsalis n. ulnaris emerges through the space between the m. flexor carpi ulnaris and the ulnar bone to reach the dorsal surface of the hand where it divides into five dorsal digital branches, *nn. digitales dorsales,* for the little and ring fingers and the ulnar side of the middle finger.

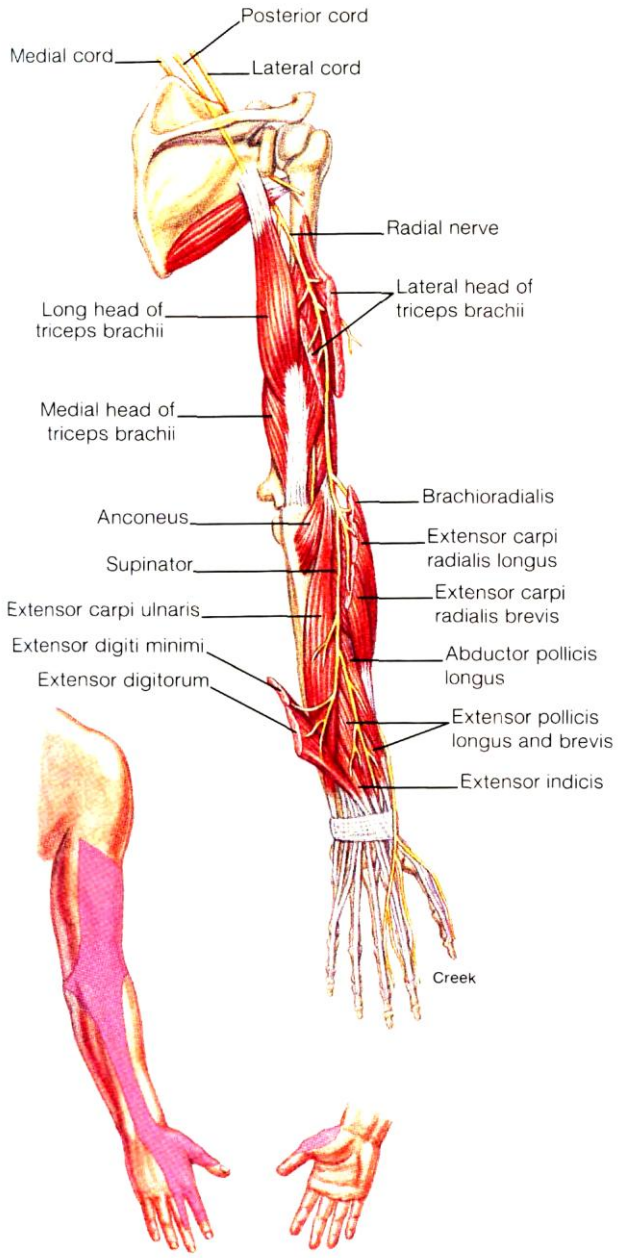
Ramus palmaris n. ulnaris, the terminal branch of the ulnar nerve, at the level of the os pisiforme divides into the superficial and deep branches, of which the superficial *(ramus superficialis)* supplies, via a small muscle branch, the m. palmaris brevis and then the skin on the ulnar side of the palm and, on dividing, gives off three nn. digitales palmares proprii to both sides of the little finger and to the ulnar side of the ring finger.

Ramus profundus, the deep branch of the ulnar nerve, together with the deep branch of the a. ulnaris passes through the space between the m.flexor and m. abductor digiti minimi and accompanies the deep palmar arch. There it innervates all the muscles of hypothenar, all mm. interossei, the third and fourth mm. lumbricales, and from the muscles of the thenar—m. adductor pollicis and the deep head of the m. flexor pollicis brevis. Ramus profundus ends in a thin anastomosis with n. medianus **.**

4. The **medial cutaneous nerve of the arm** *(n. cutaneus brachii medialis)* arises from the medial trunk of the plexus and passes along the axilla medially to the a. axillaris; it usually joins with the perforating branch of the second thoracic nerve (n. intercostobrachialis), and supplies the skin on the medial surface of the upper arm up to the ulnar joint.

5. The **medial cutaneous nerve of the forearm** *(n. cutaneus antebrachii medialis)* also arises from the medial trunk of the plexus and lies in the axilla next to the ulnar nerve; in the upper part of the upper arm it is located medially of the brachial artery next to v. basilica together with which it pierces the fascia and becomes subcutaneous. This nerve innervates the skin on the ulnar (medial) side of the forearm down to the articulations of the hand.

6. The **radial nerve** (n. *radialis),* is a continuation of the posterior trunk of the brachial plexus. It passes posteriorly of the brachial artery together with the profunda brachii artery onto the posterior surface of the upper arm, runs around the humerus to be lodged in the canalis humeromuscularis, and then, piercing the lateral intermuscular septum from back to front, emerges into the space between the m. brachioradialis and m. brachialis. Here the nerve divides into the superficial (ramus superficialis) and deep (ramus profundus) branches. Prior to this, the radial nerve gives rise to the *following branches:*



Muscular branches (rami musculares) on the upper arm for extensors— m. triceps and m. anconeus. The last small branch also supplies the capsule of the elbow joint and the radial: epicondyle of the upper arm.

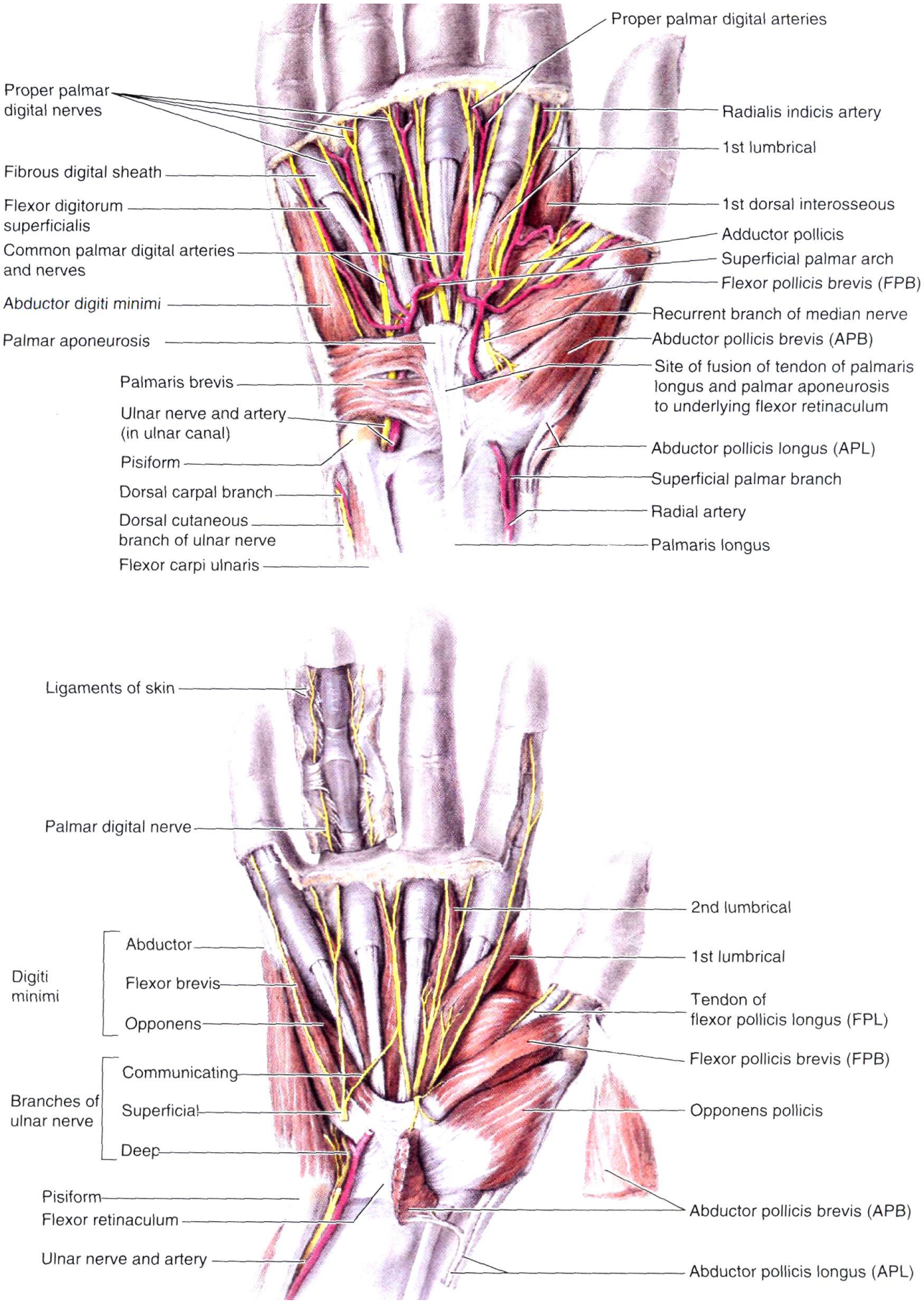
The *posterior cutaneous nerve of the arm* and *the lower lateral cutaneous nerve of the arm (nn. cutanei brachii posterior* and *lateralis inferior)* branch out in the skin of the posterior and inferior parts of the posterolateral surface of the upper arm.

The *posterior cutaneous nerve of the forearm (n. cutaneus antebrachii posterior)* arises from the radial nerve in the canalis humeromuscularis, emerges under the skin at the origin of the m. brachioradialis and spreads over the dorsal surface of the forearm.

Muscular branches (rami-musculares) pass to the m. brachioradialis and m. extensor carpi radialis longus.

The *superficial branch of the radial nerve (ramus superficialis)* passes to the forearm into the sulcus radialis laterally of the a. radialis, and then in the lower third of the forearm through the space between the radial bone and the tendon of the m. brachioradialis goes over to the dorsal surface of the hand and supplies with five dorsal branches, the *dorsal digital nerves (nn. digitales dorsales)* along the sides of the thumb and index finger, and the radial side of the middle finger. These branches usually end at the level of the distal interphalangeal joints. They anastomose with the ramus dorsalis n. ulnaris. Thus every finger is supplied with two dorsal and two palmar nerves passing along both sides. The dorsal nerves arise from the radial nerve and the ulnar nerve, each innervating two and a half fingers. The palmar nerves arise from the median nerve and the ulnar nerve, with the former supplying three and a half fingers (beginning with the thumb), and the latter the remaining one and a half fingers

The *deep branch (ramus profundus)* passes through the m. supinator and, having supplied it with a branch, continues onto the dorsal surface of the forearm, innervating the m. extensor carpi radialis brevis and all the posterior muscles of the forearm. The continuation of the deep branch, n. interosseus (antebrachii) posterior, descends between the extensors of the thumb to the radiocarpal joint, which it supplies. It can be seen by the route followed by the radial nerve that it supplies all the extensors both of the upper arm and of the forearm and also a radial group of muscles in the forearm. In correspondence with this it also innervates the skin on the extensor surface of the upper arm and forearm. The radial nerve, which is the continuation of the posterior trunk, functions as if it were the posterior nerve of the hand.

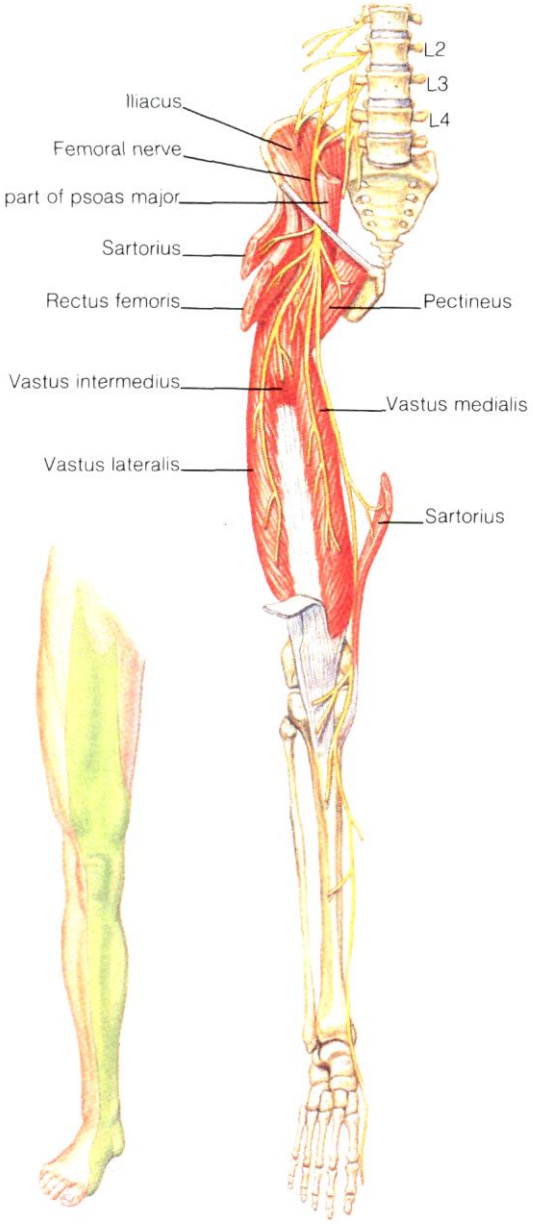

Proper palmar digital arteries
Proper palmar digital nerves
Radialis indicis artery
1st lumbrical
Fibrous digital sheath
1st dorsal interosseous
Flexor digitorum superficialis
Adductor pollicis
Common palmar digital arteries and nerves
Superficial palmar arch
Flexor pollicis brevis (FPB)
Abductor digiti minimi
Recurrent branch of median nerve
Palmar aponeurosis
Abductor pollicis brevis (APB)
Site of fusion of tendon of palmaris longus and palmar aponeurosis to underlying flexor retinaculum
Palmaris brevis
Ulnar nerve and artery (in ulnar canal)
Abductor pollicis longus (APL)
Pisiform
Superficial palmar branch
Dorsal carpal branch
Radial artery
Dorsal cutaneous branch of ulnar nerve
Palmaris longus
Flexor carpi ulnaris
Ligaments of skin
Palmar digital nerve
2nd lumbrical
Digiti minimi
Abductor
1st lumbrical
Flexor brevis
Tendon of flexor pollicis longus (FPL)
Opponens
Flexor pollicis brevis (FPB)
Branches of ulnar nerve
Communicating
Opponens pollicis
Superficial
Deep
Pisiform
Abductor pollicis brevis (APB)
Flexor retinaculum
Ulnar nerve and artery
Abductor pollicis longus (APL)

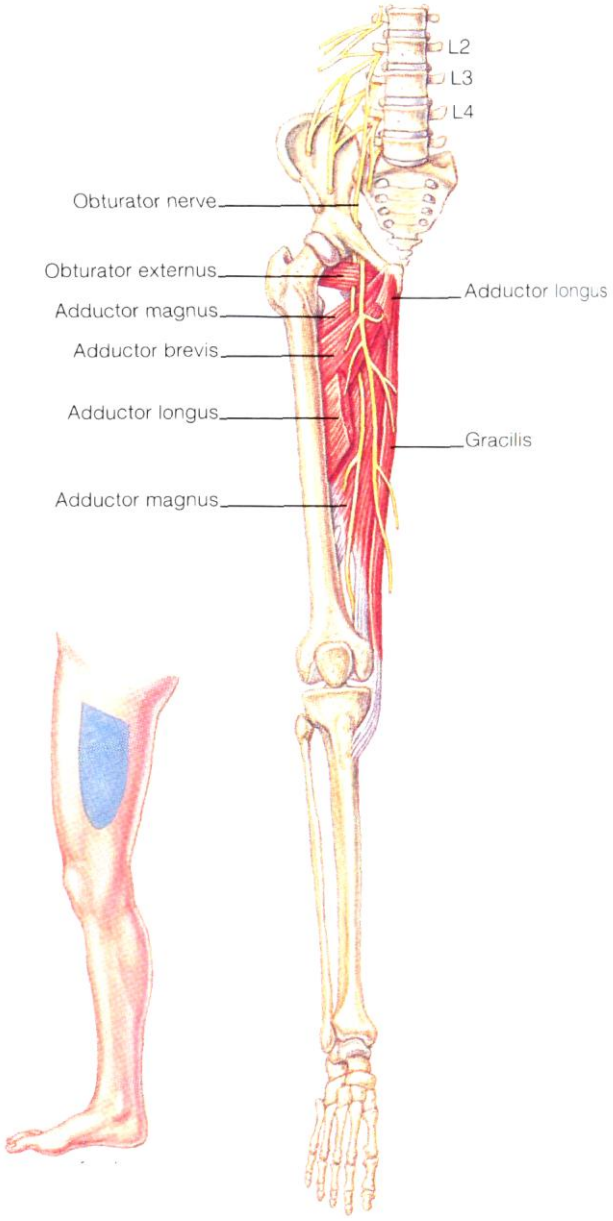
THE LUMBOSACRAL PLEXUS

The **lumbosacral plexus** *(plexus lumbosacralis)* is composed of the anterior branches of the lumbar, sacral and coccygeal nerves. This common plexus is divided into separate parts, or separate plexuses: lumbar, sacral and coccygeal.

The Lumbar Plexus

The **lumbar plexus (***plexus lumbalis)* is formed of the anterior branches of three superior lumbar nerves and the upper part of the fourth superior lumbar nerve, and of a small branch from the twelfth intercostal nerve. The plexus lies in front of the transverse processes of the lumbar vertebrae in the thickness of the m. psoas major and gives rise to a number of branches which emerge partly from under the lateral, partly from under the medial edge of this muscle, while another part of them pierces it and appears on its anterior surface.

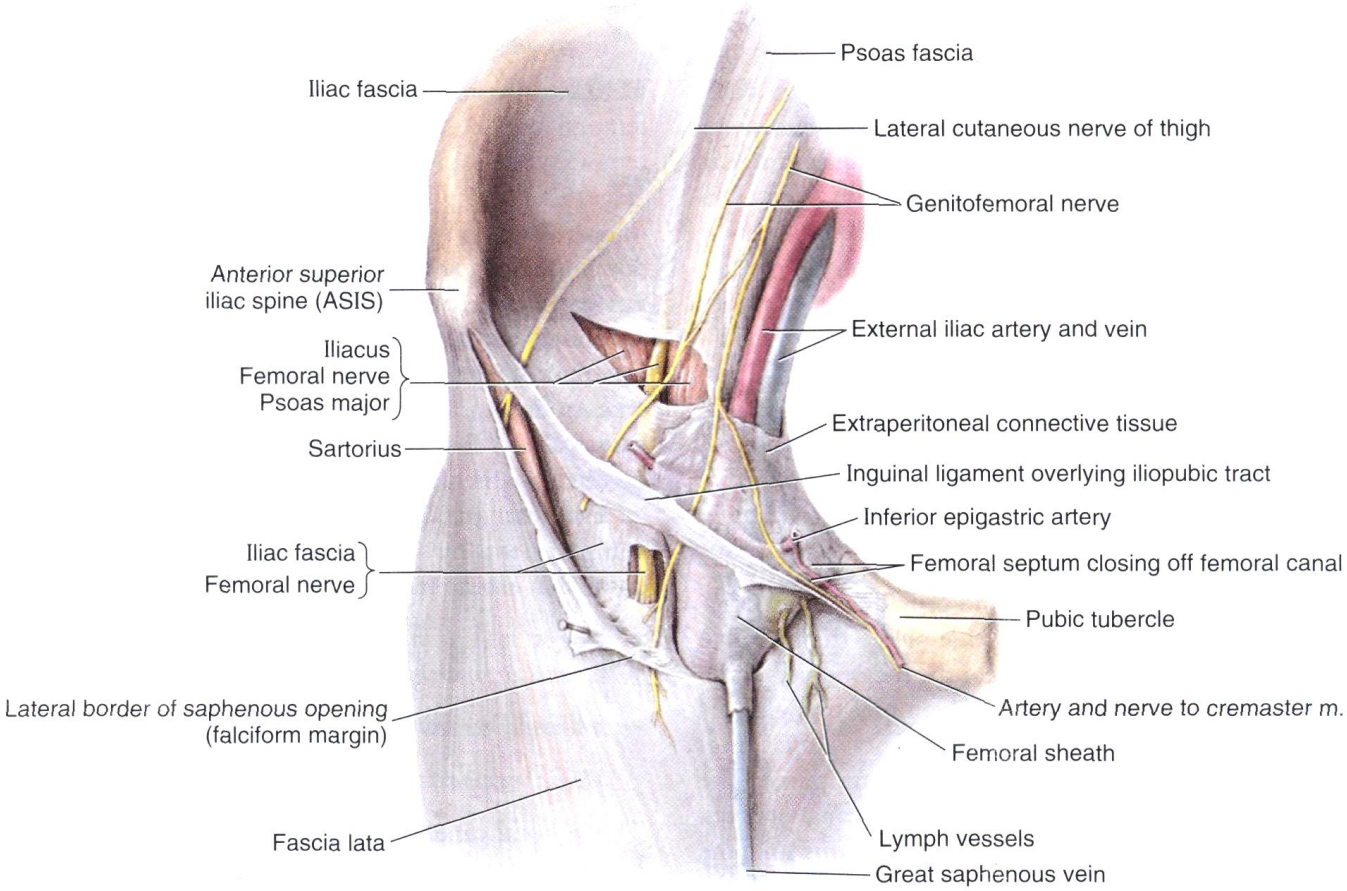




These branches are as follows.

1. **Rami musculares** to the m. psoas major and minor, m. quadratus lumborum and mm. intertransversarii laterales lumborum.

2. The **iliohypogastric** nerve *(n. iliohypogastricus)* emerges from under the lateral edge of the m. psoas major and stretches on the anterior surface of the m. quadratus lumborum parallel to the twelfth intercostal nerve. The iliohypogastric nerve is a segmentary nerve and like the latter it passes between the transverse and internal oblique muscles of the abdomen, supplying them with muscular branches, and also innervates the skin of the upper part of the buttocks and the inguinal canal above the level of its superficial orifice.



Anterior view

3. The **ilioinguinal nerve** *(n. ilioinguinalis)* is also a segmentary nerve, it emerges from under the lateral edge of the m. psoas major and runs parallel to and downward of the iliohypogastric nerve, and then directly in the inguinal canal, exits through the superficial inguinal ring and branches out in the skin of the pubis and scrotum or the labia majora.

4. The **genitofemoral nerve** *(n. genitofemoralis)* runs through the thickness of the m. psoas major onto its anterior surface and divides into two branches, one of which, the *femoral branch (r. femoralis),* descends forward to inguinal ligament, passes under it and branches in the skin of the thigh immediately below this ligament. The other, the *genital branch (r. genitalis),* pierces the posterior wall of the inguinal canal and joins the spermatic cord, supplying the m. cremaster and the membranes of the testicle.

5. The **lateral cutaneous nerve of the thigh** *(n. cutaneus femoris lateralis)* originates from under the lateral edge of the m. psoas major and passes over the surface of the m. iliacus from top to bottom and then laterally to the spina iliaca anterior superior, where it pierces the abdominal wall and emerges onto the thigh, becomes subcutaneous and descends along the lateral surface of the thigh to the knee, innervating the skin.

The skin of the external surface of the thigh is also innervated by the iliohypogastric and subcostal nerves.

6. The **femoral nerve** *(n. femoralis)* is the largest branch of the lumbar plexus . It emerges through the lacuna musculorum onto the anterior side of the thigh. It lies laterally of the femoral artery, separating from it with a deep fascia, fasciae latae, and then ramifies into numerous branches. Some of these branches, *rami musculares,* innervate the m. quadriceps, m. sartorius and m. pectineus, while others, the *rami cutanei anteriores,* supply the skin of the anteromedial surface of the thigh. One of the cutaneous branches of the femoral nerve, a very long branch, the *saphenous nerve,* stretches in canalis adductorius laterally of the femoral artery. At the hiatus adductorius the nerve leaves the artery, pierces the anterior wall of the canal and becomes superficial. On the leg the nerve is
accompanied by the v. saphena magna. It gives rise to the *infrapatellar branch (ramus infrapatellaris)* in the skin of the lower part of the leg and **to** the *medial cutaneous nerve of the thigh (rami cutanei cruris mediales)* in the skin of the medial surface of the leg down to the medial edge of the foot.

In addition to the principal femoral nerve there is a supplementary femoral nerve.

7. The **obturator nerve** *(n. obturatorius)* passes through the obturator canal to the thigh and divides into the anterior and posterior branches. The *posterior branch (ramus posterior)* innervates the m. obturatorius externus, m. adductor magnus and the hip joint; the *anterior branch (ramus anterior)* supplies the other adductor muscles together with the m. gracilis and m. pectineus, and, besides, it gives rise to a long cutaneous branch (ramus cutaneus) which passes down between the adductor muscles. The cutaneous branch runs under the skin on the medial side of the thigh in its lower half, which it innervates.

The Sacral Plexus

The **sacral plexus** *(plexus sacralis)* , the most significant of all the plexuses, is composed of the anterior branches of the fourth (lower part) and fifth lumbar nerves and of similar branches of four sacral nerves , which emerge from the anterior sacral foramen. The proximity of many bundles of the plexus to the sacroiliac joint determines the variety of localization and irradiation of pain in case of the disease of this joint. In joining with one another, the nerves of the plexus form a number of loops whose apices merge at the lower edge of the m. piriformis to form a thick trunk of the sciatic nerve passing through the foramen infrapiriforme from the pelvic cavity. The branches originating from the sacral plexus may be divided into short and long ones. The short ones branch out in the region of the pelvic girdle and the long branches supply the whole lower extremity except for that part which is supplied by branches of the lumbar plexus.

The short branches :

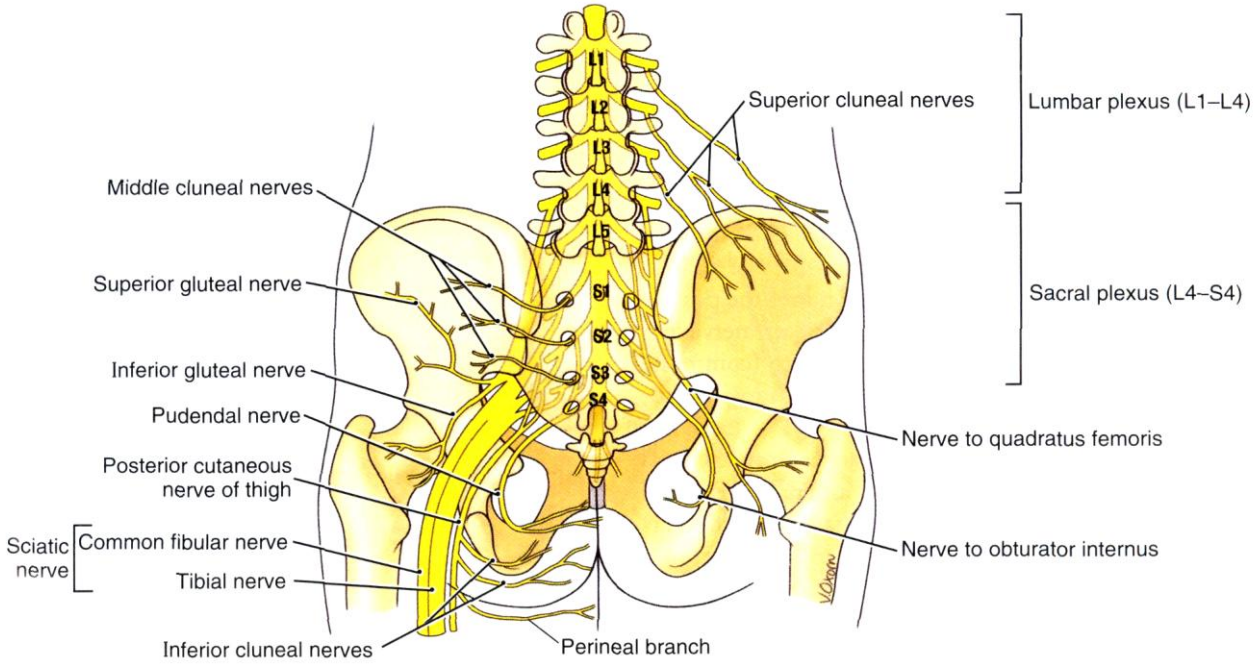
1. The **muscular branches** *(rami musculares)* for the m. piriformis , m. obturatorius internus with mm. gemelli and quadratus femoris , for mm. levator ani and coccygeus .

2. The **superior gluteal nerve** *(n. gluteus superior)* emerges through the foramen suprapiriforme from the pelvis together with the artery of the same name and then extends to the m. gluteus medius, m. gluteus minimus and m. tensor fasciae latae.

3. The **inferior gluteal nerve** *(n. gluteus inferior)* emerges through the foramen infrapiriforme lateral of the artery of the same name; its branches supply the m. gluteus maximus and the capsule of the hip joint.

4. The **pudendal nerve** *(n. pudendus)* emerges through the foramen infrapiriforme together with the a. pudenda interna and, curving around the spina ischiadica, passes back into the pelvis through the foramen ischiadicum minus. Further the pudendal nerve together with the same artery passes along the lateral wall of the fossa ischiorectalis. Within the limits of the latter it gives off the inferior haemorrhoidal nerves (nn. rectales inferiores) which supply the external sphincter (m. sphincter ani externus) and the skin of the region around the anus.

Table **Nerves of Gluteal Region and Posterior Thigh**



Nerve	Origin	Course	Distribution
Clunial			
Superior	*As lateral cutaneous branches* of posterior rami of L1–L3 spinal nerves	*Pass inferolaterally across iliac crest*	*Supply skin of superior buttock* as far as tubercle of iliac crest
Middle	As lateral cutaneous branches of posterior rami of S1–S3 spinal nerves	Exit through posterior sacral foramina and pass laterally to gluteal region	Supply skin over sacrum and adjacent area of buttock
Inferior	Posterior cutaneous nerve of thigh (anterior rami of S2–S3 spinal nerves)	Emerges from inferior border of gluteus maximus and ascends superficial to it	Supplies skin of inferior half of buttock as far as greater trochanter
Sciatic	Sacral plexus (anterior and posterior divisions of anterior rami of L4–S3 spinal nerves)	Enters gluteal region via greater sciatic foramen inferior to piriformis and deep to gluteus maximus; descends in posterior thigh deep to biceps femoris; bifurcates into tibial and common fibular nerves at apex of popliteal fossa.	Supplies no muscles in gluteal region; supplies all muscles of posterior compartment of thigh (tibial division supplies all but short head of biceps, which is supplied by common fibular division)
Posterior cutaneous nerve of thigh	Sacral plexus (anterior and posterior divisions of anterior rami of S1–S3 spinal nerves)	Enters gluteal region via greater sciatic foramen inferior to piriformis and deep to gluteus maximus, emerging from inferior border of latter; descends in posterior thigh deep to fascia lata	Supplies skin of inferior half of buttock (through inferior clunial nerves),skin over posterior thigh and popliteal fossa, and skin of lateral perineum and upper media thigh (via its perineal branch).
Superior gluteal	Sacral plexus (posterior divisions of anterior rami of L4–S1 spinal nerves)	Enters gluteal region via greater sciatic foramen superior to piriformis; courses laterally between gluteus medius and minimus as far as tensor of fascia lata	Innervates gluteus medius, gluteus minimus, and tensor of fascia lata muscles
Inferior gluteal	Sacral plexus (posterior divisions of anterior rami of L5–S2 spinal nerves)	Enters gluteal region via greater sciatic foramen inferior to piriformis and deep to inferior part of gluteus maximus, dividing into several branches	Supplies gluteus maximus
Nerve to quadratus femoris	Sacral plexus (anterior divisions of anterior rami of L4–S1 spinal nerves)	Enters gluteal region via greater sciatic foramen inferior to piriformis, deep (anterior) to sciatic nerve	Innervates hip joint, inferior gemellus, and quadratus femoris

Nerves of Gluteal Region and Posterior Thigh *(continued)*

Nerve	Origin	Course	Distribution
Pudendal	Sacral plexus (anterior divisions of anterior rami of S2–S4 spinal nerves)	Exits pelvis via greater sciatic foramen inferior to piriformis; descends posterior to sacrospinous ligament; enters perineum through lesser sciatic foramen	Supplies no structures in gluteal region or posterior thigh (principal nerve to perineum)
Nerve to obturator internus	Sacral plexus (posterior divisions of anterior rami of L5–S2 spinal nerves)	Exits pelvis via greater sciatic foramen inferior to piriformis; descends posterior to sacrospinous ligament; enters perineum through lesser sciatic foramen	Supplies superior gemellus and obturator internus

At the level of the tuber ischiadicum at the posterior edge of the diaphragma urogenitale the pudendal nerve divides into the *perineal nerves* and *dorsal nerve of the penis (nn. perinei* and *n. dorsalis penis)* (clitoridis). The first run forward and innervate the m. ischiocavernosus, m. bulbospongiosus and m. transversa perinei superficialis and the skin of the perineum. The terminal branches supply the skin of the posterior side of the scrotum, the *scrotal branches (nn. scrotales posteriores),* and the labia majora, *labial branches (nn. labiales posteriores).* The dorsal nerve of the penis (clitoridis) attends a. dorsalis penis in the thickness of the diaphragma urogenitale, gives off small branches to the m. transversus perinei profundus and m. sphincter uretrae, and passes onto the dorsum penis (or clitoris) where it is distributed in the skin mainly of the glans penis. A large number of vegetative fibres pass in the composition of the pudendal nerve.

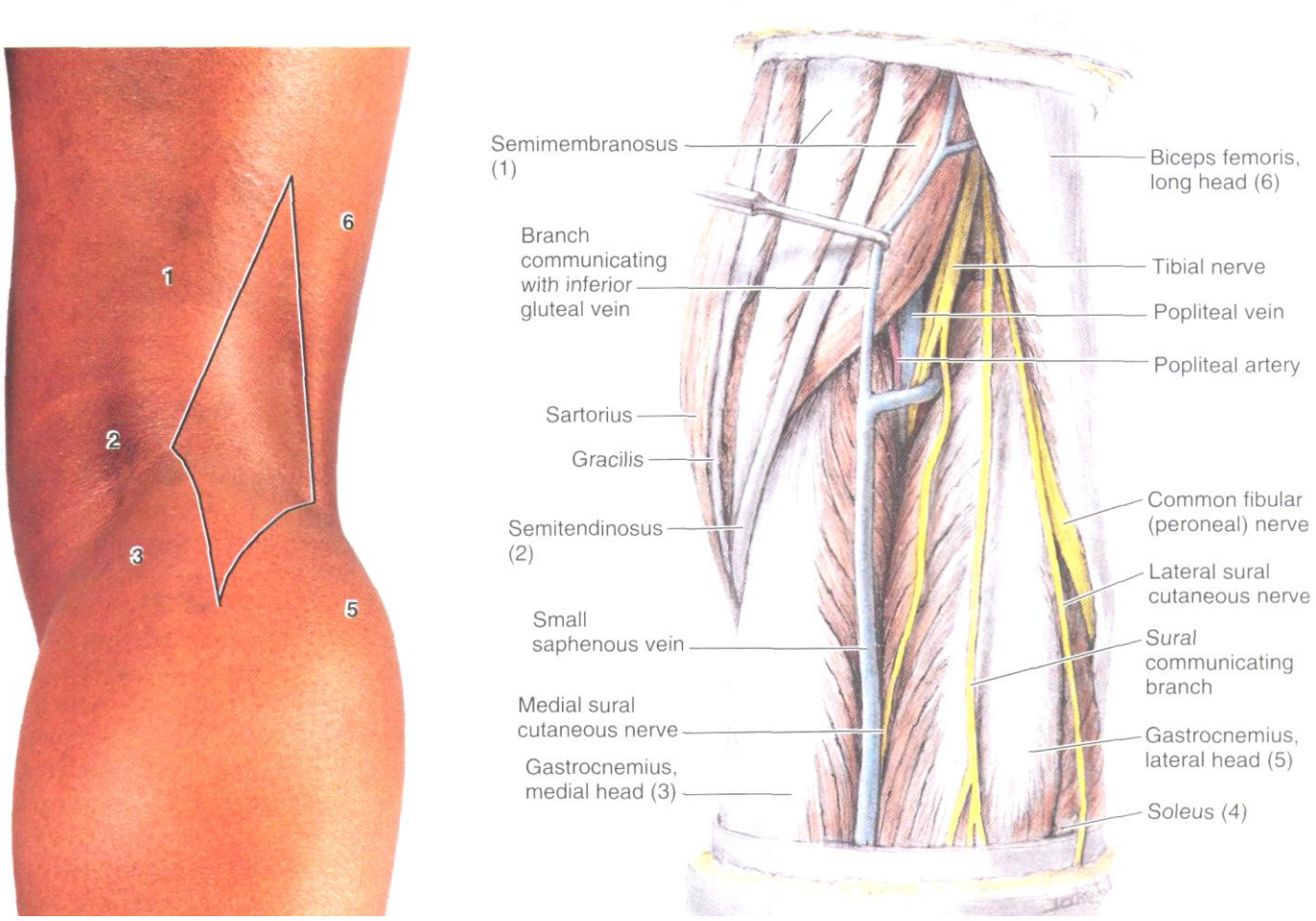
The long branches:

1. The **posterior cutaneous nerve of the thigh** *(n. cutaneus femor is posterior)* emerges from the pelvis together with the sciatic nerve and then descends under the m. gluteus maximus onto the posterior surface of the thigh. From its medial side it gives off small *gluteal branches* which run under the skin of the lower part of the buttock *(nn. clunium inferiores)* and to the perineum—*perineal branches (rami perineales)* . On the surface of the posterior thigh muscles it reaches down to the popliteal fossa and gives rise to numerous branches which are distributed in the skin of the posterior surface of the thigh and the calf region.

2. The **sciatic nerve** *(n. ischiadicus)* is the largest nerve in the entire body and is actually the direct continuation of the sacral plexus that contains fibres of all its roots. It emerges from the pelvic cavity through the large ischiadic foramen below the m. piriformis and is covered by the m. gluteus maximus. Further down the nerve emerges from under the lower edge of this muscle and descends perpendicularly on the posterior surface of the thigh under the flexors of the leg. In the upper part of the popliteal fossa it usually divides into its two main branches: the medial thicker one — the **medial popliteal nerve** (n. *tibialis)* and the lateral, thinner one—the **lateral popliteal nerve** *(n. peroneus [fibularis] communis).* Quite often the nerve **is** already divided into two separate trunks the entire length of the posterior part of the thigh.

Branches of the sciatic nerve:

1. **Muscular branches** *(rami musculares)* to the posterior muscles of the thigh: m. semitendinosus, m. semimembranosus and to the long head the m. biceps femoris and also to the posterior part of the m. adductor magnus. The short head of the m. biceps receives a small branch from the peroneal nerve. A small branch also arises from the peroneal nerve to the knee joint.



2. The **medial popliteal nerve** *(n. tibialis)* descends directly through the middle of the popliteal fossa along the tract of the popliteal vessels, then enters the canalis cruropopliteus, accompanying the a. and vv. tibiales posteriores in this canal, until it reaches the medial malleolus. Behind the latter the medial popliteal nerve divides into its terminal branches—the *lateral* and *medial plantar nerves (nn. plantares lateralis* and *medialis)* in the planter sulci of the same name. In the popliteal fossa the *rami musculares* branch out from the medial popliteal nerve to the m. gastrocnemius, m. plantaris, m. soleus and m. popliteus. Several small branches pass to the knee joint. Moreover, in the popliteal fossa the medial popliteal nerve gives rise to a long cutaneous branch the *lateral cutaneous nerve of calf of the leg (n. cutaneus surae medialis),* which runs down together with the v. saphena parva and innervates the skin of the posteromedial surface of the leg. On the leg the medial popliteal nerve supplies all three deep muscles with small branches: m. tibialis posterior, m. flexor hallucis longus and m. flexor digitorum longus and the posterior side of the talocrural articulation and behind the medial malleolus it gives rise to cutaneous branches, *rami calcanei mediales,* which pass to the skin of the heel and the medial edge of the foot **.**

The *medial plantar nerve (n. plantaris medialis)* together with the artery of the same name passes in the sulcus plantaris medialis along the medial edge of the m. flexor digitorum brevis and supplies this muscle and the muscles of the medial group, with the exception of the m. adductor hallucis and the lateral head of the m. flexor hallucis brevis. The nerve finally ramifies into seven nerves—*proper plantar digital nerves (nn. digitales plantares proprii)* of which one passes to the medial edge of the big toe and also supplies the first and second mm. lumbricales while the remaining six nerves innervate the skin of the sides of toes facing each other, beginning with the lateral side of the big toe and ending with the medial side of the fourth toe.

The *lateral plantar nerve (n. plantaris lateralis)* runs in the same direction as the artery of the same name in the sulcus plantaris lateralis. It supplies by means of rami musculares all three muscles of the lateral group of the sole and the m. quadratus plantae and divides into two branches, a deep and a superficial one. The deep branch (ramus profundus) runs together with the plantar arterial arch and supplies the third and fourth mm. lumbricales and all the dorsal interossei muscles, and also the m. adductor hallucis and the lateral head of the m. flexor hallucis brevis. The superficial branch (ramus superficialis) gives off branches to the skin of the sole and divides into three *proper plantar digital nerves (nn. digitales plantares proprii)* running to both sides of the fifth toe and to the side of the fourth toe
facing the fifth. In general, the distribution of the medial and lateral plantar nerves corresponds to the direction taken by the ulnar and median nerves of the hand.

3**.** The **lateral popliteal nerve** *(n. peroneus [fibularis] communis)* , runs laterally of the n. tibialis to the head of the fibula where it pierces the beginning of the peroneus longus muscle and divides into the superficial and deep branches. On its way the lateral popliteal nerve gives rise to the *lateral cutaneous nerve of calf of the leg (n. cutaneus surae lateralis)* which innervates the skin of the lateral surface of the leg. Below the middle of the leg the lateral cutaneous nerve joins the medial cutaneous nerve to form the *sural nerve (n. suralis)* which curves around the lateral malleolus from the back giving rise to branches to the skin of the heel (rami calcanei laterales), and then continues under the name of the *dorsal lateral cutaneous nerve of the foot (n. cutaneus [pedis] dorsalis lateralis)* along the lateral edge of the dorsal surface of the foot, also supplying the skin of this region on the lateral side of the small toe.

The *superficial branch of the musculocutaneous nerve of the lower limb (n. peroneus [fibularis] superficialis),* descends between the mm. peronei into the canalis musculoperoneus superior, giving them muscle branches. On the border between the middle and lower third of the leg it pierces the fascia functioning only as a cutaneous nerve and descends to the middle of the dorsal surface of the foot to divide into two branches. One of them the *medial branch of the musculocutaneous nerve of the lower limb (n. cutaneus [pedis] dorsalis medialis)* supplies the medial surface of the big toe and the edges of the second and third toes facing each other (nervi digitales dorsales). The other, the *lateral branch of the musculocutaneous nerve of the lower limb (n. cutaneus [pedis] dorsalis intermedius)* divides into the nn. digitales dorsales pedis supplying the approximate surfaces of the second to fifth toes.

The *deep branch of the anterior tibial nerve (n. peroneus [fibularis] profundus),* passes in attendance to the a. tibialis anterior, giving branches to the m. tibialis anterior, m. extensor digitorum longus and m. extensor hallucis longus and the ramus articularis to the talocrural joint. The anterior tibial nerve together with the artery attending it emerges onto the dorsal surface of the foot, innervates the short extensor of the toes and then, dividing into two *digital branches (nn. digitales dorsales)* supplies the skin of the surfaces of the big and second toes facing each other.

Part of the sacral plexus which belongs to the animal nervous system is made up of preganglionary parasymphathetic fibres which begin in the lateral horns of the second to fourth segments of the spinal cord. These fibres as *pelvic splanchnic nerves (nervi splanchnici pelvini)* pass to the nerve plexuses of the pelvis that innervate the internal organs of the pelvis: the urinary bladder, the sigmoid colon, the rectum and the internal genital organs.

The Coccygeal Plexus

The coccygeal plexus *(plexus coccygeus)* is composed of the **anterior** branches of the fifth sacral and the coccygeal nerves. It gives rise to **the** thin **anococcygeal nerves** *(nn. anococcygei)* which join with the **posterior branch of** the coccygeal nerve, and branches out in the skin at the top of the coccyx.

THE SCIENCE OF THE VESSELS (ANGIOLOGY)

The vascular systems of man and other vertebrates can be classified into two systems, according to the character of the circulating fluid:
(1) the **blood vascular system,** made up of tubes (the arteries, veins, and heart), through which the blood circulates;
(2) the **lymphatic system,** made up of tubes along which lymph, a colourless fluid, flows.
In the process of embryogenesis, the lymphatic system comes into contact with the blood circulation system and becomes an additional channel for the veins. The fluid in the lymph vessels flows in the same direction as blood in the veins, i.e., from the tissues to the heart. There are, however, substantial differences in the character of the removal of substances by veins and lymph vessels. For the most part, dissolved substances are absorbed by the blood vessels and solid particles by the lymph vessels. Absorption in the blood occurs much faster. When methylene blue is introduced subcutaneously, for example, it appears in the urine earlier than its presence can be detected in the thoracic duct.

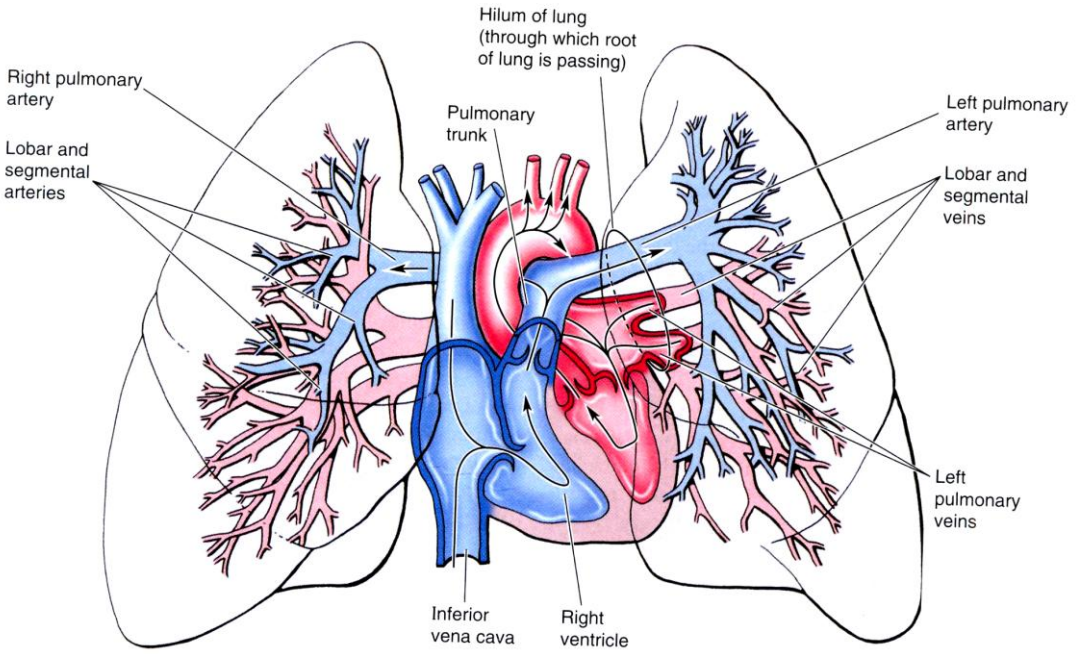
Lesser (pulmonary) circulation enriches the blood with oxygen in the lungs. The process begins in the right ventricle into which venous blood from the right atrium flows through the right atrioventricular orifice. The pulmonary trunk arises from the right ventricle; in the lungs it branches into arte-ries, which narrow into capillaries. In the capillary networks entwining the lung vesicles, the blood yields carbon dioxide in exchange for a new supply of oxygen (pulmonary respiration). The oxidized blood turns crimson, and on becoming arterial flows from the capillaries to the veins, which, merging to form four pulmonary veins (two veins per side), drain into the left atrium of the heart. Lesser (pulmonary) circulation ends in the left atrium, while the arterial blood that had entered the atrium proceeds through the left atrioventricular orifice into the left ventricle where the process of greater circulation begins.

Greater (systemic) **circulation** supplies all the organs and tissues of the body with nutrients and oxygen. The process begins in'the left ventricle of the heart, from which the aorta, carrying arterial blood, arises. Arterial blood, crimson in colour, contains the nourishment and oxygen necessary for the life of the organism. The aorta branches into the arteries, which pass to all the organs and tissues of the body and narrow into arterioles and fur-ther into capillaries. The capillaries in turn form venules and then veins. Metabolism and gas exchange between the blood and body tissues take place through the walls of the capillaries. The arterial bipod flowing in the capilla-ries yields the nutrients and oxygen it carries and, in exchange, receives the products of metabolism and carbon dioxide (tissue respiration). Thus, the blood that flows into the venous bed is poor in oxygen but rich in carbon dioxide and, therefore, dark in colour. It is possible to determine whether an injury has occurred to an artery or to a vein by the colour of the blood. The veins form two large trunks, the vena cava superior and the vena cava inferior, which end in the right atrium of the heart. Greater (systemic) circulation ends in this part of the heart.

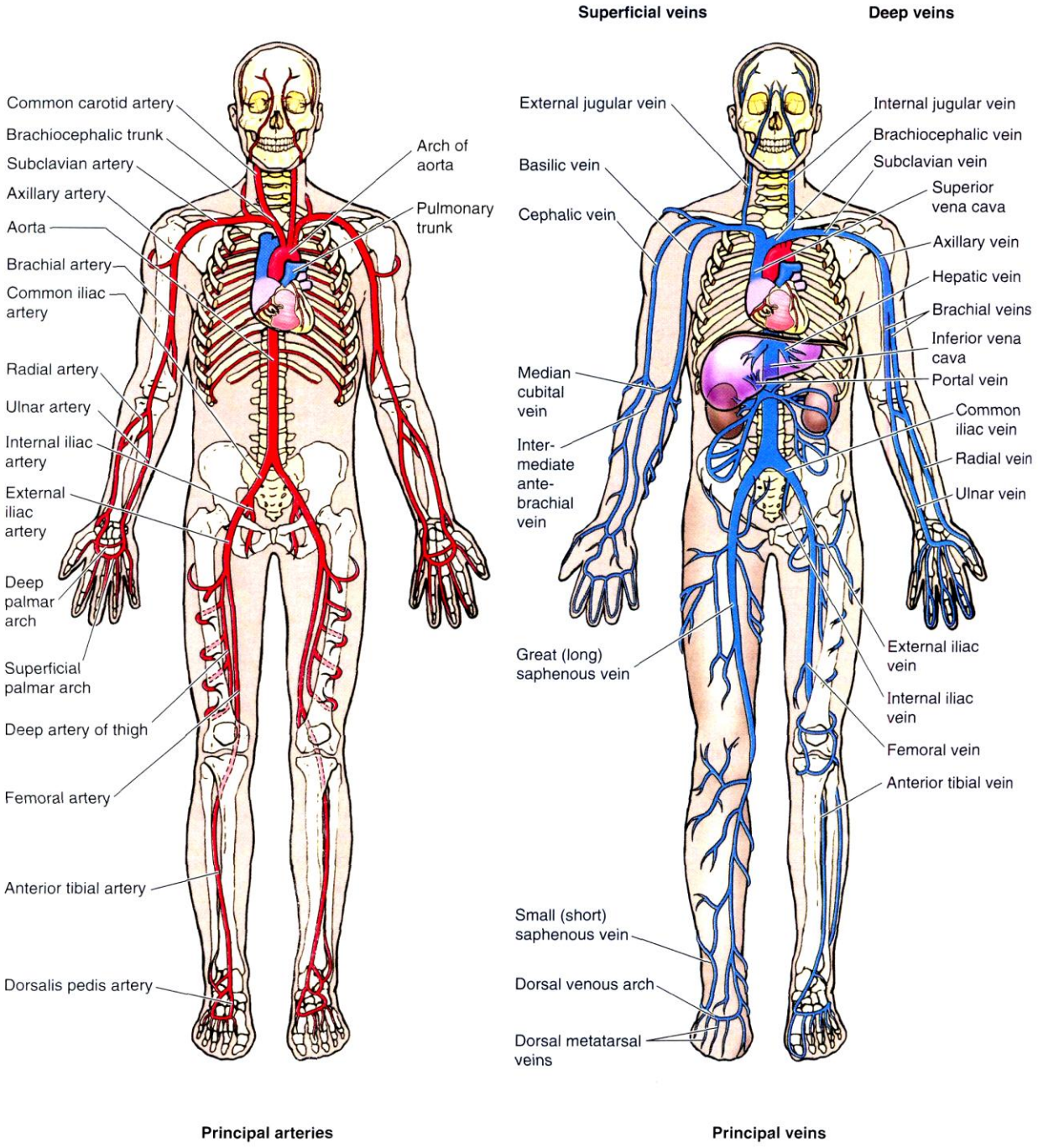
Another system of circulation, called the **third (cardiac) circulation,** services the heart itself. It begins with the coronary arteries, which arise from the aorta, and ends with the veins of the heart. These veins form the venous sinus, which drains into the right atrium, while the rest of the veins open into the atrial cavity directly.

The blood vessels passing from the heart to the organs and carrying blood to them are called ***arteries.***
The blood vessels passing from the organs to the heart and carrying blood to them are called ***veins***.

Lesser (pulmonary) circulation



Greater (systemic) **circulation**



THE HEART

The **heart** *(cor)* is a hollow muscular organ, which receives blood from the venous trunks draining into it and pumps the blood into the arterial system. The cavity of the heart is subdivided into four chambers: two atria and two ventricles. The left atrium and the left ventricle comprise the left heart, also called the arterial heart, because of the type of blood it contains; the right atrium and right ventricle comprise the right or venous heart. Contraction of the right and left atria occurs simultaneously. The ventricles also contract simultaneously, but in regular sequence with the atria. Contraction of the walls of the heart chambers is called *systole.* Their relaxation is called *diastole.*

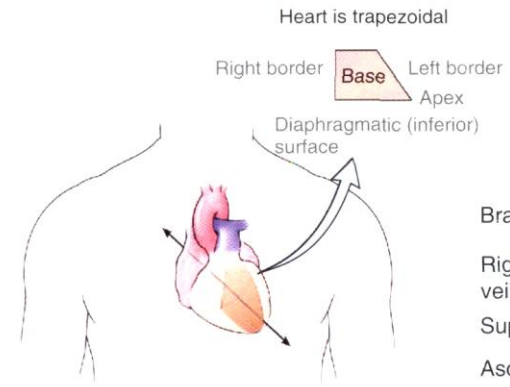
The heart is shaped like a slightly flattened cone. In it we distinguish
-an apex,
-a base,
-the anterosuperior and inferior surfaces,
- the right and left borders.

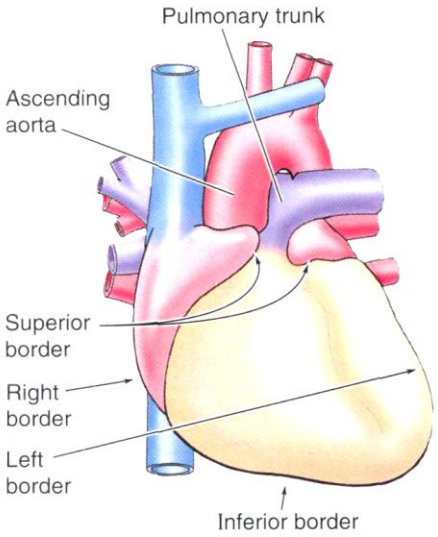
The rounded **apex of the heart** *(apex cordis)* faces downward, forward, and to the left, reaching the fifth intercostal space 8-9 cm to the left of the midline; the apex is formed by the left ventricle .

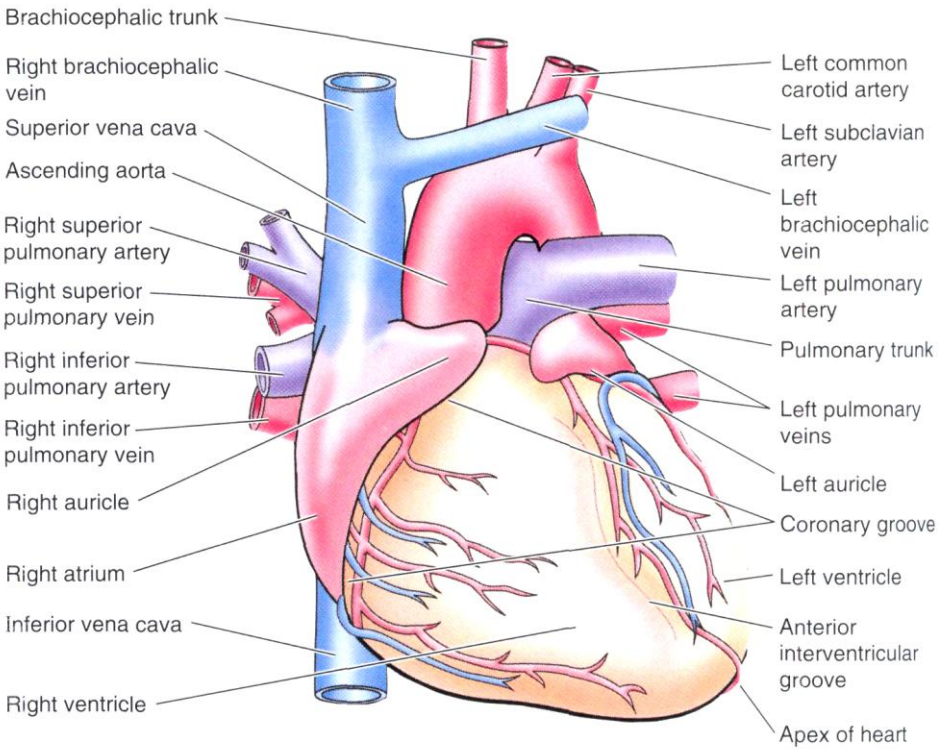
The **base of the heart** *(basis cordis)* faces upward, backward, and to the right. It is formed by the atria and, in front, by the aorta and pulmonary trunk.

The **anterosuperior, or sternocostal surface of the heart** *(facies sternocostalis)* faces forward, upward, and to the left and is located behind the body of the sternum and the cartilages of the third to sixth ribs. The *atrioventricular groove (sulcus coronarius)* passing transversely to the longitudinal heart axis and separating the atria from the ventricles, divides the heart into an upper area formed by the atria and a larger, lower area formed by the ventricles. An *anterior interventricular groove (sulcus interventricularis anterior)* on the sternocostal surface passes on the borderline between the ventricles; the greater part of the anterior surface is formed by the right ventricle, the smaller part by the left ventricle.

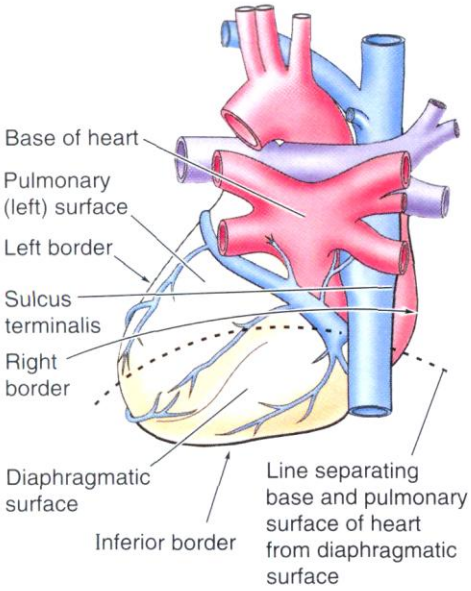
The **inferior** or **diaphragmatic surface** *(facies diaphragmatica)* adjoins the central tendon at the diaphragm. An posterior *interventricular groove (sulcus interventricularis posterior)* runs on the surface and separates the surface of the left ventricle (larger) from the surface of the right ventricle (smaller). The lower ends of the anterior and inferior interventricular grooves of the heart fuse to form the incisure of the apex of the heart *(incisura apicis cordis)* on the right heart border immediately to the right of the apex.

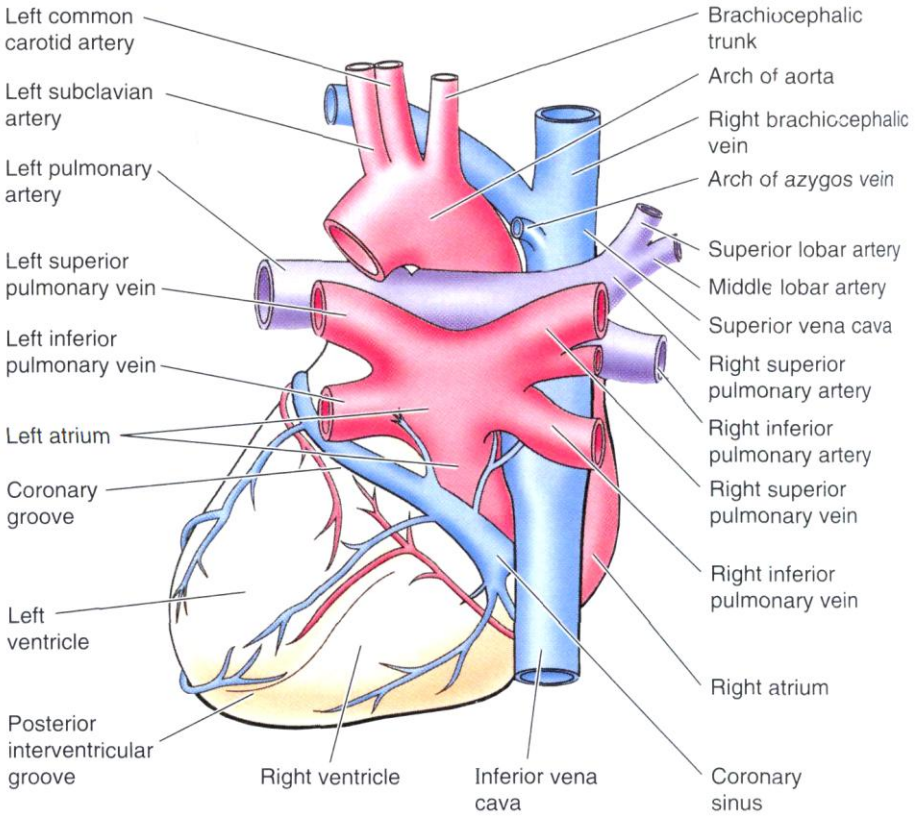






Anterior views





Posteroinferior views

CHAMBERS OF THE HEART

The atria are blood-receiving chambers. The ventricles, in contrast, pump blood from the heart into the arteries. The right and left atria and ventricles are separated by a septum. The atria and ventricles communicate by the right and the left atrioventricular orifice (ostium atrioventriculare dextrum and sinistrum) . Through these openings blood is directed from the atrial cavities during their contraction into the cavities of the ventricles.

THE RIGHT ATRIUM

The **right atrium** *(atrium dextrum)* is shaped like a cube . In the back it receives the superior vena cava above and the inferior vena cava below. In front, the atrium is continuous with a hollow process, the *auricle of right atrium (auricula dextra).* The right and left auricles embrace the base of the aorta and the pulmonary trunk.

The *atrial septum (septum interatriale)* is set obliquely.

The inner surface of the right atrium is smooth except for a small frontal area and for the inner surface of the auricle where the *pectinate muscles (musculi pectinati)* form a series of small vertical columns. Superiorly the pectinate muscles are continuous with a crest *(crista terminalis/*

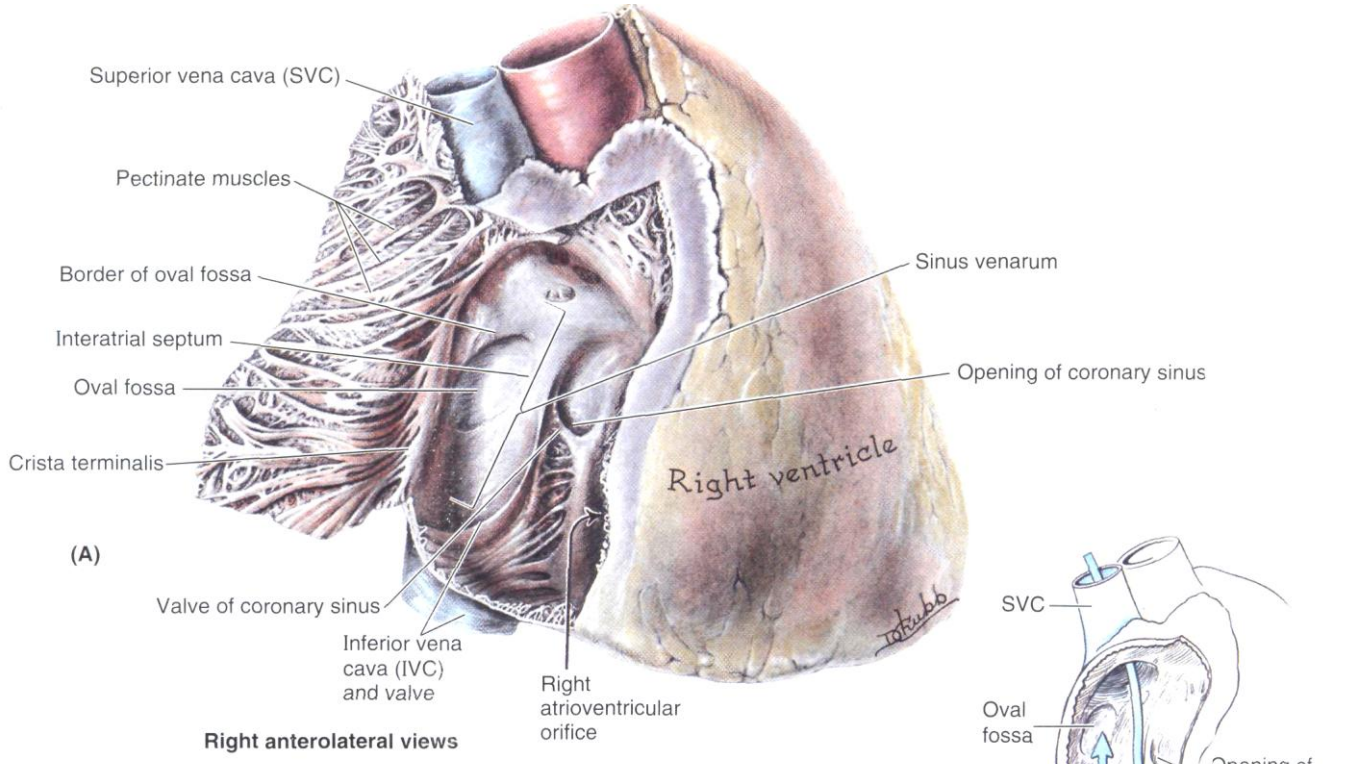


Figure **Right atrium of heart.** A. The smooth-walled part of the atrium, the sinus venarum, is derived from absorption of the venous sinus of the embryonic heart. All of the venous structures entering the right atrium (superior and inferior vena cavae and coronary sinus) open into the sinus venarum. The rough-walled part of the atrium is derived from the primordial atrium. The shallow oval fossa is the site of fusion of the embryonic valve of the oval foramen with the interatrial septum. **B.** The inflow from the superior vena cava (*SVC*) is directed toward the right atrioventricular orifice, whereas blood from the inferior vena cava (*IVC*) is directed toward the oval fossa, as it was before birth.

On the septum separating the right atrium from the left is an oval depression *(fossa ovalis).* Detween the openings of the inferior vena cava and the right atrioventricular orifice, the *sinus coronarius cordis,* which collects blood from the veins of the heart, drains into the right atrium.

THE RIGHT VENTRICLE

The right ventricle *(ventriculus dexter)* is shaped like a triangular pyramid. The cavity of the ventricle is subdivided into two parts:

- the *corpus* - the section nearest the right atrioventricular orifice,
- the *conus arteriosus*, which is continuous with the pulmonary trunk.

The right atrioventricular orifice leading from the cavity of the right atrium into the cavity of the right ventricle is supplied with a *tricuspid valve (valva atrioventricularis dextra* s. *valva tricuspidalis),* which prevents the return of blood into the atrium during systole; the blood flows into the pulmonary trunk. Three cusps of the valve are designated, according to their location, as the cuspis anterior, cuspis posterior, and cuspis septalis. The free margins of the cusps face into the ventricle. Tendinous threads *(chordae tendineae)* are attached to them. At their other ends these chordae are attached to the apices of the *papillary muscles (musculi papillare).*

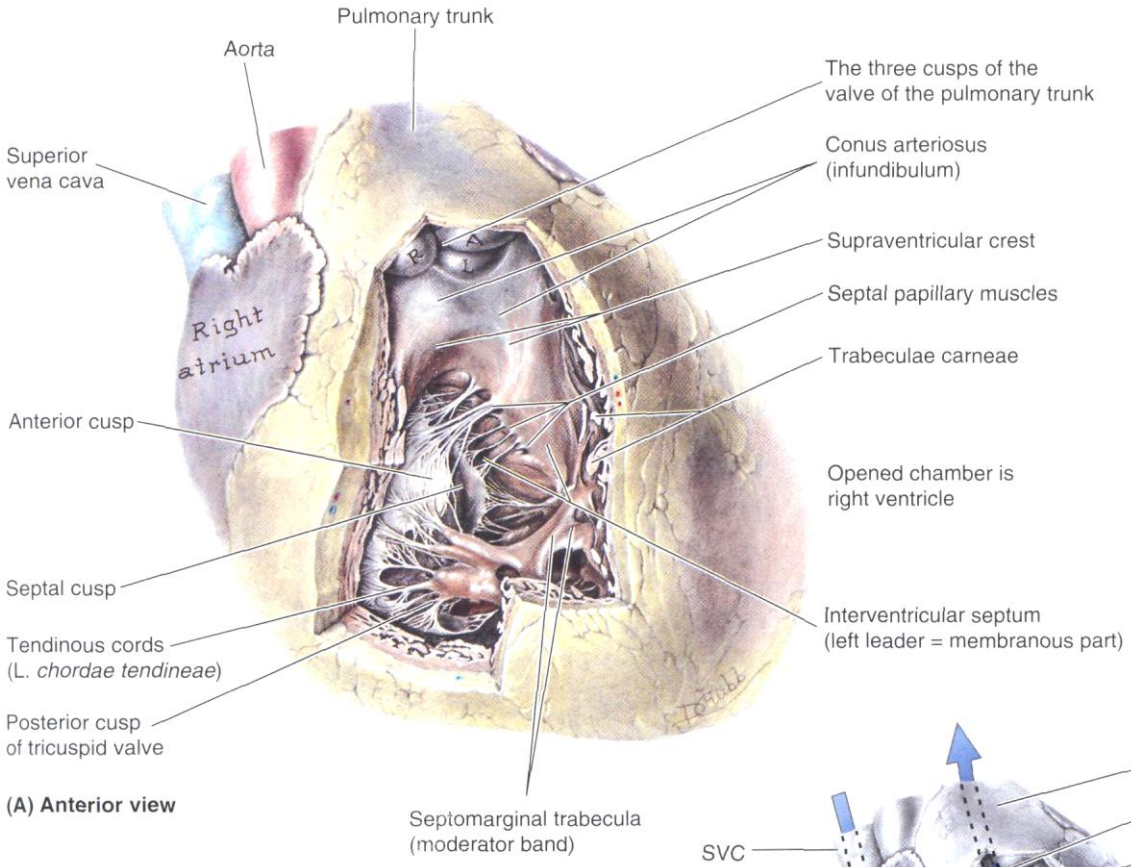
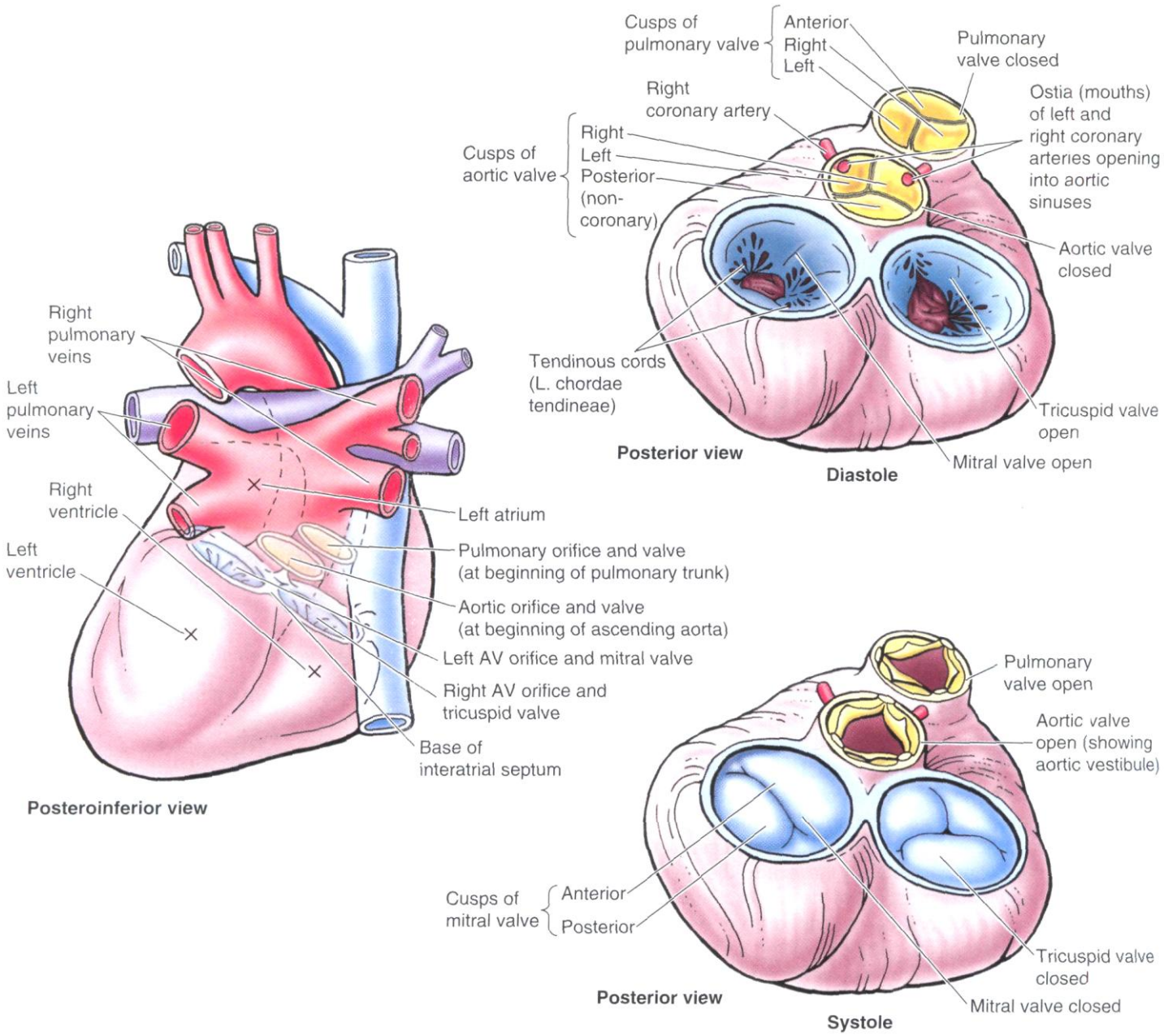


Figure **Interior of right ventricle of heart. A.** The entrance to the ventricle, the right atrioventricular orifice, is situated inferiorly and posteriorly. The smooth funnel-shaped outflow tract of the chamber, the conus arteriosus, lies superiorly and leads to the pulmonary orifice, the exit to the pulmonary trunk, where the ventricular aspect of the cusps of the tricuspid valve are shown. Tendinous cords extend from the papillary muscles to the cusps of the tricuspid valve. **B.** The inflow of blood enters the chamber from its posterior and inferior aspect, flowing anteriorly and to the left (toward the apex); the outflow of blood to the pulmonary trunk leaves superiorly and posteriorly.

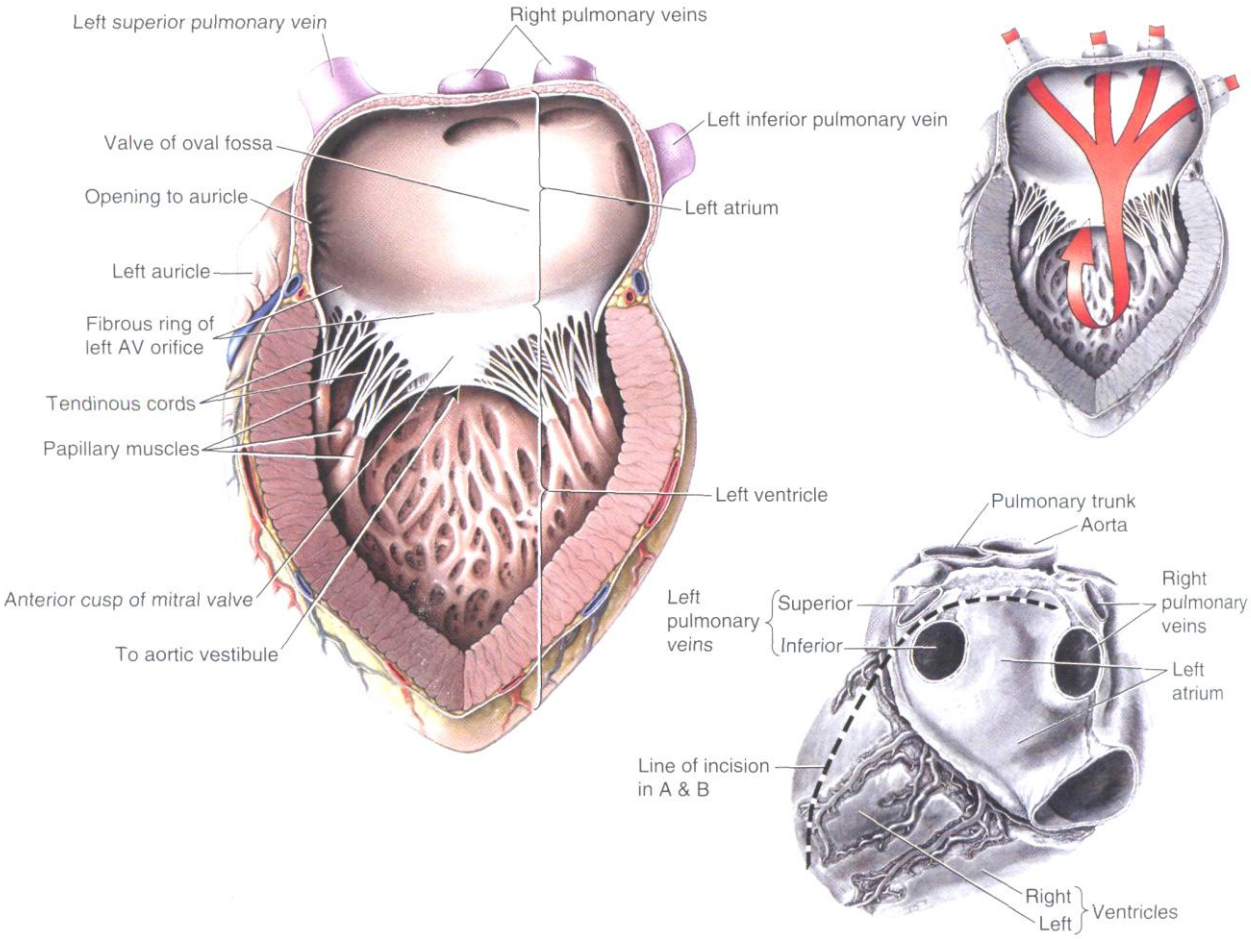
The papillary muscles are conical muscular projections, with the apex projecting into the cavity of the ventricle and the base continuous with the ventricular wall, where are usually three papillary muscles in the right ventricle; the anterior muscle, the largest, gives rise to tendinous chords attached to the anterior and posterior cusps of the tricuspid valve; the smaller posterior muscle sends tendinous chords to the posterior and septal cusps, and, finally, a third inconstant septal papillary muscle usually sends tendinous chords to the anterior cusps.
The wall of the right ventricle is smooth in the region of the conus arteriosus, but elsewhere there are inwardly projecting *muscular trabeculae (trabeculae carneae).*
Blood from the right ventricle enters the pulmonary trunk through an orifice, the *ostium trunci pulmonalis*, supplied with a valve, the *valva trunci pulmonalis*, which prevents the return of blood from the pulmonary trunk into the right ventricle during diastole. The valve is composed of three semilunar cusps called the semilunar valvulae.



One of them is attached to the anterior third of the circumference of the pulmonary trunk (valvula semilunaris anterior) and the other two to the posterior section of the circumference (valvulae semilunares dextra and sinistra). A small nodule, the nodulus valvulae semilunaris, is found in the middle of the free inner border of each valve. The nodules make the valves close more tightly.

THE LEFT ATRIUM

The left atrium *(atrium sinistrum)* adjoins posteriorly the descending aorta and the oesophagus. Two pulmonary veins drain into it from each side. The auricle of the left atrium *(auricula sinistra)* protrudes anteriorly, passing around the left side of the aorta and pulmonary trunk. The auricle contains pectinate muscles.



THE LEFT VENTRICLE

The left ventricle *(ventriculus sinister)* has a conical shape. The trabeculae carneae are thinner and more numerous in the left than in the right ventricle, and there are more of them on the diaphragmatic wall and in the region of the apex. The orifice leading from the cavity of the left atrium into the left ventricle, the ostium atrioventriculare sinistrum, is oval, and it is supplied with a *bicuspid valve (valva atrioventricularis sinistra* (mitralis s. *bicuspidalis).*

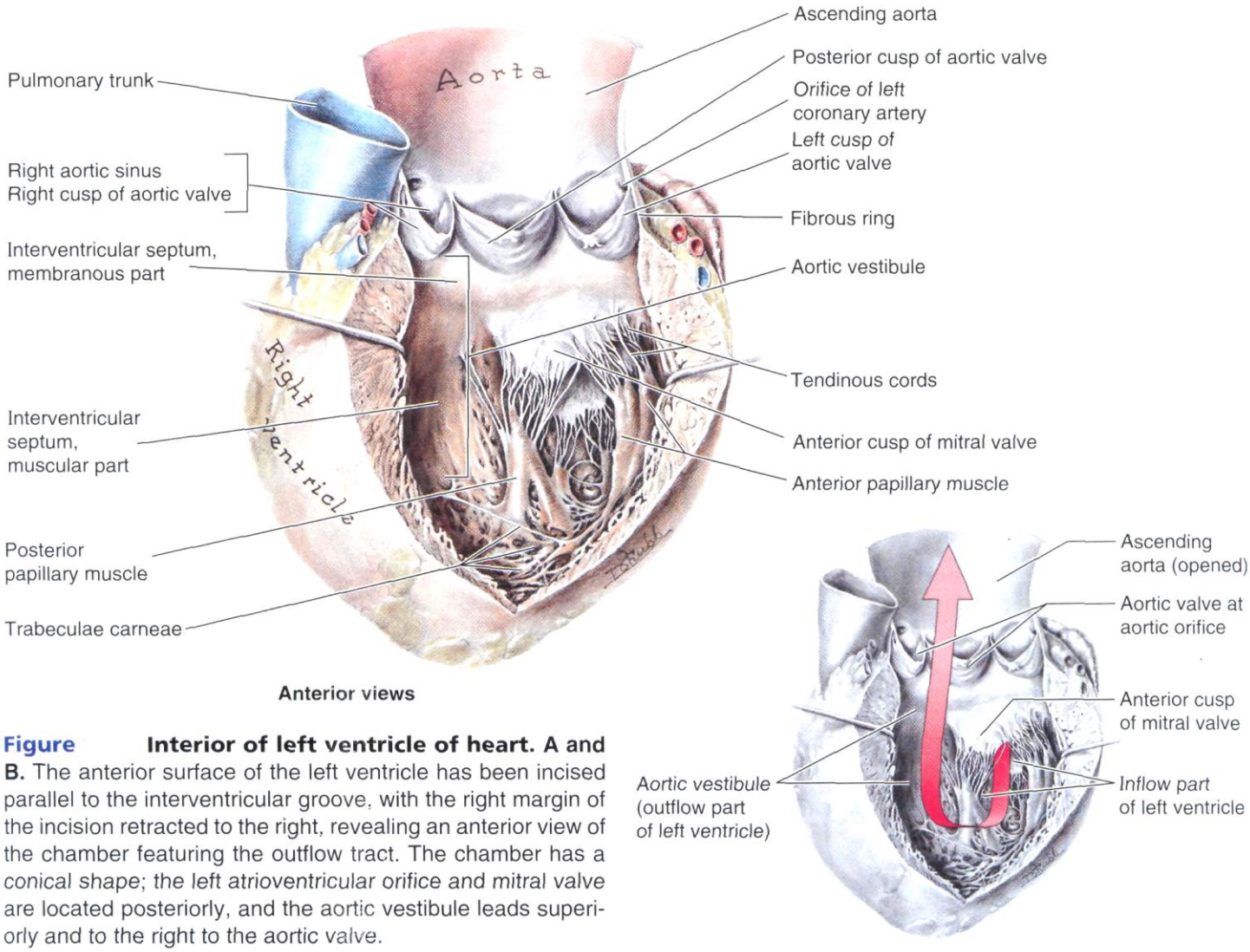


Figure **Interior of left ventricle of heart. A and B.** The anterior surface of the left ventricle has been incised parallel to the interventricular groove, with the right margin of the incision retracted to the right, revealing an anterior view of the chamber featuring the outflow tract. The chamber has a conical shape; the left atrioventricular orifice and mitral valve are located posteriorly, and the aortic vestibule leads superiorly and to the right to the aortic valve.

The smaller cusp is to the left and back (cuspis posterior), the larger to the right and front (cuspis anterior). The free margins of the valve face into the ventricular cavity; the chordae tendineae are attached to them. There are two papillary muscles, anterior and posterior, in the left ventricle. They are much larger than the papillary muscles in the right ventricle. Each muscle sends tendinous threads to both cusps of the mitral valve. The aortic orifice is called *ostium aortae,* and the part of the ventricle closest to it is called the *conus arteriosus.*

The *aortic valve (valva aortae)* is similar in structure to the valve of the pulmonary trunk. One of the valvules, the valvula semilunaris posterior occupies the posterior one-third of the aortic circumference. The other two, the valvulae semilunares dextra and sinistra, occupy the right and left sides of the orifice.

The *ventricular septum (septum interventriculare)* consists mainly of muscle tissue *(pars muscularis),* except for the uppermost area where it is formed by fibrous tissue covered on both sides with the endocardium *(pars membranacea).*

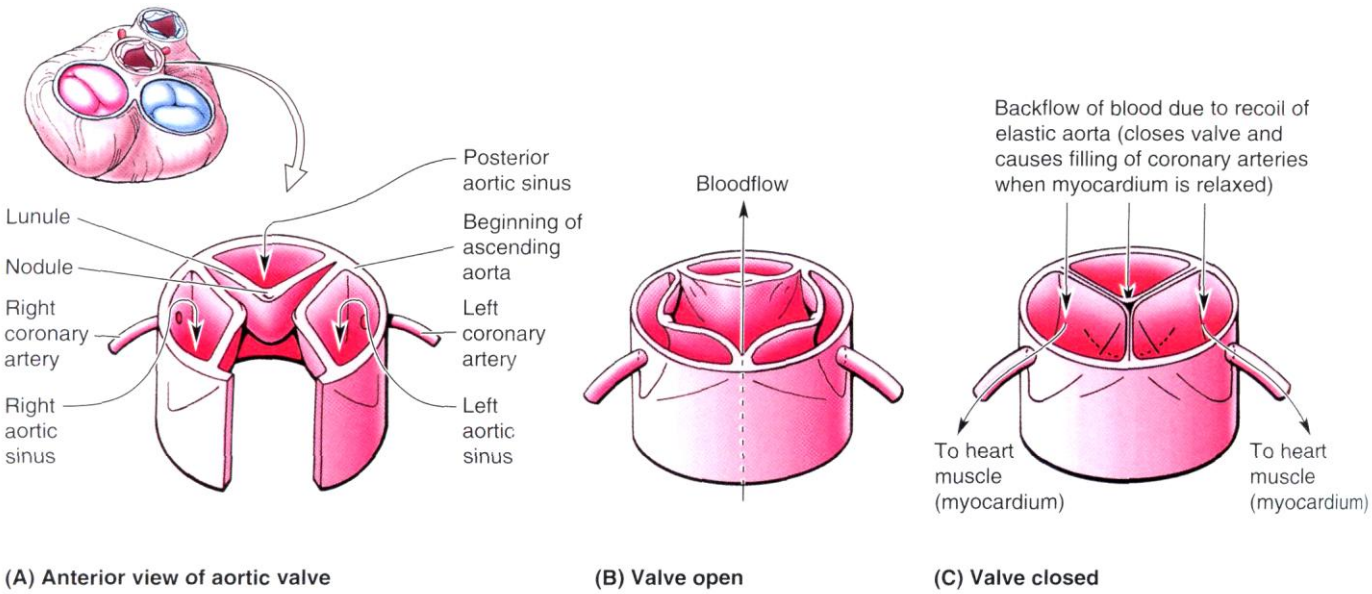


Figure **Aortic valve, aortic sinuses, and coronary arteries. A.** Like the pulmonary valve, the aortic valve has three semilunar cusps: right, posterior, and left. Each cusp has a fibrous nodule at the midpoint of its free edge and a thin connective tissue area, the lunule, to each side of the nodule. **B.** Blood ejected from the left ventricle forces the cusps apart. **C.** When the valve closes, the nodules and lunules meet in the center. The coronary arteries arise from the right and left aortic sinuses (spaces superior to the cusps).

STRUCTURE OF THE HEART WALLS

The walls of the heart are made up of three layers: an inner layer, the endocardium, a middle layer, the myocardium, and an outer layer, the epicardium, which is the visceral membrane of the pericardium . The thickness of the cardiac walls consists mainly of the middle layer, the myocardium, made up of muscle tissue. The outer layer, the epicardium, is the visceral lining of the serous pericardium. The inner layer, the endocardium, lines the heart cavities.

Two layers are distinguished in the heart musculature: the muscular layers of the atrium, and the muscular layers of the ventricles. The fibres of both arise from two *fibrous rings (anuli fibrosi)* one of which surrounds the right atrioventricular orifice and the other, the left atrioventricular orifice. Since the fibres of the atrium are not, as a rule, continuous with those of the ventricle, the atria can contract separately from the ventricles. A superficial and a deep muscular layer are distinguished in the atria: the superficial layer consists of circular or transverse fibres, whereas the deep layer is made up of longitudinal fibres arising from the fibrous rings and encircling the atrium like a loop.

The musculature of the ventricles is even more complex. Three layers can be distinguished in it. A thin superficial layer is composed of longitudinal fibres which arise from the right fibrous ring and descend obliquely, passing also onto the left ventricle; on the heart apex, they form a whorled mass *(vortex cordis),* making loops in the depths of the muscle and forming the longitudinal inner layer; the upper ends of the fibres of this layer are attached to the fibrous rings. The fibres of the middle layer, between the longitudinal outer and inner layers, are more or less circular. In contrast to the fibres of the superficial layer, however, they do not pass from one ventricle to the other but are independent components of each ventricle.

An important role in the rhythmic work of the heart and in the coordination of the activity of the musculature of the separate heart chambers is played by the **conducting system of the heart.**

The following nodes and bundles are distinguished in the **conducting system** .

1. The *atrioventricular bundle (fasciculus atrioventricularis)* arises as a thickening of the atrioventricular node, *nodus atrioventricularis* (the node of Aschoff and Tawara), lying in the wall of the right atrium near the cuspis septalis of the tricuspid valve. The fibres of the node are directly connected with the atrial musculature and continue into the septum between the ventricles as the bundle of His (discovered slightly earlier by Kent). In the septum between the ventricles, the bundle of His divides into right and left crura *(crus dextrum* and *crus sinistrum),* which pass into the walls of the respective ventricles and give off branches under the endocardium in the musculature. The atrioventricular bundle is significant in the work of the heart since it conducts the wave of contraction from the atria to the ventricles that regulates the rhythm of the systole of the atria and ventricles.

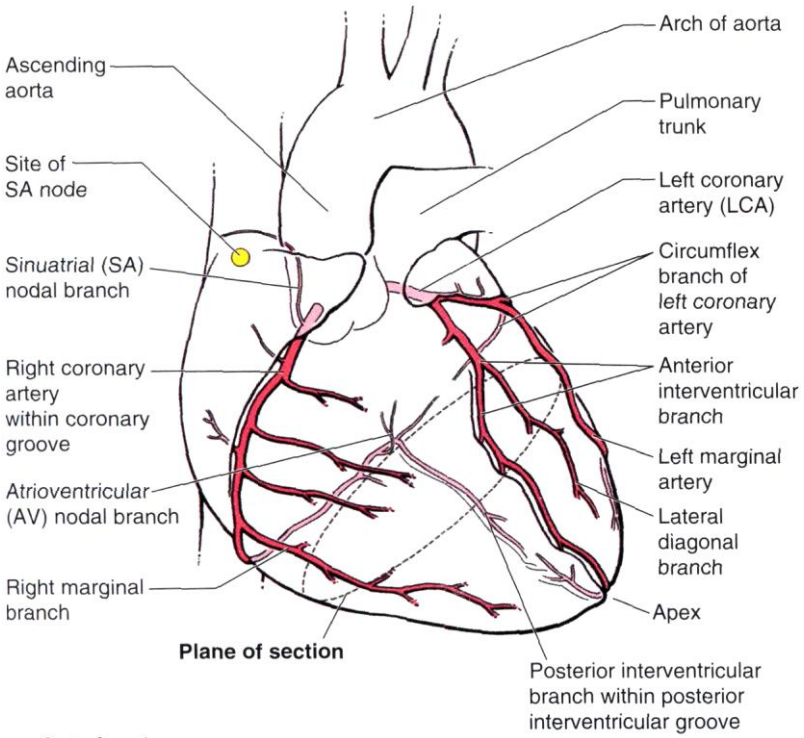
2. The *sinoatrial node (nodus sinuatrialis)* or *Keith-Flack's sinoatrial bundle* is located in an area of the right atrial wall corresponding to the sinus venosus in cold-blooded animals (in sulcus terminalis, between the superior vena cava and the right auricle). It is connected with the musculature of the atria and is important for their rhythmic contraction.

The atria are, therefore, connected to each other by the sinoatrial bundle and to the ventricles by the atrioventricular bundle.

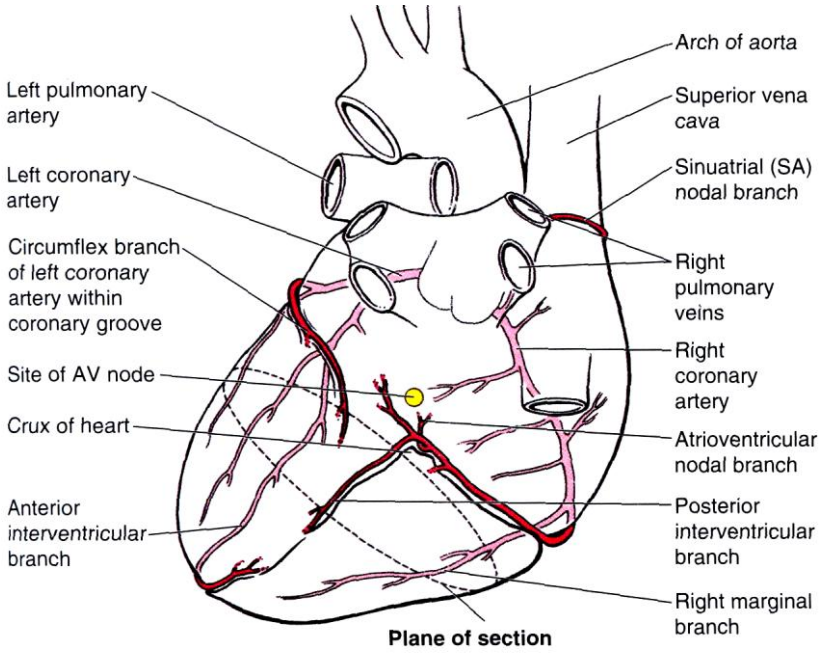
The **epicardium** covers the outer surface of the myocardium and is an ordinary serous membrane lined by the mesothelium.

The **endocardium** forms the lining of the inner surface of the heart cavities. It is made up, in turn, of a layer of connective tissue rich in elastic fibres and smooth muscle cells, a layer of connective tissue over the first layer with an admixture of elastic fibres, and an inner endothelial layer, the presence of which distinguishes the endocardium from the epicardium. In origin, the endocardium corresponds to the vascular wall, while its three layers correspond to the three vascular coats. All the heart valves are folds (duplicatures) of the endocardium.

The various structural features of the heart determine the characteristics of its vessels, which form the cardiac circulatory system: the *right* and *left coronary arteries (a. coronaria dextra* and *a. coronaria sinistra)* arise from the bulbus aortae below the superior margins of the semilunar valves. As a result, during systole the entrance to the coronary arteries is closed by the valves, while the arteries themselves are compressed by the contracted heart muscles. As a consequence, the supply of blood to the heart diminishes during systole; blood enters the coronary arteries during diastole when the openings of these arteries in the orifice of the aorta are not closed by the semilunar valves. The right coronary artery *(a. coronaria dextra)* arises from the aorta corresponding to the right semilunar valvule and passes between the aorta and the auricle of the right atrium laterally. From there it curves around the right border of the heart in the coronary sulcus and passes over to its posterior surface. Here it is continuous with the *interventricular branch (ramus inteventricularis posterior).* The interventricular branch descends in the posterior interventricular sulcus to the heart apex where it anastomoses with the branch of the left coronary artery.



Anterior view



Posteroinferior view

Table **Arterial Supply to Heart**

Artery/Branch	Origin	Course	Distribution	Anastomoses
Right coronary	Right aortic sinus	Follows coronary (AV) groove between atria and ventricles	Right atrium, SA and AV nodes, and posterior part of IVS	Circumflex and anterior IV branches of left coronary artery
SA nodal	Right coronary artery near its origin (in 60%)	Ascends to SA node	Pulmonary trunk and SA node	
Right marginal	Right coronary artery	Passes to inferior margin of heart and apex	Right ventricle and apex of heart	IV branches
Posterior interventricular	Right coronary artery (in 67%)	Runs in posterior IV groove to apex of heart	Right and left ventricles and posterior third of IVS	Anterior IV branch of left coronary artery (at apex)
AV nodal	Right coronary artery near origin of posterior IV artery	Passes to AV node	AV node	
Left coronary	Left aortic sinus	Runs in AV groove and gives off anterior IV and circumflex branches	Most of left atrium and ventricle, IVS, and AV bundles; may supply AV node	Right coronary artery
SA nodal	Circumflex branch (in 40%)	Ascends on posterior surface of left atrium to SA node	Left atrium and SA node	
Anterior interventricular	Left coronary artery	Passes along anterior IV groove to apex of heart	Right and left ventricles and anterior two thirds of IVS	Posterior IV branch of right coronary artery (at apex)
Circumflex	Left coronary artery	Passes to left in AV groove and runs to posterior surface of heart	Left atrium and left ventricle	Right coronary artery
Left marginal	Circumflex branch	Follows left border of heart	Left ventricle	IV branches
Posterior interventricular	Left coronary artery (in 33%)	Runs in posterior IV groove to apex of heart	Right and left ventricles and posterior third of IVS	Anterior IV branch of left coronary artery (at apex)

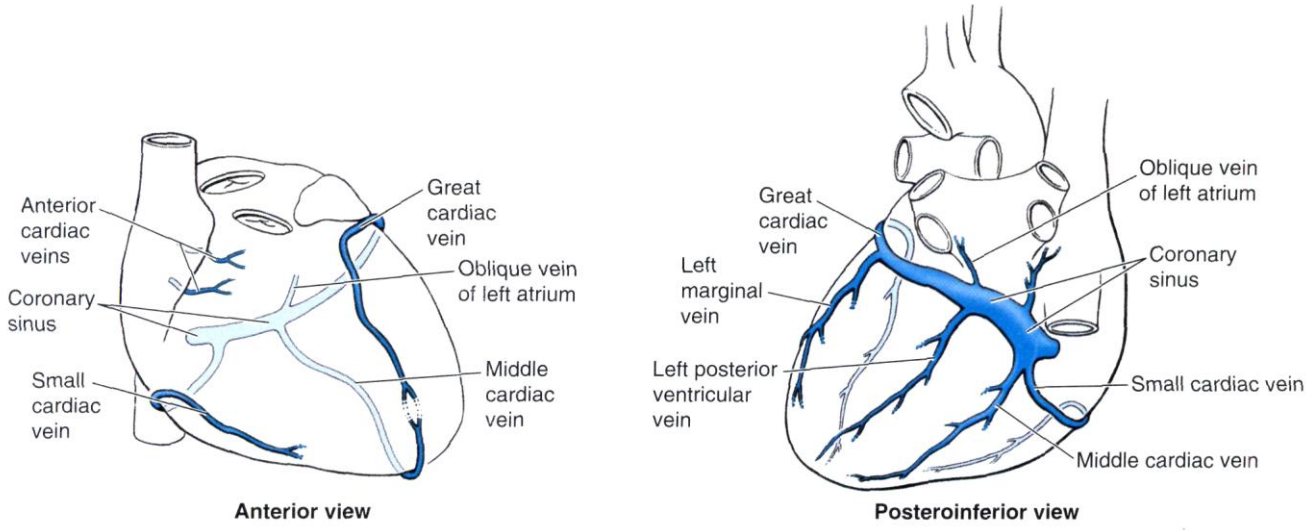
AV, atrioventricular; *IV*, interventricular; *IVS*, interventricular septum; *SA*, sinuatrial.

The branches of the right coronary artery vascularize: the right atrium, part of the anterior and the entire posterior wall of the right ventricle, a small area of the posterior wall of the left ventricle, the interatrial septum, the posterior one-third of the interventricular septum, the papillary muscles of the right ventricle, and the posterior papillary muscle of the left ventricle.

The left coronary artery *(a. coronaria sinistra)* arises from the aorta at the left similunar valvule and also lies in the coronary sulcus to the front of the left atrium. Between the pulmonary trunk and the left auricle, it gives off two branches: a thinner, anterior *interventricular branch (ramus interventricularis anterior)* and a larger, left *circumflex branch (ramus circumflexus).*

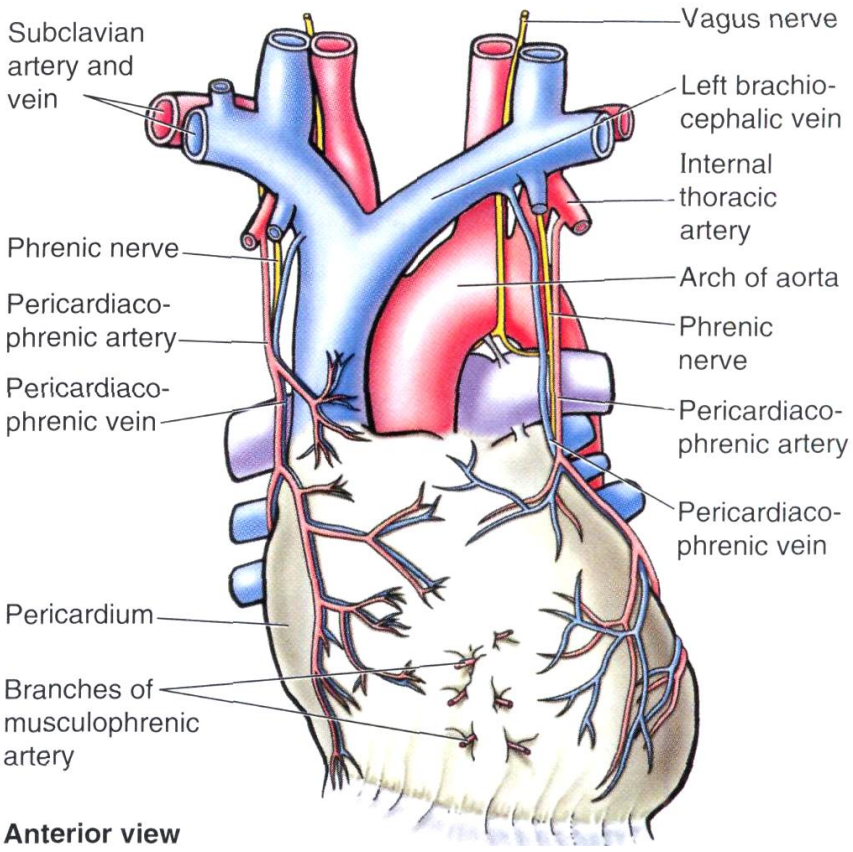
The first descends along the anterior interventricular sulcus to the heart apex where it anastomoses with the branch of the right coronary artery. The second is a continuation of the main trunk of the left coronary artery; it curves around the heart from the left side in the coronary sulcus and is also connected with the right coronary artery. As a result, an arterial ring forms along the whole coronary sulcus, which is located in a horizontal plane and from which branches to the heart rise perpendicularly. The ring is a functional adaptation for the collateral circulation of the heart. The branches of the left coronary artery vascularize the left atrium, the entire anterior and the greater part of the posterior left ventricular wall, part of the anterior wall of the right ventricle, the anterior two-thirds of the interventricular septum, and the anterior papillary muscle of the left ventricle.

1. Veins of the system of the coronary sinus, *sinus coronarius cordis.* The sinus is a remnant of the left Cuvier's duct and is located in the posterior section of the coronary sulcus of the heart between the left atrium and the left I ventricle. Its thicker right end opens into the right atrium near the inter ventricular septum, between the valvule of the inferior vena cava and the atrial septum.
The following veins drain into the coronary sinus: (a) v. cordis magna arises at the heart apex, ascends in the anterior interventricular sulcus of the heart, turns to the left and, curving over the left side of the heart, is foontinuous with the coronary sinus; (b) v. posterior ventriculi sinistri is lone or more small venous trunks on the posterior surface of the left ventricle which drain into the coronary sinus or into v. cordis magna; (c) v. obliqua atrii sinistri is a small branch on the posterior surface of the left atrium , which arises from the peri-cardial fold containing a cord of connective tissue, the plica venae cavae, also a remnant of the left vena cava; (d) v. cordis media lies in the posterior interventricular sulcus and, on reaching the transverse sulcus, right half of the transverse sulcus, usually drains into the v. cordis media where the latter reaches the transverse sulcus.



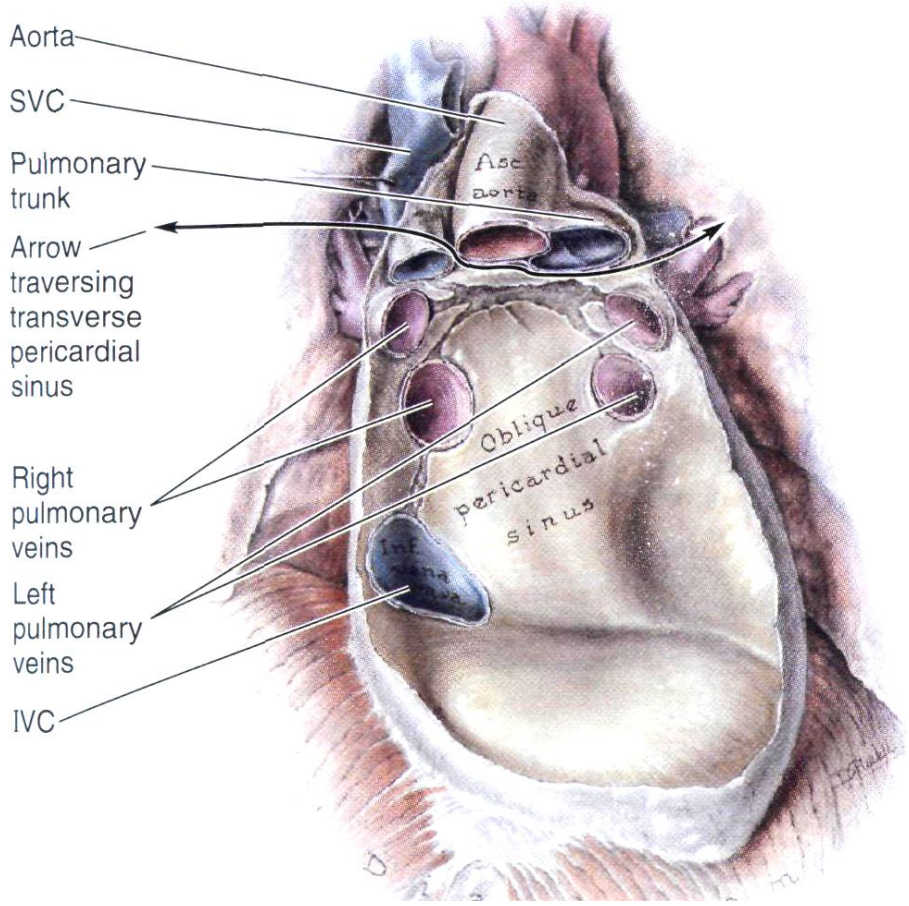
2. The anterior cardiac veins, *vv. cordis anteriores,* small veins on the anterior surface of the right ventricle, drain directly into the cavity of the right atrium.
3. The smallest cardiac veins, vv. *cordis minimae,* are very small venous trunks, which do not appear on the heart's surface but, having formed from capillaries, drain directly into the cavities of the atria and ventricles.

The nerves innervating the heart musculature, with its distinctive structure and function, are complex and form numerous plexuses. The whole nervous system of the heart is composed of: (1) arriving nerve trunks; (2) plexuses in the heart itself; and (3) plexuses connected with those of the ganglionic fields.



THE PERICARDIAL SAC

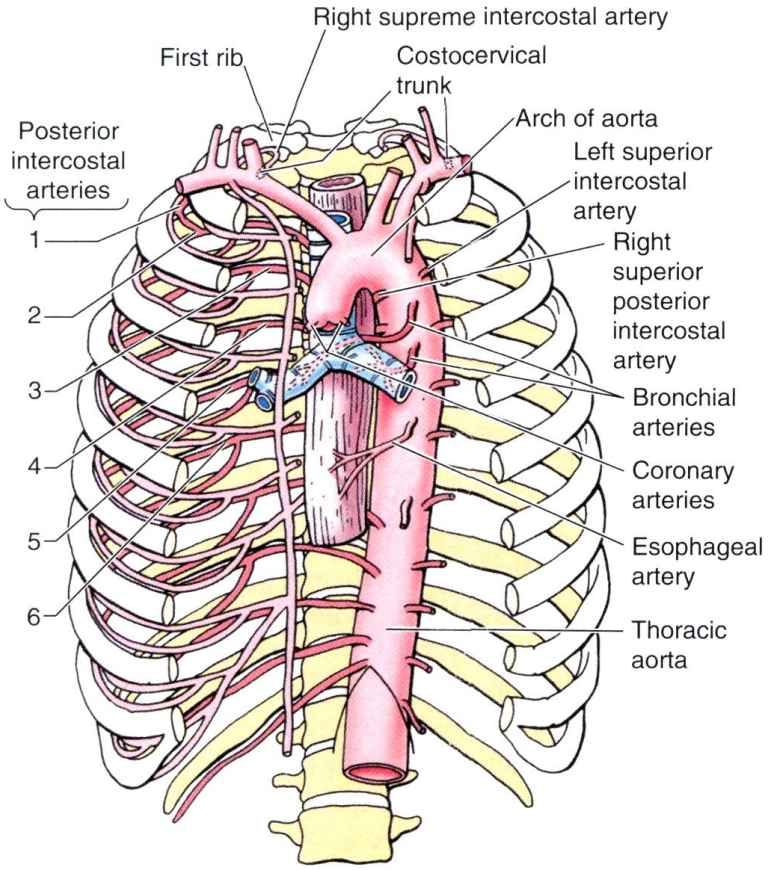
The pericardial sac *(pericardium)* is a closed serous sac, in which two layers are distinguished: an outer fibrous layer, the pericardium fibrosum, and an inner serous layer, the pericardium serosum.. The serous pericardium is, in turn, divided into r two layers: a visceral layer or the *epicardium* mentioned above, and a *parietal* payer, which fuses with the inner surface of the fibrous pericardium and lines lit.



AORTA

AORTA is the largest arterial vessel of systemic circulation. It subdivides on ascending part of aorta, aortic arch and descending part of aorta, which has thoracic and abdominal portions of aorta.

Ascending part of **aorta** leaves the left ventricle behind left margin of sternum on level III intercostal space. Ascending part of aorta lies behind and a little to the right from pulmonary trunk, rises up and to level of second right costal cartilage passes into arc.



The **Arch of the Aorta** turns posteriorly to the left from second costal cartilage to left side of fourth thoracic vertebral body, where passes into descending aorta. From convex aortic arch surface starts to from the right to the left:

-brachiocephalic trunk,
-left common carotid artery ,
-left subclavian artery.

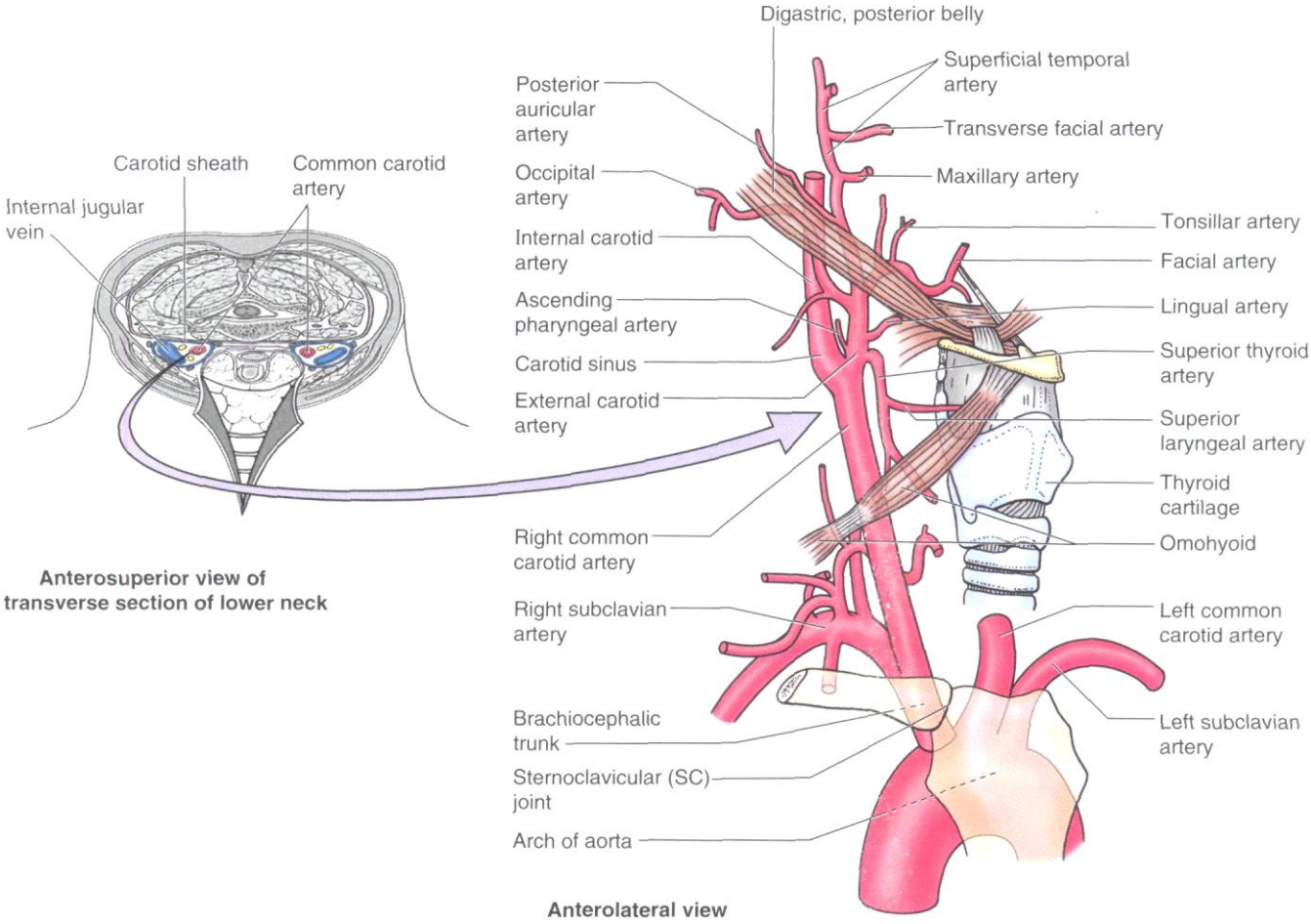
Descending aorta has *thoracic part of aorta*, which passes in posterior mediastinum and lies to the left from bodies of thoracic vertebrae and *abdominal part* of aorta, which starts on level of XII thoracic vertebra, passes through *aortic hiatus* of diaphragm, and extends to level of IV lumbar vertebra. Here abdominal aorta gives off the pair parietal branches, pair and odd (unpair) visceral branches and finishes in bifurcation, dividing into two common iliac arteries.

BRANCHES OF THE DESCENDING AORTA

The branches of the descending aorta can be classified into:
the **parietal branches** (rami parietales), stretching to the walls of the cavities, and the **visceral branches** (rami viscerales), running to the contents of the cavities, the viscera.

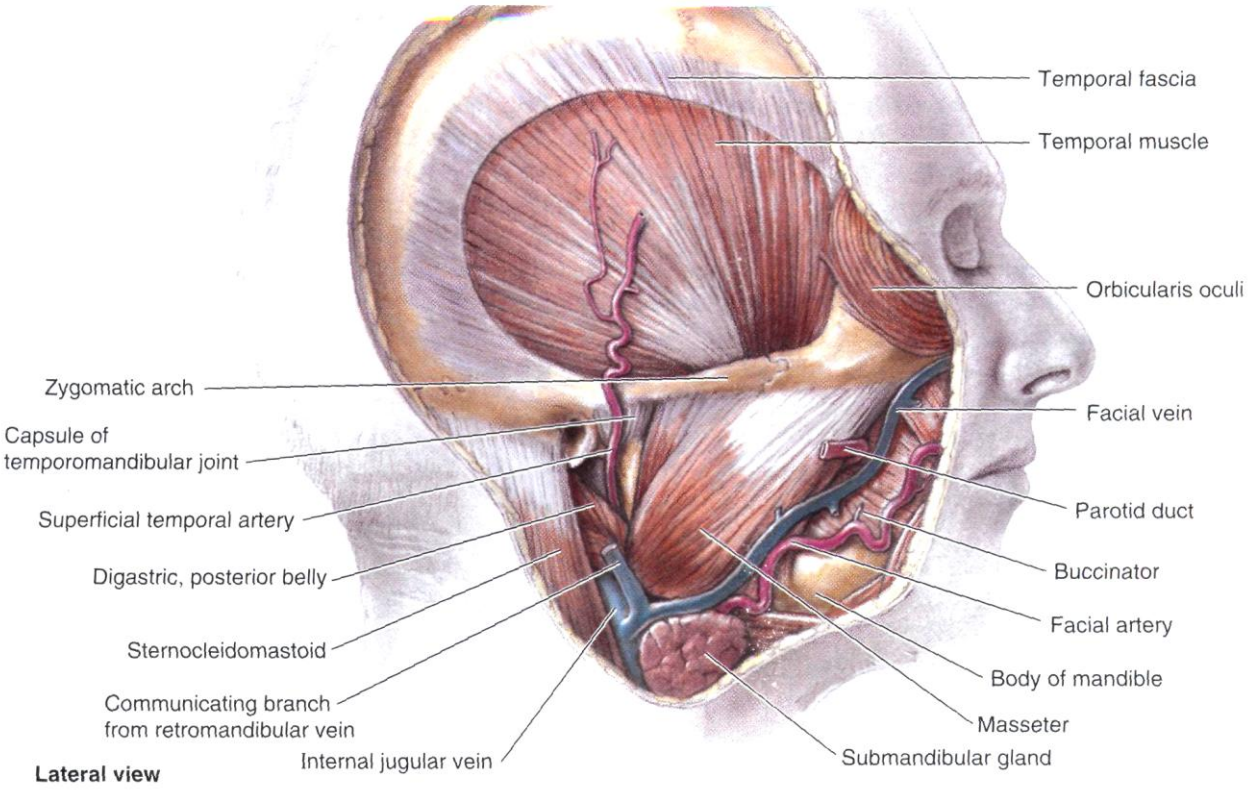
THE COMMON CAROTID ARTERY

The **common carotid artery** *(a. carotis communis)* arises from the brachiocephalic trunk on the right and independently from the arch of the aorta on the left side. Both common carotid arteries run upward on the side of the trachea and oesophagus. The right common carotid artery consists only of a cervical section and is, thus, shorter than the left, which consists of a thoracic section (from the arch of the aorta to the **left** sternoclavicular joint) and a cervical section. The common carotid artery passes in the trigonum caroticum and, at the level of the superior border **of** the thyroid cartilage or body of the hyoid bone, divides into its terminal branches, the **external** and **internal carotid arteries (a.** *carotis externa* and *a. carotis interna)* (bifurcation).

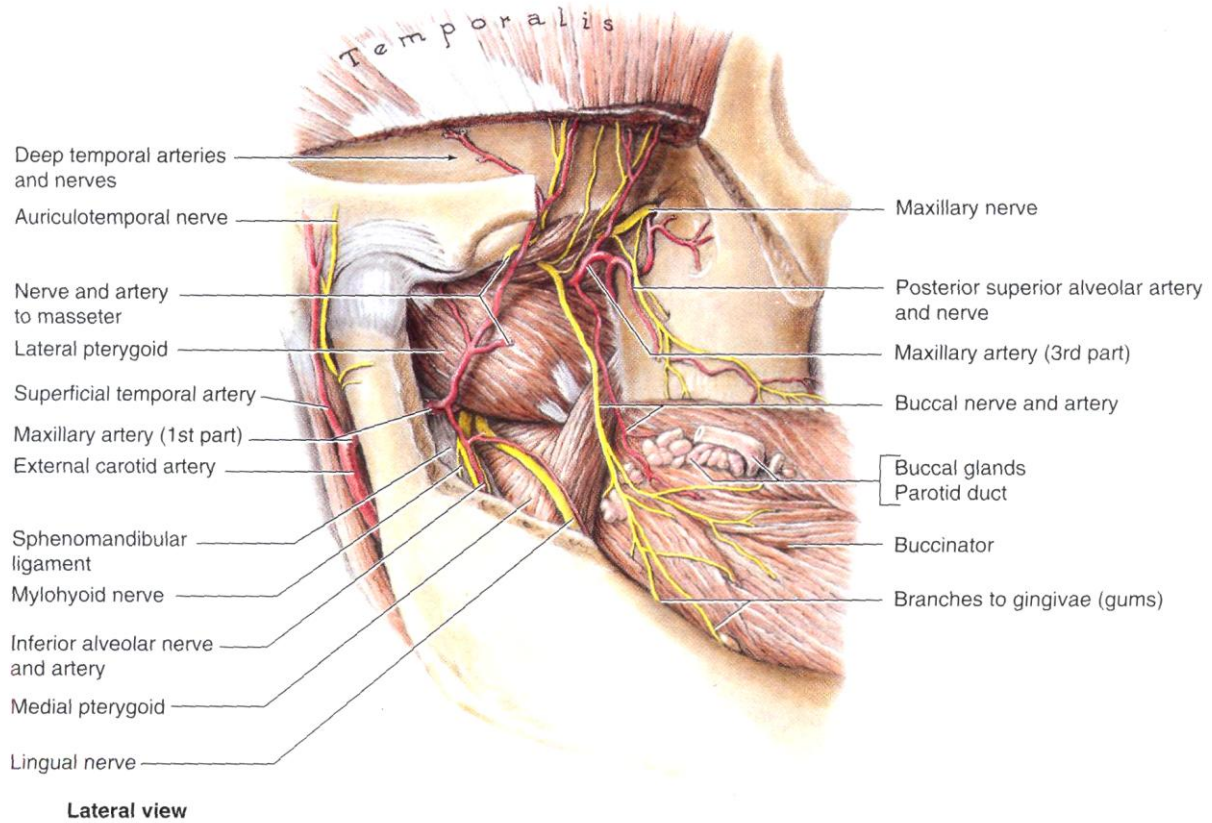


The External Carotid Artery

The **external carotid artery** *(a. carotis externa)* supplies blood to the external part of the head and neck and is, therefore, distinct from the internal carotid artery penetrating into the cavity of the skul. From its point of origin, the external carotid artery runs upward, passing media to the posterior belly of the digastric and stylohyoid muscles, pierces the parotid gland, and divides into its terminal branches behind the neck of the mandibular condyloid process.
Most of the branches of the external carotid artery may be divided into three groups, called triplets, each containing three arteries—the anterior, middle, and posterior groups.

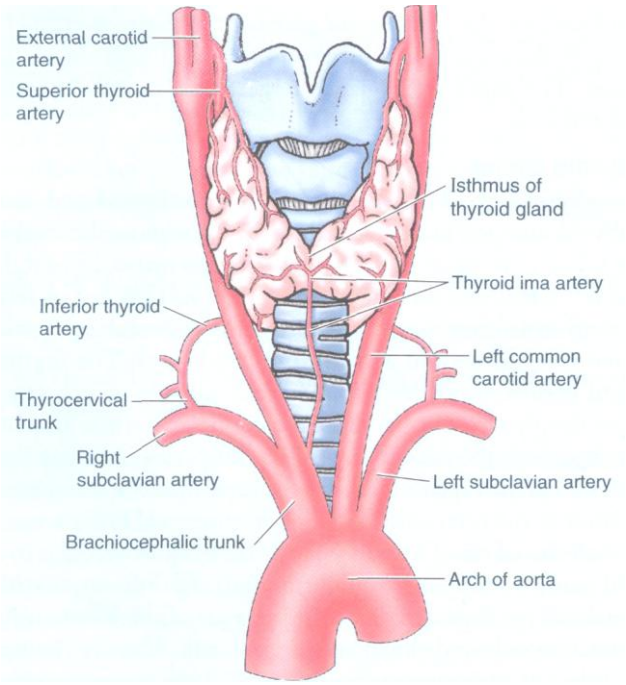


Lateral view



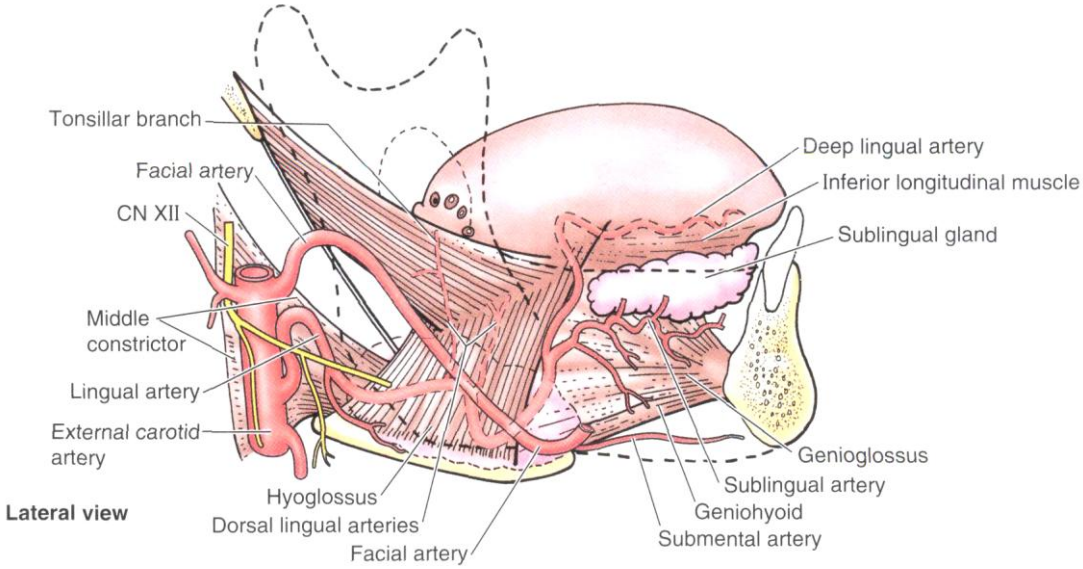
Lateral view

The ***anterior group***:



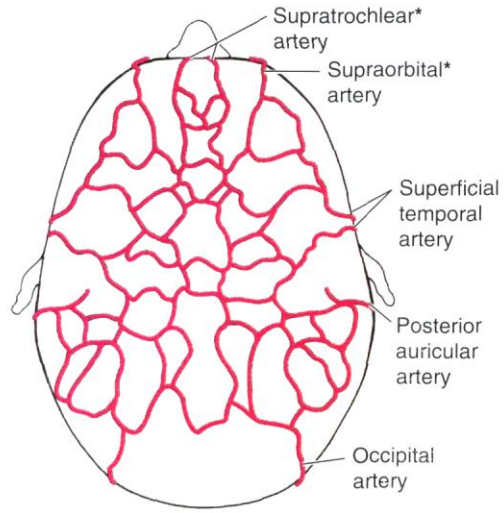
1.The **superior thyroid artery** *(a. thyreoidea superior)* arises from the external carotid artery immediately above its origin and runs downward and anteriorly to the thyroid gland where it anastomoses with the other thyroid arteries. Along the way it gives off branches to the sternocleidomastoid and thyrohyoid muscles, the hyoid bone, and the larynx.

2. The **lingual artery** *(a. lingualis)* arises at the level of the greater horns of the hyoid bone, runs upward through Pirogov's triangle where it is covered by the hyoglossus muscle, and then passes to the tongue. Before entering the tongue it gives off branches to the hyoid bone, palatine tonsils, and the sublingual gland. The lingual artery extends to the tip of the tongue, where it is called the deep lingual artery *(a. profunda linguae).* It gives off multiple branches to the back of the tongue *(rr. dorsales linguae)* along the way.

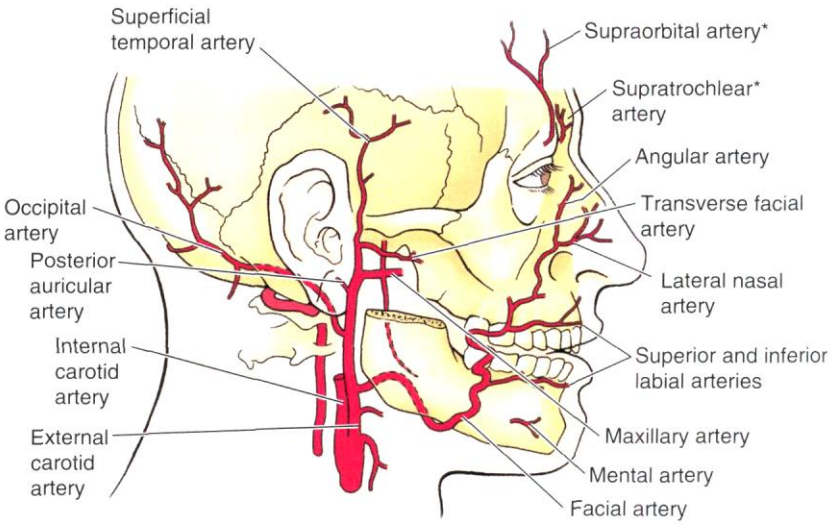


3. The **facial artery** *(a. facialis)* arises slightly above the lingual artery at the level of the mandibular angle, passes medially of the posterior belly of the digastric muscle, and reaches the anterior border of the masseter muscle where it bends at a right angle over the border of the mandible onto the face. It passes further to the medial angle of the eye where its terminal branch *(a. angularis)* anastomoses with the dorsal artery of the nose *(a. dorsalis nasi)* (a branch of the ophthalmic artery from the system of the internal carotid artery). Before bending over the mandible it gives off branches to the adjacent structures: the pharynx and soft palate, palatine tonsils, submandibular gland and oral diaphragm, and salivary glands.

After the bend it gives rise to branches to the upper lip *(a. labialis superior)* and lower lip *(a. labialis inferior).*



(A) Superior view



(B) Lateral view

*Source = internal carotid artery; all other labeled arteries are from external carotid

Table Superficial Arteries of the Face and Scalp

Artery	Origin	Course	Distribution
Facial	External carotid artery	Ascends deep to submandibular gland; winds around inferior border of mandible and enters face	Muscles of facial expression and face
Inferior labial	Facial artery near angle of mouth	Runs medially in lower lip	Lower lip
Superior labial		Runs medially in upper lip	Upper lip and ala (side) and septum of nose
Lateral nasal	Facial artery as it ascends alongside nose	Passes to ala of nose	Skin on ala and dorsum of nose
Angular	Terminal branch of facial artery	Passes to medial angle (canthus) of eye	Superior part of cheek and inferior eyelid
Occipital	External carotid artery	Passes medial to posterior belly of digastric and mastoid process; accompanies occipital nerve in occipital region	Scalp of back of head, as far as vertex
Posterior auricular		Passes posteriorly, deep to parotid gland, along styloid process between mastoid process and ear	Scalp posterior to auricle and auricle
Superficial temporal	Smaller terminal branch of external carotid artery	Ascends anterior to ear to temporal region and ends in scalp	Facial muscles and skin of frontal and temporal regions
Transverse facial	Superficial temporal artery within parotid gland	Crosses face superficial to masseter and inferior to zygomatic arch	Parotid gland and duct, muscles and skin of face
Mental	Terminal branch of inferior alveolar artery	Emerges from mental foramen and passes to chin	Facial muscles and skin of chin
Supraorbital[a]	Terminal branch of ophthalmic artery, a branch of internal carotid artery	Passes superiorly from supraorbital foramen	Muscles and skin of forehead and scalp
Supratrochlear[a]		Passes superiorly from supratrochlear notch	Muscles and skin of scalp

[a]Source is internal carotid artery.

The ***posterior group***.
4. The **occipital artery** *(a. occipitalis)* arises below the posterior belly of the digastric muscle, lies in the sulcus on the mastoid process, emerges under the skin in the occipital region, and gives off branches which stretch to the vertex. The occipital artery gives off some various small branches to the surrounding muscles, to the auricle, and to the dura mater of the posterior cranial fossa.
5. The **posterior auricular artery** *(a. auricularis posterior)* arises above the posterior belly of the digastric muscle, runs upward and to the back the skin behind the auricle, and reaches the region of the parietal tube Its branches are distributed both outside the ear (in the auricle and in the skin and muscles of the back of the head) and inside the ear (in the tympanic cavity into which its branch penetrates through the stylomastoid foramen.
6. The **sternocleidomastoid artery** *(a. sternocleidomastoidea)* runs the muscle of the same name.

The ***middle group*** *:*
7. The **ascending pharyngeal artery** *(a. pharyngea ascendens)* arise from the external carotid artery close to its origin and ascends on the wall of the pharynx and supplies it, the soft palate, the palatine tonsil, the eustachian tube, the tympanic cavity, and the dura mater with blood.

8. The **superficial temporal artery** *(a. temporalis superficialis)*, one of two terminal branches of the external carotid artery, stretches as the cotinuation of this artery in front of the external acoustic meatus onto the temple under the skin on the fascia of the temporal muscle. On the level of the superior orbital border, it divides into two large anterior and posterior branch *(ramus frontalis* and *ramus parietalis),* which branch out in the region of the vertex and temple. The artery gives off branches to the parotid gland, the lateral surface of the auricle, and the external acoustic meatus. One of the branches arising from the superficial temporal artery below the zygomat arch passes forward next to the parotid duct and branches out on the postrior surface of the face; another branch originates above the zygomatic an and runs to the lateral angle of the eye, to the orbicular muscle of the eye and to the zygomatic bone. The superficial temporal artery supplies the temporal muscle.

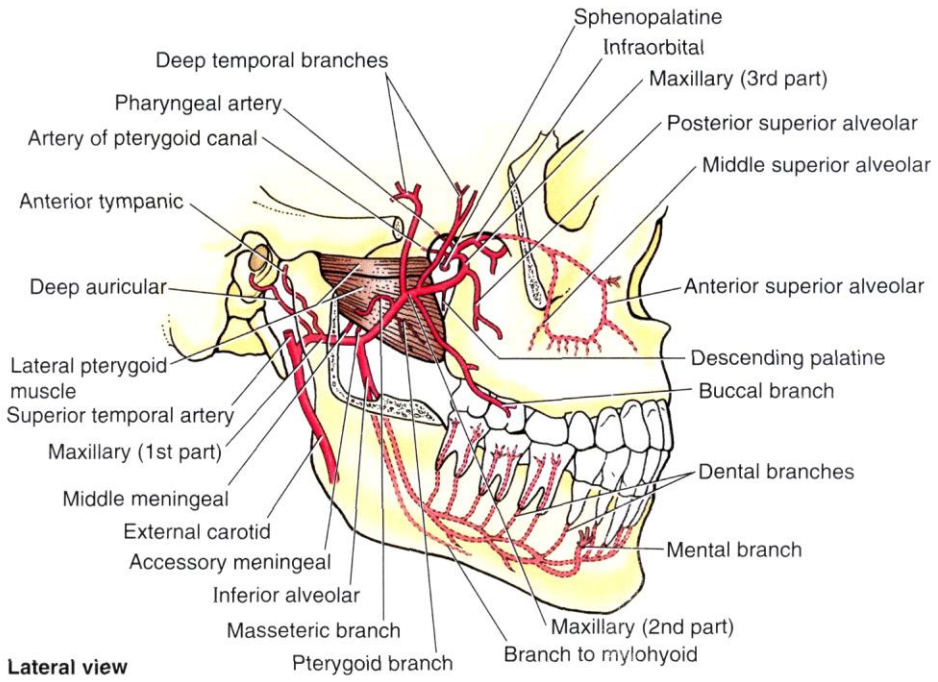
9.The **maxillary artery** *(a. maxillaris)* is another terminal branch of the external carotid artery. For the sake of convenience it is classified into three sections:
-the first curves around the neck of the mandibula;
-the second passes in the infratemporal fossa on the surface of the lateral pterygoid muscle and
-thethird penetrates the pterygopalatine fossa .

The branches of the first section ascend to the external acoustic meatus and penetrate into the tympanic cavity through the fissura petrotympanica. Its largest branch, the middle meningeal artery *(a. meningea media),* passes to the dura mater of the middle cranial fossa, which it enters through the foramen spinosum.

The first section also gives off the inferior alveolar artery, inferior dental artery *(a. alveolaris inferior),* which stretches downward to the teeth and passes into the mandible through the canalis mandibulae. It leaves the canal through the foramen mentale where it is called *a. mentalis,* which branches out in the skin and muscles of the chin.

The branches of the second section pass to the mucous membrane of the maxillary sinus and upper molars *(aa. alveolares superiores posteriores)* and to all the muscles of mastication and the cheek muscles.

Parts and Branches of the Maxillary Artery



Lateral view

Part	Course	Branches	Distribution
First (mandibular) part	Proximal (posterior) to lateral pterygoid muscle; runs horizontally, deep (medial) to neck of condylar process of mandible and lateral to stylomandibular ligament	Deep auricular artery	Supplies external acoustic meatus, external tympanic membrane, and temporomandibular joint
		Anterior tympanic artery	Supplies internal aspect of tympanic membrane
		Middle meningeal artery	Enters cranial cavity via foramen spinosum to supply periosteum, bone, red bone marrow, dura mater of lateral wall and calvaria of neurocranium, trigeminal ganglion, facial nerve and geniculate ganglion, tympanic cavity, and tensor tympani muscle
		Accessory meningeal artery	Enters cranial cavity via foramen ovale; its distribution is mainly extracranial to muscles of infratemporal fossa, sphenoid bone, mandibular nerve, and otic ganglion
		Inferior alveolar artery	Descends to enter mandibular canal of mandible via mandibular foramen; supplies mandible, mandibular teeth, chin, mylohyoid
Second (pterygoid) part	Adjacent (superficial or deep) to lateral pterygoid muscle; ascends obliquely anterosuperiorly, medial to temporal muscle	Masseteric artery	Traverses mandibular notch, supplying temporomandibular joint and masseter
		Deep temporal arteries	Anterior and posterior arteries ascend between temporal muscle and bone of temporal fossa, supplying mainly muscle
		Pterygoid branches	Irregular in number and origin; supply pterygoid muscle
		Buccal artery	Runs anteroinferiorly with buccal nerve to supply buccal fat-pad, buccinator, and buccal oral mucosa
Third (pterygopalatine) part	Distal (anteromedial) to lateral pterygoid muscle; passes between heads of lateral pterygoid and through pterygomaxillary fissure into pterygopalatine fossa	Posterior superior alveolar artery	Descends on maxilla's infratemporal surface with branches traversing alveolar canals to supply maxillary molar and premolar teeth, adjacent gingiva, and mucous membrane of maxillary sinus
		Infraorbital artery	Traverses inferior orbital fissure, infraorbital groove, canal, and foramen; supplies inferior oblique and rectus muscles, lacrimal sac, maxillary canines and incisors teeth, mucous membrane of the maxillary sinus, and skin of infraorbital region of face
		Artery of pterygoid canal	Passes posteriorly through pterygoid canal; supplies mucosa of upper pharynx, pharyngotympanic tube, and tympanic cavity
		Pharyngeal branch	Passes through palatovaginal canal to supply mucosa of nasal roof, nasopharynx, sphenoidal air sinus, and pharyngotympanic tube
		Descending palatine artery	Descends through palatine canal, dividing into greater and lesser palatine arteries to mucosa and glands of hard and soft palate
		Sphenopalatine artery	Terminal branch of maxillary artery, traverses sphenopalatine foramen to supply walls and septum of nasal cavity; frontal, ethmoidal, sphenoid, and maxillary sinuses; and anteriormost palate

anches of the third section: (1) *a. infraorbitalis* enters the eye socket through the fissura orbitalis inferior, then passes through the canalis infraorbitalis to the anterior surface of the maxilla, and sends branches to the lower eyelid, to the lacrimal sac, and down to the upper lip and cheek. Here it anastomoses with the branches of the facial artery. While still in the eye socket, a. infraorbitalis gives off branches to the muscles of the eyeball. As it passes through the inferior orbital canal, it supplies the canine tooth and incisors *(aa. alveolares superiores anteriores)* and the mucosa of the maxillary sinus with small branches; (2) some of the branches reaching the pharynx and the eustachian tube descend to the canalis palatinus major, pass through the foramina palatina majus and minorus, and spread out in the soft and hard palates; (3) *a. sphenopalatina* runs through the orifice of the same name into the nasal cavity, giving off branches to its lateral wall and to the septum; the anterior part of the nasal cavity receives blood through aa. ethmoidales anterior and posterior (from a. ophthalmica).

The Internal Carotid Artery

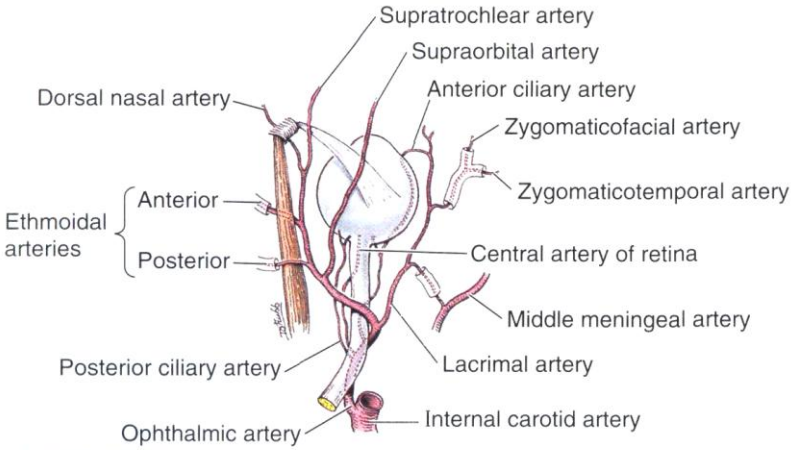
Having branched off from the common carotid artery the **internal carotid artery** *(a. carotis interna)* rises to the base of the skull and enters the canalis caroticus in the temporal bone . It does not give off branches in the region of the neck. In accordance with the convolutions of the canalis caroticus, the internal carotid artery at first runs vertically and then curves anteromedially. At the top of the pyramid of the temporal bone, the artery enters the cavity of the skull through the foramen caroticum internum. It rises along the sulcus caroticus of the sphenoid bone. Passing through the thickness of the cavernous sinus, the artery makes its last turn at the canalis opticus, giving off its first branch, a. ophthalmica, after which it perforates the dura mater and pia mater and, finally, divides into its terminal branches:

The branches of internal carotid artery are:

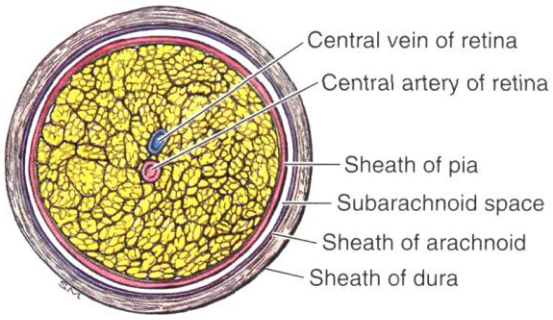
1. The caroticotympanic branches *(rr. caroticotympanici)* are small, thin branches penetrating the posterior wall of the canalis caroticus into the tympanic cavity.
2. The ophthalmic artery *(a. ophlhalmica)* , together with n. opticus, penetrates the canalis opticus into the orbital cavity where it divides into its terminal branches. Along the way to the orbit, it gives off several branches.

The rami of a. ophthalmica include branches to:

(1) the dura mater, anastomosing with a. meningea media (a branch of a. maxillaris from the system of a. carotis externa);
(2) the lacrimal gland (*a. lacrimalis);*
(3) the eyeball, *aa. ciliares,* ending the vascular coat of the eyeball; one of these branches, *a. centralis retinae,* penetrates the optic nerve and, together with it, branches out in the retina;
(4) the muscles of the eyeball;
(5) the eyelids, *aa. palpebrales laterales* and *mediales;* both groups of arteries along the margin of each eyelid form anastomoses, the arcus palpebralis superior and inferior;
(6) the mucosus tunic of the nasal cavity, *aa. ethmoidales anterior* and *posterior;* (7) *a.supraorbitalis,* exiting from the orbit through the incisura supraorbital foramen;
(8) *a. dorsalis nasi,* descending along the ridge of the nose.



Superior view



Transverse section of optic nerve

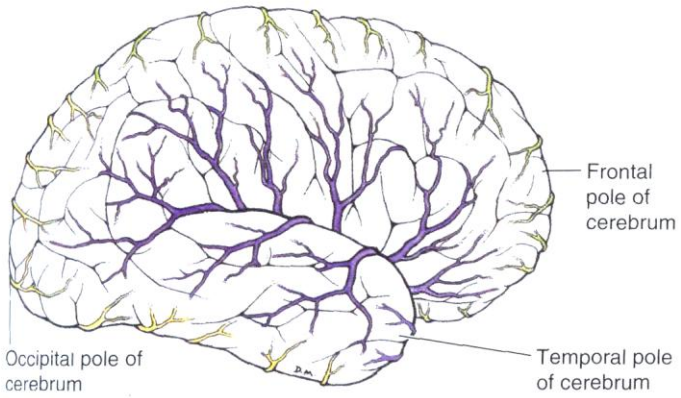
Table Arteries of the Orbit

Artery	Origin	Course and Distribution
Ophthalmic	Internal carotid artery	Traverses optic foramen to reach orbital cavity
Central artery of retina	Ophthalmic artery	Runs in dural sheath of optic nerve and pierces nerve near eyeball; appears at center of optic disc; supplies optic retina (except cones and rods)
Supraorbital		Passes superiorly and posteriorly from supraorbital foramen to supply forehead and scalp
Supratrochlear		Passes from supraorbital margin to forehead and scalp
Lacrimal		Passes along superior border of lateral rectus muscle to supply lacrimal gland, conjunctiva, and eyelids
Dorsal nasal		Courses along dorsal aspect of nose and supplies its surface
Short posterior ciliaries		Pierce sclera at periphery of optic nerve to supply choroid, which in turn supplies cones and rods of optic retina
Long posterior ciliaries		Pierce sclera to supply ciliary body and iris
Posterior ethmoidal		Passes through posterior ethmoidal foramen to posterior ethmoidal cells
Anterior ethmoidal		Passes through anterior ethmoidal foramen to anterior cranial fossa; supplies anterior and middle ethmoidal cells, frontal sinus, nasal cavity, and skin on dorsum of nose
Anterior ciliary	Muscular (rectus) branches of ophthalmic artery	Pierces sclera at attachments of rectus muscles and forms network in iris and ciliary body
Infraorbital	Third part of maxillary artery	Passes along infraorbital groove and foramen to face

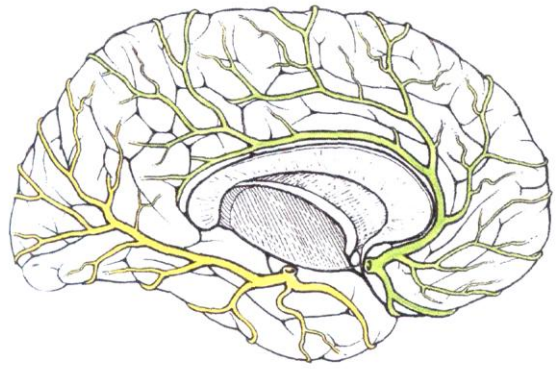
3. The anterior cerebral artery *(a. cerebri anterior),* which is smaller in size, stretches forward medially to the start of the longitudinal sulcus of the brain, curves around the knee of the corpus callosum, and stretches along the inner surface of the cerebral hemisphere back to the beginning of the occipital lobe, giving off branches along the way to the cerebral cortex. At the origin of the longitudinal sulcus of the brain, it joins with the artery of the same name from the other side by means of a transverse trunk, *a. communicans anterior.*

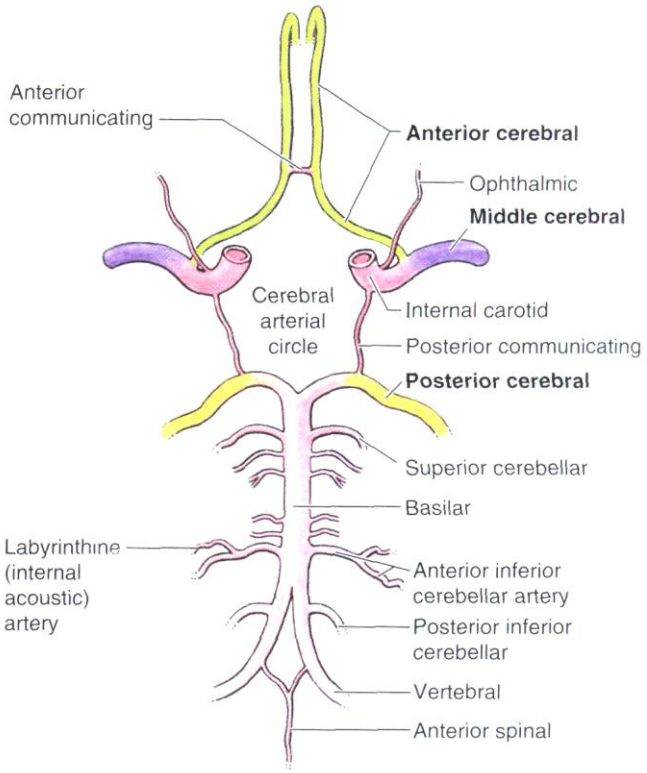
4.

5. The medial cerebral artery *(a. cerebri media)* passes laterally into the depth of the lateral cerebral sulcus. On the surface of insula, it starts dividing into branches that emerge onto the surface of the hemispheres and supply the external surface of the frontal, temporal, and parietal lobes with blood, with the exception of the posterior parts of the brain, which receive blood from the system of a. vertebralis.
5. The choroid artery *(a. chorioidea)* passes back laterally and, on reaching the surface of the temporal lobe of the brain, enters the inferior horn of the lateral ventricle and terminates in plexus chorioideus.
6. The posterior communicating artery *(a. communicans posterior)* passes back and drains into a. cerebri posterior (from a. vertebralis).



Right lateral view of right hemisphere


Medial view of left hemisphere



(C) Inferior view

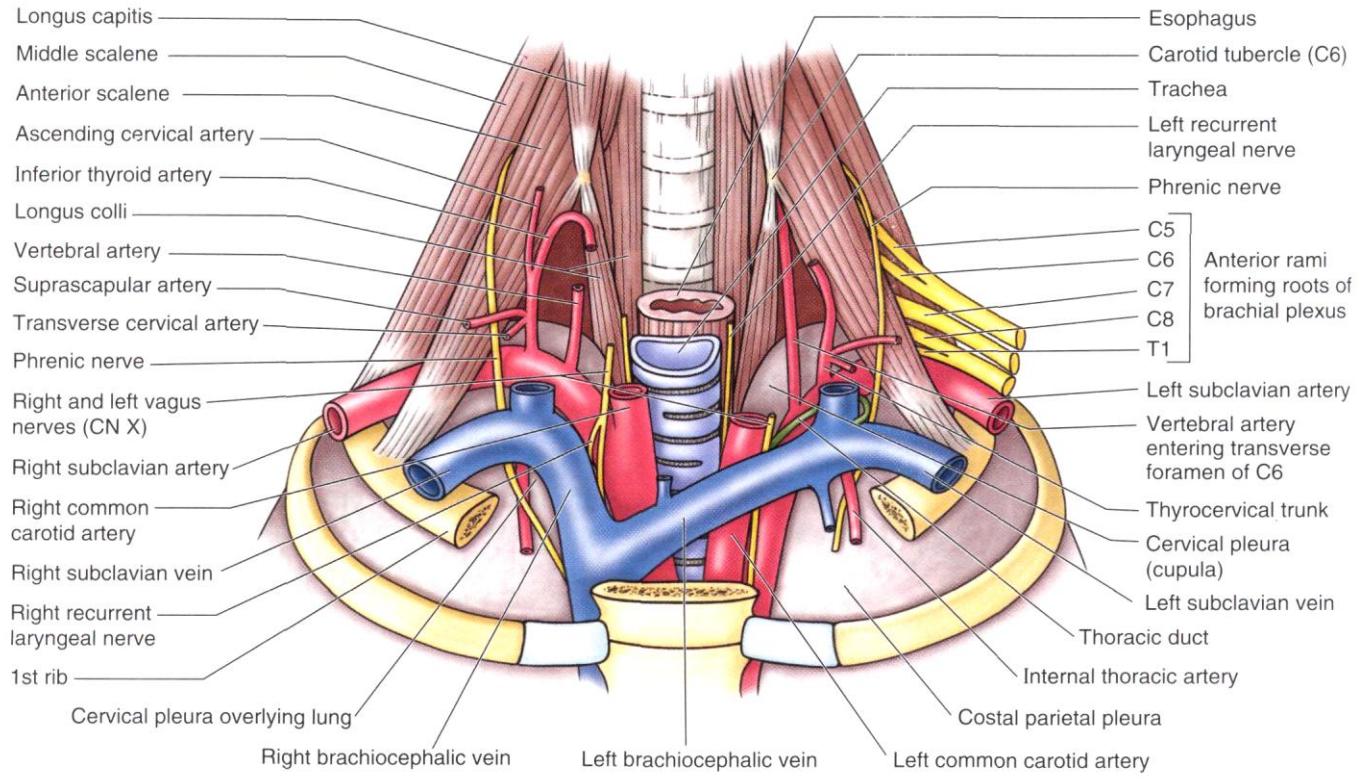
Table **Arterial Supply of the Cerebral Hemispheres**

Artery	Origin	Distribution
Internal carotid	Common carotid artery at superior border of thyroid cartilage	Gives branches to walls of cavernous sinus, pituitary gland, and trigeminal ganglion; provides primary supply to brain
Anterior cerebral	Internal carotid artery	Cerebral hemispheres, except for occipital lobes
Anterior communicating	Anterior cerebral artery	Cerebral arterial circle (of Willis)
Middle cerebral	Continuation of internal carotid artery distal to anterior cerebral artery	Most of lateral surface of cerebral hemispheres
Vertebral	Subclavian artery	Cranial meninges and cerebellum
Basilar	Formed by union of vertebral arteries	Brainstem, cerebellum, and cerebrum
Posterior cerebral	Terminal branch of basilar artery	Inferior aspect of cerebral hemisphere and occipital lobe
Posterior communicating	Posterior cerebral artery	Optic tract, cerebral peduncle, internal capsule, and thalamus

In the subarachnoid space, a. communicans anterior, the beginning segments of aa. cerebri anteriores, aa. communicantes posteriores, and aa. cerebri posteriores (from a. vertebralis) join to form a closed *arterial circle* — circulus arteriosus cerebri (Willis' circle) .

THE SUBCLAVIAN ARTERY

Only the left subclavian artery *(a. subclavia)* belongs to the group of arteries branching directly off the aortic arch . The artery on the right is a branch of the truncus brachiocephalicus. As a result, the right subclavian artery is slightly shorter than the left.



(A) Anterior view

The artery has three segments.

The branches of the first segment of the subclavian artery (up to its entry into the spatium interscalenum):

1. The **vertebral artery** (*a. vertebralis)* passes into the foramen transversarium of the sixth cervical vertebra, and rises through the openings in the transverse processes of the cervical vertebrae to the membrana atlantooccipitalis posterior, which it perforates to enter the cranial cavity through the foramen magnum of the occipital bone. Within the skull, the vertebral arteries from both sides pass toward the median line and form a single unpaired artery (a. basilaris) near the posterior edge of the pons. Along the way, this artery gives off small branches to the muscles, the spinal cord and dura mater of the posterior cranial fossa, as well as the large branches.

(a) *A. spinalis anterior* branches off in the cranial cavity near the junction of two vertebral arteries and passes down to the median line to meet with the branch of the same name from the contralateral side; they merge into a single trunk.

(b) *A. spinalis posterior* branches off the vertebral artery as soon as it enters the cranial cavity and also runs down both sides of the spinal cord. As a result, three arterial trunks descend along the spinal cord: the unpaired trunk of the anterior surface (a. spinalis anterior) and two paired trunks on the posterolateral surface, one on each side (aa. spinales posteriores).

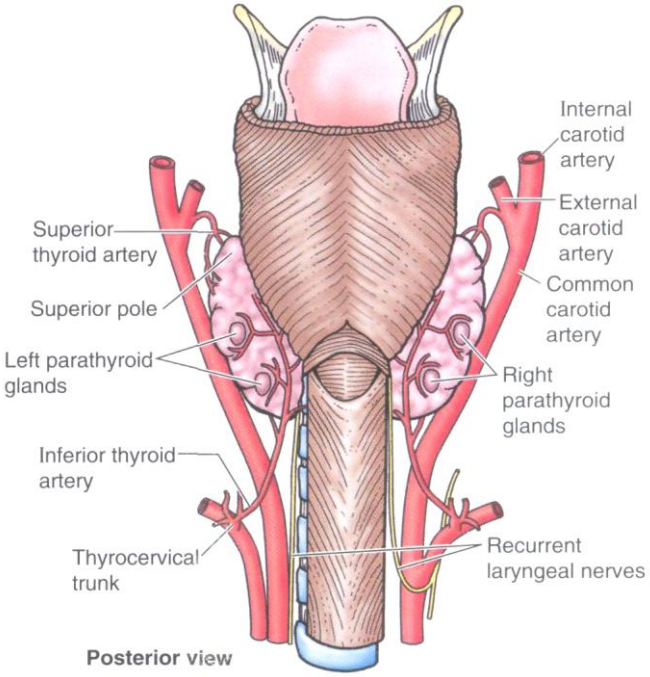
A. cerebelli inferior posterior is the largest branch of a. vertebralis ; it arises near the pons, turns back and branches out on the lower surface of the cerebellum.

The **basilar artery** *(a. basilaris)* is formed by the union of both vertebral arteries; it is unpaired and lies in the median sulcus of the pons. At the anterior margin of the pons, it divides into two *aa. cerebri posteriores* (one on each side). Small branches lead from the trunk of a. basilaris to the pons, into the internal ear, passing through the meatus acusticus internus. Two branches lead to the cerebellum: *a. cerebelli inferior anterior* and *a. cerebelli superior.*

A. vertebralis, which passes parallel to the trunk of the common carotid artery and participates, together with it, in supplying the brain with blood, is a collateral vessel for the head and neck. A. basilaris, two vertebral arteries joined in one trunk and two aa. spinales anteriores also joined in one trunk, form Zakharchenko's arterial circle, which, together with circulus arteriosus cerebri, is important in the collateral circulation of the medulla oblongata.

2. The **thyrocervical trunk** *(truncus thyreocervicalis)* branches upward from a. subclavia at the medial margin of m. scalenus arterior; the trunk runs for a distance of about 4 mm and then divides into the following branches:

(a) *a. thyreoidea inferior* passes to the posterior surface of the thyroid gland between a. carotis communis in front and a. vertebralis in back, giving off *a. laryngea inferior*, which branches out in the muscles and the mucosa of the larynx and anastomoses with a. laryngea superior with branches to the trachea, oesophagus, and thyroid gland; these last branches anastomose with branches of a. thyreoidea superior in the system a. carotis externa; (b) *a. cervicalis ascendens* passes up along m. scalenus anterior and supplies the deep muscles of the neck; (c) *a. suprascapularis* passes down and laterally from the trunk to the incisura scapulae branches out in the dorsal muscles of the shoulder , anastomosing with a. circumflexa scapulae.



3. The internal thoracic artery (a. *thoracica interna)* originates from a. subclavia opposite the origin of a. vertebralis and descends medially, close to the pleura; beginning from the cartilage of the first rib, it extends vertically When it reaches the lower edge of the seventh rib cartilage, a. thoracica interna divides into two terminal branches: *a. musculophrenica,* which stretches laterally along the line of attachment of the diaphragm and gives off small branches to it and to the nearest intercostal spaces; and *a. epigastrica superior,* which continues the descent of a. thoracica interna, penetrating the sheath of the rectus abdominis muscle and, on reaching the level of the navel, anastomoses with a. epigastrica inferior (from a. iliaca externa). Along its way, a. thoracica interna gives off branches to the nearest anatomical formations: to the connective tissue of the anterior mediastinum, thymus, lower end of the trachea, and the bronchi, to six upper intercostal spaces, and to the mammary glands.

Its long branch, *a. pericardiacophrenica*, passes, together with n. phrenicus, to the diaphragm, giving off small branches along the way to the pleura and pericardium. Its *rami intercostales anteriores* run through the six superior intercostal spaces and anastomose with aa. intercostales posteriores (from the aorta).

The branches of the second segment of the subclavian artery:

4. The costocervical trunk *(truncus costocervicalis)* divides into two branches: (a) *deep cervical artery (a. cervicalis profunda),* and (b) *superior intercostal artery (a. intercostalis suprema),* which branches into the first and second intercostal spaces.

The branches of the third segment of the subclavian artery:

5. The transverse cervical artery *(a. transversa colli)* perforates the plexus brachialis, supplies the neighbouring muscles, and descends along the vertebral edge of the scapula to its inferior corner.

THE AXILLARY ERTERY

The axillary artery (a. axillaris) is a direct continuation of the subclavi-an artery. . In turn, a. axillaris is continuous with the brachial artery. The proximal border of the trunk of the axillary artery is on a level with the external edge of the first rib. The distal border is on the inferior edge of m. teres major (at the origin of the brachial artery). The axillary artery lies in the axillary cavity, which is medial of the shoulder joint and the humerus; in front and medial of it is v. axillaris with the nerve trunks of the brachial plexus on three sides. At its lower end this neurovascular bundle is covered with skin, fascia, and fatty tissue containing lymphatic nodes.

Three segments of a. axillaris are distinguished along its length:

(1) the trigonum clavipectorale, from the clavicle to the superior margin of m. pectoralis minor;

(2) the trigonum pectorale, posteriorly of m. pectoralis minor;

(3) the trigonum subpectorale, from the inferior margin of m. pectoralis minor to the inferior margin of m. pectoralis major.

The branches of a. axillaris in the trigonum clavipectorale:

1. The superior thoracic artery (a. thoracica suprema) branches out in m. subclavius, both pectoral muscles, m. serratus anterior, and the nearest intercostal muscles.

The acromiothoracic artery (a. thoracoacromialis) originates at the superior margin of m. pectoralis minor and divides into branches, some of which pass upward and laterally to the acromion. There they anastomose with a. suprascapularis to form a network of vessels that take part in supplying the shoulder joint with blood. Other branches stretch torn, deltoideus and to both pectoral muscles.

In the trigonum pectorals:

3. The lateral thoracic artery *(a. thoracica lateralis)* descends on the lateral wall of the chest and gives off branches to the mammary gland and the surrounding muscles.

In the trigonum subpectorale:

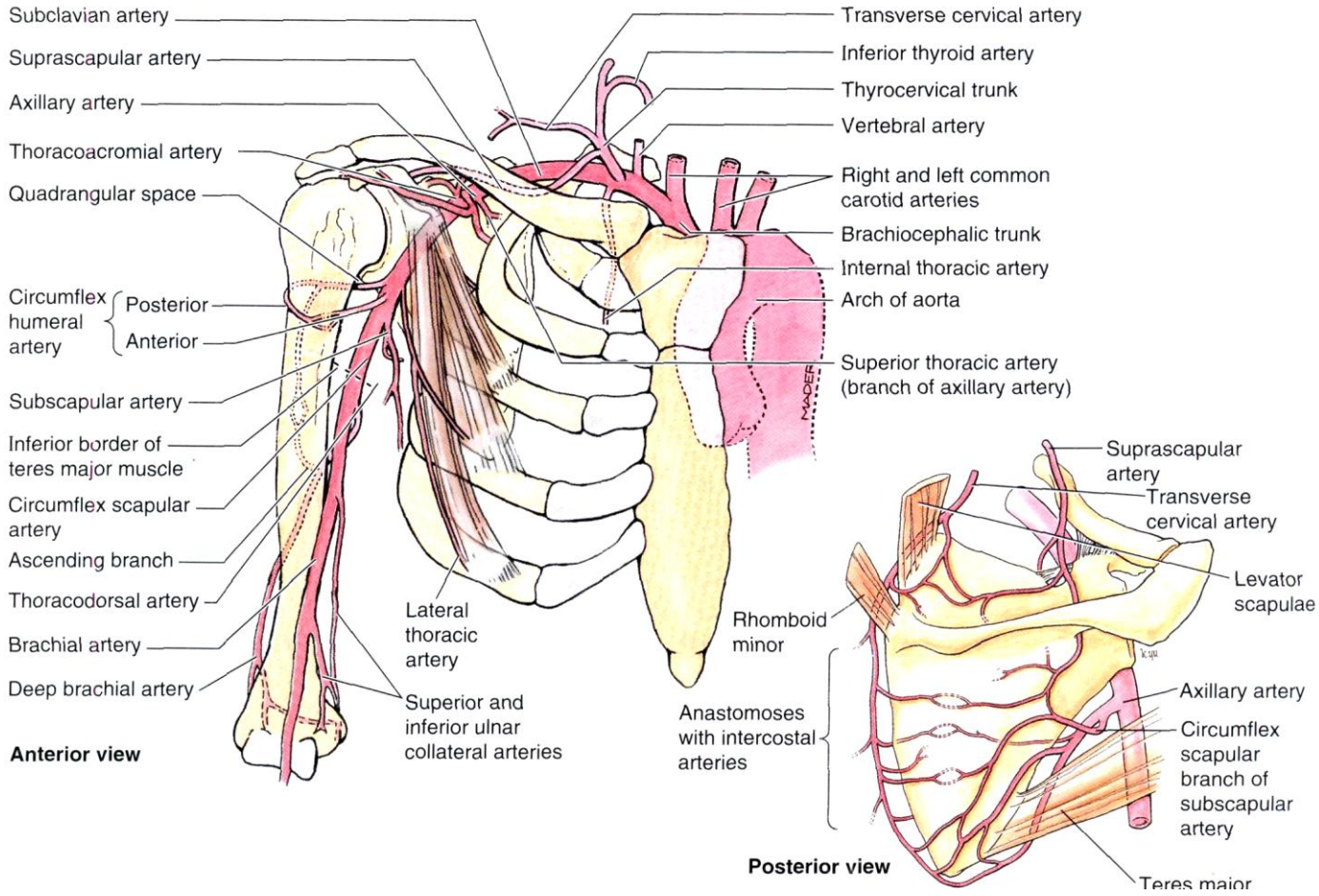
4. The subscapular artery (a. subscapularis) is the largest branch of the axillary artery. It rises near the inferior border of the subscapular artery and descends along this artery, giving off branches to it; the subscapular ar tery soon separates into two trunks: (a) a. circumflexa scapulae, which passes through the foramen trilaterum to the dorsal surface of the scapula where it anastomoses with a. suprascapularis; and (b) a. thoracodorsalis, which is a continuation of the subscapular artery and passes along the lateral border of the scapula.

5. The posterior circumflex humeral artery (a. circumflexa humeri posterior) passes to the back into the foramen quadrilaterum and winds posteriorly around the surgical neck of the humerus; it is covered by the deltoid muscle, to which it gives off branches.

6. The anterior circumflex humeral artery (a. circumflexa humeri anterior) curves around the brachial bone. Smaller than the posterior circumflex artery, it begins on the same level and passes in the lateral direction, curving round the neck of the humerus anteriorly, anastomosing with a. circumflexa humeri posterior, and giving off branches to the muscles and the brachial joint.

All the branches of the axillary artery anastomose widely with branches of the subclavian artery. Ligation of the axillary artery above the point where a. subscapularis branches off is, therefore, more effective than when ligation is lower. Similarly, ligation of the subclavian artery at its origin often results in gangrene, whereas ligation distally from the origin at the truncus thyrocervicalis does not lead to such complications.

Table **Arteries of the Proximal Upper Limb (Shoulder Region and Arm)**



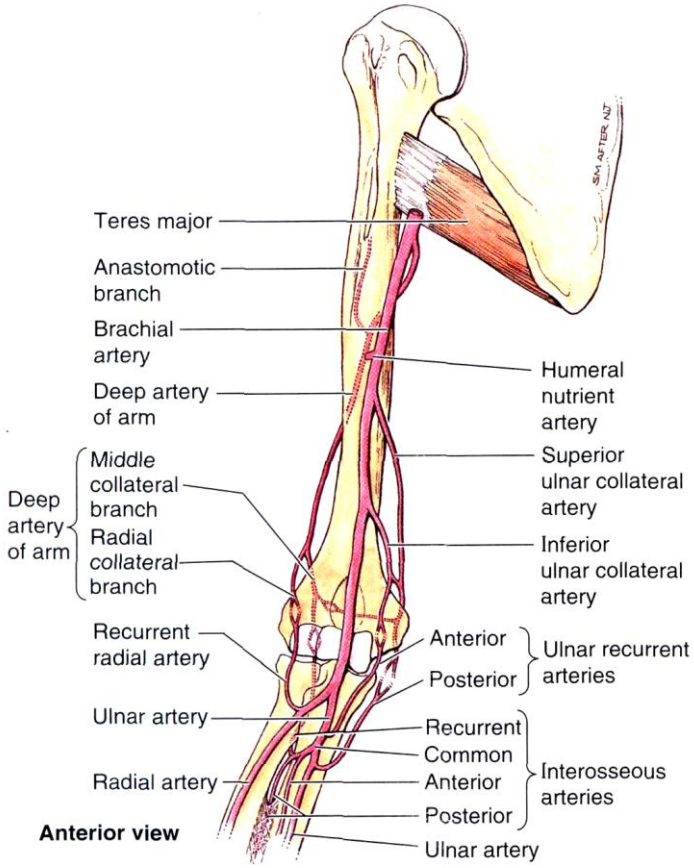
THE BRACHIAL ARTERY

The brachial artery (a. brachialis) is continuous with the axillary artery . Beginning at the lower border of m. teres major, it leads to the sulcus bicipitalis medialis where, at the level of the neck of the radius, it divides into its terminal branches: the radial and ulnar arteries. On its way to the sulcus bicipitalis medialis, it is attended by two brachial veins and nerves (n. medianus, n. ulnaris, n. cutaneus brachii medialis, and n. cutaneus antebrachii medialis). In addition to sending off small branches to the bone and muscles, the brachial artery gives rise to the following branches:

1. The profunda brachii artery (a. profunda brachii) rises from a. brachialis soon after the origin of the latter; it is a large branch that, together with n. radialis, passes into the canalis spiralis. The deep brachial artery gives off an artery that supplies the brachial bone with nutrients (a. diaphyseos humeri). The deep brachial artery also gives off posterior descending branch (a. collateralis media), which penetrates the thickness of m. triceps and anastomoses with a. interossea recurrens (from a. interossea posterior) and with anterior descending branch (a. collateralis radialis). The latter emerges onto the surface through the inferior opening of the canalis spiralis, advancing forward from the epicondylus lateralis and anastomosing with a. recurrens (a branch of a. radialis).

2. The ulnar collateral artery (a. collateralis ulnaris superior] rises from the brachial artery in the middle of the arm or somewhat higher and settles into the sulcus behind the epicondylus medialis, where it anastomoses with a. recurrens ulnaris posterior (branch of a. ulnaris).

3. The supratrochlear artery (a. collateralis ulnaris inferior) rises from the medial semicircle of the brachial artery about 5 cm above the end of the latter. Obliquely passing over the surface of m. brachialis in a medial and distal direction, this artery anastomoses anteriorly of the epicondylus medialis with a. recurrens ulnaris anterior (branch of a. ulnaris).



The Radial Artery

The radial artery (a. radialis) is directly continuous with the brachial artery . It passes medially of m. brachioradialis, at first under its cover and then in the sulcus radialis. In the lower one-third of the antebrachium where the muscles become tendons, a radia] artery is covered only by the fascia and skin. The pulse can be easily taken here since the artery is so close to the surface. On reaching the top of the styloid process of the radial bone, a. radialis passes to the back of the hand, curving around the lateral edge of the carpus and settling into the anatomical "snuffbox" I) from where it exits onto the palm through the first interosseous space between the bases of the first and second metacarpal bones. On the palm, a. radialis, together with the deep branch of the. ulnar artery, forms the arcus palmaris profundus, the deep palmar arch.

The branches of the radial artery:

1. The radial recurrent artery (a. reccurens radialis) originates in the cubital fossa and passes in the proximal direction toward the anterior surface of the lateral epicondyle where it anastomoses with the above mentioned a. collateralis radialis from a. profundae brachii.
2. Muscular branches (rami musculares) supply the surrounding muscles with blood.
3. The anterior carpal branch (ramus car pens palmaris) originates in the lower part of the forearm and passes to meet a similar branch rising from a. ulnaris. The anastomosis of the ramus carpeus palmaris and a. ulnaris results in rete carpi palmare on the surface of the palm.
4. The superficial palmar branch (ramus palmaris superficialis) either passes over the thenar eminence or penetrates its superficial layers and, joining the end of the ulnar artery, participates in the formation of the arcus palmaris superficialis.
5. The posterior carpal branch (ramus carpeus dorsalis) rises from the region of the anatomical "snuffbox" and, with the a. ulnaris branch, forms a network, the rete carpi dorsale, which also receives small branches from the interosseous arteries (aa. interosseae anterior and posterior).
6. The first dorsal metacarpal artery (a. metacarpea dorsalisprima) passes over the dorsal surface of the hand to the radial side of the index finger and to both sides of the thumb.
7. The princeps pollicis artery (a. princeps pollicis) branches off the radial artery as soon as the latter penetrates the first interosseous space on the palm of the hand; it runs over the palmar surface of the first metacarpal bone and divides into branches, aa. digitales palmares, to both sides of the thumb and to the radial side of the index finger.

Table **Arteries of the Forearm and Wrist**

Artery	Origin	Course in Forearm
Radial	As smaller terminal branch of brachial artery in cubital fossa	Runs inferolaterally under cover of brachioradialis; lies lateral to flexor carpi radialis tendon in distal forearm; winds around lateral aspect of radius and crosses floor of anatomical snuff box to pierce first dorsal interosseous muscle
Radial recurrent	Lateral side of radial artery, just distal to brachial artery bifurcation	Ascends between brachioradialis and brachialis, supplying both (and elbow joint); then anastomoses with radial collateral artery (from deep brachial artery)
Palmar carpal branch	Distal radial artery near distal border of pronator quadratus	Runs across anterior wrist deep to flexor tendons to anastomose with the palmar carpal branch of ulnar artery to form palmar carpal arch
Dorsal carpal branch	Distal radial artery in proximal part of snuff box	Runs medially across wrist deep to pollicis and extensor radialis tendons, anastomoses with ulnar dorsal carpal branch forming dorsal carpal arch

The Ulnar Artery

he ulnar artery (a. ulnaris) is the larger of two terminal branches of the brachial artery. From its origin in the cubital fossa (opposite the neck of the radius), it runs under m. pronator teres to the median one-third of the forearm, slanting toward the ulnar side. In the lower two-thirds, it runs parallel to the ulna first in the interval between m. flexor digitorum superficialis and m. flexor carpi ulnaris; in the lower one-third, its position becomes more superficial (sulcus ulnaris) as the muscles end in tendons. On the radial side of the pisiform bone, the ulnar artery passes into the canalis carpi ulnaris (spatium interaponeuroticum) and, crossing over to the palm, becomes part of arcus palmaris superficialis.

The branches of the ulnar artery:

1. The ulnar recurrent artery (a. recurrens ulnaris) runs in the proximal direction in the form of two branches, the ramus anterior and posterior; these branches run anteriorly and posteriorly of the medial epicondyle anastomosing with aa. collaterals ulnares superior and inferior. These anastomoses, together with the anastomoses mentioned above, which connect branches a.profunda brachii and a.radialis, result in the arterial network called the rete articulare cubiti.The common interosseous artery (a. interossea communis) has a short trunk directed toward the interosseous membrane.

At the proximal border of the membrane it divides into two branches:

(a) a. interossea anterior passes along the anterior surface of the interosseous membrane and reaches m. pronator quadratus where it pierces the membrane and recedes to the rear, ending in the rete carpi dorsale. At its origin a. interossea anterior gives off a.mediana (passing toward the palm, together with n. medianus), aa. diaphyseos radii and ulnae to the bones of the forearm, and the rami musculares to the surrounding muscles;

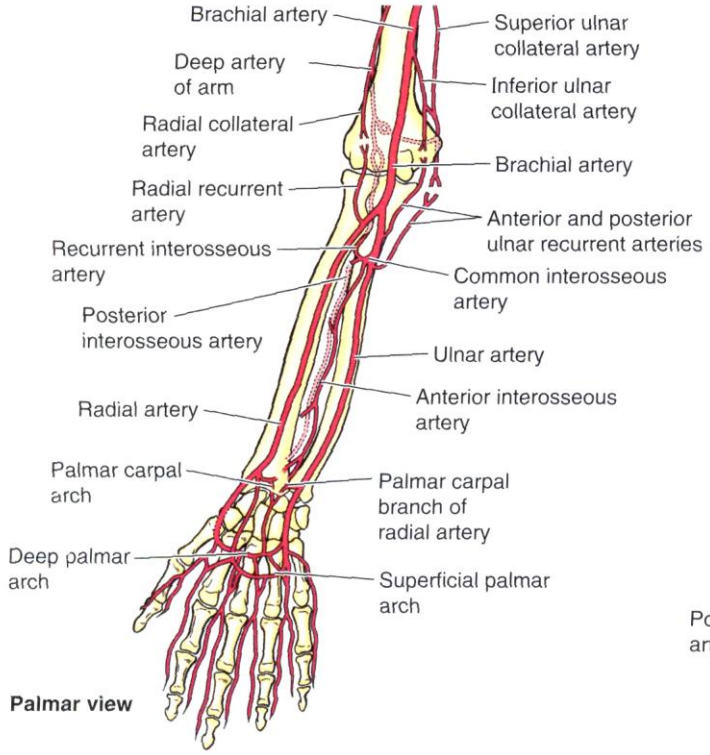
(b) a. interossea posterior passes through the superior orifice of the interosseous membrane to the dorsal side, gives off a. interossea recurrens, and lies between the superficial and deep layers of extensors. In the region of the wrist, a. interossea posterior anastomoses with a. interossea anterior.

2. The anterior carpal branch (ramus carpeus palmaris) meets and anastomoses with the palmar carpal branch of the radial artery.

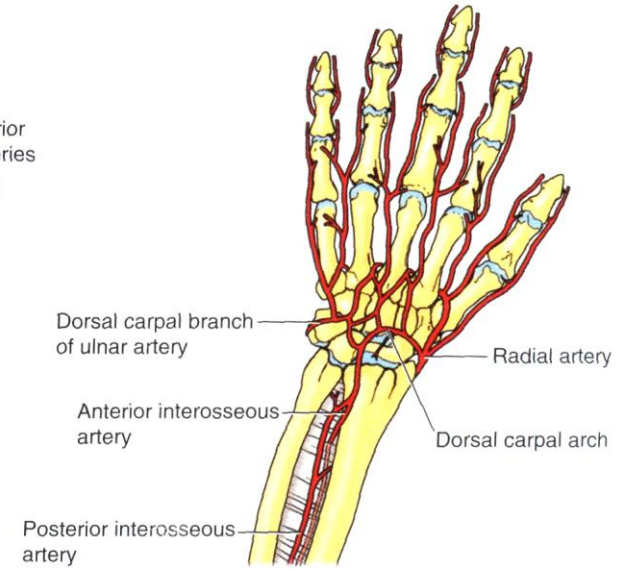
3. The posterior carpal branch (ramus carpeus dorsalis) originates near the pisiform bone and passes under m. flexor carpi to the dorsal side to meet the dorsal carpal branch of the radial artery.

The deep palmar branch (ramus palmaris profundus) passes under the tendons and nerves of the palm and, together with a. radialis (see above), participates in forming the deep palmar arch.

Table **Arteries of the Forearm and Wrist**



Palmar view



Posterior view

Artery	Origin	Course in Forearm
Ulnar	As larger terminal branch of brachial artery in cubital fossa	Descends inferomedially and then directly inferiorly, deep to superficial (pronator teres and palmaris longus) and intermediate (flexor digitorum superficialis) layers of flexor muscles to reach medial side of forearm; passes superficial to flexor retinaculum at wrist in ulnar (Guyon) canal to enter hand
Anterior ulnar recurrent artery	Ulnar artery just distal to elbow joint	Passes superiorly between brachialis and pronator teres, supplying both; then anastomoses with inferior ulnar collateral artery anterior to medial epicondyle
Posterior ulnar recurrent artery	Ulnar artery distal to anterior ulnar recurrent artery	Passes superiorly, posterior to medial epicondyle and deep to tendon of flexor carpi ulnaris; then anastomoses with superior ulnar collateral artery
Common interosseous	Ulnar artery in cubital fossa, distal to bifurcation of brachial artery	Passes laterally and deeply, terminating quickly by dividing into anterior and posterior interosseous arteries
Anterior interosseous	As terminal branches of common interosseous artery, between radius and ulna	Passes distally on anterior aspect of interosseous membrane to proximal border of pronator quadratus; pierces membrane and continues distally to join dorsal carpal arch on posterior aspect of interosseous membrane
Posterior interosseous		Passes to posterior aspect of interosseous membrane, giving rise to recurrent interosseous artery; runs distally between superficial and deep extensor muscles, supplying both; replaced distally by anterior interosseous artery
Recurrent interosseous	Posterior interosseous artery, between radius and ulna	Passes superiorly, posterior to proximal radioulnar joint and capitulum, to anastomose with middle collateral artery (from deep brachial artery)
Palmar carpal branch	Ulnar artery in distal forearm	Runs across anterior aspect of wrist, deep to tendons of flexor digitorum profundus, to anastomose with the palmar carpal branch of the radial artery, forming palmar carpal arch
Dorsal carpal branch	Ulnar artery, proximal to pisiform	Passes across dorsal surface of wrist, deep to extensor tendons, to anastomose with dorsal carpal branch of radial artery, forming dorsal carpal arch

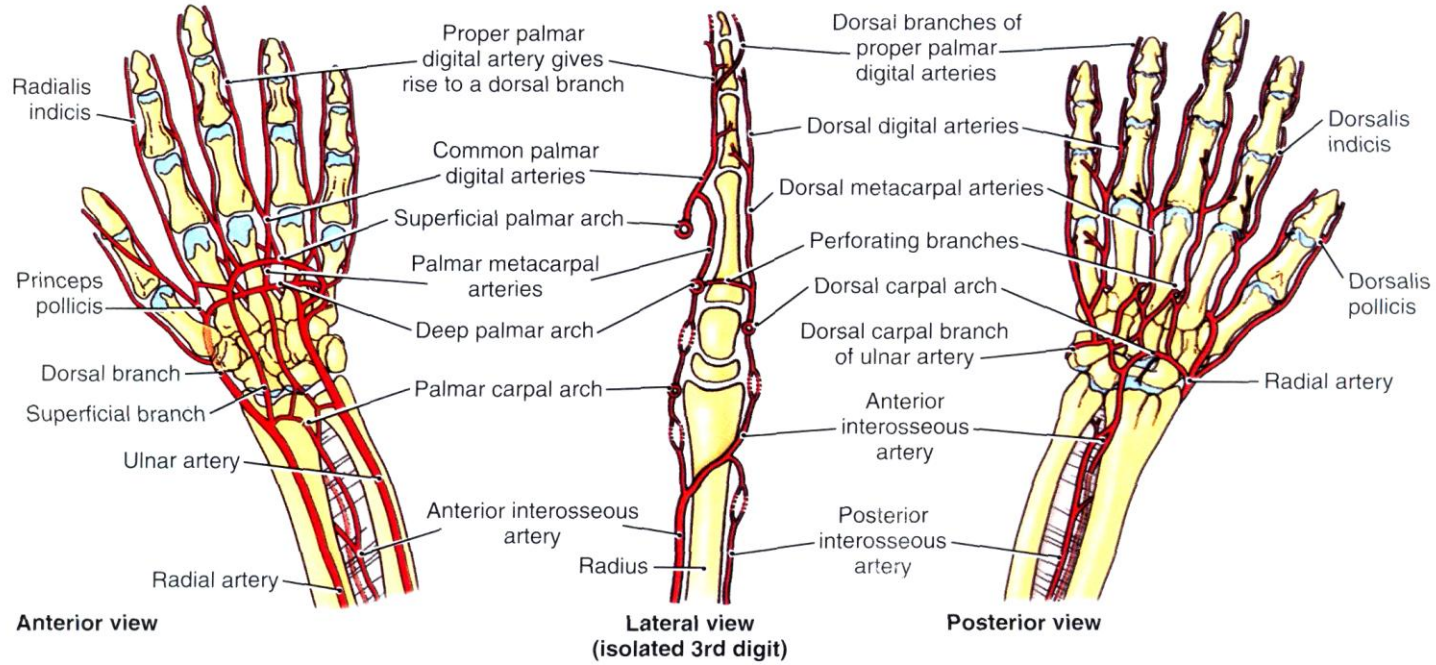
The Arches and Arteries of the Hand

There are two networks in the carpal region: palmar, the rete carpi palmare, and dorsal, the rete carpi dorsale.

The anterior carpal arch (rete carpi palmare) is formed by the union of the palmar carpal branches of the radial and ulnar arteries (see above) and the branches of the anterior interosseous artery. The palmar network of the carpus lies on the carpal ligaments under the flexor tendons; its branches supply nutrients to the ligaments and the mediocarpal and radiocarpal joints.

The posterior carpal arch (rete carpi dorsale) is formed by the union of the dorsal carpal branches of the radial and ulnar and branches of the interosseous arteries. It lies under the extensor tendons and gives off branches to: (a) the nearest joints (rr. articulares) and (b) the second, third, and fourth interosseous spaces (aa. metacarpeae dorsales). At the base of the fingers, each branch divides into branches stretching to the fingers (aa. digitales dorsales). A superficial and a deep arch are located on the palm.

Table **Arteries of the Hand**



Artery	Origin	Course
Superficial palmar arch	Direct continuation of ulnar artery; arch is completed on lateral side by superficial branch of radial artery or another of its branches	Curves laterally deep to palmar aponeurosis and superficial to long flexor tendons; curve of arch lies across palm at level of distal border of extended thumb
Deep palmar arch	Direct continuation of radial artery; arch is completed on medial side by deep branch of ulnar artery	Curves medially, deep to long flexor tendons; is in contact with bases of metacarpals
Common palmar digitals	Superficial palmar arch	Pass distally on lumbricals to webbing of fingers
Proper palmar digitals	Common palmar digital arteries	Run along sides of 2nd–5th fingers
Princeps pollicis	Radial artery as it turns into palm	Descends on palmar aspect of 1st metacarpal; divides at base of proximal phalanx into two branches that run along sides of thumb
Radialis indicis	Radial artery but may arise from princeps pollicis artery	Passes along lateral side of index finger to its distal end
Dorsal carpal arch	Radial and ulnar arteries	Arches within fascia on dorsum of hand

The superficial palmar arch (arcus palmaris superficialis) lies under the palmar aponeurosis. A continuation of the ulnar artery, the superficial arch diminishes in calibre as it moves to the radial side where it is joined by the superficial palmar branch of the radial artery. The distal convexity of the superficial arch gives rise to four aa.digitales palmares communes. Three of them pass in one line with the second, third, and fourth interosseous space, respectively, while the fourth extends to the ulnar side of the little finger. At the fold of skin between the fingers, each artery divides into two aa. digitales palmares propriae, stretching on the contiguous sides of the adjacent fingers.

The deep palmar arch (arcus palmaris profundus) lies deep under the flexor tendons on the bases of the metacarpal bones and the ligaments, proximal to the superficial arch . Formed mainly by the radial artery, the deep palmar arch, in contrast to the superficial arch, diminishes in calibre as it moves to the ulnar side of the hand where it is composed of a relatively thin, deep palmar branch of the ulnar artery. The convexity of the deep arch gives rise to three arteries extending distally to the three interosseous spaces, beginning with the second space.

These are aa. metacarpeae palmares, which anastomose with the ends of the common palmar digital arteries at the in-terdigital folds. The arch also gives rise to three small branches, aa. perfo-rantes, which pass dorsally through the interosseous spaces (second, third, and fourth) and anastomose with the dorsal metacarpal arteries on the dorsal surface of the hand.

The superficial and deep arterial arches are the result of an important functional adjustment. When the hand performs a grasping action, its ves- sels are often compressed; when the flow of blood in the superficial palmar arch is disturbed, the supply of blood to the hand does not suffer since it flows along the arteries of the deep arch in such cases. The articular networks are the result of similar adjustments: the blood flows freely through these networks to the joint even when the vessels contract and stretch during movements at the joint.

There are many possibilities for the development of collateral circulation in the upper limb. The deep brachial artery serves as a collateral vessel for the brachial artery, as does the common interosseous artery for the ulnar artery.

BRANCHES OF THE THORACIC AORTA

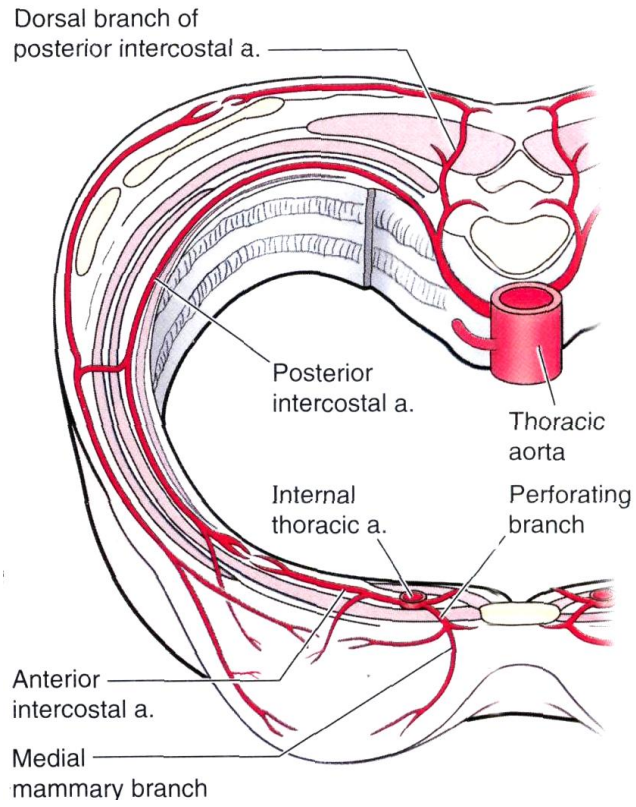
The thoracic segment of the aorta (aorta thoracica) gives off the following branches .

Rami viscerales:

1. The bronchial branches (rami bronchiales), which supply the lung as an organ, enter the lungs with the bronchi and carry arterial blood for the lymph nodes and tissue of the lung as far as the alveoli.
2. The oesophageal branches (rami oesophagei) form anastomoses with the branches of the inferior thyroid artery in the upper section of the oesophageal wall and with the branches of the left gastric artery in the lower section.
3. The mediastinal branches (rami mediastinales) pass to the lymph nodes and connective tissue of the posterior mediastinum.
4. The pericardial branches (rami pericardiaci) stretch to the pericardium.

Rami parietales:

Ten pairs of posterior intercostal arteries III-XI (aa. intercostales posteriores III-XI) branch off from the aorta (posterior intercostal arteries I and II arise from the costocervical trunk). The twelfth posterior intercostal artery passes below the rib; this is the subcostal artery (a. subcostalis).



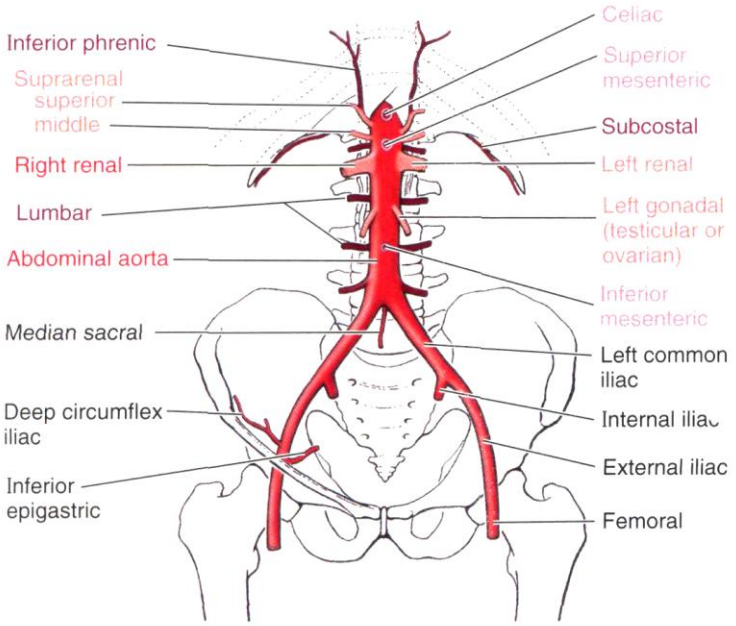
At the beginning of the intercostal spaces, each posterior intercostal artery gives rise to a dorsal branch (ramus dorsalis), extending to the spinal cord and to the muscles and skin of the back. The continuation of the initial trunk of the posterior intercostal artery, the intercostal artery proper, passes along the costal sulcus. Up to the costal angle the artery is in direct contact with the pleura; after that it lies between the external and internal intercostal muscles, and its ends form anastomoses with the anterior intercostal branches of the internal thoracic artery. The lower three intercostal arteries anastomose with the superior epigastric artery. The intercostal arteries also provide branches to the muscles, ribs, and skin, and, in females, to the mammary gland.

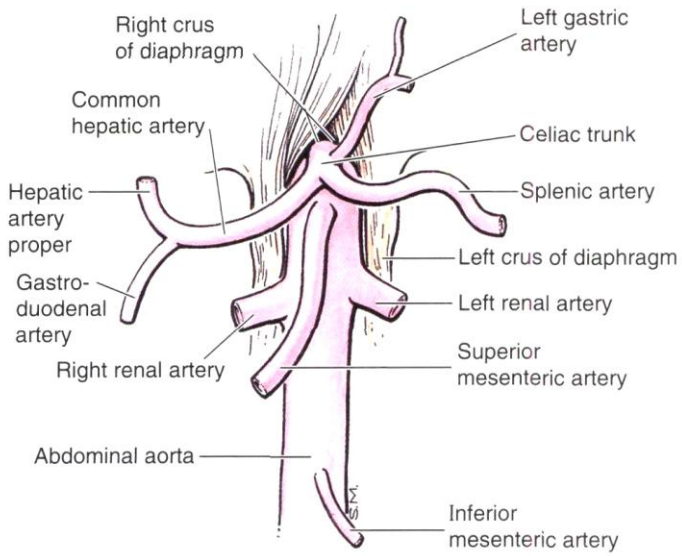
The superior phrenic arteries (aa. phrenicae superiores) are small branches of the thoracic aorta, which branch out on the superior surface of the diaphragm where they form anastomoses with the pericardiacophrenic, musculophrenic (from the internal thoracic artery), and posterior intercostal arteries.

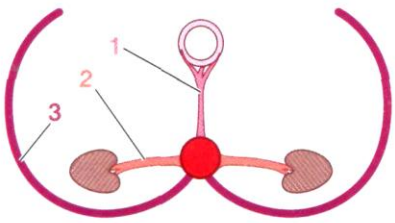
BRANCHES OF THE ABDOMINAL AORTA

The parietal branches of the abdominal aorta (rami parietales) are paired, except for the median sacral artery, which is actually the caudal segment of the aorta whose development is retarded. The visceral branches (rami viscerales) are classified as paired or unpaired .

Table Branches of the Abdominal Aorta







Three vascular planes

	Vascular plane	Class	Distribution	Abdominal Branches (Arteries)	Vertebral Level
1	Anterior midline	Unpaired visceral	Alimentary tract	Celiac	T12
				Superior mesenteric (SMA)	L1
				Inferior mesenteric (IMA)	L3
2	Lateral	Paired visceral	Urogenital and endocrine organs	Suprarenal	L1
				Renal	L1
				Gonadal (testicular or ovarian)	L2
3	Postero-lateral	Paired parietal (segmental)	Diaphragm Body Wall	Subcostal	L2
				Inferior phrenic	T12
				Lumbar	L1–L4

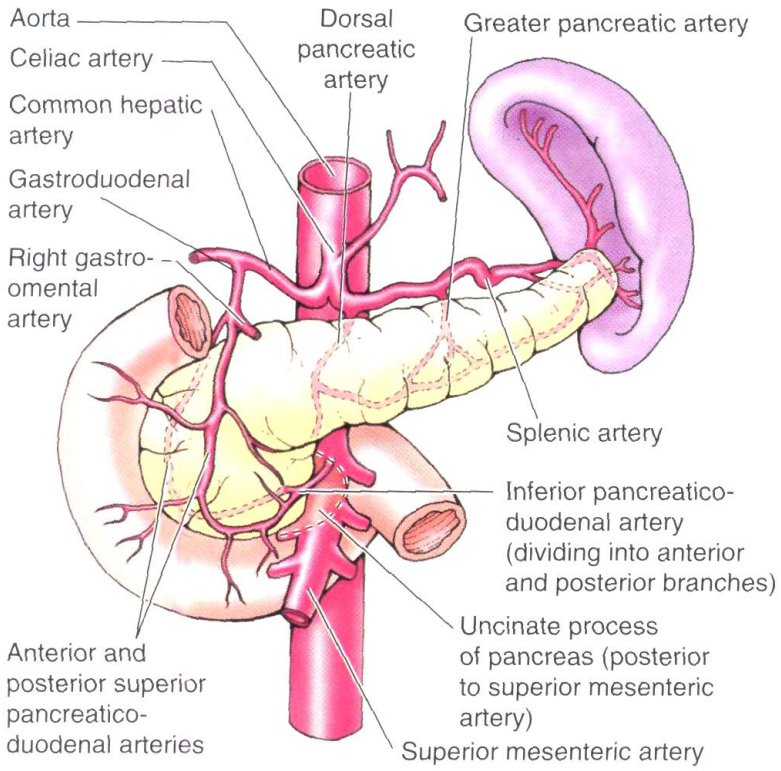
THE UNPAIRED VISCERAL BRANCHES

1. The coeliac artery (truncus celiacus) is a short (2 cm), thick artery rising at the level of the twelfth thoracic vertebra in the hiatus aorticus of the diaphragm. It passes forward above the superior border of the pancreas where it divides into three branches (the site of the division is called the tripus celiacus): the left gastric, common hepatic, and splenic arteries.

(a) The left gastric artery (a. gastrica sinistra) extends to the lesser curvature of the stomach and gives off branches to the stomach and the abdominal part of the oesophagus.

(b) The hepatic artery (a. hepatica communis) passes along the superior margin of the head of the pancreas to the superior border of the duodenum. There it produces the a. gastroduodenalis which may be multiple. Further it continues as the a. hepatica propria, which lies between the two layers of the hepatoduodenal ligament in front of the portal vein and to the left of the ductus choledochus, and reaches the porta hepatis where it divides into right and left branches (ramus dexter and ramus sinister).

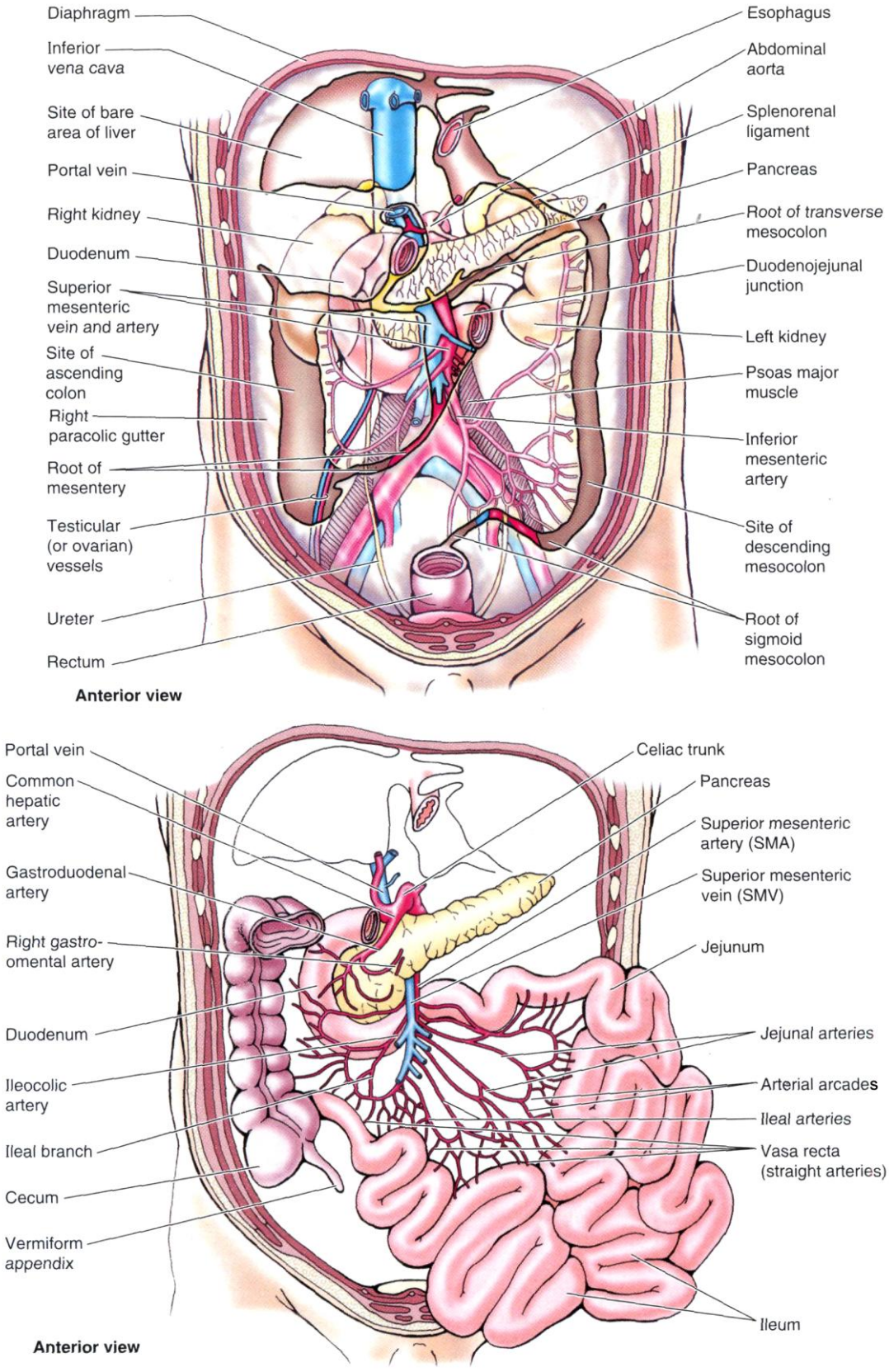
The right branch gives rise to an artery to the gall bladder, a.cystica, at the junction of the common hepatic duct and the cystic duct.



The common or proper hepatic artery gives off a branch to the lesser curvature of the stomach, a. gastrica dextra, which stretches from right to left to meet a. gastrica sinistra. The gastroduodenal artery mentioned above passes behind the duodenum and divides into two branches: the a. gastro-epiploica dextra, which passes from right to left on the greater curvature of the stomach and gives off branches to the stomach and omentum, in whose anterior wall it stretches; and the a. pancreaticoduodenalis superior, which branches out in the head of the pancreas and in the descending part of the duodenum.

(c) The splenic artery (a. lienalis s. splenica) is the largest of the three terminal branches of the coeliac trunk. It passes on the superior border of the pancreas to the spleen. At the spleen it divides into five to eight terminal branches, which enter the hilus lienis. On the way, it gives off the rami pan-creatici. Near the site of its division into terminal branches, the splenic artery gives rise to the a. gastro-epiploica sinistra, which passes from left to right on the greater curvature of the stomach and anastomoses with the a. gastro-epiploica dextra to form an arterial (inconstant) arch like the arch on the lesser curvature.

Numerous small branches arise from the arch and run to the stomach. In addition, many aa. gastricae breves arise from the splenic artery after it gives off the left gastro-epiploic artery; these short arteries can fully compensate for an impaired flow of blood in the four main arteries of the stomach. Around the stomach the four main arteries form an arterial ring, or corona, which consists of two arches situated on the lesser curvature, called the left and right gastric arteries, and on the greater curvature, called the left and right gastro-epiploic arteries. These main arteries are thus also referred to as the coronary arteries of the stomach.



2. The superior mesenteric artery (a. mesenterica superior) arises from the anterior surface of the aorta directly below the coeliac artery, passes forward and downward into the slit between the inferior border of the pancreas in front and the horizontal part of the duodenum behind, enters the mesentery of the small intestine, and descends to the right iliac fossa.

The branches of the superior mesenteric artery are as follows:

(a) the inferior pancreaticoduodenal arteries (aa. pancreaticoduodenales inferiores) pass to the right on the concave surface of the duodenum to meet the superior pancreaticoduodenal arteries;

(b) the intestinal arteries (aa. intestinales) (ten to sixteen branches) pass to the left, to the jejunum (aa. jejunales) and ileum (aa. ilei); on the way they dichotomize and the neighbouring branches anastomose, as a result of which three rows of arches form along aa. jejunales and two rows along aa. ilei. The arches are the result of functional adjustments to ensure the supply of blood to the intestine during any movement or position of its loops. The arches encircle the intestinal tube with many fine branches;

(c) the ileocolic artery (a. ileocolica) branches off the superior mesenteric artery to the right, supplies branches to the distal part of the ileum and caecum, and sends the a. appendicularis, which passes behind the terminal segment of the ileum, to the vermiform process;

(d) the right colic artery (a. colica dextra) stretches behind the peritoneum to the ascending colon and divides next to it into two branches—an ascending branch, which rises to meet a. colica media, and a descending branch, which descends to meet a. ileocolica; the resulting arches send branches to the adjoining parts of the colon;

(e) the middle colic artery (a. colica media) passes between the layers of the transverse mesocolon and on reaching the transverse colon divides into the right and left branches which diverge to their respective sides. The right branch anastomoses with a. colica dextra, the left branch with a. colica sinistra (see below).

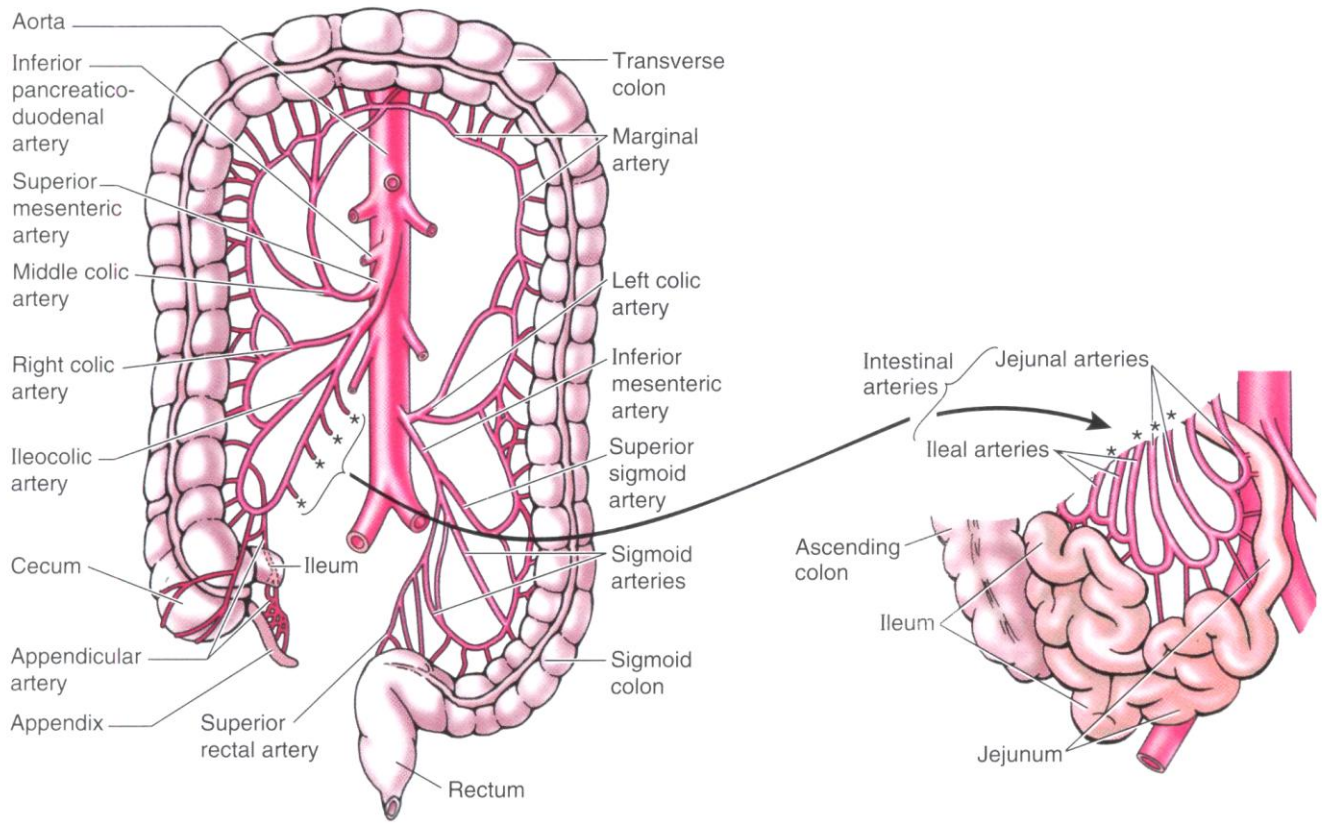
3. The inferior mesenteric artery (a.mesenterica inferior) branches off on the level of the inferior edge of the third lumbar vertebra (one vertebra above the aortic bifurcation) and passes downward and slightly to the left, lying behind the peritoneum on the anterior surface of the left psoas major muscle.The branches of the inferior mesenteric artery are as follows:
(a) the superior left colic artery (a.colica sinistra) divides into two branches, an ascending branch passing to the left flexure of the colon to meet the middle colic artery (from the superior mesenteric artery) and a descending branch anastomosing with aa.sigmoideae;

(b) the inferior left colic arteries (aa. sigmoideae) (usually two), pass to the sigmoid colon; their ascending branches anastomose with branches of a.colica sinistra, the descending branches with a. rectalis superior;

(c) the superior rectal artery (a. rectalis superior) is a continuation of the inferior mesenteric artery; it descends in the root of the mesentery of the sigmoid colon into the true pelvis, crossing the left common iliac artery in front, and divides into lateral branches, which lead to the rectum and anastomose with the sigmoid arteries and with the middle rectal artery (from the internal iliac artery).

As the result of communications between the branches of aa. colicae dextra, media, and sinistra and aa. rectales, the large intestine is attended by a chain of interconnected anastomoses for its entire length.

Table **Arterial Supply to the Intestines**



Artery	Origin	Course	Distribution
Superior mesenteric	Abdominal aorta	Runs in root of mesentery to ileocecal junction	Part of gastrointestinal tract derived from midgut
Intestinal (jejunal and ileal) (n = 15–18)	Superior mesenteric artery	Passes between two layers of mesentery	Jejunum and ileum
Middle colic	Superior mesenteric artery	Ascends retroperitoneally and passes between layers of transverse mesocolon	Transverse colon
Right colic	Superior mesenteric artery	Passes retroperitoneally to reach ascending colon	Ascending colon
Ileocolic	Terminal branch of superior mesenteric artery	Runs along root of mesentery and divides into ileal and colic branches	Ileum, cecum, and ascending colon
Appendicular	Ileocolic artery	Passes between layers of mesoappendix	Appendix
Inferior mesenteric	Abdominal aorta	Descends retroperitoneally to left of abdominal aorta	Supplies part of gastrointestinal tract derived from hindgut
Left colic	Inferior mesenteric artery	Passes retroperitoneally toward left to descending colon	Descending colon
Sigmoid (n = 3–4)	Inferior mesenteric artery	Passes retroperitoneally toward left to descending colon	Descending and sigmoid colon
Superior rectal	Terminal branch of inferior mesenteric artery	Descends retroperitoneally to rectum	Proximal part of rectum
Middle rectal	Internal iliac artery	Passes retroperitoneally to rectum	Midpart of rectum
Inferior rectal	Internal pudendal artery	Crosses ischioanal fossa to reach rectum	Distal part of rectum and anal canal

THE PAIRED VISCERAL BRANCHES

The paired visceral branches arise in the order of the location of organs, which is the result of their embryonic determination.

1. The middle suprarenal artery (a. suprarenalis media) arises from the aorta next to the origin of the superior mesenteric artery and passes to the suprarenal gland.
2. The renal artery (a. renalis) branches off the aorta almost at a right angle at the level of the second lumbar vertebra and passes transversely to the hilum of the corresponding kidney.

The calibre of the renal artery is almost equal to that of the superior mesenteric artery, which is explained by the uropoietic function of the kidney for which a rich flow of blood is needed. In some cases, the renal artery arises from the aorta in two or three trunks and quite often enters the kidney with many trunks, not only in theregion of the hilum but also along the whole medial border. This is important to bear in mind in preliminary ligation of the arteries during surgical removal of the kidney. In the hilum of the kidney, the renal artery usually divides into three branches, which, in turn, divide in the renal sinus into numerous small branches .

The right renal artery is behind the inferior vena cava, the head of the pancreas, and the descending part of the duodenum. The left artery passes behind the pancreas. The renal vein lies in front of and somewhat lower than the artery. The renal artery gives rise to the a. suprarenalis inferior, ascending to the inferior part of the suprarenal gland, and also gives off a small branch to the ureter.

3. The testicular artery (a. testicularis) is a long, slender vessel rising from the aorta directly below the origin of the renal artery or, sometimes, from the renal artery itself. The origin of the artery that supplies the testis is located so high because the testis develops in the embryo in the lumbar region where, at the shortest distance from the aorta, the testicular artery appears. When the testis later descends into the scrotum, the testicular artery is simultaneously elongated. By the time of birth, this artery descends on the anterior surface of the psoas major muscle, sends a branch to the ureter, approaches the deep inguinal ring, and, together with the ductus deferens, reaches the testis, hence the name testicular artery. The ovarian artery (a.ovarica), the corresponding artery in females, does not enter the inguinal canal but passes into the true pelvis and then to the ovary as acomponent of the suspensory ligament.

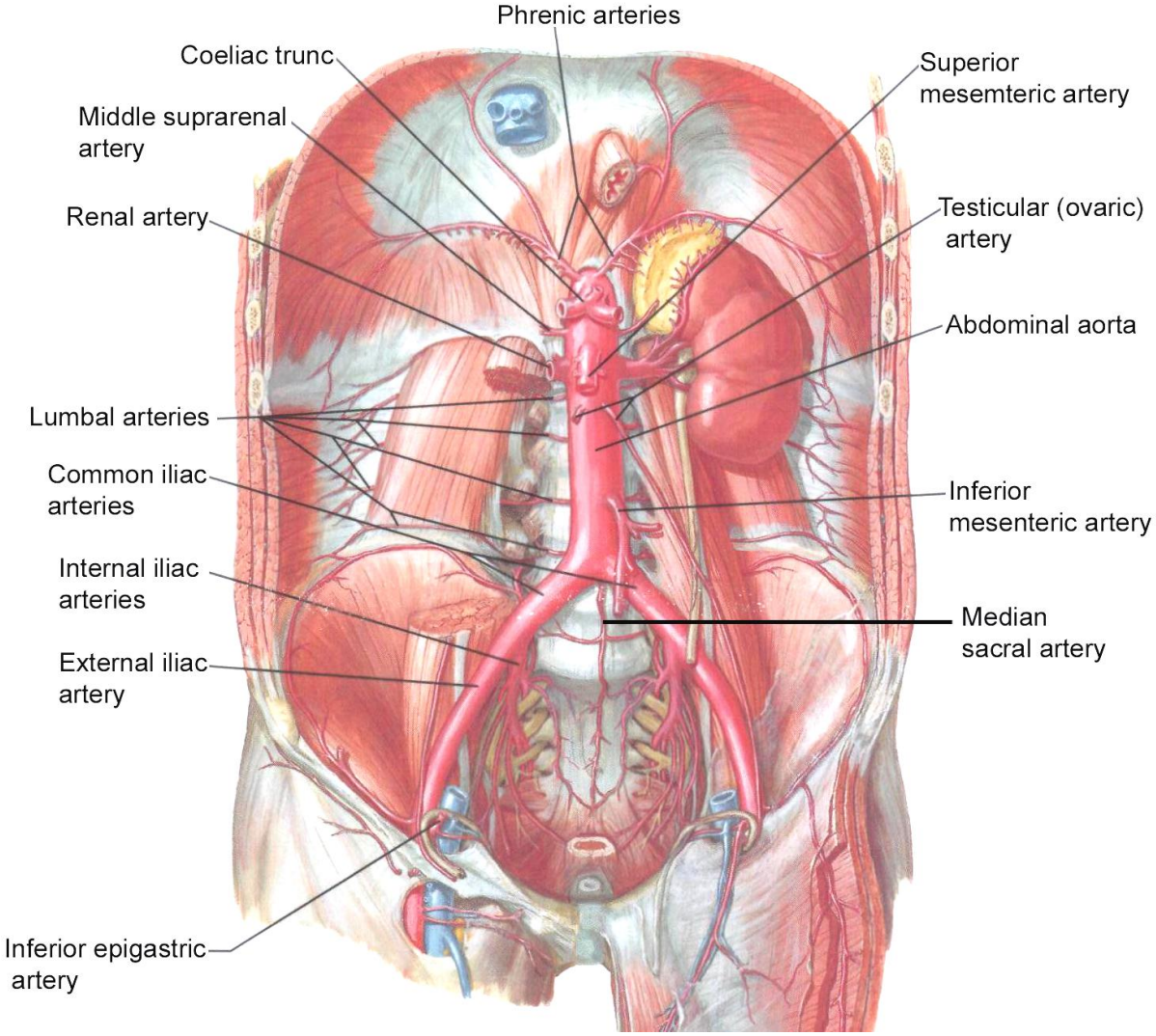
THE PARIETAL BRANCHES OF THE ABDOMINAL AORTA

1. The inferior phrenic artery (a. phrenica inferior) supplies blood to the lumbar part of the diaphragm. It gives rise to a small branch, a. suprarenalis superior, to the adrenal gland.

2. The lumbar arteries (aa. lumbales), usually four on each side (a fifth artery sometimes arises from a. sacralis mediana), correspond to the segmental intercostal arteries of the thoracic region. They supply blood to the corresponding vertebrae, the spinal cord, and the muscles and skin of the small of the back and abdomen and anastomose with each other, with the inferior intercostal and the superior and inferior epigastric arteries.

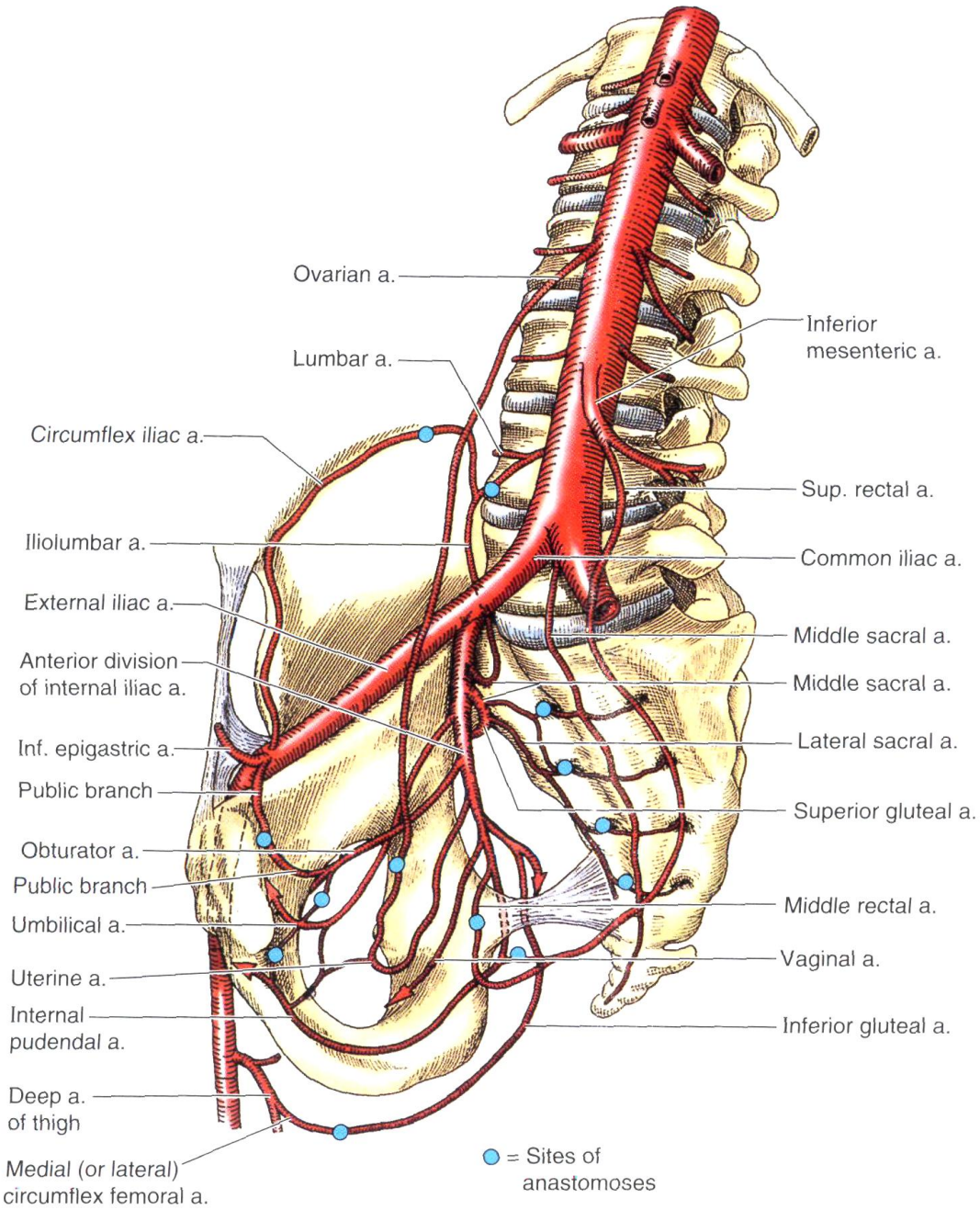
3. The median sacral artery (a. sacralis mediana), which is an unpaired vessel, is a continuation of the aorta that fails to develop (caudal aorta). It descends on the anterior midline of the two lower lumbar vertebrae, sacrum and coccyx, and terminates here as small branches in the coccygeal body (glomus coccygeum).

4. The common iliac artery (a. iliaca communis). The right and left arteries are two end branches into which the aorta divides at the level of the fourth lumbar vertebra. The division occurs slightly to the left of the midline, as a result of which the right common iliac artery is 6-7 mm longer than the left artery. From the site of the bifurcation (bifurcatio aortae), the common iliac arteries diverge at an acute angle (approximately 60 degrees in males and 68-70 degrees in females due to the wider female pelvis) and pass downward and laterally to the sacroiliac joint. Here each artery divides into two end branches: the internal iliac artery (a. iliaca interna), supplying the walls and organs of the pelvis with blood, and the external iliac artery (a. iliaca ezterna), serving mainly the lower limb. The common iliac arteries originate as the initial segments of the umbilical arteries of the embryo. The distally located segments of the embryonal umbilical arteries are obliterated in the adult and transform into ligamenta umbilicalia mediales.



THE INTERNAL ILIAC ARTERY

The internal iliac artery (a. iliaca interna), arising from the distal end of the common iliac artery at the level of the sacroiliac joint, descends into the true pelvis and extends to the superior edge of the greater sciatic foramen (see Fig. 44). Its division into parietal and visceral branches is marked by wide individual variation, but it usually divides at the level of the superior edge of the greater sciatic foramen into two main branches: the posterior trunk, which gives rise to aa. iliolumbalis, sacralis lateralis, and glutea superior, and the anterior trunk, from which the remaining branches of the internal iliac artery rise.



The internal iliac artery is covered along its length by the peritoneum, and in front of it extends the ureter.

This must be borne in mind during surgery to avoid ligation of the ureter instead of the artery; the internal iliac vein passes behind the artery.

The parietal branches of the internal iliac artery:

1. The iliolumbar artery (a. iliolumbalis) runs behind m. psoas major into the iliac fossa where it forms an anastomosis with the deep circumflex iliac artery rising from the external iliac artery.

2. The lateral sacral artery (a. sacralis lateralis) (sometimes there are two arteries on each side) supplies blood to the levator and the piriform muscles and the nerve trunks of the sacral plexus and gives off branches, the rami spinales, to the foramina sacralia pelvina; it anastomoses with the median sacral artery.

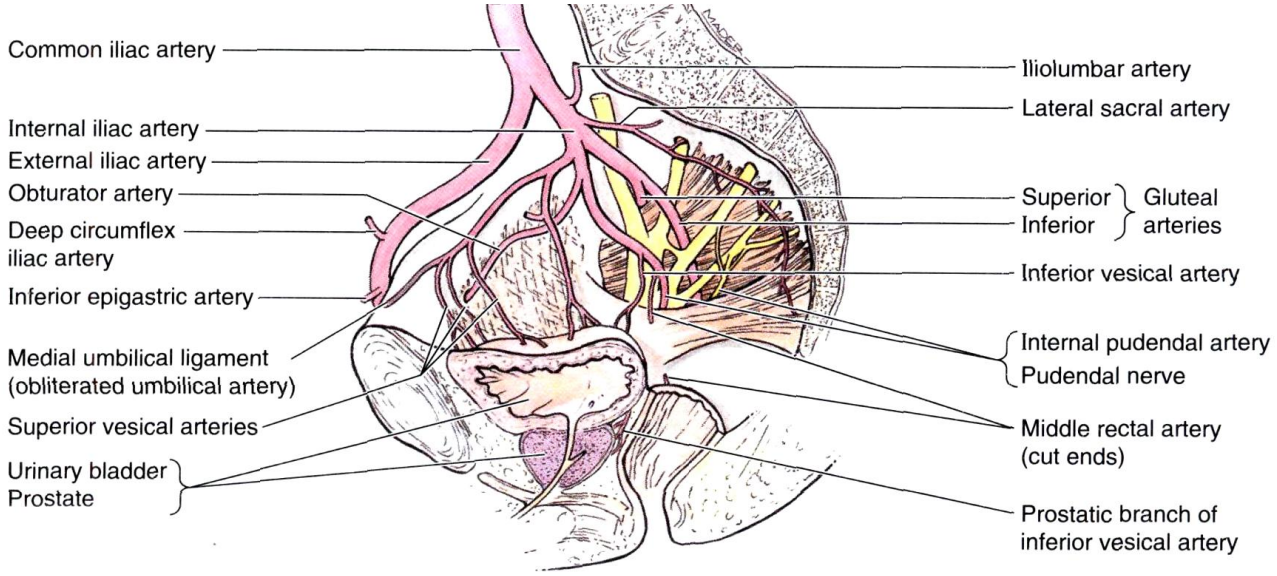
3. The superior gluteal artery (a. glutea superior) is a continuation of the posterior division of the internal iliac artery. It leaves the pelvis through the foramen suprapiriforme and reaches the gluteal muscle along with the superior gluteal nerve.

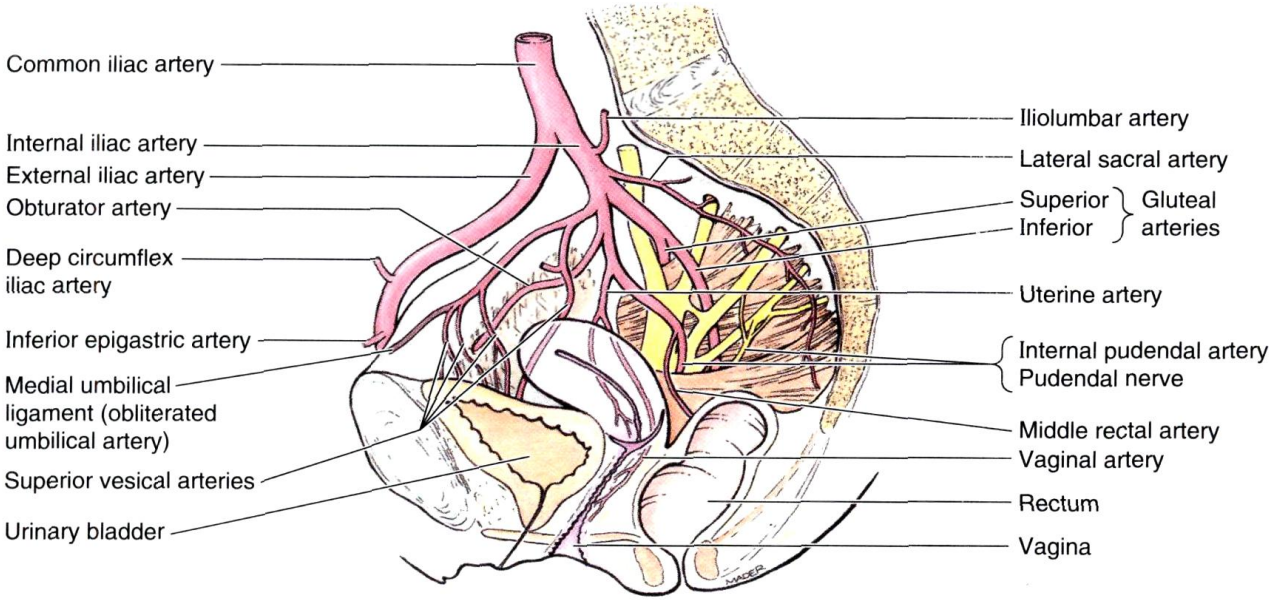
4. The obturator artery (a. obturatoria) passes to the obturator foramen. Before entering the obturator canal it gives off the ramus pubicus, which extends on the posterior surface of the pubic bone and anastomoses with the ramus pubicus of the inferior epigastric artery. On leaving the obturator canal it supplies the external obturator muscle and the adductors and gives rise to the ramus acetabularis.

The latter penetrates the hip joint through the acetabular notch and supplies the head of the femur and its ligaments with blood.

5. The inferior gluteal artery (a. glutea inferior) passes through the foramen infrapiriforme with the internal pudendal artery and the sciatic nerve and gives off a long, slender branch, the companion artery of the sciatic nerve (a. comitans n. ischiadici), to the latter.

On leaving the pelvic cavity the inferior gluteal artery gives rise both to muscular branches (which lead to the gluteal and other proximate muscles) and anastomosing branches (which join with the obturator, superior gluteal, and medial circumflex femoral arteries).


Common iliac artery
Internal iliac artery
External iliac artery
Obturator artery
Deep circumflex iliac artery
Inferior epigastric artery
Medial umbilical ligament (obliterated umbilical artery)
Superior vesical arteries
Urinary bladder
Prostate
Iliolumbar artery
Lateral sacral artery
Superior
Inferior
Gluteal arteries
Inferior vesical artery
Internal pudendal artery
Pudendal nerve
Middle rectal artery (cut ends)
Prostatic branch of inferior vesical artery


Common iliac artery
Internal iliac artery
External iliac artery
Obturator artery
Deep circumflex iliac artery
Inferior epigastric artery
Medial umbilical ligament (obliterated umbilical artery)
Superior vesical arteries
Urinary bladder
Iliolumbar artery
Lateral sacral artery
Superior
Inferior
Gluteal arteries
Uterine artery
Internal pudendal artery
Pudendal nerve
Middle rectal artery
Vaginal artery
Rectum
Vagina

The visceral branches of the internal iliac artery:

1. The umbilical artery (a. umbilicalis) retains its lumen in the adult only for a small distance, from its origin to the site where it gives off the superior vesical artery; the remaining segment of its trunk to the umbilicus obliterates and transforms into the medial umbilical ligament.

2. The ureteric branches (rami ureterici) go to the ureter (these may arise from the umbilical artery).

3. The superior and inferior vesical arteries (aa. vesicales superior and inferior); the superior vesical artery arises from the unobliterated part of a. umbilicalis and branches out in the upper part of the urinary bladder; the inferior vesical artery originates from a. iliacae internae and supplies the ureter and the fundus of the urinary bladder with blood, anastomosing with the superior vesical arteries. It also gives off branches to the vagina (in females) and to the prostate and seminal vesicles (in males).

4. The artery of vas deferens (a. ductus deferentis); the ductus deferentis artery in males runs to the ductus deferens and, accompanied by it, reaches the testis, to which it also gives off branches.

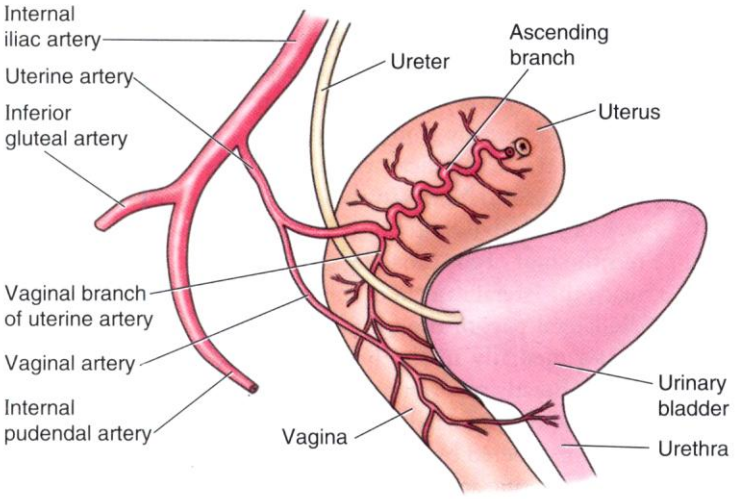
5. The uterine artery (a. uterina) (in females) originates either from the trunk of a. iliacae internae or from the beginning segment of a. umbilicalis, passes medially, and, reaching the lateral side of the uterine neck between the two layers of lig. latum uteri, sends a branch, a. vaginalis, downward (it may branch off directly from a. iliaca interna) to the walls of the vagina. The uterine artery itself turns upward along the line of attachment of a wide ligament to the uterus. It gives off small branches to the uterine tube, ramus tubarius, and to the ovary, ramus ovaricus; a. uterina is twisted in women who have given birth.

6. The middle rectal artery (a. rectalis media) originates either from a. iliaca interna or from a. vesicalis inferior branching throughout the walls of the rectum and anastomosing with aa. rectales superior and inferior. This artery also sends branches to the ureter, urinary bladder, prostate, seminal vesicles, and, in females, to the vagina.

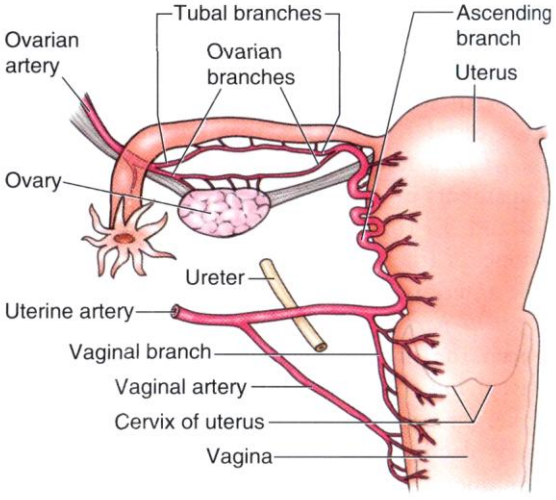
The internal pudendal artery (a. pudenda interna), which in the pelvis gives off only small branches to the nearest muscles and roots of the plexus sacralis, is mainly concerned with supplying blood to the organs situated lower than the diaphragma pelvis and to the region of the perineum.

It passes out of the pelvis through the foramen infrapiriforme and then, bending around the posterior side of spina ischiadica, again enters the pelvis through the small ischiatic foramen into the fossa ischioectalis. Here it divides into branches supplying the lower segment of the rectum in the region of a. rectalis inferior, the urethra, the muscles of the perineum and the vagina (in females), Cowper's glands (in males), and the external genitalia (a. dor-salis penis s. clitoridis, a. profunda penis s. clitoridis).

Uterine arteries:



Lateral view



Anterior view

Rectel arteries:

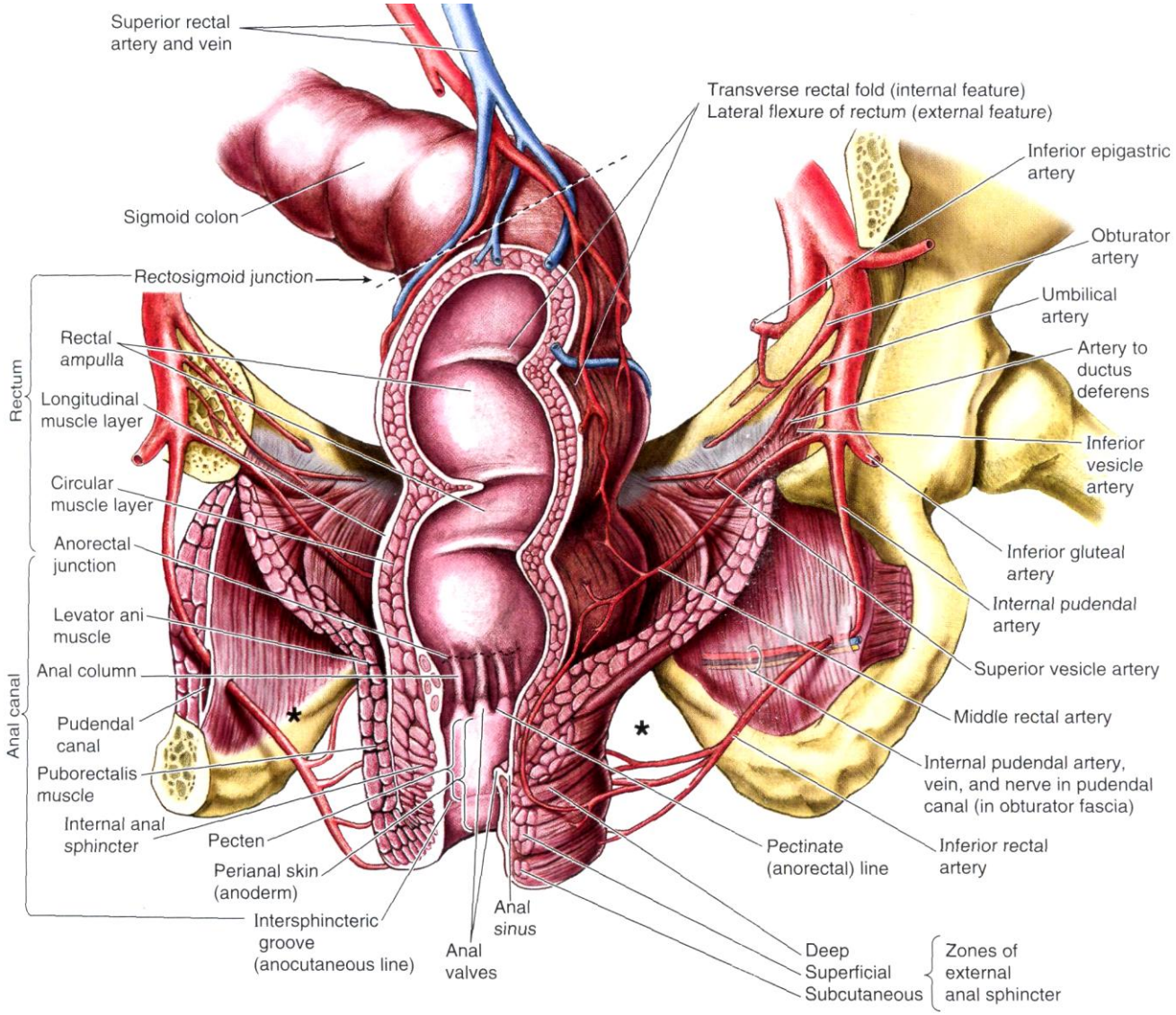


Table **Arteries of the Pelvis** *(Continued)*

Artery	Origin	Course	Distribution	Anatomoses
Anterior divisioin of internal iliac	Internal iliac artery	Passes anteriorly along lateral wall of pelvis, dividing into visceral, obturator, and internal pudendal arteries	Pelvic viscera, muscles of superior medial thigh, and perineum	
Umbilical	Anterior division of internal iliac artery (Patent proximal umbilical artery)	Runs a short pelvic course, gives off superior vesical arteries, then obliterates, becoming medial umbilical ligament	Superior aspect of urinary bladder and, in some males, ductus deferens (via superior vesical arteries and artery to ductus deferens)	(Occasionally the patent part of the umbilical artery)
Superior vesical		Usually multiple; pass to superior aspect of urinary bladder	Superior aspect of urinary bladder; in some males, ductus deferens (via artery to ductus deferens)	Inferior vesical (♂); vaginal artery (♀)
Obturator		Runs anteroinferiorly on obturator fascia of lateral pelvic wall, exiting pelvis via obturator canal	Pelvic muscles, nutrient artery to ilium, head of femur, and muscles of medial compartment of the thigh	Inferior epigastric (via pubic branch); umbilical artery
Inferior vesical (♂)	(Superior or inferior vesical artery) (Inferior vesical artery)	Passes subperitoneally in lateral ligament of bladder, giving rise to prostatic artery (♂) and occasionally the artery to the ductus deferens	Inferior aspect of male urinary bladder, prostate, and seminal glands; occasionally ductus deferens	Superior vesical artery
Artery to ductus deferens (♂)		Runs subperitoneally to ductus deferens	Ductus deferens	Testicular artery; cremasteric artery
Prostatic branches (♂)		Descends on posterolateral aspects of prostate	Prostate and prostatic urethra	Deep perineal (internal pudendal)
Uterine (♀)		Runs anteromedially in base of broad ligament/superior cardinal ligament, gives rise to vaginal branch, then crosses ureter superiorly to reach lateral aspect of uterine cervix	Uterus, ligaments of uterus, medial parts of uterine tube and ovary, and superior vagina	Ovarian artery (via tubal and ovarian branches); vaginal artery
Vaginal (♀)		Divides into vaginal and inferior vesical branches, the former descending on the vagina, the latter passing to the urinary bladder	Vaginal branch: lower vagina, vestibular bulb, and adjacent rectum; inferior vesical branch: fundus of urinary bladder	Vaginal branch of uterine artery, superior vesical artery
Internal pudendal		Exits pelvis via infrapiriform part of greater sciatic foramen, enters perineum (ischioanal fossa) via lesser sciatic foramen, passes via pudendal canal to UG triangle	Main artery of perineum, including muscles and skin of anal and urogenital triangles, erectible bodies	(Umbilical artery; prostatic branches of inferior vesical artery in males)
Middle rectal		Descends in pelvis to inferior part of rectum	Seminal glands and inferior part of rectum	Superior and inferior rectal arteries
Inferior gluteal		Exits pelvis via infrapiriform part of greater sciatic foramen	Pelvic diaphragm (coccygeus and levator ani) piriformis, quadratus femoris, superiormost hamstrings, gluteus maximus, and sciatic nerve	Deep femoral artery (via medial and lateral femoral circumflex arteries)
Posterior *division of* internal iliac	Internal iliac *artery*	Passes posteriorly and gives rise to *parietal branches*	Pelvic wall and gluteal region	
Illiolumbar	Posterior division of internal iliac artery	Ascends anterior to sacroiliac joint and posterior to common iliac vessels and psoas major, dividing into iliac and lumbar branches	Psoas major, iliacus, and quadratus lumborum muscles; cauda equina in vertebral canal	Circumflex iliac artery and 4th (and lowest) lumbar artery
Lateral sacral (superior and inferior)		Runs on anteromedial aspect of piriformis to send branches into pelvic sacral foramina	Piriformis, structures in sacral canal, erector spinae, and overlying skin	Medial sacral arteries (from median sacral artery)
Superior gluteal		Exits pelvis via suprapiriform portion of greater sciatic foramen	Piriformis, all three gluteal muscles, and tensor of fascia lata	Lateral sacral, inferior gluteal, internal pudendal, deep circumflex femoral, lateral circumflex femoral

THE EXTERNAL ILIAC ARTERY

The external iliac artery (a. iliaca externa), beginning at the level of the sacroiliac joint, stretches down and forward along the medial edge of m. psoas to the inguinal ligament (see Fig. 44); when it passes from under this ligament onto the femur, it is called the femoral artery. Besides small branches to m. psoas, a. iliaca externa gives rise to two large branches, which originate very near the inguinal ligament.

(1) The inferior epigastric artery (a. epigastrica inferior) passes medially and then upward, between the fascia transversalis in front and the peritoneum parietale in back (the plica umbilicalis lateralis is located in its fold), and enters the sheath of the rectus abdominis muscle. It then leads upward along the posterior surface of the muscle where its branches anastomose with a. epigastrica superior (from a. thoracica interna).

In its beginning segment it bends around the medial edge of the deep orifice of the inguinal canal, at which point it gives off two branches:
(a) the ramus pubicus to the symphysis pubica, which anastomoses with a. obturatoria; and (b) a. cremasterica, which leads to m. cremaster and the testis;

(2) The deep circumflex iliac artery (a. circumflexa ilium profunda), bending around the iliac bone, passes parallel to the inguinal ligament toward the iliac crest posteriorly, supplying m. transversus and the iliac muscle with blood.

Arteries of the Lower Extremity

The large arteries of the lower extremities, just like the arteries of the upper extremities, were formed gradually; the appearance of a. femoralis on the femur, for instance, was preceded by a. ischiadica, which accompanied the nerve of the same designation and later disappeared. The appearance of a.tibialis ant. and a.tibialis post, on the crus was preceded by a. peronea. The latter eventually played the role of a collateral vessel of the crus.

The Femoral Artery

The femoral artery (a. femoralis) is a continuation of the trunk of the external iliac artery, so called because it passes under the inguinal ligament through the lacuna vasorum near the middle of this ligament . To stop bleeding at the femoral artery, the artery is compressed at the site where it exits onto the femur to the os pubis. Medially from the femoral artery is the femoral vein, with which the artery passes to the femoral triangle, proceeding first into the sulcus iliopectineus and then into the sulcus femoralis anterior and penetrating further through the canalis adductorius into the popliteal fossa where it continues in a. poplitea. The branches of a. femoralis:

1. The superficial epigastric artery (a.epigastrica superficialis) arises near the very beginning of the femoral artery and passes in front of the inguinal ligament under the skin into the region of the navel.

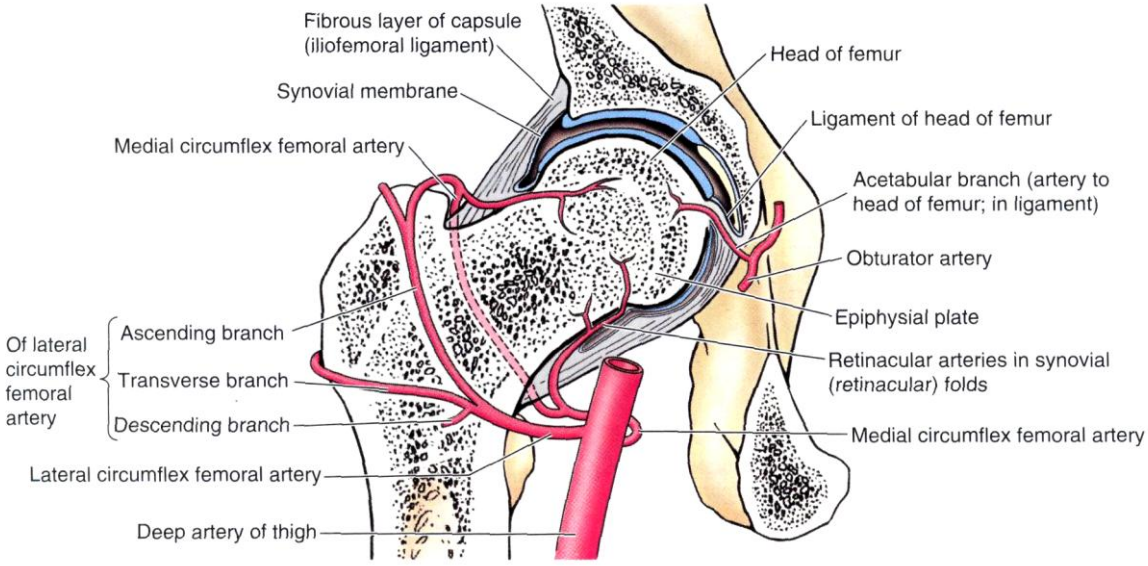
2. The superficial circumflex iliac artery (a. circumflexa ilium superficialis) encircles the iliac bone and proceeds along the inguinal ligament to the skin in the region of spina iliaca anterior superior.

3. The external pudendal arteries (aa. pudendae externae), usually two in number, branch out in the region of the hiatus saphenus and lead medially to the external genitals, to the scrotum or labia majora.

4. The profunda femoris artery (a. profunda femoris) is the main vessel through which vascularization of the femur is accomplished. It is a thick trunk, which originates from the posterior side of a. femoralis 4 to 5 cm below the inguinal ligament, lying first behind the femoral artery, then appearing from the lateral side, and, giving off numerous branches, rapidly diminishing in calibre.

The branches of a. profunda femoris:

(a) a. circumflexa femoris medialis, heading medially and upward, divides into the transverse branch, the ramus transversus, which leads to m. pectineus and the adductor muscles of the femur, and a larger, deep ramus profundus, which passes between m. iliopsoas and m. pectineus onto the posterior surface of the femur where it branches out on the posterior surface of the adductor muscles, givingoff a small, preliminary branch to the hip joint, and anastomoses with a. glutea inferior and a. obturatoria;



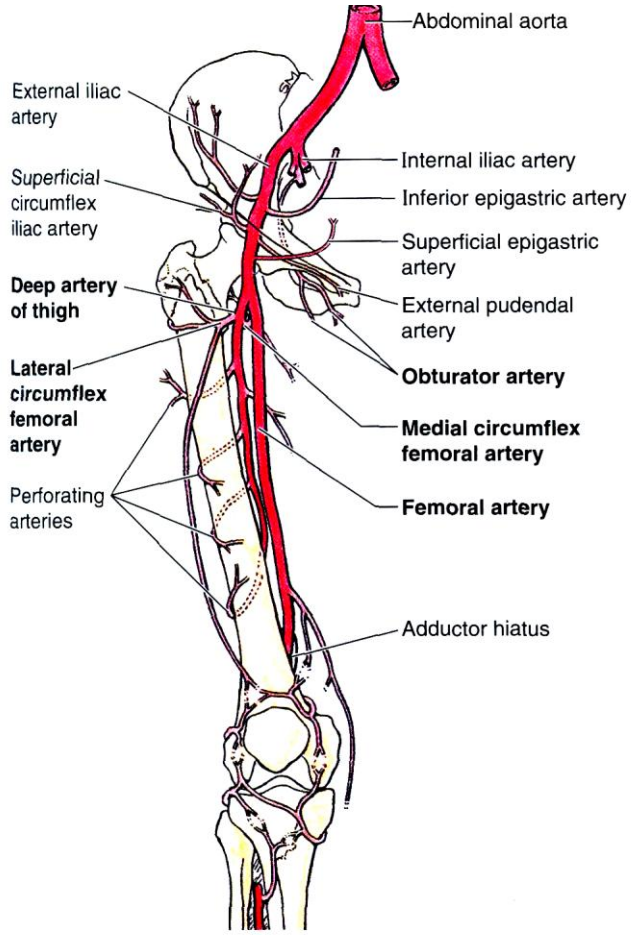
Anterior view of coronally sectioned hip joint

(b) a. circumflexa femoris lateralis branches off somewhat lower than the previous one; it passes laterally under m. rectus where it divides into the ramus ascendens (passing upward and laterally to the greater tro-chanter, anastomosing with the branches a. circumflexae femoris medialis and a. gluteae inferioris) and the ramus descendens (branching into m. quadriceps);

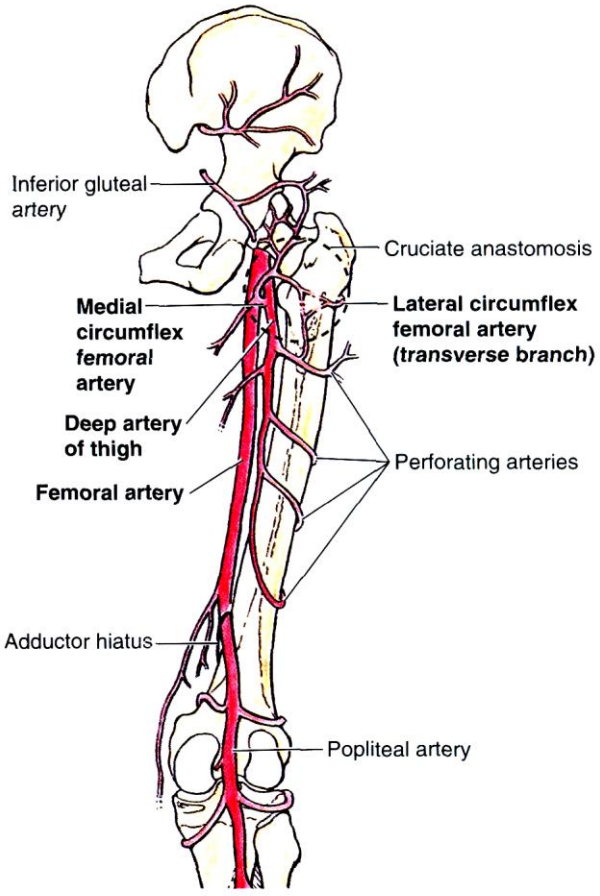
(c) aa.perforantes (three) branch off the posterior surface of the deep femoral artery and, perforating the adductor muscles, move to the posterior surface of the femur; the first perforating artery, the largest of the three, supplies the superior artery to the femur (a. diaphyseos femoris superior), while the third supplies the inferior artery (a. diaphyseos femoxis inferior); aa.perforantes are significant in ligation of the femoral artery below the effluent branches of the deep femoral artery.

5. The muscular branches (rami musculares) of the femoral artery leadto the muscles of the femur.

6. The descending genicular artery (a. genu descendens) branches off a.femoralis on its way into the canalis adductorius and, exiting through the anterior wall of this canal with n. saphenus, supplies m. vastus medialis with blood and participates in the formation of the arterial network of the knee joint.



Anterior view

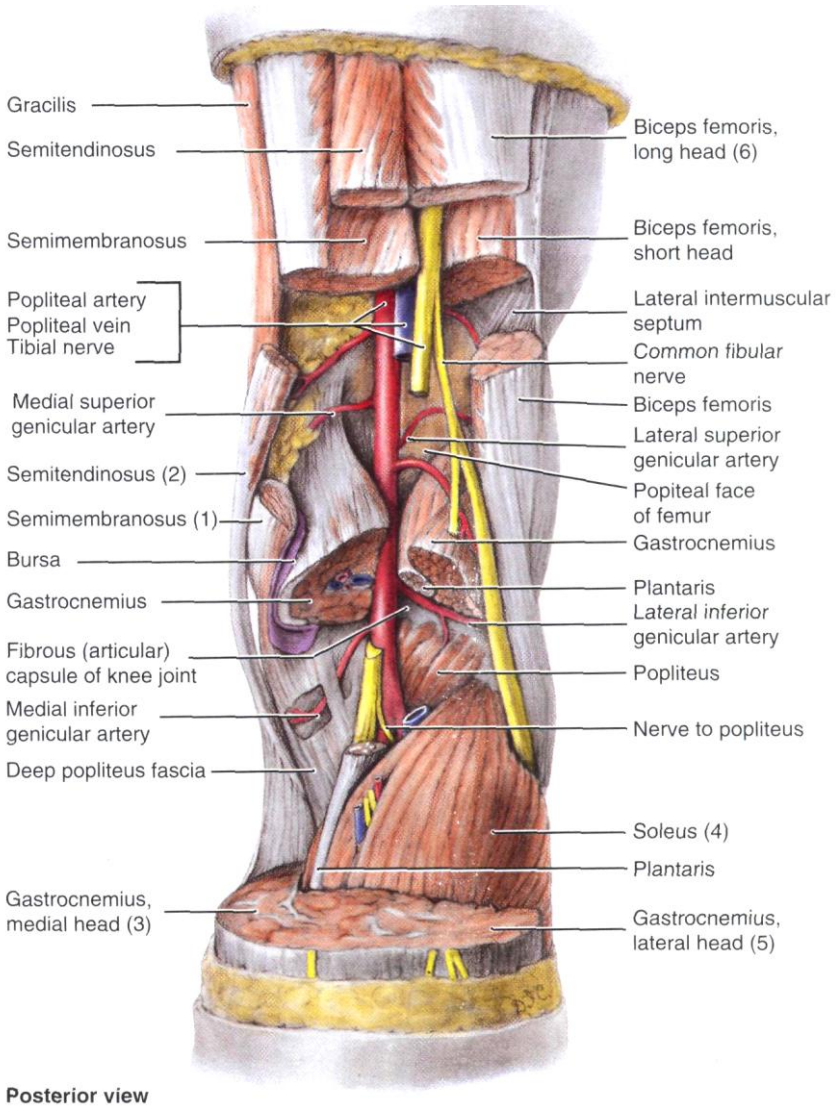


Posterior view

Artery	Origin	Course	Distribution
Femoral	Continuation of external iliac artery distal to inguinal ligament	Descends through femoral triangle bisecting it; then courses through adductor canal; terminates as it traverses adductor hiatus, where its name becomes popliteal artery	Branches supply anterior and anteromedial aspects of thigh
Deep artery of thigh	Femoral artery 1–5 cm inferior to inguinal ligament	Passes deeply between pectineus and adductor longus; descending posterior to latter on medial side of femur	Three to four perforating branches pass through adductor magnus muscle, winding around femur to supply muscles in medial, posterior, and lateral part of anterior compartments
Medial circumflex femoral	Deep artery of thigh; may arise from femoral artery	Passes medially and posteriorly between pectineus and iliopsoas; enters gluteal region and gives rise to posterior retinacular arteries; then terminates by dividing into transverse and ascending branches	Supplies most of blood to head and neck of femur; transverse branch takes part in cruciate anastomosis of thigh; ascending branch joins inferior gluteal artery
Lateral circumflex femoral	Deep artery of thigh; may arise from femoral artery	Passes laterally deep to sartorius and rectus femoris, dividing into ascending, transverse, and descending arteries	Ascending branch supplies anterior part of gluteal region; transverse branch winds around femur; descendingbranch joins genicular periarticular anastomosis
Obturator	Internal iliac artery or (in ~ 20%) as an accessory or replaced obturator artery from the inferior epigastric artery	Passes through obturator foramen; enters medial compartment of thigh and divides into anterior and posterior branches, which pass on respective sides of adductor brevis	Anterior branch supplies obturator externus, pectineus, adductors of thigh, and gracilis; posterior branch supplies muscles attached to ischial tuberosity

The Popliteal Artery

The popliteal artery (a. poplitea) is the direct continuation of the femoral artery . In the popliteal fossa the popliteal artery is situated on the very bone itself (where it can be pressed against the bone when the extremity is half bent) and the posterior surface of the articular bursa to the front and somewhat medially from v. poplitea; still further to the back is the nerve (n. tibialis); further down, the artery lies on the posterior surface of m. poplitei covered by the heads of m. gastrocnemii and then, approaching under the edge of m. solei, separates into two terminal branches (aa. tibiales anterior and posterior).



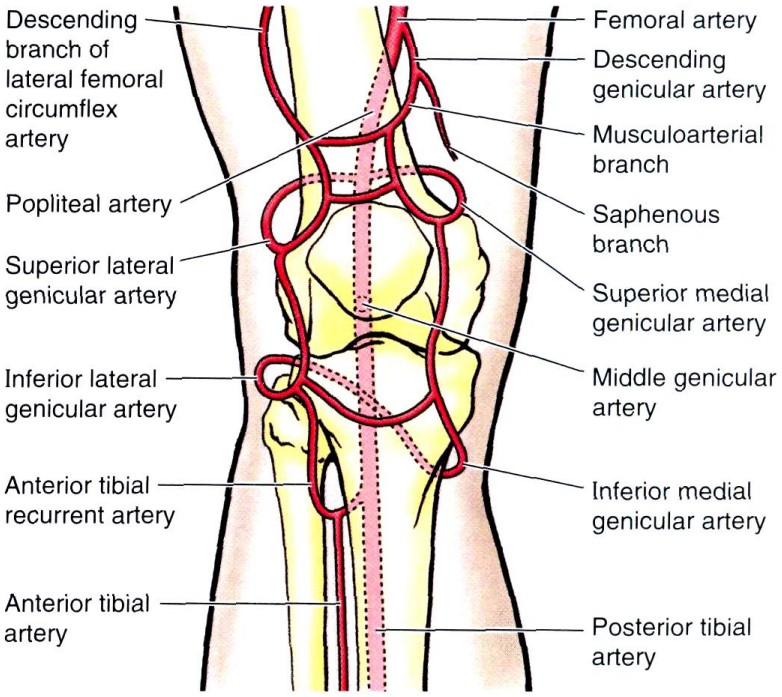
Posterior view

The branches of a. popliteae:

1.. The superior lateral and medial genicular arteries (aa. genu super-iores lateralis and medialis) branch off at the level of the top edge of the con-dyles of the femur, each curving round the knee joint from its own side. They move on to the anterior surface of the joint where they form an anastomosis and take part in forming the arterial network of the knee joint (rete articulare genu).

2. The inferior lateral and medial genicular arteries (aa. genu inferiores lateralis and medialis) branch out in the region of the knee joint as do the superior arteries. The inferior arteries, however, branch away from a.poplitea at the level of the lower edge of the condyles of the femur.

3. The middle genicular artery (a. genu media) branches away in the middle between the superior and inferior arteries of the knee joint, perforates the articular bursa, and branches out in cruciate ligaments.



Anterior view

The Anterior Tibial Artery

The anterior tibial artery (a. tibialis anterior) is one of two terminal branches of the popliteal artery (the smaller one in calibre). Immediately after it arises, it perforates the deep muscles of the flexor surface of the crus and, through an opening in the interosseous septum, passes into the anterior region of the crus and then between m. tibialis anterior and m. extensor di-gitorum longus; lower it lies between m. tibialis anterior and m. extensor hallucis longus. It passes superficially over the talocrural articulation covered by skin and fascia; its continuation on the back of the foot is called a. dorsalis pedis.

The branches of a. tibialis anterior:

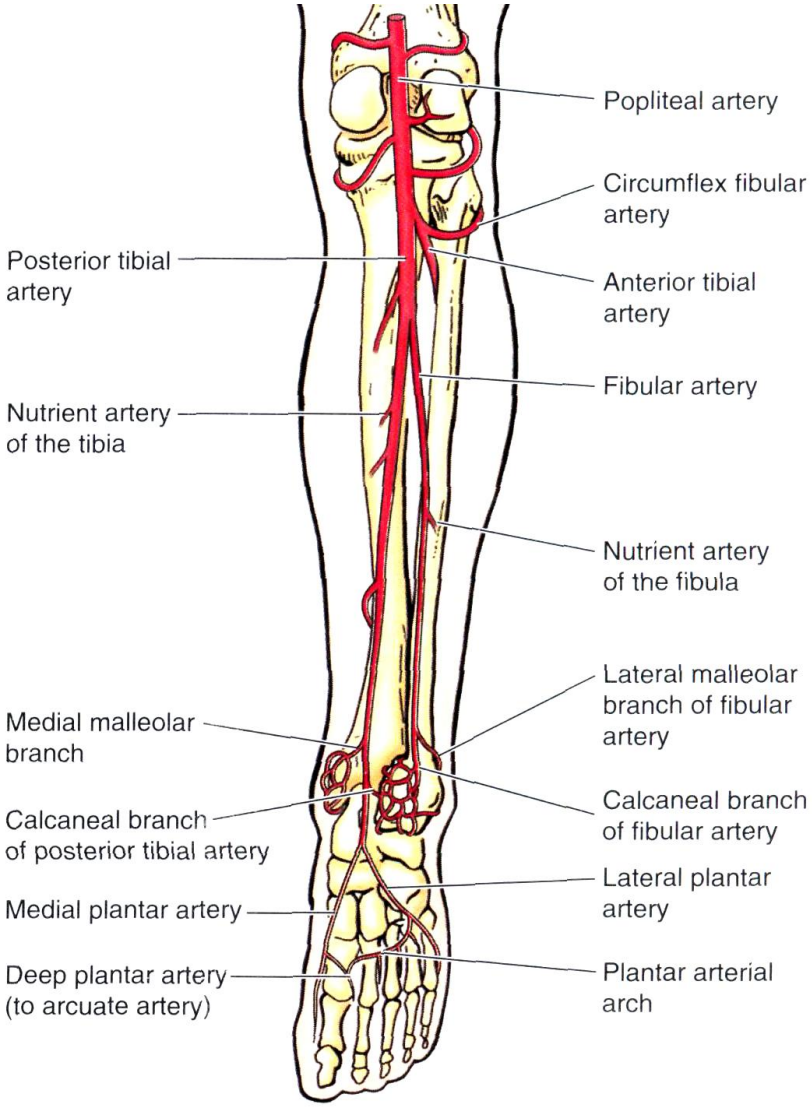
1. The posterior recurrent branch of anterior tibial artery (a. recurrent tibialis posterior) branches away while still on the posterior side of the crus, leads upward, and gives off branches to the knee joint and to the joint between the fibula and tibia.
2. The anterior recurrent branch of anterior tibial artery (a. recurrent tibialis anterior) arises from the anterior side of the crus leading up to the lateral edge of the kneecap and takes part in forming the rete articulare genu.
3. The medial and lateral anterior malleolar arteries (aa. malleolares anteriores medialis and lateralis) take part in forming the rete malleolare mediale and laterale.

The Posterior Tibial Artery

The posterior tibial artery (a. tibialis posterior) can be regarded as a continuation of the popliteal artery. Descending along the canalis cruro-popliteus, at the border of the middle one-third of the crus with the inferior it emerges from under the medial edge of m. solei and comes nearer the surface. In the lower one-third of the crus, a. tibialis posterior lies between m. flexor digitorum longus and m. flexor hallucis longus, located medially from the Achilles tendon, covered here only with skin and the fascial layer. Passing the medial malleolus posteriorly, it divides on the sole into two of its terminal branches: the lateral and medial plantar arteries (aa. plantares medialis and lateralis). The pulse of a. tibialis posterior is palpated by pressing it against the medial malleolus.

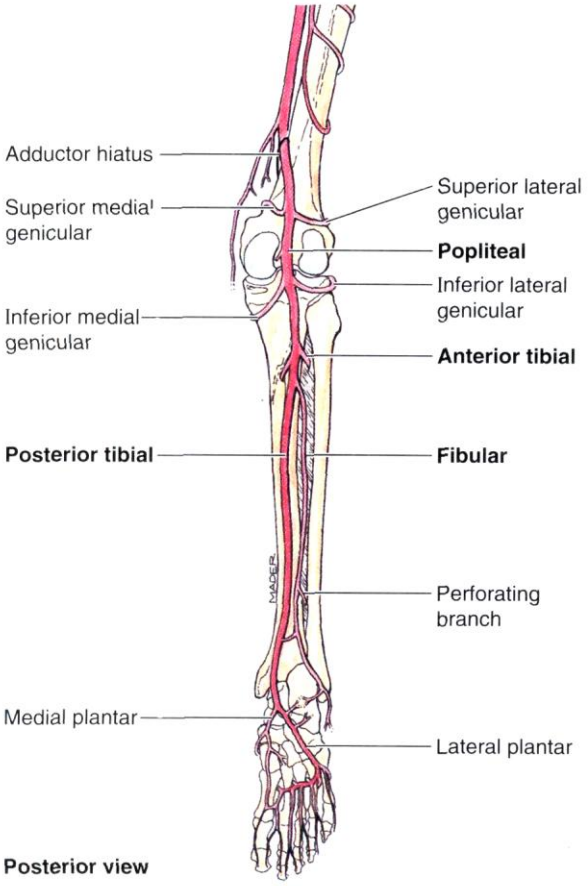
The biggest branch of the posterior tibial artery, the peroneal artery (a. peronea) (fibularis) originates from a. tibialis posterior in the upper one-third of the latter, passing downward and laterally into the canalis musculo-peroneus inferior and ending at the calcaneus.

On their way a. tibialis posterior and a. peronea give off branches to the proximate bones, muscles, joints (posterior malleolar branches), and skin.

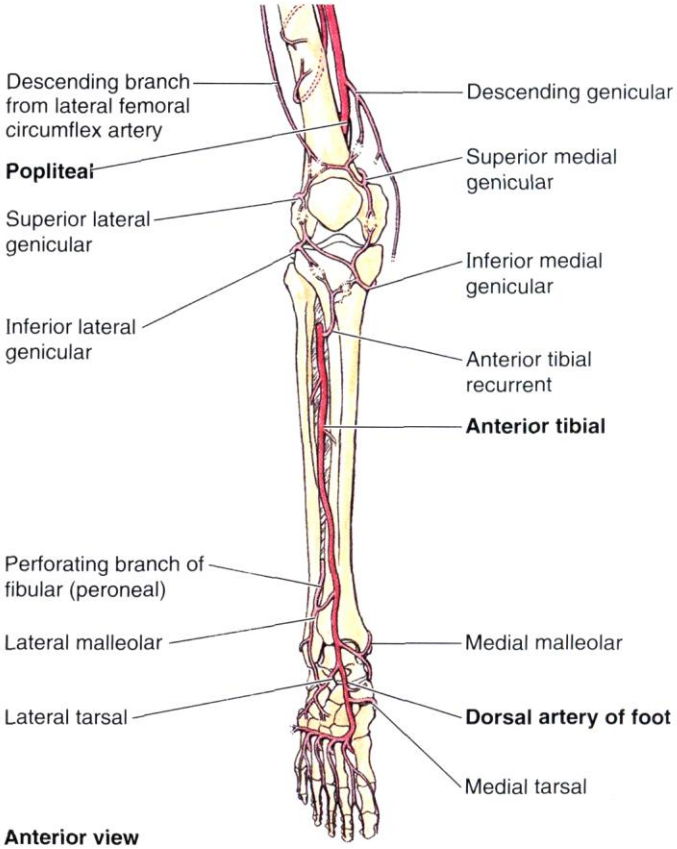


Posterior view with foot plantar flexed

Table **Arteries of the Leg**



Posterior view



Anterior view

Artery	Origin	Course	Distribution in Leg
Popliteal	Continuation of femoral artery at adductor hiatus in adductor magnus	Passes through popliteal fossa to leg; ends at lower border of popliteus muscle by dividing into anterior and posterior tibial arteries	Superior, middle, and inferior genicular arteries to both lateral and medial aspects of knee
Anterior tibial	Popliteal	Passes between tibia and fibula into anterior compartment through gap in superior part of interosseous membrane and descends this membrane between tibialis anterior and extensor digitorum longus	Anterior compartment of leg
Doral artery of foot (L. *dorsalis pedis*)	Continuation of anterior tibial artery distal to inferior extensor retinaculum	Descends anteromedially to first interosseous space and divides into plantar and arcuate arteries	Muscles on dorsum of foot; pierces first dorsal interosseous muscles as deep plantar artery to contribute to formation of plantar arch
Posterior tibial	Popliteal	Passes through posterior compartment of leg and terminates distal to flexor retinaculum by dividing into medial and lateral plantar arteries	Posterior and lateral compartments of leg; circumflex fibular branch joins anastomoses around knee; nutrient artery passes to tibia
Fibular	Posterior tibial	Descends in posterior compartment adjacent to posterior intermuscular septum	Posterior compartment of leg: perforating branches supply lateral compartment of leg

The Arteries of the Foot

The dorsalis pedis artery (a. dorsalis pedis) passes on the back of the foot. A continuation of the anterior tibial artery, it is situated on the bones in the ligaments with the tendon of the long extensor of the big toe passing medially and the medial belly of the short extensor of the toes passing laterally.

Here, on a. dorsalis pedis, one can palpate the pulse by pressing it to the bones. In addition to two or three small branches spreading out in the skin of the dorsal and medial sides of the foot, the dorsal artery of the foot gives off the following branches:
(a) the medial tarsal arteries (aa. tarseae mediales) to the medial edge of the foot; the tarsal artery (a. tarsea lateralis) branches off laterally at the level of the head of the talus, passing to the lateral side. The end of the artery merges with the next branch of the artery of the foot, the arcuate artery;

(b) the arcuate artery (a. arcuata) branches off opposite the medial sphenoid bone, passes laterally along the bases of the metatarsal bones, and anastomoses with the lateral tarsal and plantar arteries. The arcuate artery gives off three arteries anteriorly: aa. metatarseae dorsales,the second, third and fourth metatarsal dorsal arteries, which pass to the corresponding interosseous metatarsal spaces, each dividing into two aa. digitales dorsales to thesides of the fingers facing each other. Each of the metatarsal arteries gives off anterior and posterior perforating branches, which pass to the sole of the foot. Often a. arcuata is poorly developed, and a. metatarsea lateralis serves as a substitute. This should be taken into account in checking the pulse on the arteries of the foot in endarteritis;

(c) the first dorsal metatarsal artery (a. metatarsea dorsalis prima), which is one of two terminal branches of the dorsal artery of the foot, leads to the space between the first and second toes where it divides into two digital branches; prior to the division a branch is given off to the medial side of the big toe;

(d) the deep plantar branch (ramus plantaris profundus) is the second largest of the terminal branches into which the dorsal artery of the foot divides. It passes through the first metatarsal space to the sole, where it participates in forming the arcus plantaris.

There are two plantar arteries on the sole of the foot: aa.plantares medialis and lateralis. These are the terminal branches of the posterior tibial artery.

The thinner of the two, the medial plantar artery (a. plantaris medialis), is situated in the sulcus plantaris medialis. It terminates at the head of the first metatarsal bone, joining the first plantar metatarsal artery or draining into the arcus plantaris. Along the way it gives off small branches to the adjoining muscles, joints, and skin.

The larger lateral plantar artery (a. plantaris lateralis) passes into the sulcus plantaris lateralis medially of the base of the fifth metatarsal bone. There it turns sharply to the middle and, forming a convex arch (arcus plantaris) on the bases of the metatarsal bones, terminates laterally of the first metatarsal bone, anastomosing with the ramus plantaris profundus a. dorsal-is pedis. Moreover, it gives off a small branch that joins a. plantaris medialis. Thus, the arteries of the sole, under constant pressure in standing and walking, form two arches, which, in distinction from the arches of the hand, are situated not in parallel, but in mutually perpendicular planes: in the horizontal plane between aa. plantares medialis and lateralis and in the vertical plane between a. plantaris lateralis and r.plantaris profundus.

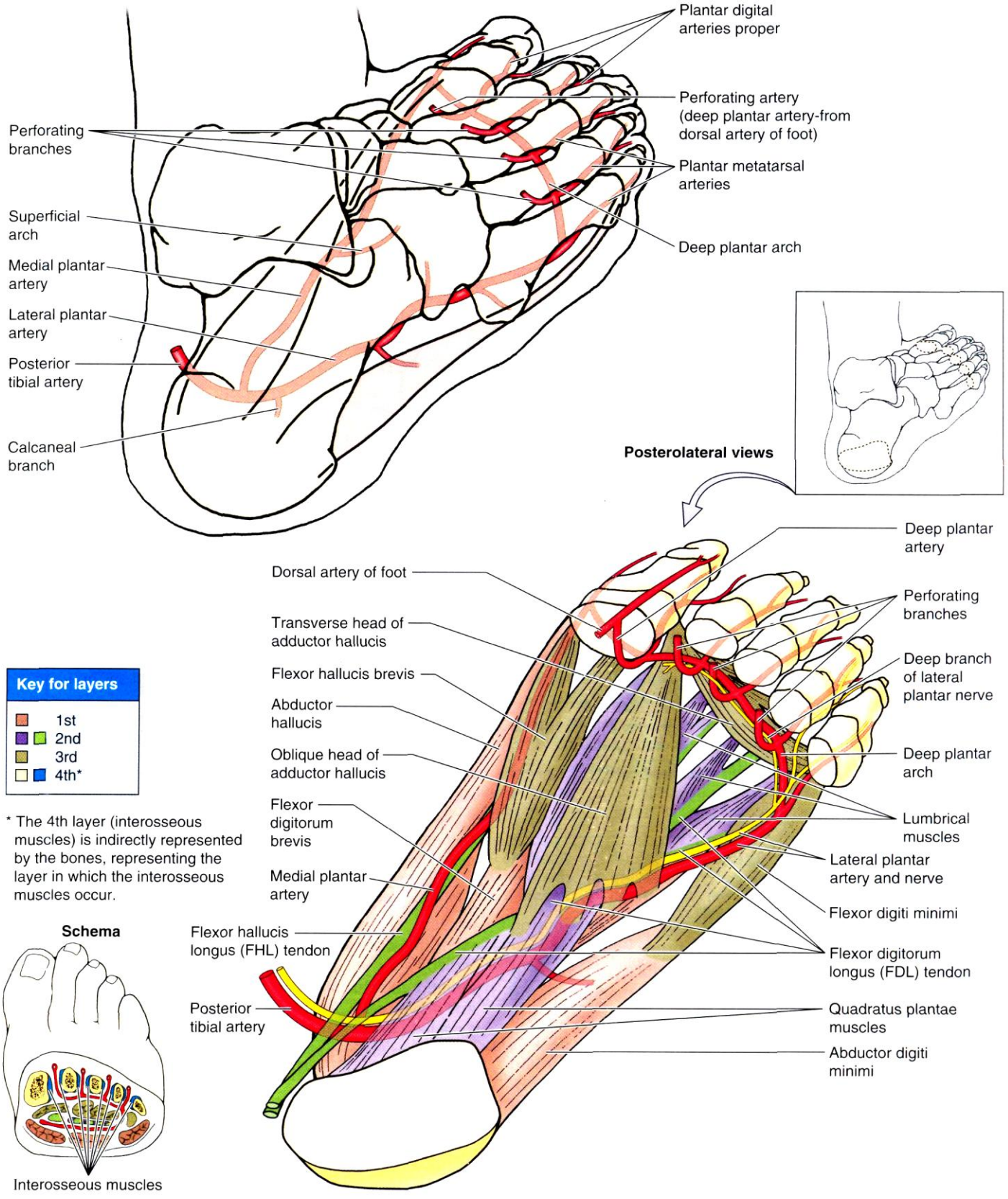
The branches of the lateral plantar artery:
(a) small branches to the adjoining muscles and skin;

(b) the plantar metatarsal arteries (aa. metatarseae plantares) (four), which, at the posterior end of each of the metatarsal spaces, join the perforating dorsal posterior arteries.

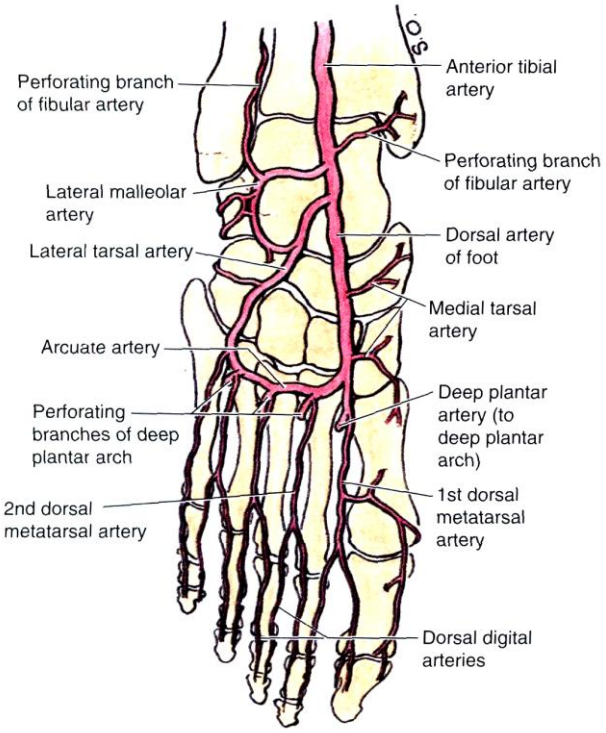
(c) At the anterior end, they join the perforat- ing anterior arteries and separate into plantar digital arteries, aa. digitales plantares, which, beginning from the second phalanx, send small branches to the dorsal side of the toes.

As a result, on the foot there are two rows of perforating arteries connecting the dorsal vessels with the vessels of the sole. To join aa.metatarseae plantares and aa.metatarseae dorsales, these perforating vessels form anastomoses between a. tibialis anterior and a. tibialis posterior. It may, therefore, be stated that these two main arteries of the cms have two types of anastomoses on the foot in the region of the metatarsus:

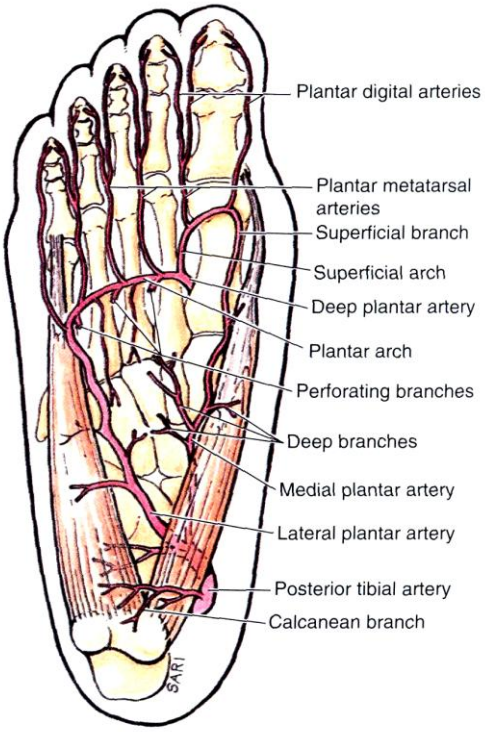
(1) arcus plantaris, and
(2) rami perforantes.


Plantar digital arteries proper
Perforating artery (deep plantar artery-from dorsal artery of foot)
Plantar metatarsal arteries
Deep plantar arch
Perforating branches
Superficial arch
Medial plantar artery
Lateral plantar artery
Posterior tibial artery
Calcaneal branch
Posterolateral views
Deep plantar artery
Dorsal artery of foot
Perforating branches
Transverse head of adductor hallucis
Deep branch of lateral plantar nerve
Flexor hallucis brevis
Abductor hallucis
Deep plantar arch
Oblique head of adductor hallucis
Flexor digitorum brevis
Lumbrical muscles
Lateral plantar artery and nerve
Medial plantar artery
Flexor digiti minimi
Flexor hallucis longus (FHL) tendon
Flexor digitorum longus (FDL) tendon
Posterior tibial artery
Quadratus plantae muscles
Abductor digiti minimi
Key for layers
1st
2nd
3rd
4th*
* The 4th layer (interosseous muscles) is indirectly represented by the bones, representing the layer in which the interosseous muscles occur.
Schema
Interosseous muscles

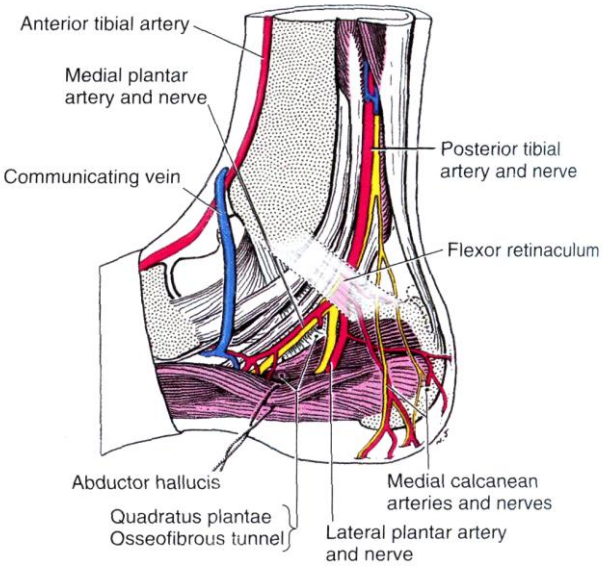
Arches of the foot:



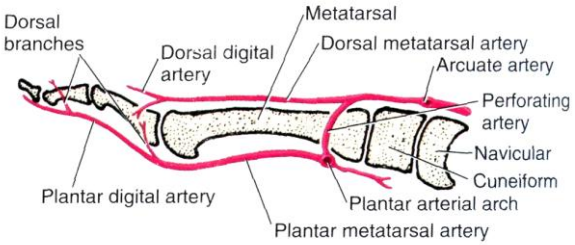
Dorsum of foot



(B) Plantar aspect of foot

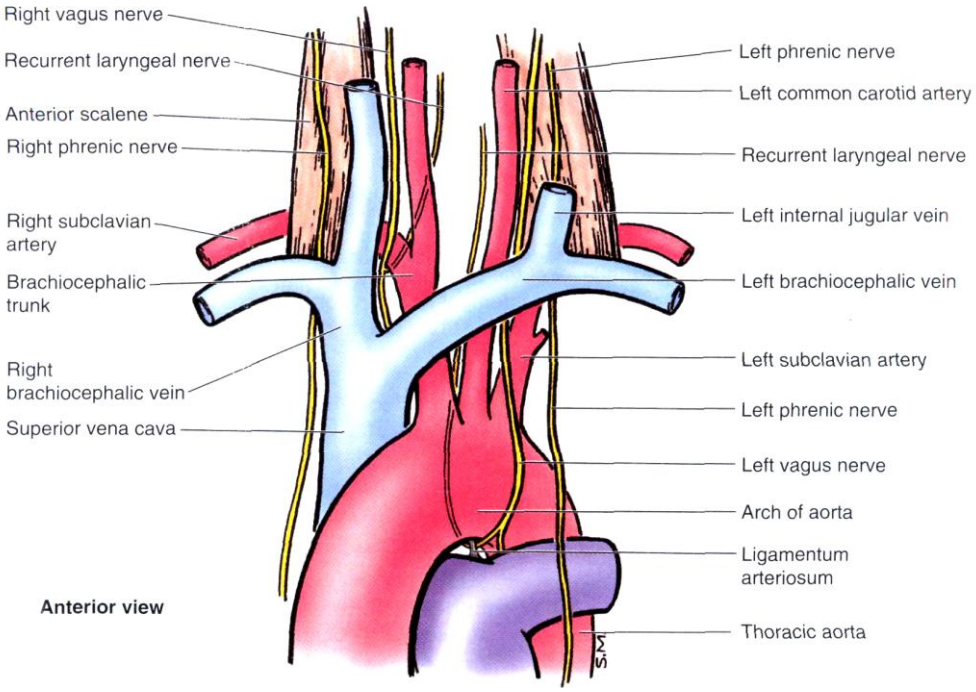


Blood supply of the toe:

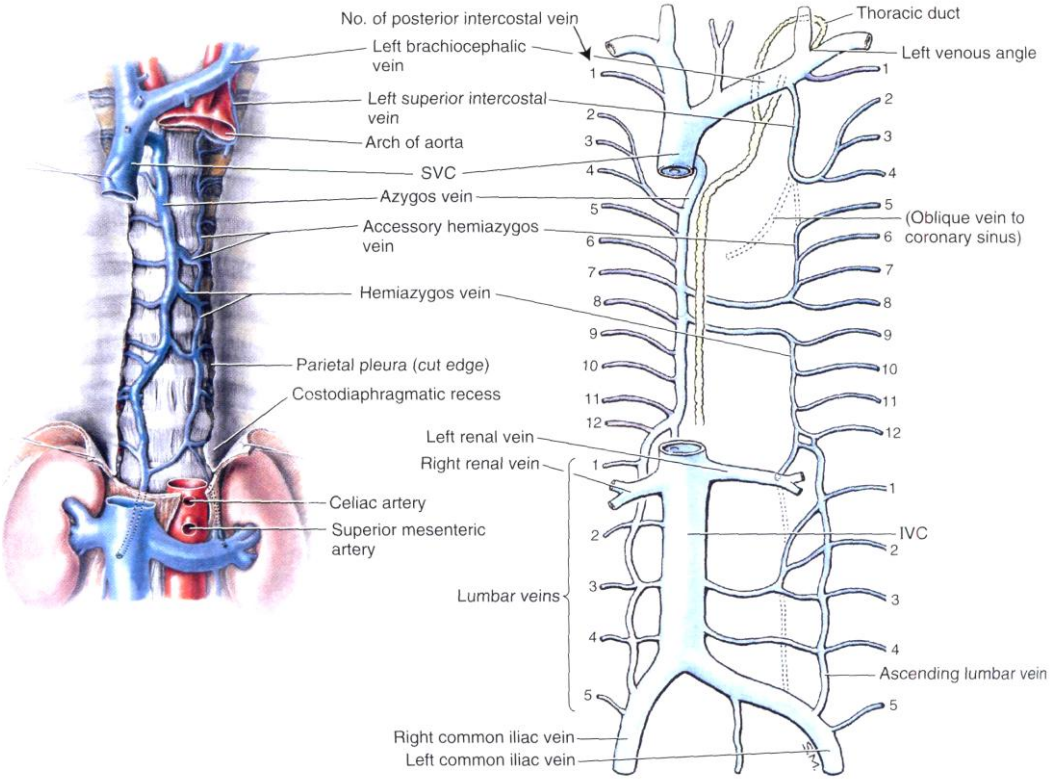


SYSTEM OF SUPERIOR VENA CAVA

Superior vena cava is generated by reason of confluence of right and left brachiocephalic veins behind joint of cartilage of first right rib with sternum. Superior vena cava on level of third right cartilage empties into right atrium. Azygos vein empties into superior vena cava from right side.



Brachiocephalic veins form by the confluence of subclavian vein, internal jugular and sometimes External jugular vein. This place is called as **venous angle,** where thoracic lymphatic duct empties (left side), and right lymphatic duct (right side). Inferior thyroid veins from thyroid plexus, inferior laryngeal vein and thymic vein, pericardial veins from pericardium, bronchic veins and esophageal veins from esophagus fall into brachiocephalic veins.



Azygos vein continues into thoracic cavity from right ascending lumbar vein. Azygos vein receives posterior intercostal veins, esophageal veins, bronchic veins, pericardial veins and mediastinal veins, also hemizygos vein.

Internal jugular vein is a largest vessel, which drainage blood from area of head and neck. Internal jugular vein originates from sygmoidsinus of dura mater encephali, where it begins on level of jugular foramen by superior bulb and lies behind internal carotid artery and vagus nerve. Inferior jugular bulb is situated near the confluence with subclavian vein.

Internal jugular has the following extracranial influxes:

- pharyngeal veins;
- lingual vein;
- superior thyroid vein;

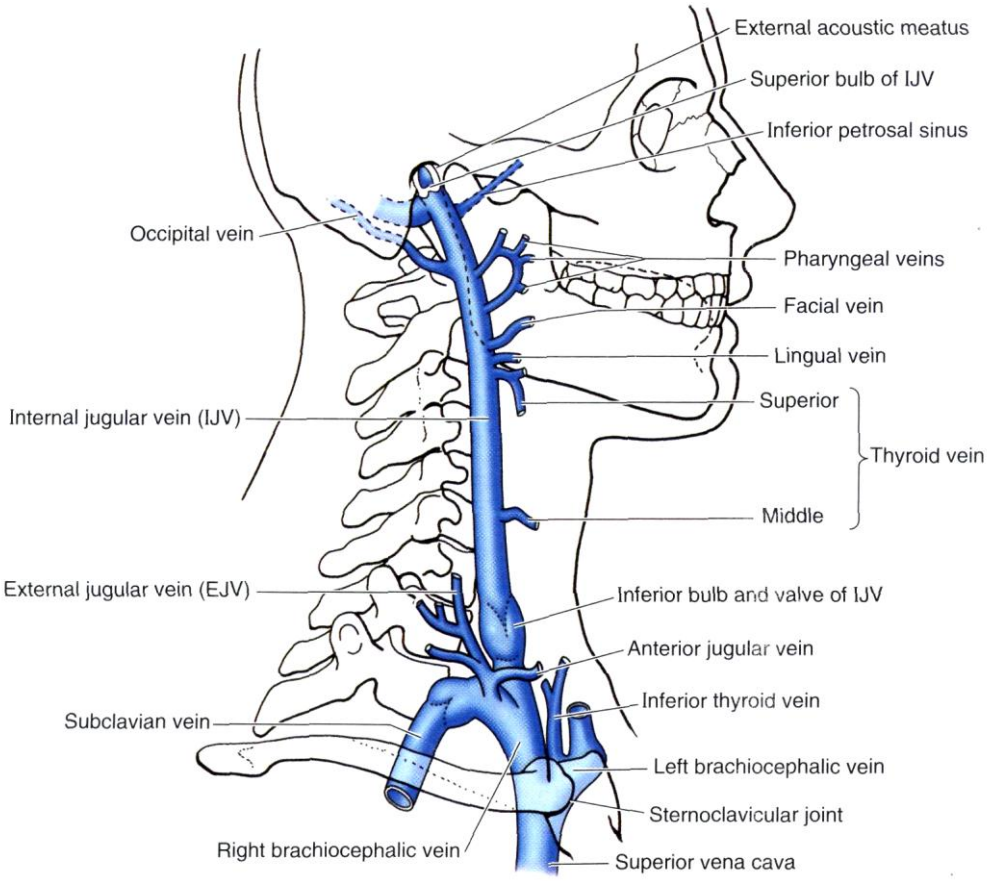
'facial vein, which receives retromandibular vein

- retromandibular vein empties into facial vein, or into internal jugular vein.

Follow vessels belong to intracranial tributaries of internal jugular vein:

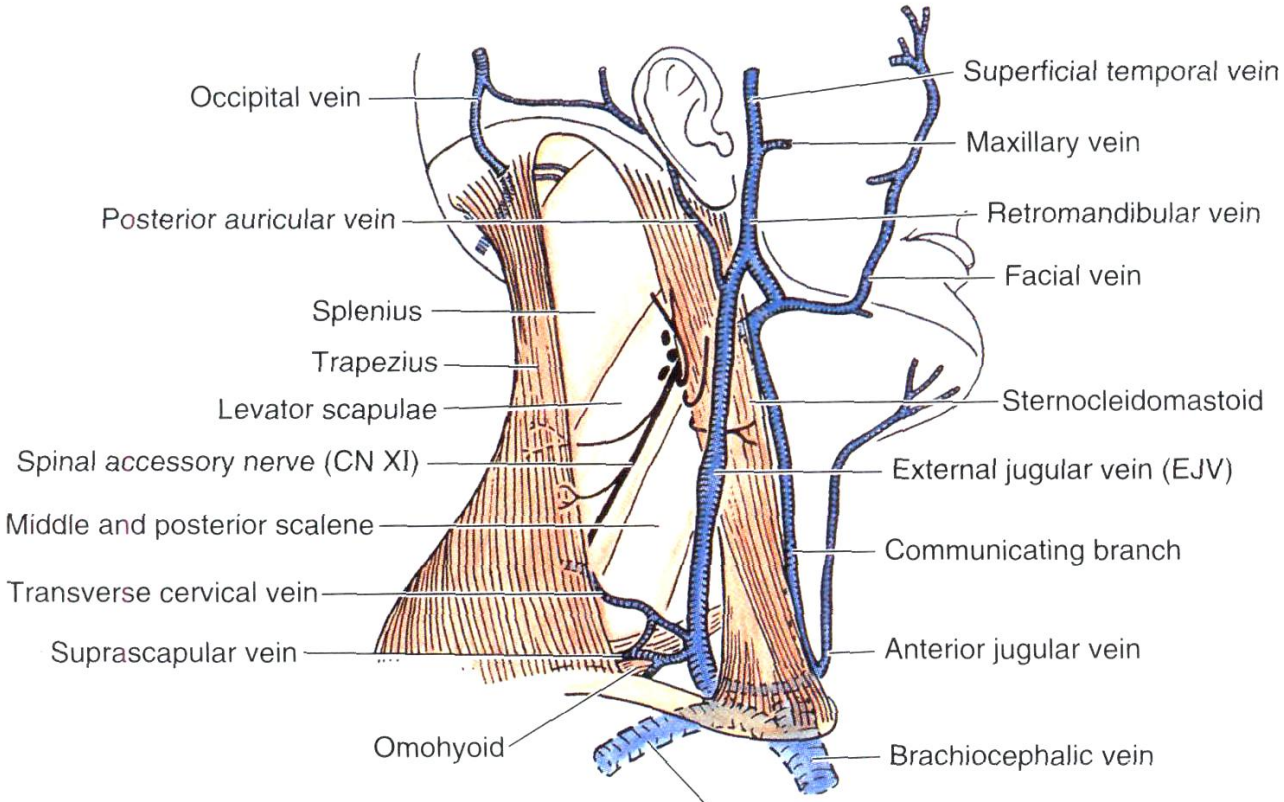
- venous sinuses of dura mater encephali and veins of brain;
- diploic veins from skull bones;
- meningeal veins are from cranial dura mater;
- superior ophthalmic vein and inferior ophtalmic vein is from sight organ;
- labyrinthic veins - from internal ear;

emissary veins from intracranial veins and sinuses of dura mater and communicate with extracranial veins.



External jugular vein is generated by the confluence of occipital vein andposterior auricular vein, which accompany same name arteries. External jugular vein receives anterior jugular vein, which collect blood from anterior neck area and, anastomosing each other, form jugular venous arc.

Subclavian vein continues from axillary vein, lies in same name sulcus of first rib and collects blood from thoracic veins and dorsal scapular vein.



Lateral view of right side

Veins of upper limb are subdivided into superficial and deep.

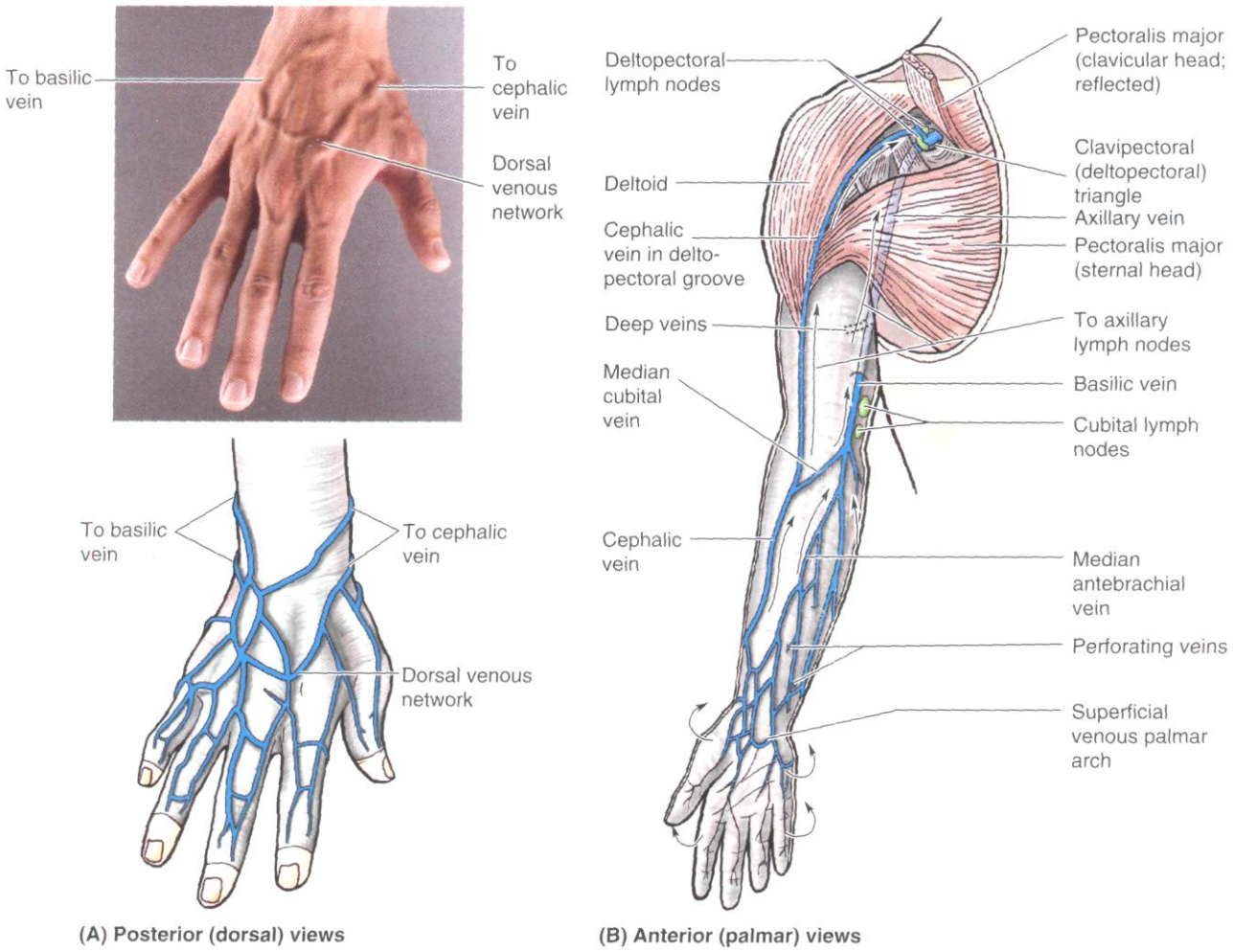


Figure **Superficial veins and lymph nodes of upper limb. A.** The digital veins drain into the dorsal venous network on the dorsum of the hand, which leads to two prominent superficial vessels: the cephalic and basilic veins. **B.** The basilic and cephalic veins ultimately drain into the origin and termination of the axillary vein, respectively. The median cubital vein is the communication between the basilic and the cephalic veins in the cubital fossa. Perforating veins connect the superficial veins to the deep veins. *Arrows* indicate the flow of lymph within lymphatic vessels that converge toward the vein and drain into the cubital and axillary lymph nodes.

They are communicated by numerous anastomoses and have valves.
Superficial veins are developed richer than deep one.

Cephalic vein starts from radial part of dorsal venous hand net. From dorsal hand-surface it passes on anterior surface of radial margin across forearm, lies into lateral biceps brachii sulcus, then into sulcus between deltoid and major pectoral muscles and empties under clavicle into axillary vein.

Basilica vein collects blood from ulnar part of dorsal venous hand net, lies on ulnar side of anterior forearm surface, passes on medial biceps brachii sulcus and empties into one of brachial veins.

Intermediate cubiti vein passes obliquely in area of cubital fossa from cephalic to basilica veins.

The Deep veins of **upper limb** are double, they start from superficial palmar venous arch and deep palmar venous arch then accompanies same name arteries and.

Axillar vein is odd, it accompanies same name artery and continues into subclavian vein.

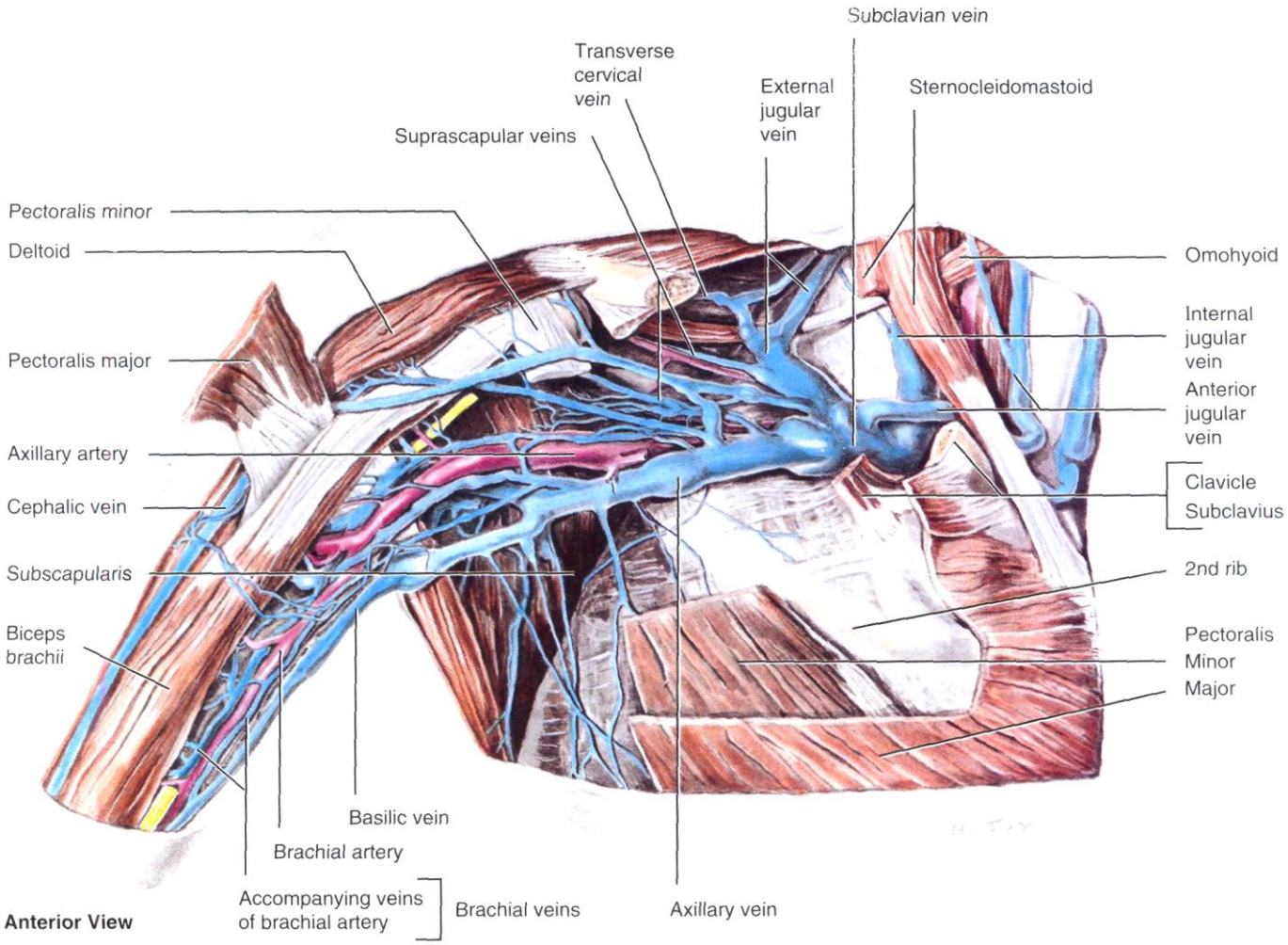
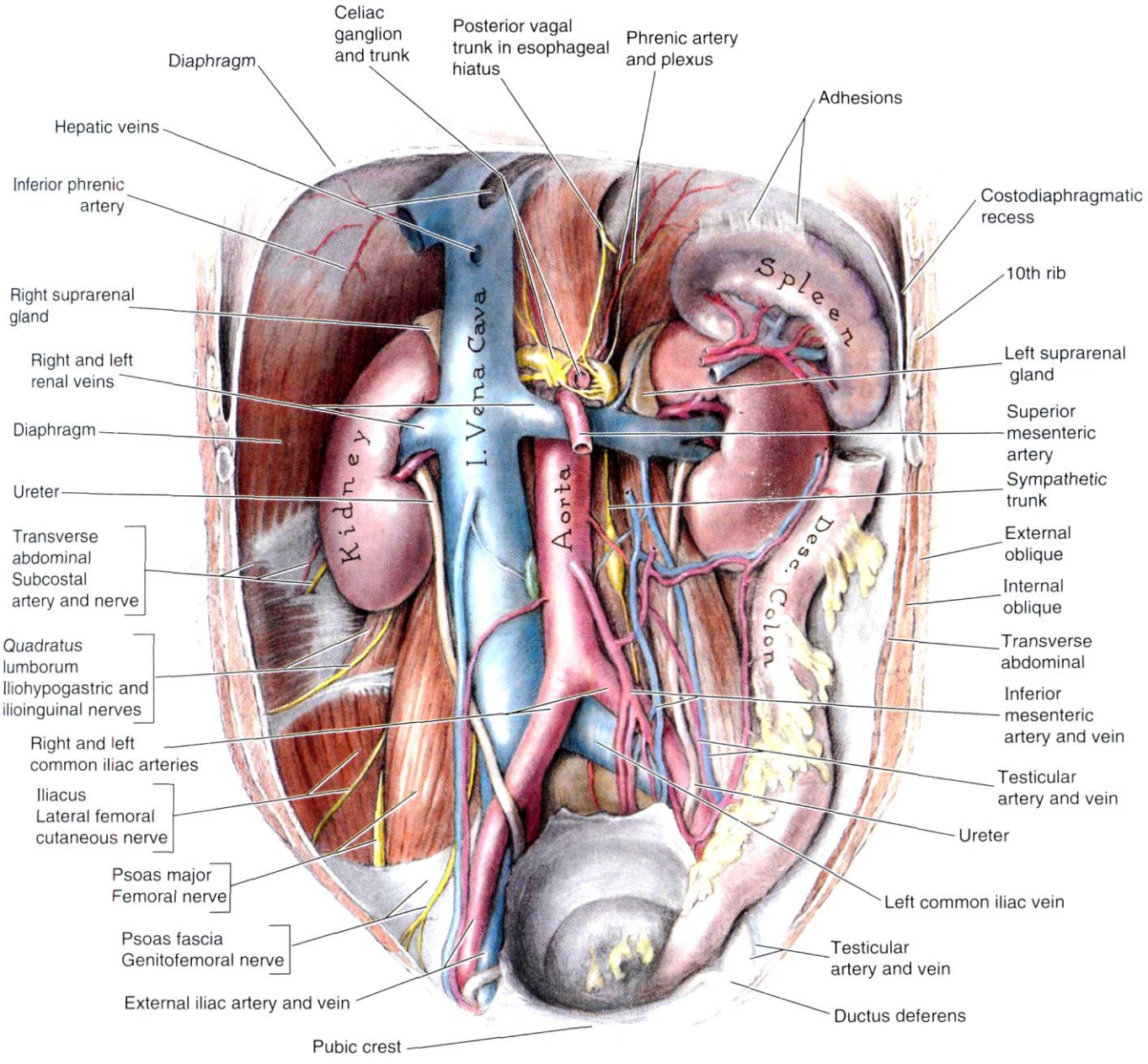


Figure **Veins of axilla.** Observe that the basilic vein parallels the brachial artery to the axilla, where it merges with the accompanying veins (L. *venae comitantes*) of the axillary artery to form the axillary vein. Note the large number of highly variable veins in the axilla, which are also tributaries of the axillary vein.

THE SYSTEM OF VENA CAVA INFERIOR

The inferior vena cava (v. cava inferior), the thickest venous trunk in the body, lies in the abdominal cavity close to the right side of the aorta . It is formed at the level of the fourth lumbar vertebra by the merger of two common iliac veins slightly below the division of the aorta and immediately to the right of it. The vena cava inferior passes upward and somewhat to the right so that the higher it rises, the further it is from the aorta. The lower segment of the vein adjoins the medial edge of the right psoas muscle and then passes onto its anterior surface; its upper segment rests on the lumbar part of the diaphragm. Lying in the sulcus venae cavae on the posterior surface of the liver, the inferior vena cava then passes through the foramen venae cavae of the diaphragm into the thoracic cavity and immediately drains into the right atrium.



The veins draining directly into the vena cava inferior correspond to the paired branches of the aorta (except vv. hepaticae). They are divided into parietal and visceral veins.

The parietal veins:
(1) the right and left lumbar veins (vv. lumbales dextrae and sinistrae), four veins on each side corresponding to arteries of the same name receive anastomoses from the vertebral plexus; they join by longitudinal trunks, vv. lumbales ascendens;
(2) the phrenic veins (vv. phrenicae inferiores) drain into the inferior vena cava where it passes in the sulcus of the liver.

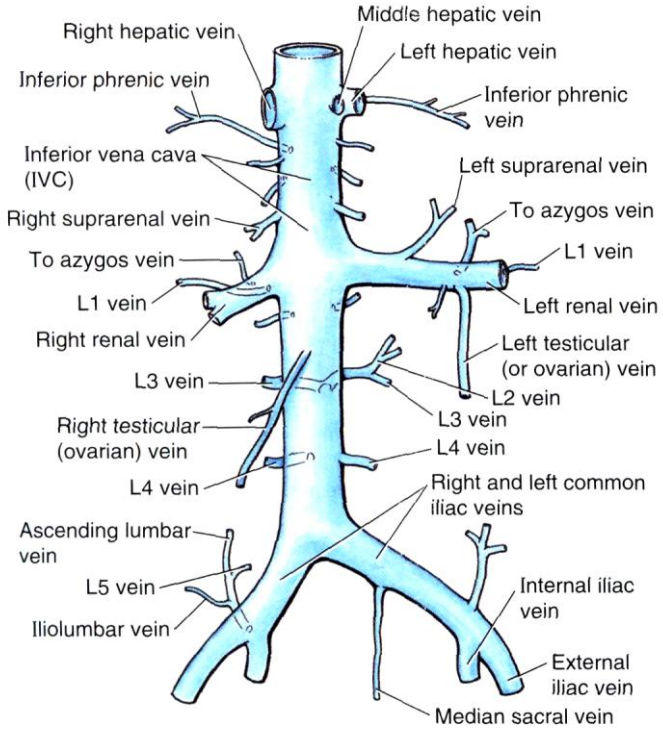
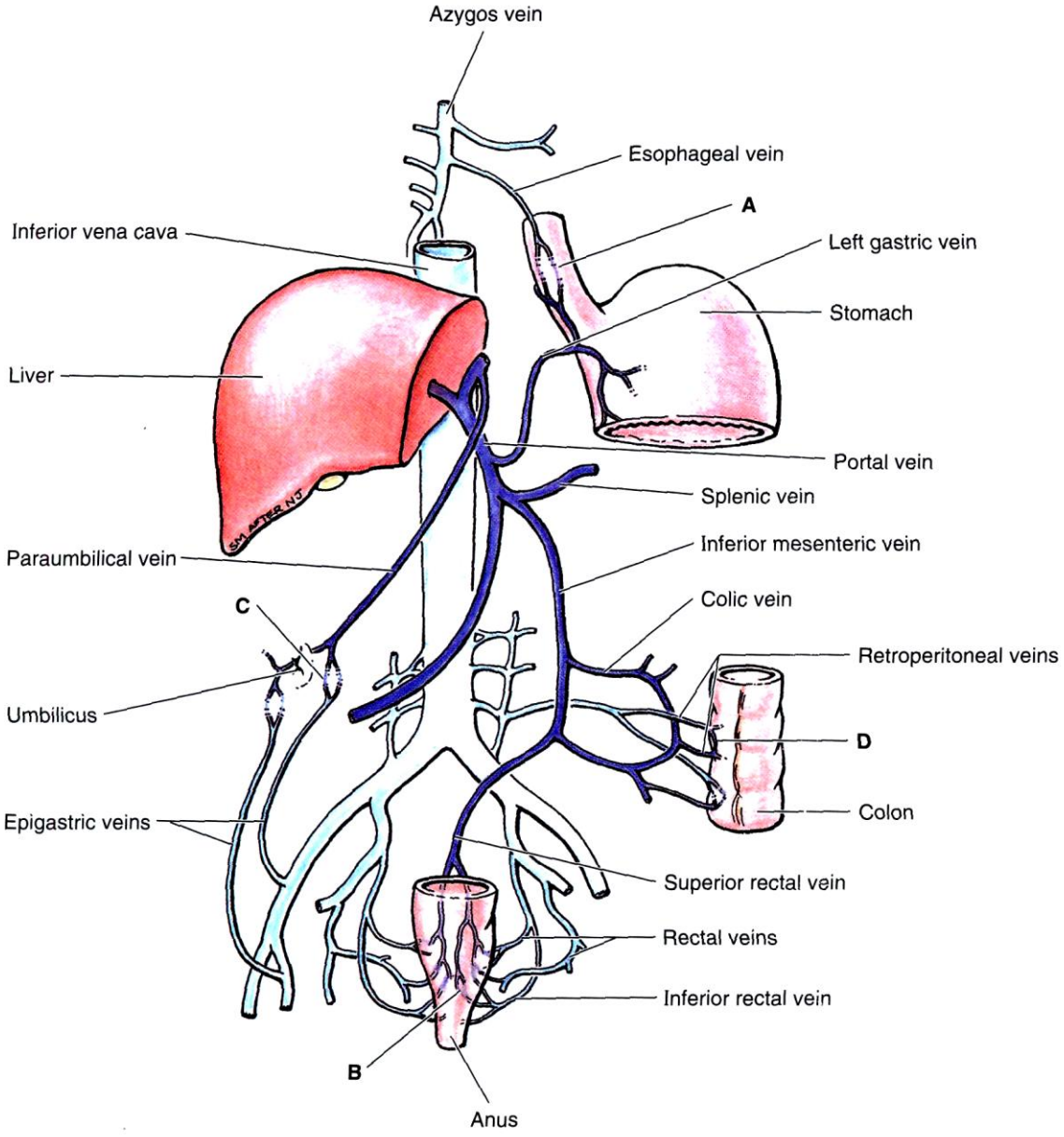


Figure **Inferior vena cava and its tributaries.** The asymmetry in the renal and common iliac veins reflects the placement of the IVC to the right of the midline.

The visceral veins:
(1) the testicular veins (vv. testiculares) in males (ovarian veins in females) originate in the region of the testes and form plexuses with arteries of the same name (plexus pampiniformis).
(2) the right suprarenal vein (v. suprarenalis dextra) drains into the inferior vena cava immediately above the renal vein; v. suprarenalis sinistra usually fails to reach the vena cava and drains into the renal vein in front of the aorta;
(3) the hepatic veins (vv. hepaticae) empty into the vena cava inferior as it passes over the posterior surface of the liver; the hepatic veins carry blood from the liver, which receive it through the portal vein and hepatic artery .

THE PORTAL VEIN

The portal vein (v. portae) collects blood from all unpaired organs of the abdominal cavity with the exception of the liver . Blood carrying nutrients absorbed in the gastrointestinal tract is carried by the portal vein to the liver where the nutrients are neutralized and glycogen is deposited. Blood from the pancreas, which supplies insulin for the regulation of sugar metabolism, and from the spleen, which yields the products of disintegration of blood elements used by the liver to secrete bile, is also carried by the portal vein. The structural ties between the portal vein and the gastrointestinal tract and its large glands (liver and pancreas) are both functional and genetic.

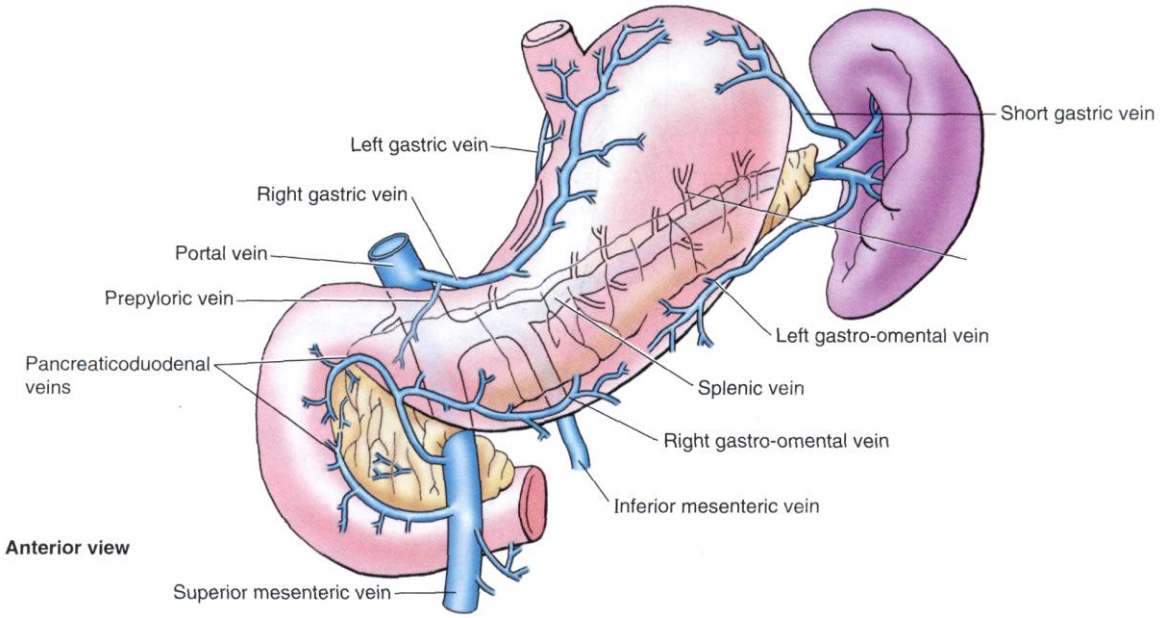


The portal vein is a thick venous trunk located in lig. hepatoduodenale with the hepatic artery and ductus choledochus. The portal vein forms behind the head of the pancreas out of the splenic vein (v. lienalis) and two mesenteric veins (vv. mesentericae), superior and inferior. On its way to the hepatic porta in the peritoneal ligament already mentioned, the portal vein receives w. gastricae sinistra and dextra and v. prepylorica and divides in the porta hepatis into two branches, which pass into the parenchyma of the liver where they spread into a multitude of small branches which entwine the hepatic lobules (vv. interlobulares).

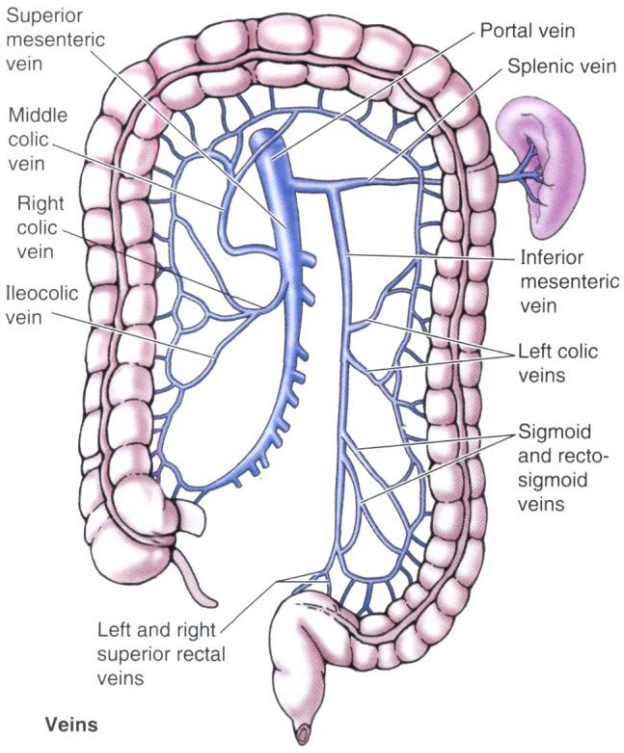
Numerous capillaries penetrate the lobules and eventually join in vv. centrales (see the section on the liver), which merge in the hepatic veins draining into the inferior vena cava. Thus, in distinction from other veins, the system of the portal vein fits between two networks of capillaries: the first capillary network provides a source for the venous trunks that comprise the portal vein, while the second network runs throughout the liver, where the portal vein splits into its terminal branches.

The Splenic Vein

The splenic vein (v. lienalis) carries blood from the spleen, the stomach (through v. gastro-epiploica sinistra and vv. gastricae breves), and the pancreas, along the upper edge of which it passes posteriorly and below the splenic artery to v. portae.



The Mesenteric Veins



The superior and inferior mesenteric veins (vv. mesentericae superior and inferior) correspond to the arteries of the same name. The superior mesenteric vein drains venous branches from the small intestine (vv. in-testinales), the caecum, the ascending colon, and the transverse colon (v. coli-ca dextra and v. colica media) and, passing behind the head of the pancreas, joins the lower mesenteric vein. The inferior vein originates from the venous plexus of the rectum, the plexus venosus rectalis. Passing upward from this plexus, the vein receives branches from the sigmoid colon (vv. sigmoideae), the descending colon (v. colica sinistra), and from the left half of the transverse colon. V. mesenterica inferior then merges with the v. mesenterica superior behind the head of the pancreas either jointly with the splenic vein or independently.

THE COMMON ILIAC VEINS

The right and left common iliac veins (w. iliacae communes) join at the level of the lower edge of the fourth lumbar vertebra to form the vena cava inferior . The right common iliac vein is located behind the iliac artery; the left vein lies below and behind the artery of the same name. The left vein, then, turns medially and passes behind the right common iliac artery to merge with the right common iliac vein to the right of the aorta. Each common iliac vein at the level of the sacroiliac joint comprises, in its turn, two veins: external and internal iliac veins.

The Internal Iliac Vein

The internal iliac vein (v. iliaca interna) is a short but thick trunk located behind the internal iliac artery. The veins that make up the internal iliac vein correspond to arterial branches of the same name. Normally, these veins are binary outside the pelvis but merge into a single trunk on entering it. A number of venous plexuses, which anastomose with one another, are formed among the branches of the internal iliac vein.

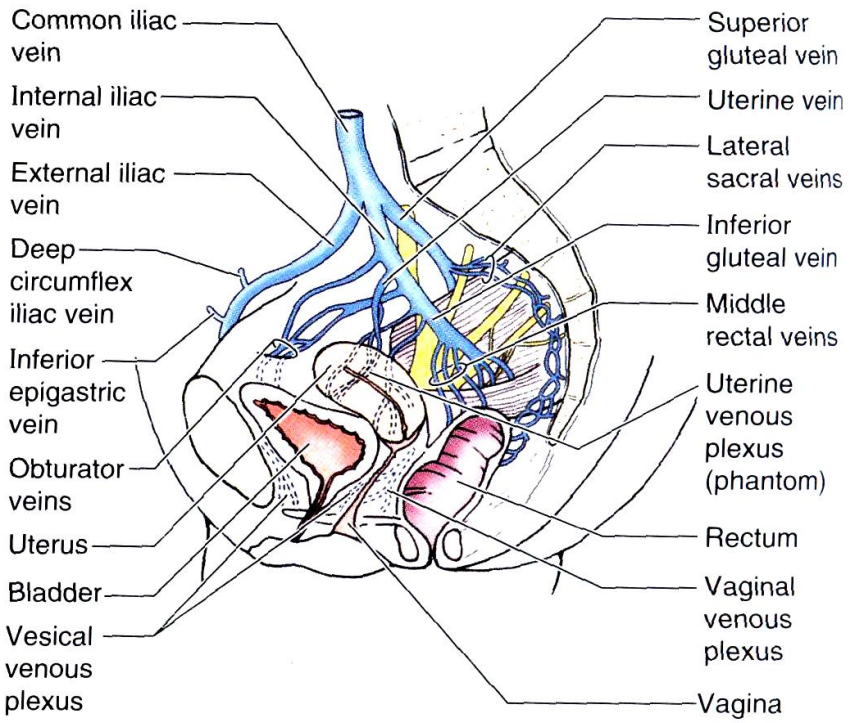
1. The anterior sacral venous plexus (plexus venosus sacralis) consists of sacral veins, lateral and medial.

2. The rectal venous plexus (plexus venosus rectalis s. hemorrhoidalis [BNA]) is a plexus in the walls of the rectum. Three plexuses can be distin guished: submucous, subfascial, and subcutaneous. The submucous or internal venous plexus, plexus rectalis internus, in the region of the lower ends of the columnae rectalis consists of several venous nodules arranged in the shape of a ring. The abducent veins of this plexus perforate the muscular coat of the intestine and merge with the veins of the subfascial or external plexus, plexus rectalis externus. V. rectalis superior and vv. rectales mediae arise from the latter, accompanying arteries of the same name. V. rectalis superior drains through the inferior mesenteric vein into the portal vein system, while vv. rectales mediae empty into the system of the vena cava inferior through the internal iliac vein. A third (subcutaneous) plexus forms in the region of the external sphincter of the anus, plexus subcutaneus ani, which make up vv. rectales inferiores draining into v. pudenda interna.

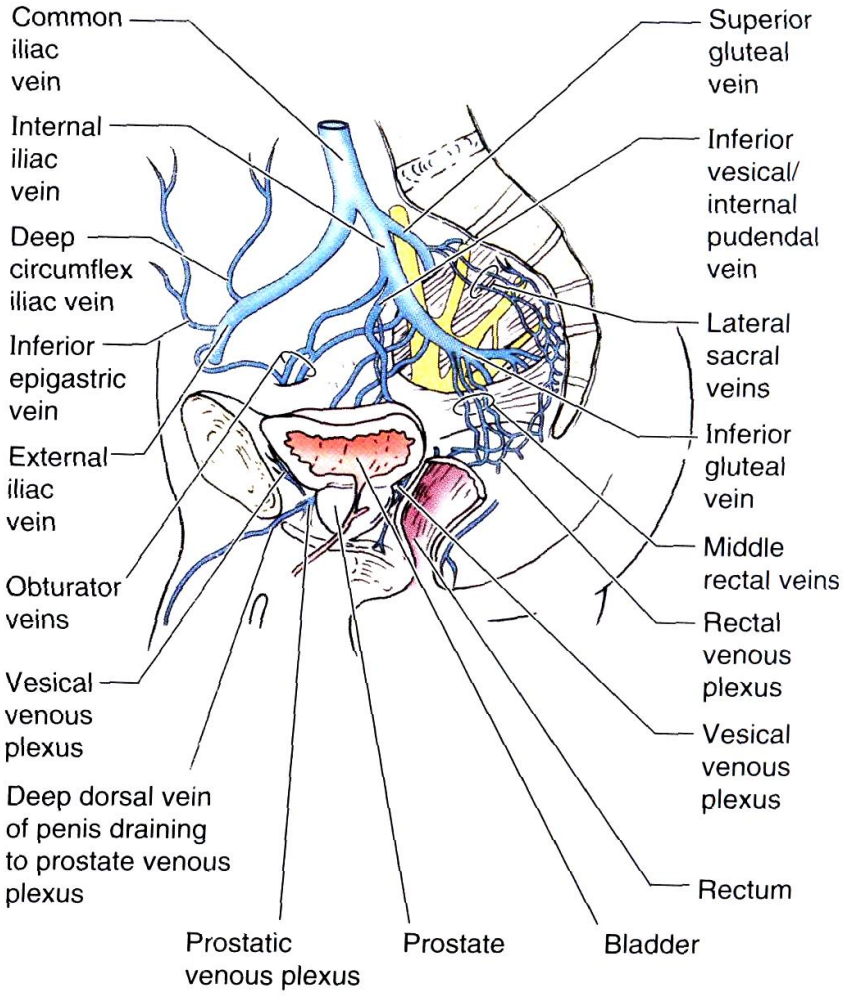
3. The vesical venous plexus (plexus venosus vesicalis) is located in the region of the fundus of the urinary bladder; the blood from this plexus is drained into the internal iliac vein through vv. vesicales.

4. The prostatic venous plexus (plexus venosus prostaticus) is situated between the urinary bladder and the pubic adhesion, encompassing the pros tate and the seminal vesicles in males. The unpaired v. dorsalis penis drains into the plexus venosus prostaticus. V. dorsalis clitoridis in females corre sponds to v. dorsalis penis in males.

5. The uterine venous plexus (plexus venosus uterinus) and the vaginal venous plexus (plexus venosus vaginalis) in females are located in the wide ligaments along the sides of the uterus and further downward along the lateral walls of the vagina. The blood from them drains mainly through v. uterina into the internal iliac vein, although part is also drained through the ovarian vein (plexus pampiniformis).



Female: medial view from left

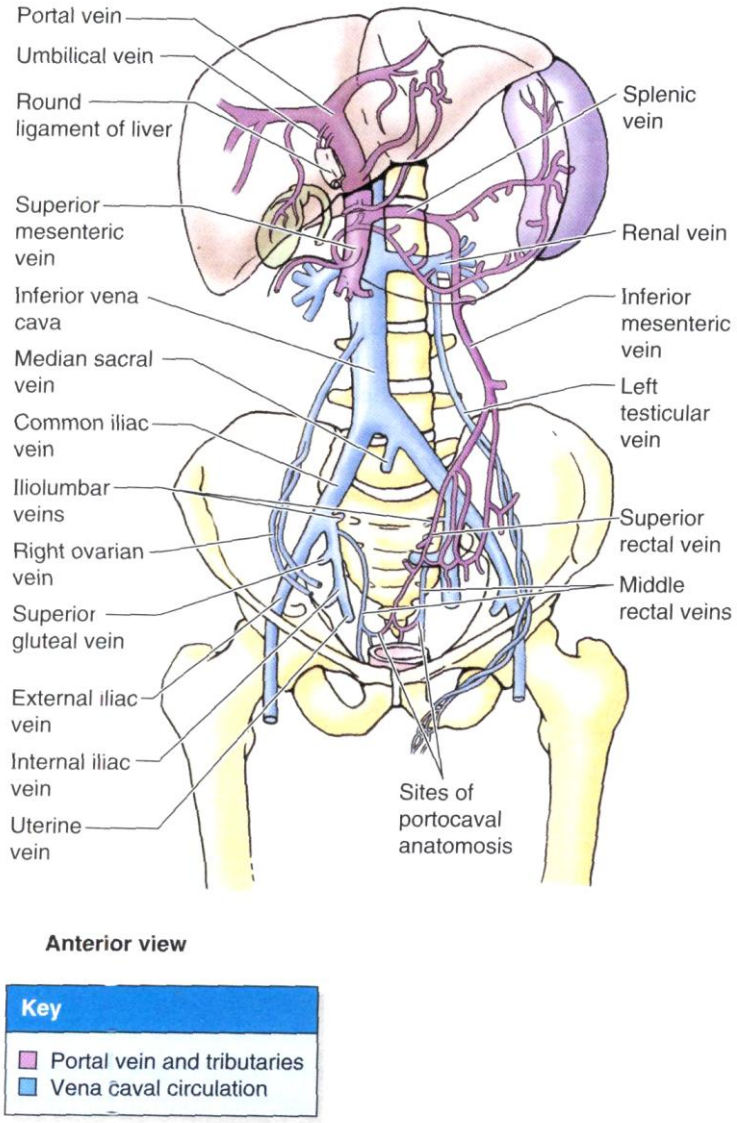


Male: medial view from left

PORTOCAVAL AND CAVACAVAL ANASTOMOSES

The roots of the portal vein anastomose with the roots of veins from the systems of the superior vena cava and inferior vena cava, forming so-called portocaval anastomoses, which are of practical significance . If we imagine the abdominal cavity in the shape of a cube, these anastomoses are located on all sides of the cube:

1. On the top, in the pars abdominalis of the oesophagus between the roots of v. gastrica sinistra, which empties into the portal vein, and vv. esophageae, which drain into vv. azygos and hemiazygos and further into v. cava superior.
2. On the bottom, in the lower part of the rectum between v. rectalis superior, which drains through v. mesenterica inferior into the portal vein, and vv. rectales media (flowing into v. iliaca interna) and inferior (flowing into v. pudenda interna), which together drain into v. iliaca interna and further into v. iliaca communis from the system of the vena cava inferior.



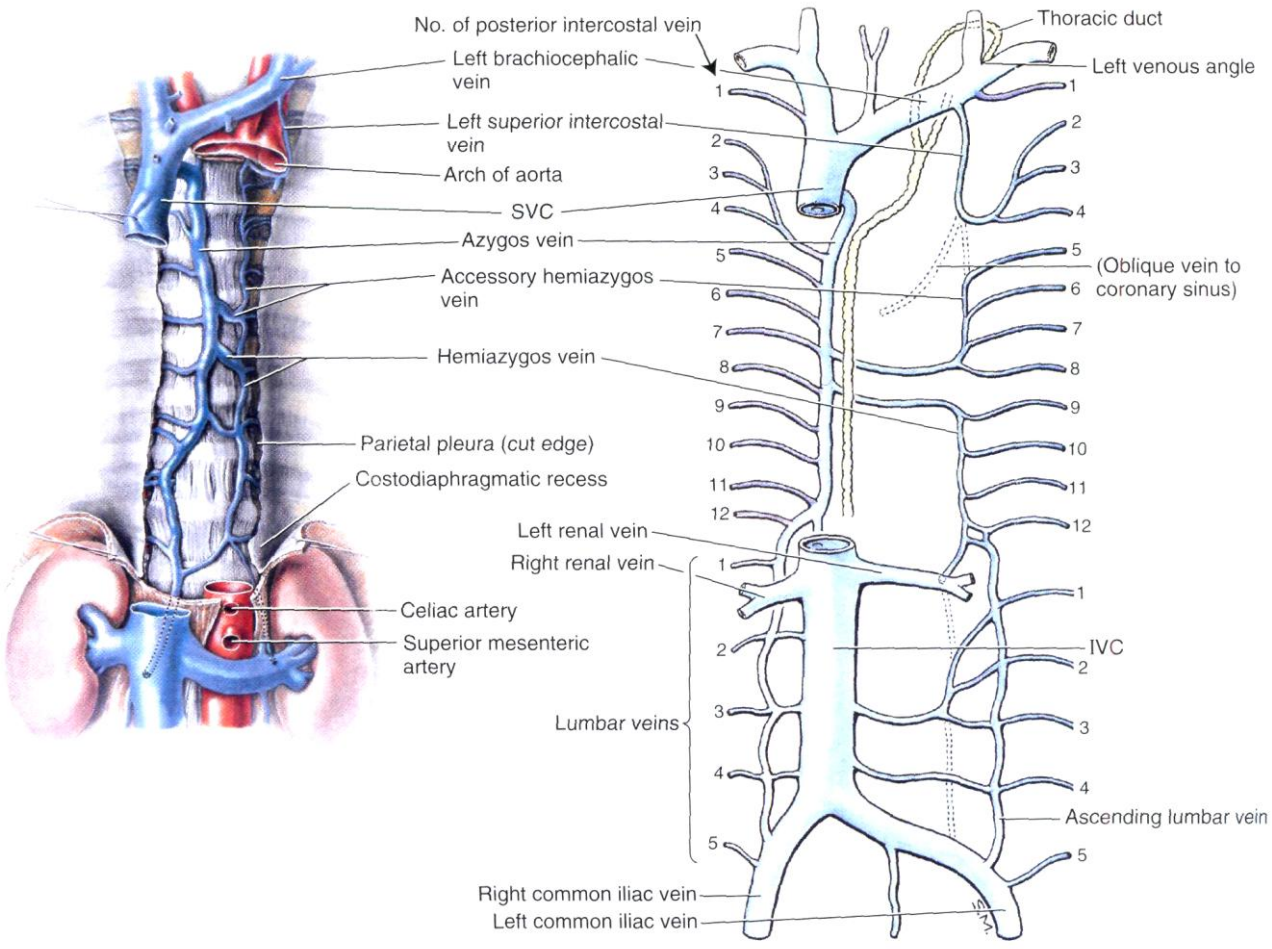
In the front, in the region of the navel where the branches of vv. para-umbilicales (passing through the thickness of lig. teres hepatis to the portal vein), v. epigastrica superior from the system of the vena cava superior (v. thoracica interna, v. brachiocephalica), and v. epigastrica inferior from the system of the vena cava inferior (v. iliaca externa, v. iliaca communis) anastomose.

Portocaval and cavacaval anastomoses, thus, provide a bypass for the drainage of blood when obstacles appear in the liver (e.g., in cirrhosis). In such cases the veins around the navel dilate and acquire a typical appearance known as Medusa's head (the extensive links of the veins of the thymus and thyroid glands with the veins of the surrounding organs participate in the formation of cavacaval anastomoses).

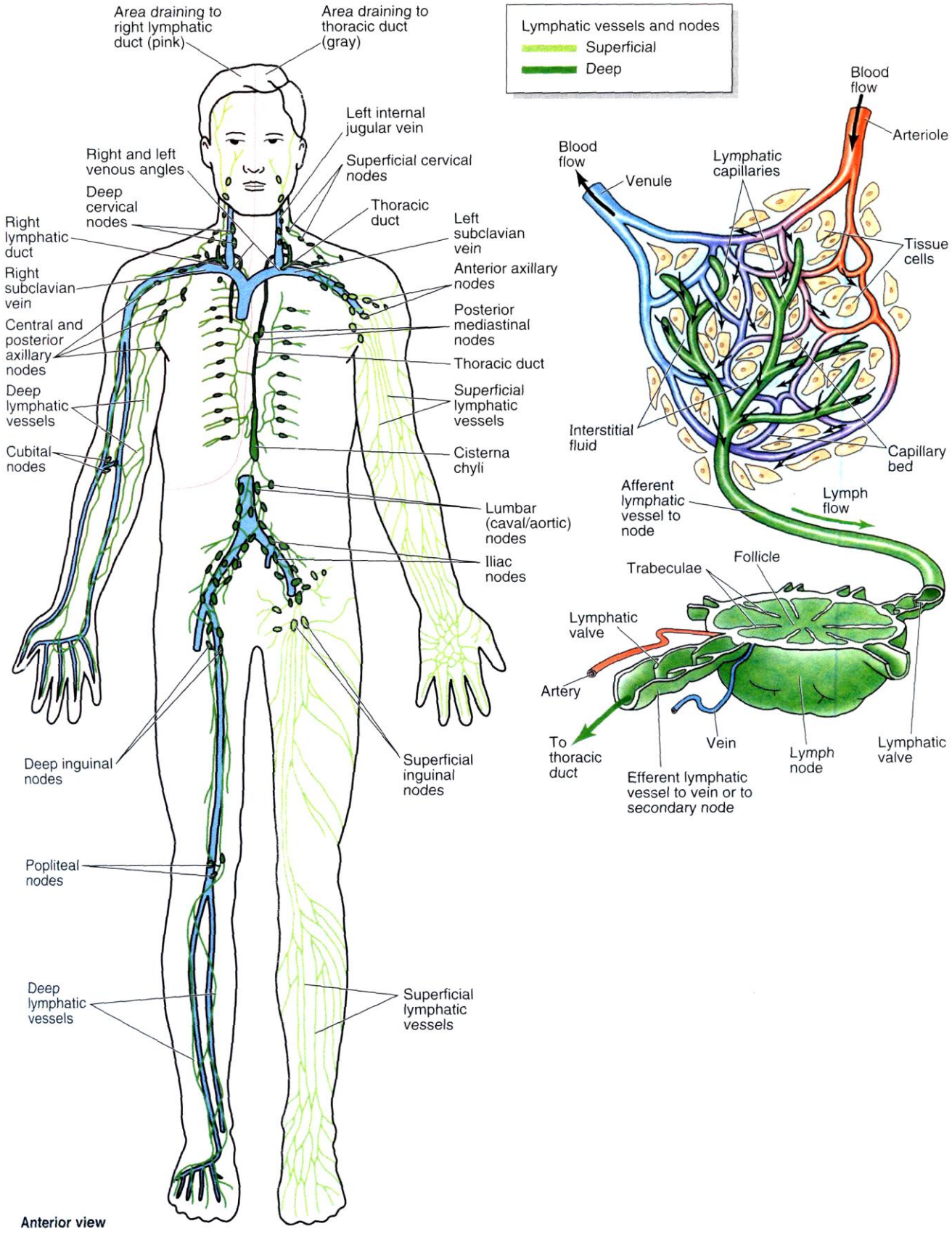
4. In the back, in the lumbar region between the roots of the veins of the mesoperitoneal segments of the large intestine (from the system of the portal vein) and the parietal vv. lumbales (from the system of the vena cava inferior). All these anastomoses form what is known as the Retzius system.

5. There is, in addition, a cavacaval anastomosis on the posterior abdominal wall among the roots of vv. lumbales (from the system of the vena cava inferior). These roots are connected with the paired v. lumbalis ascendens, which is the origin of vv. azygos (to the right) and hemiazygos (to the left) (from the system of the vena cava superior).

6. The cavacaval anastomosis between vv. lumbales and the inter-vertebral veins, which in the neck region serve as roots of the vena cava superior.



LYMPHATIC SYSTEM



Lymphoid Tissue

The above section was just a brief survey of the system of lymph vessels and lymph transport. The lymph nodes, or filters, were mentioned repeatedly, but detailed discussion of them has been postponed until now. There has been a reason for this. The lymph nodes are made of a specialized tissue called lym-phoid (lim'foid) tissue. A number of other organs are also made of lymphoid tissue, but some of them have nothing directly to do with the system of lymph transport itself.

Although lymphoid tissue is distributed through out the body, some organs are specialized structures of the lymphatic system. We will look at some of these typical organs of lymphoid tissue, but first let us consider some properties of this kind of tissue and see what characteristics these organs have in common.

Functions

Some of the general functions of lymphoid tissue include the following:
1. Removal of impurities such as carbon particles, cancer cells, pathogenic organisms, and dead blood cells through filtration and phagocytosis.
2. Processing of lymphocytes. Some of these lymphocytes produce antibodies, substances in the blood that aid in combating infection.

Lymphatic system subdivides into primary lymphatic organs *(marrow* medulla ossium and thymus), secondary lymphatic organs (spleen, lymphatic phaiyngeal ring, lymphatic nodes). Beside lymphatic organs, a lymphatic system has close vessel system and is part of vascular system. Lymph is a liquid, like a blood plasma it brings out the metabolic products from tissues.

Function of lymphatic system:
• taking of lymph from tissues to venous channel (drainage);
• lymphopoetic (marrow, thymic gland, lymphatic nodes);
• immune barrier (neutralizing foreign elements which got to organism). Malignant cells spread (metastasis) by lymphatic channels. Lymphatic system the following attributes, which make it *like* a venous system:
• vessels have the valves;
• lymph flows from tissues to heart.

Characteristics which *differ* lymphatic system from venous one:
• lymphatic nodes are situated on course of lymphatic channels;
• lymphatic system is tubular vessel system, which is close on one hand, and second - open into venous flow.

Lymphatic vessels *are absent* in central nervous system, spleen parenchyma, skin epithelium, cartilage, cornea, lens, placenta, hypophysis, and internal ear.
Vessel portion of lymphatic system consists of:
1) capillary networks which collect the lymph in the various organs and tissues;
2) vessels
3) trunks
4) ducts on which ways
5) nodes are located.

Lymphatic Capillaries

The lymphatic capillaries resemble the blood capillaries in that they are made of one layer of flattened (squamous) epithelial cells, also called endothelium, which allows for easy passage of soluble materials and water.

Unlike the capillaries of the blood stream, the lymphatic capillaries begin blindly; that is, they do not serve to bridge two larger vessels. Instead, one end simply lies within a lake of tissue fluid, while the other communicates with the larger lymphatic vessel. In the small intestine are some specialized lymphatic capillaries, called lacteals, which act as one pathway for the transfer of fats from digested food to the bloodstream. This process is covered in the chapter dealing with the digestive system.

The *Capillaries* have the lateral recesses and form close net. In volumetric organs (kidneys, liver) they have three dimensions structure. In flat walls of hollow organs they are disposed in plane. Their wall consists of one layer of endothelial cells.

Lymphatic Vessels

The lymphatic vessels are thin walled and delicate and have a beaded appearance because of indentations where valves are located. These valves prevent backflow in the same way as those found in some veins. Although there is no pumping mechanism comparable to the heart, compression of the lymphatic vessels by contraction of the skeletal muscles during movement and expansion of the chest in breathing help maintain the forward flow of lymph.

Lymphatic vessels include superficial and deep sets. The surface lymphatics are immediately below the skin, often continuing near the superficial veins. The deep vessels are usually larger and accompany the deep veins.

Lymphatic vessels are named according to location. For example, those in the breast are called mammary lymphatic vessels, those in the thigh femoral lymphatic vessels, and those in the leg tibial lymphatic vessels. All the lymphatic vessels form networks, and at certain points they carry lymph into the regional nodes (the nodes that "service" a particular area). For example, nearly all of the lymph from the upper extremity and the breast passes through the axillary lymph nodes, while that from the lower extremity passes through the inguinal nodes. Lymphatic vessels carrying lymph away from the regional nodes eventually drain into one of the two terminal vessels, the right lymphatic duct or the thoracic duct, which empty into the bloodstream.

The right lymphatic duct is a short vessel about-1.25 cm ($^{1}/2$ inch) long that receives the lymph that comes from only the right side of the head, neck, and thorax, as well as from the right upper extremity. It empties into the right subclavian vein. Its opening into this vein is guarded by two pocket-like semilunar valves to prevent blood from entering the duct. The rest of the body is drained by the thoracic duct.

The *Vessels* subdivide into intraorganic and extraorganic, which subdivide into deep and superficial. Vessels have the valves, their wall consists of following layers:

1) endotelial (internal membrane);
2) muscular;
3) external membrane.

Lymph Nodes

The lymph nodes, as we have seen, are designed to filter the lymph once it is drained from the tissues. The lymph nodes are small, rounded masses varying from pinhead size to as long as 2.5 cm (1 inch). Each node has a fibrous connective tissue capsule from which partitions extend into the substance of the organ. Inside the node are masses of lymphatic tissue, with spaces set aside for the production of lymphocytes. At various points in the surface of the node, lymphatic vessels pierce the capsule to carry lymph into the spaces inside the pulplike nodal tissue. An indented area called the hilus (hi'lus) serves as the exit for lymph vessels carrying lymph out of the node. At this region other structures, including blood vessels and nerves, connect with the organ.

The Lymphatic nodes dispose on course of lymphatic vessels. They are organs of lymphopoesis and formation of antibodies, in pursuance the role of lymphoreticular filter.

Follow nodes are distinguished:
1. regional are the that cany a lymph from some body area or organ;
2. nodes have a name of accompany vessels;
3. superficial nodes;
4. deep nodes are situated under fascia;
5. *visceral* nodes are situated in body cavities;
6. parietal nodes are situated in walls of body cavities.

Each ganglion is covered outer by fibrous envelope - *capsule,* from which a frame-work of processes *(trabeculcuc)* proceeds inward. On node surface carries the concave place - *hilus,* where arteries and nerves enter into node, and the veins and efferent lymphatic vessels leave the interior. Node is built from *stroma* and *parenchyma.* Stroma of node consists of reticular tissue, where blood cells (mainly lymphocytes) disposed in loops. Cortex and medulla represent node parenchyma. *Medullar sinuses* are situated in lymphoid tissue, they are disposed between trabeculae and by bands of medulla, where lymph flows. The *afferent vessels* carry lymph into node and sinuses, *efferent vessels* commences from interior and transport lymph to the next lymphatic nodes, trunks and ducts.

Lymphatic Trunks:

1) *subclavian trunk* (right and left); 2) *jugular trunk* (right and left); 3) *broncho-mediastinal trunk* (right and left). They collect lymph from suitable half of head, neck, upper limbs, left or right half of thoracic cavity. These trunks fall into right venous angle or into left venous angle are these venous angles which are formed by subclavian vein and internal jugular vein. 4) *lumbar trunk* (right and left) collects lymph from lower limbs.

Lymphatic Ducts:

Thoracic duct forms in abdominal cavity on level of XII thoracic -II lumbar vertebrae by the confluence of *right and left lumbar lymphatic trunks.* There is triangular dilatation, *thzcisterna chyli* or cistern of thoracic duct in this spot. Duct has abdominal part, thoracic part, cervical part and arch of thoracic duct. Last rounds a pleura cupola and ends by opening into the angle of junction of the left subclavian vein with the left internal jugular vein. In thoracic cavity a thoracic duct is situated in posterior mediastinum. It collects lymph from both lower limbs, abdominal, pelvic and left half of thoracic cavities.

Right lymphatic duct is short, by length 10-12 mm, which is formed by confluence *of right subclavian trunk, jugular trunk* and *broncho-mediastinal trunk* and runs into *right venous angle.* This duct transports

lymph from right half of head, neck, right upper limb, right half of thoracic cavity. Frequently this duct can be absent, then the trunks independently fall into right venous angle or into terminal portion of thoracic duct.

LYMPHATIC VESSELS AND REGIONAL LYMPHATIC NODES

The Lymphatics of the Lower Extremity

The superficial and deep vessels are distinguished in lower limb. The superficial vessels are situated over superficial fascia and deep vessels positioned closely to deep blood vessels. *Popliteal* nodes and *inguinal* nodes are distinguished in lower limb. Last one subdivide into deep inguinal nodes and superficial inguinal nodes. Superficial inguinal nodes dispose along inguinal ligament and lie on superficial sheet of fascia lata femoris. Their efferent vessels pass to external iliac nodes, which accompany same name artery.

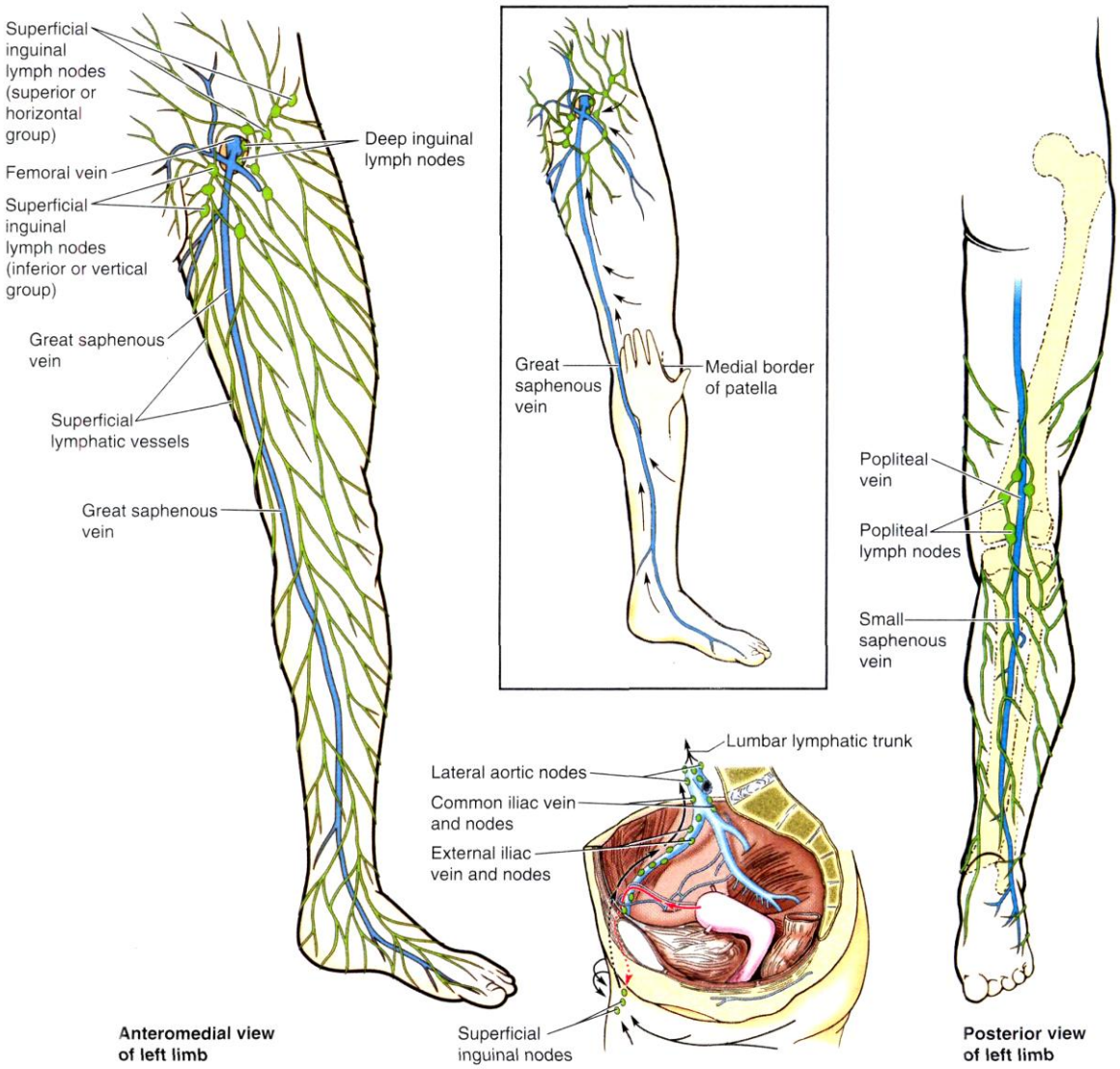
The superficial vessels of lower limb formed from capillary skin networks and subcutaneous cellular tissue and form *medial, lateral* and *posterior* vessel groups,

Medial group of superficial vessels formed in skin of I, II and III fingers, medial part of foot and medial surface of shin. These vessels run along vena saphena magna and empty into superficial inguinal nodes.

Lateral group of superficial vessels of lower limb formed laterally in area of fingers in dorsal foot surface and lateral surface of shin. These vessels beneath knee join to medial group.

Posterior group of superficial vessels of lower limb starts in skin of heel and plantar surface of lateral foot margin, passes along the vena saphaena parva and runs into popliteal lymphatic nodes.

Deep vessels of lower limb drainage muscles, joints, synovia! sheaths, bones, nerves, accompany deep arteries and veins and empty into deep inguinal nodes.



Medial view: *Arrows* represent the continuation of lymph drainage from the lower limb via the superficial inguinal and iliac nodes

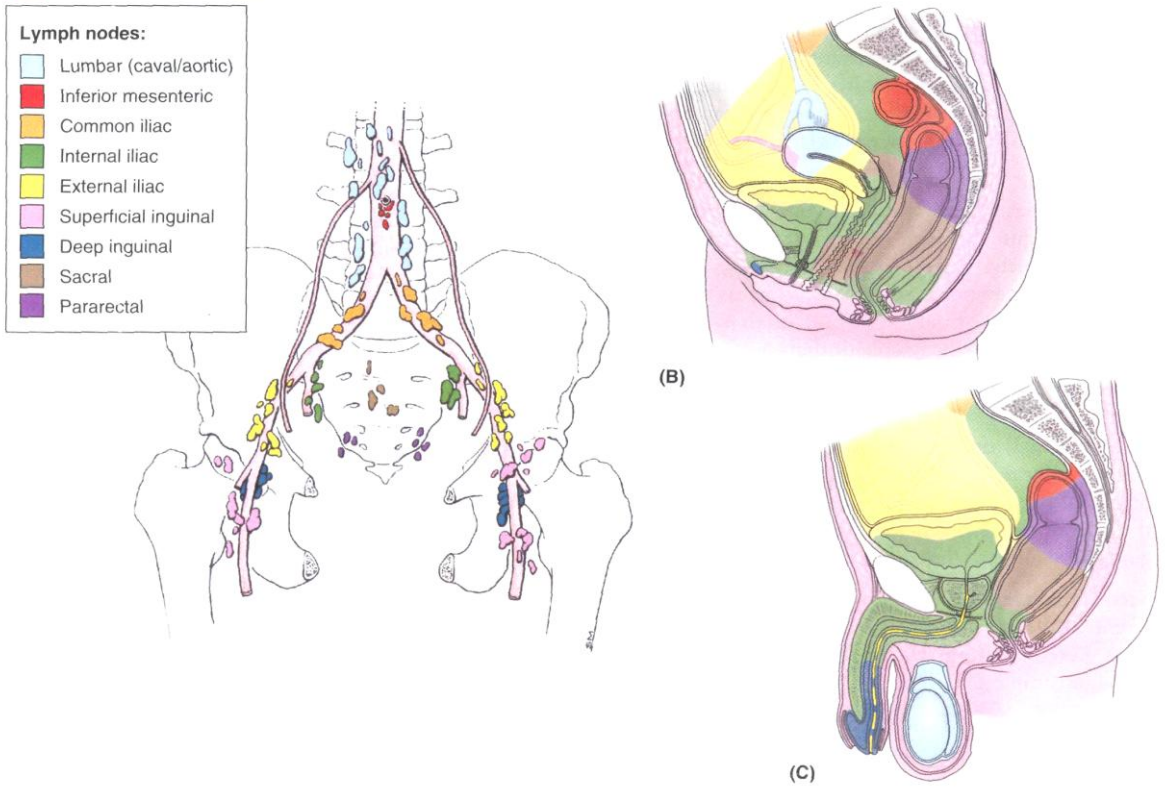
The Lymphatics of the Pelvis

In pelvic area differ the visceral and parietal lymphatic nodes.

The visceral lymphatic nodes dispose near pelvic organs and they *arQ'.paravesical, prevesical*and *retrovesical nodes, lateral vesical nodes, parauterine nodes, paravaginal nodes andpararectal* or *anorectal nodes.* The efferent vessels from these nodes pass into *iliac nodes,* mainly to *common iliac nodes* and to *retroaortic nodes.* Lymph flows from ovaries into *lumbar nodes.*

The parietal lymphatic nodes disposed along the course of big vessels *common iliac nodes; internal iliac nodes,* which unite *gluteal* and *sacral nodes. External iliac nodes* join *obturator nodes.* The efferent vessels from these nodes pass first into *common iliac nodes,* then into retroaortic nodes, and from them - into *lumbar lymphatic nodes.*

Table Lymphatic Drainage of the Structures of the Pelvis and Perineum



Lymph Node Group		Structures Typically Draining to Lymph Node Group	
Lumbar	*Female:* along ovarian vessels	Gonads and associated structures; common iliac nodes	*Female:* ovary; uterine tube (except isthmus and intrauterine parts); fundus of uterus
	Male: along testicular vessels		*Male urethra:* testis; epididymis
Inferior mesenteric		Superiormost rectum; sigmoid colon; descending colon; pararectal nodes	
Common iliac		External and internal iliac lymph nodes	
Internal iliac		Inferior pelvic structures; deep perineal structures; sacral nodes	*Female:* base of bladder; inferior pelvic ureter; anal canal (above pectinate line); inferior rectum; middle and upper vagina; cervix; body of uterus
			Male: prostatic urethra; prostate; base of bladder; inferior pelvic ureter; inferior seminal glands; cavernous bodies; anal canal (above pectinate line); inferior rectum
External iliac		Anterosuperior pelvic structures; deep inguinal nodes	*Female:* superior bladder; superior pelvic ureter; upper vagina; cervix; lower body of uterus
			Male: superior bladder; superior pelvic ureter; upper seminal gland; pelvic part of ductus deferens; intermediate and spongy urethra (secondary)

(continues)

The Lymphatics of the Abdomen

In abdominal cavity, as and in pelvis, lymphatic nodes may be divided into two sets, parietal and visceral.

The Visceral lymphatic nodes dispose along the course of big vessels come away from abdominal aorta, they receive lymph from all internal abdominal organs: *coeliac nodes, right/left gastric nodes, lymphatic unnulus ofcardia, right/left gastroepiploic nodes, pyloric nodes, pancreatic nodes, splenic nodes, pancreatoduodenal nodes, hepatic nodes, superior mesenteric nodes* and *inferior mesenteric nodes.* The lymphatic vessels of the small intestine receive the special designation of *lacteals* or *chyliferous* vessels; they differ in no respect from the lymphatic vessels generally excepting that during the process of digestion they contain a milk-white fluid, the chyle. The lymphatic vessels and nodes of the small intestine positioned in mesentery and empty into *intestinal trunk.* The vessels take away lymph from these nodes, pass *to lumbar nodes.* Efferent vessels of last form the lumbar trunks, which flowing together form a *thoracic duct.*

The parietal lymphatic nodes disposed around aortae and inferior vene cava *-right/left*and *intermidiate lumbar nodes, lateral aortic nodes, preaortic* nodes, *retroaortic nodes, lateral caval* nodes, *precaval* nodes, *retrocaval* nodes, *inferior phrenic* nodes and *inferior epigastric* nodes.

Lymphatic vessels of superior half of abdominal wall pass upward *tothGOxillar* lymphatic nodes. The vessels of inferior half of abdominal wall pass downward to *inguinal* lymphatic nodes.

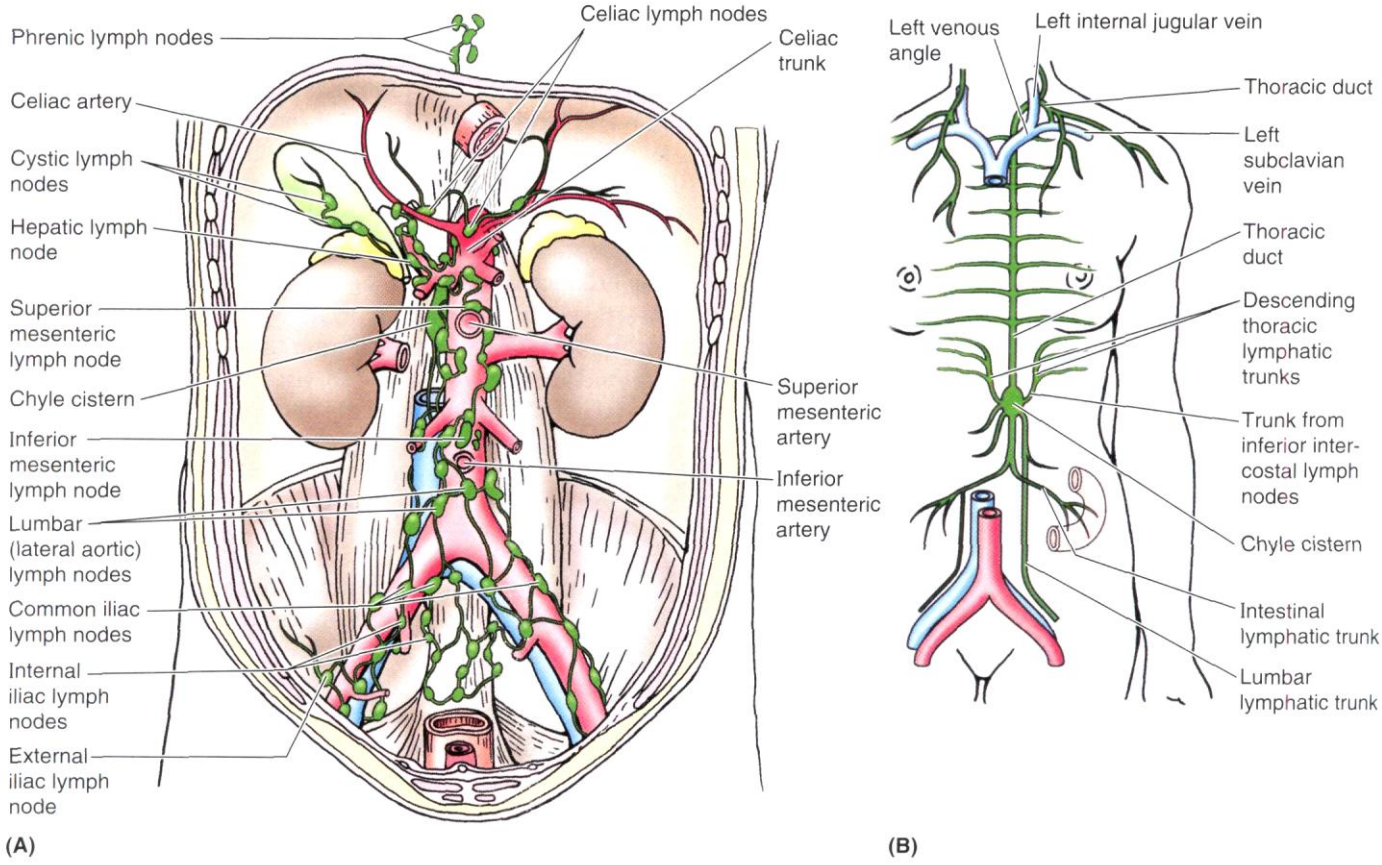


Figure **Lymphatic drainage of posterior abdominal wall and lymphatic trunks of abdomen. A.** The parietal lymph nodes are shown. The external iliac, common iliac, and lumbar (aortic) lymph nodes lie in a continuous chain along the abdominal aorta and its terminal branches, receiving lymph from the posterior abdominal wall as well as the efferent drainage of lymph nodes of the abdominal viscera and lower limbs. **B.** The abdominal lymphatic trunks are shown. The thoracic duct begins posterior to the aorta at the aortic hiatus as a convergence of lymphatic trunks that may or may not take the form of a chyle cistern. The converging lymphatic trunks include the paired lumbar lymph trunks, the intestinal lymphatic trunk(s), and a pair of descending thoracic lymphatic trunks. All lymphatic drainage from the lower half of the body converges in the abdomen to enter the beginning of the thoracic duct. The thoracic duct conducts it to the convergence of the left internal jugular and subclavian veins (left venous angle) where the lymph enters the venous system.

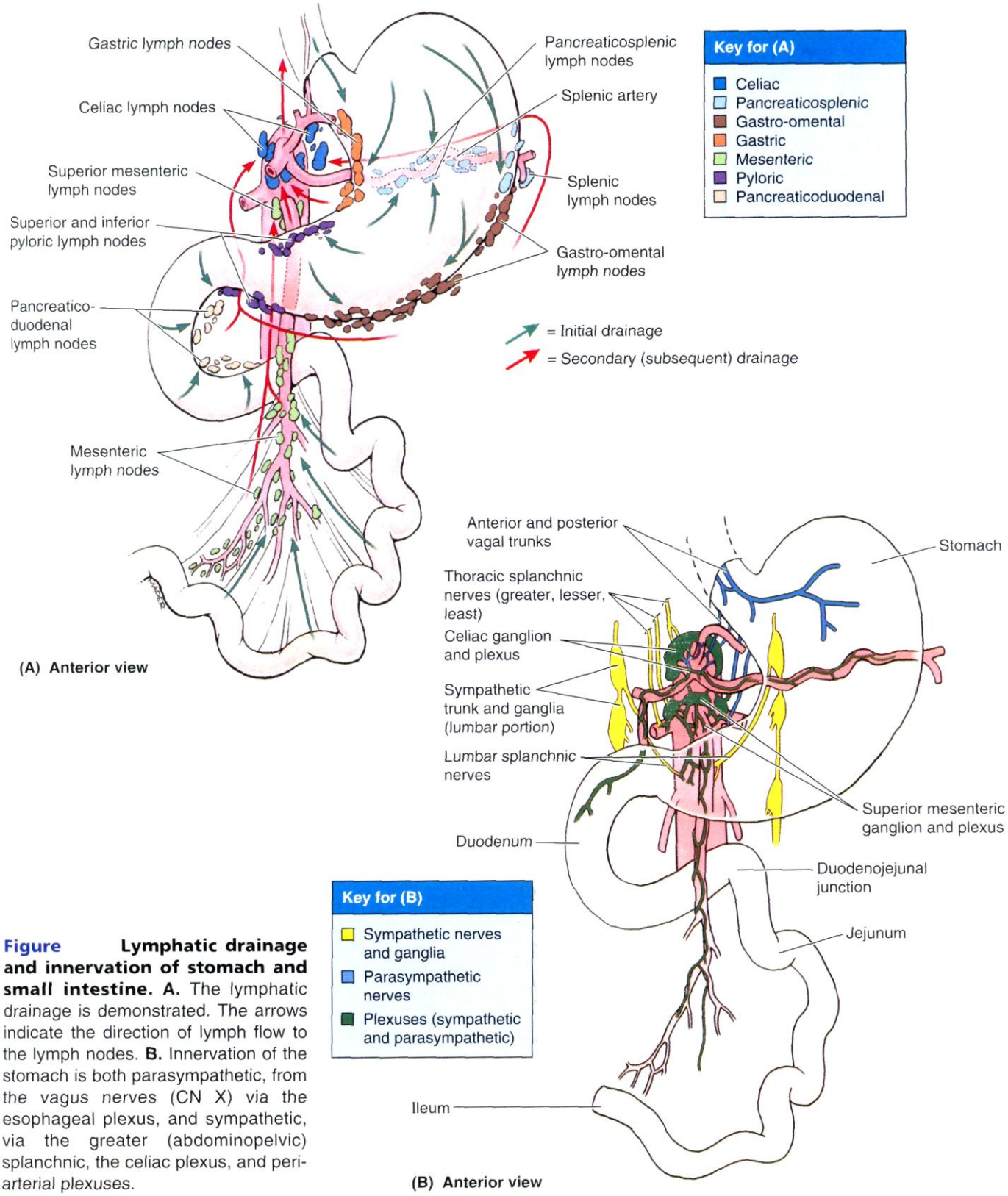
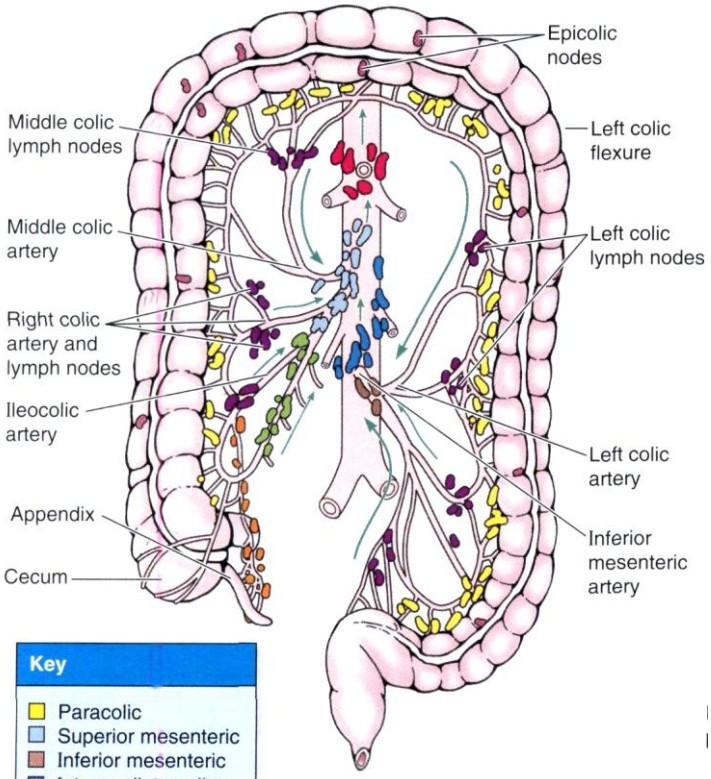


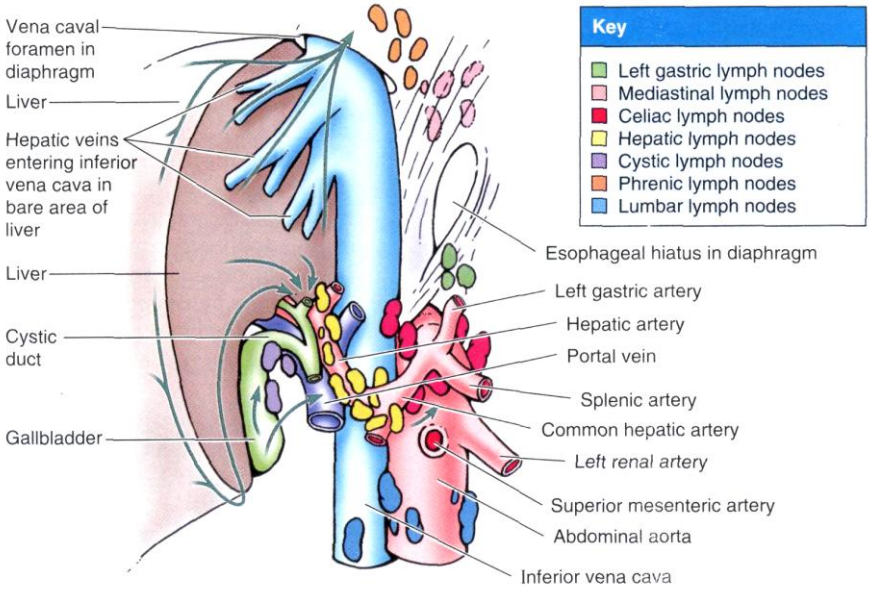
Figure Lymphatic drainage and innervation of stomach and small intestine. A. The lymphatic drainage is demonstrated. The arrows indicate the direction of lymph flow to the lymph nodes. **B.** Innervation of the stomach is both parasympathetic, from the vagus nerves (CN X) via the esophageal plexus, and sympathetic, via the greater (abdominopelvic) splanchnic, the celiac plexus, and peri-arterial plexuses.

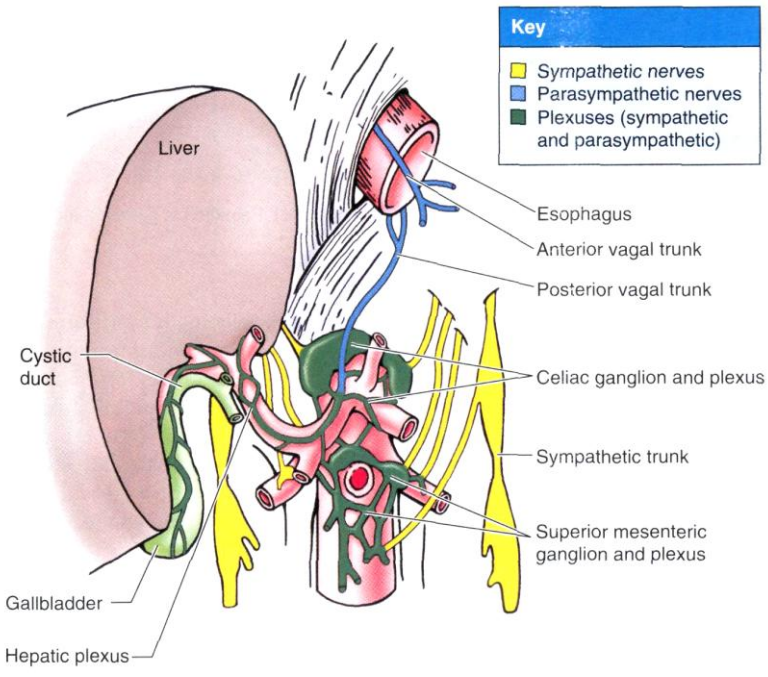
Lymphatic nodes of large intestine



Lymph nodes

Lymphatic nodes and lymphatic vessels of the liver and bill bladder

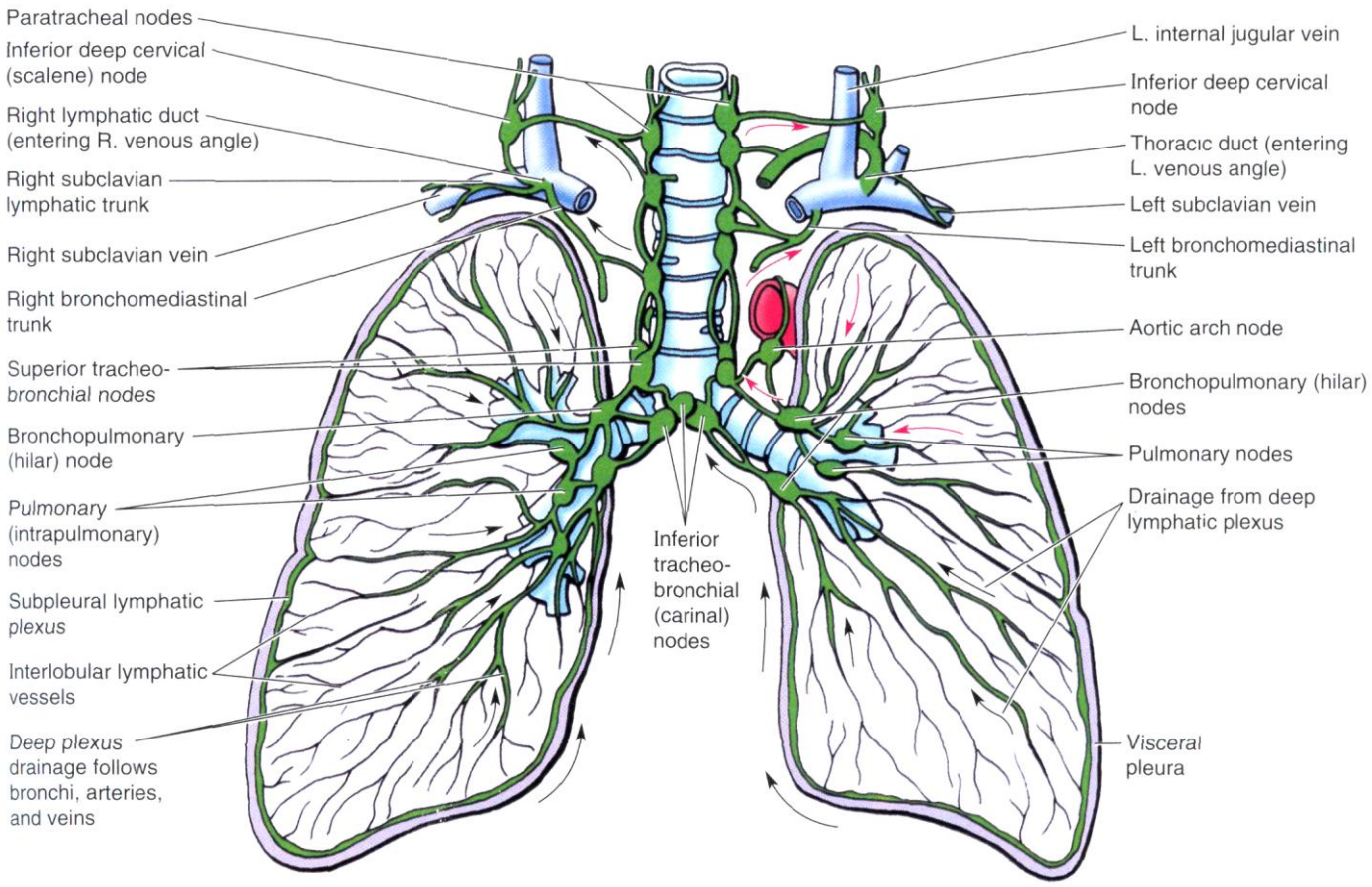




The Lymphatic Vessels of the Thorax

Lymphatic nodes of the thorax may be divided into two sets, parietal and visceral.There distinguish the-folio wing *parietal* nodes of thorax:

1. Parastemal nodes collect lymph from pericardium, pleura, anterior thoracic wall, diaphragmatic surface of liver, mammary gland.



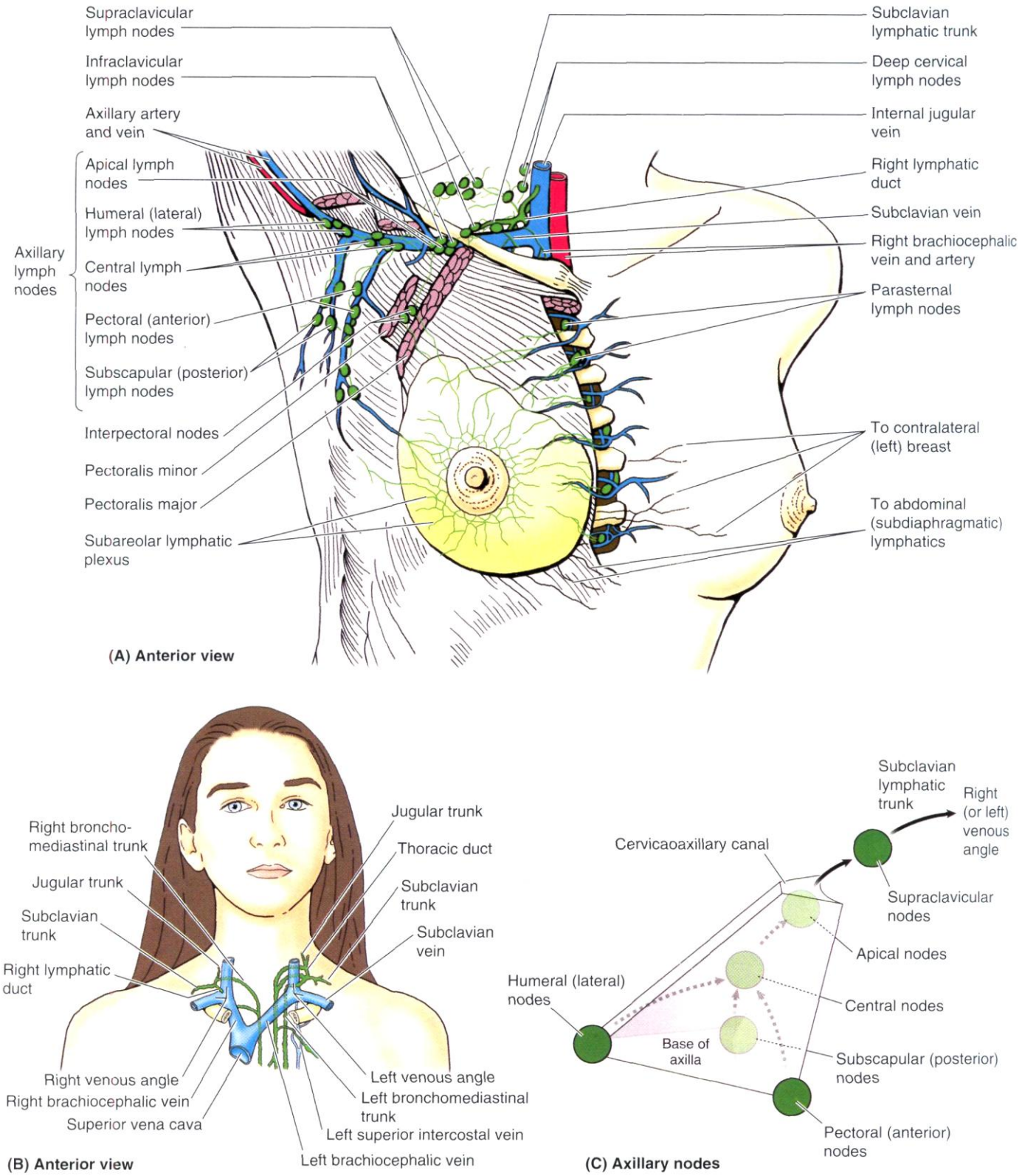
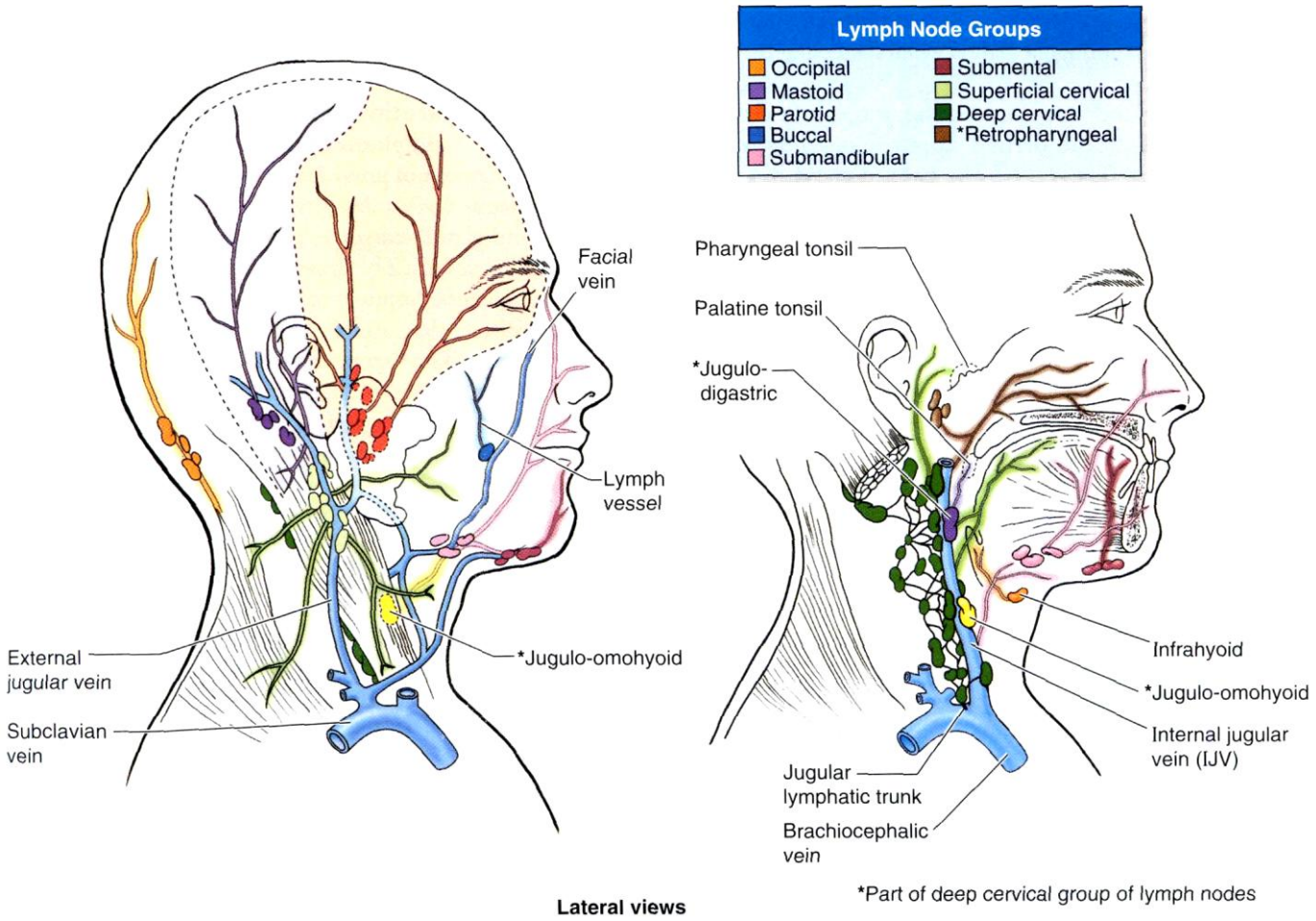


Figure **Axillary lymph nodes and lymphatic drainage of right upper limb and breast. A.** Of the five groups of axillary lymph nodes, most lymphatic vessels from the upper limb terminate in the humeral (lateral) and central lymph nodes, but those accompanying the upper part of the cephalic vein terminate in the apical lymph nodes. The lymphatics of the breast are discussed in Chapter 1. **B.** Lymph passing through the axillary nodes enters efferent lymphatic vessels that form the subclavian lymphatic trunk, which usually empties into the junctions of the internal jugular and subclavian veins (the venous angles). Occasionally, on the right side, this trunk merges with the jugular lymphatic and/or bronchomediastinal trunks to form a short right lymphatic duct; usually on the left side, it enters the termination of the thoracic duct. **C.** The positions of the five groups of axillary nodes, relative to each other and the pyramidal axilla. The typical pattern of drainage is shown.

The Lymphatics of the Head, Face, and Neck

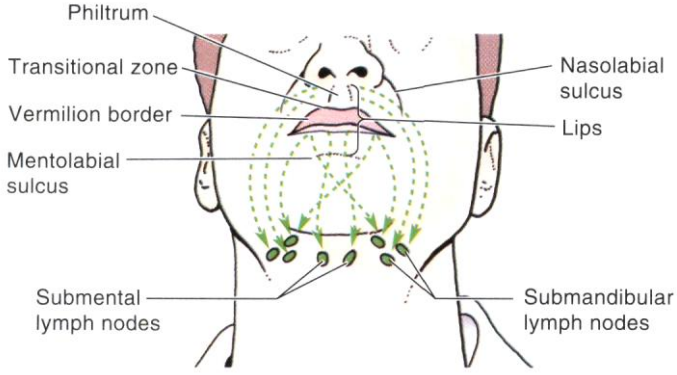
Lymph from head and neck gathers into *right* and *left jugular lymphatic trunks*, which pass on each side near internal jugular vein and fall: right - into right lymphatic duct or into right venous angle and left - into thoracic duct or immediately into left venous angle. Before duct lymph passes through regional lymphatic nodes.

Lymph from head runs into nodes positioned on boundary between head and neck. They include the following: 1) *occipital* nodes, 2) *mastoid* nodes, 3) *superficial parotid* nodes, 4) *deep parotid* nodes, 5) *submandibular* nodes, *6)facial* nodes, *l}submental* Efferent vessels from these nodes extend in ***deep cervical nodes.***



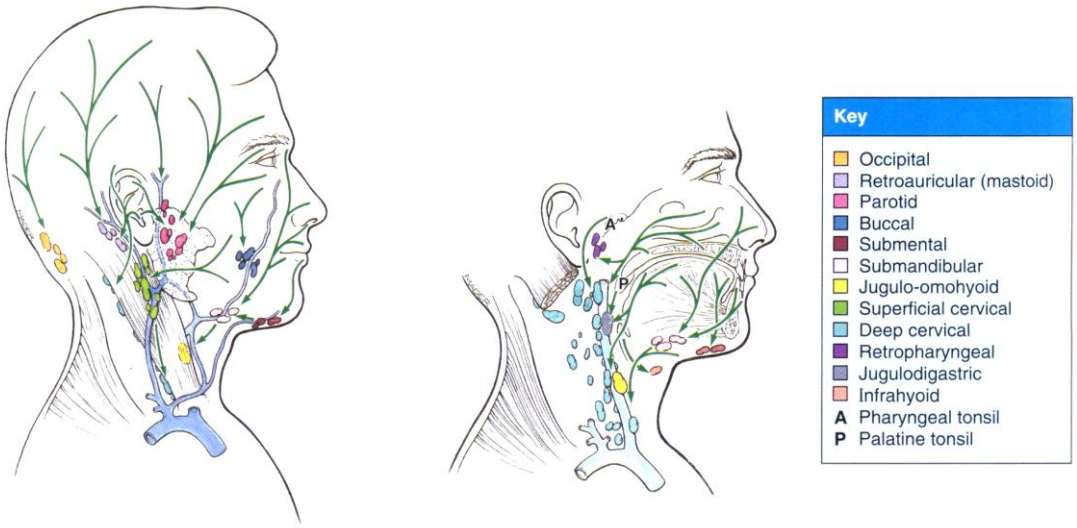
Lateral views

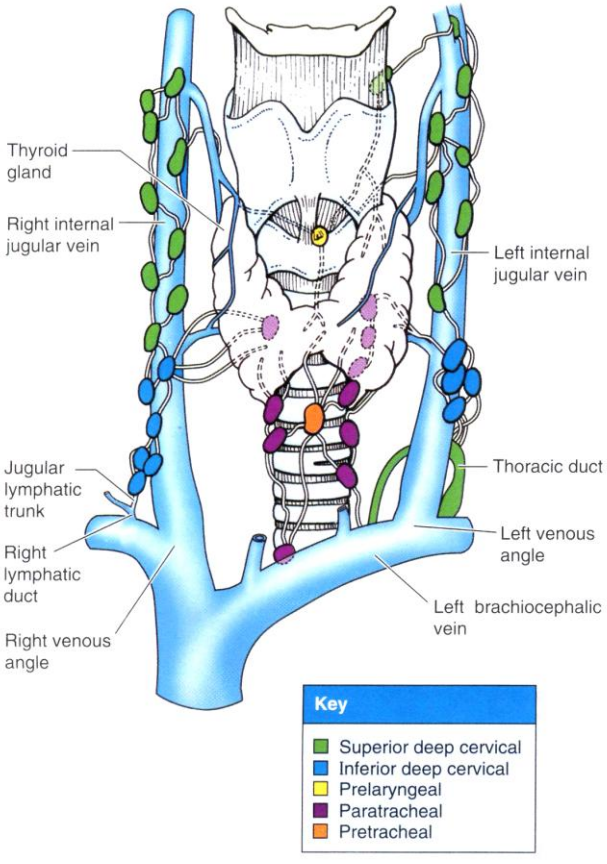
*Part of deep cervical group of lymph nodes



Anterior view

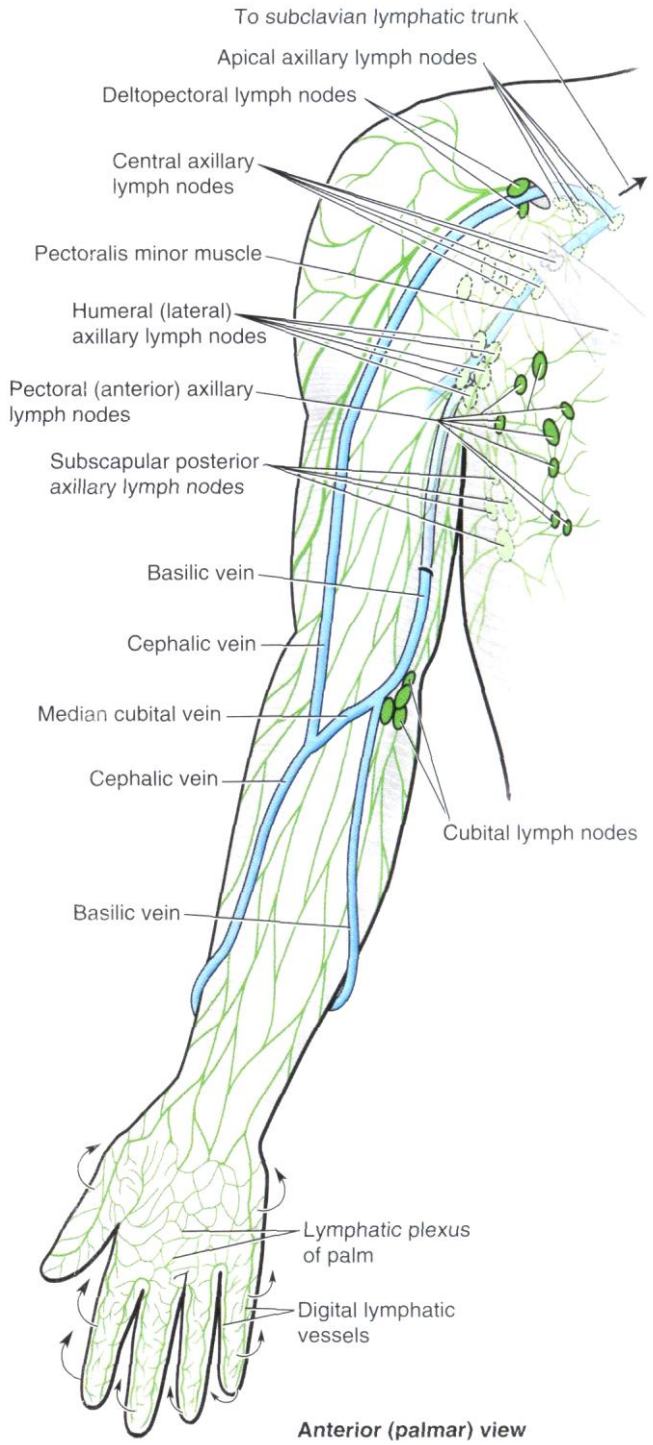
There are two groups of lymphatic nodes on neck - *anterior* cervical nodes and *lateral* cervical nodes, which subdivide into *superficial* and *deep.* Anterior deep lymphatic nodes: *prelaryngeal* nodes, *thyroid nodes*, *pretracheal* nodes, *paratracheal* nodes. The superficial lateral nodes lie along external jugular vein, and deep - along internal jugular vein.





Lymphatic nodes of upper limb may be divided into two sets, *superficial* and *deep*.

The superficial vessels and nodes of upper limb pass along the course of vena basilica and vena cephalica and compose lateral, medial and middle groups. *Lateral group* of superficial vessels carries lymph from skin of I-III fingers, lateral forearm surface and arm to axillar lymphatic nodes. *Medial group* of superficial vessels carries lymph from IV-V fingers, hand, medial forearm side and brachium to cubital and axillar lymphatic nodes. *Middle group* carries lymph from palmar forearm surface to cubital fossa and here part of vessels joins to lateral grand, and part to medial group. The superficial lymphatic nodes accompany the superficial hand veins. They collect lymph from skin and subcutaneous tissue. From them lymph passes to ***cubital nodes*** and ***axillar nodes.***



Deep vessels and nodes of upper limb accompany the deep big vessels and carry lymph into deep nodes and superficial nodes, and from here -into *cubital nodes* and *axillar lymphatic nodes.* Axillar nodes receive the vessels from upper limb, thoracic wall, and mammary gland. The efferent vessels from axillar nodes form a ***subclavian*** *trunk* (left and right).

Lymphatic annulus of pharynx belongs to secondary lymphatic organs and consists of *lingual tonsil, palatine tonsil, pharyngeal tonsil* and *tubarius tonsil.* They have tonsillar cryptae and tonsillar fossulae and lymphatic nodules. These tonsils are described in part "pharynx". Tonsils are agglomerations of lymphoid tissue, which is disposed in area of entrance to pharynx and nasopharynx. They are placed around initial portions of high respiratory and digestive paths (lymphoepithelial *ring of Pyrohov-Valdeyer).*

The ***Lymphatic follicles of gastrointestinal*** *tract* are agglomeration lymphoid tissue in mucous membrane of the stomach (the gastric lymphatic follicles), small intestine *(solitary lymphatic follicles* and *aggregate lymphatic follicles - Payer patches),* large intestine *(solitary lymphatic follicles* and *aggregate lymphatic follicles of vermiform processes).* The largest amount of Payer patches is situated in distal portion of iliac bowel. T-lymphocytes migrate freely from lymphatic follicles through epithelium of mucous membrane into intestinal shaft of light.