

Functional Anatomy of the vascular system of the head and neck

Anatomical peculiarities of the cerebral arteries

Anatomical peculiarities of the cerebral veins

Vascular anastomoses of the head and neck

Variants and anomalies of the blood vessels of the head and neck

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Anatomical peculiarities of the cerebral arteries

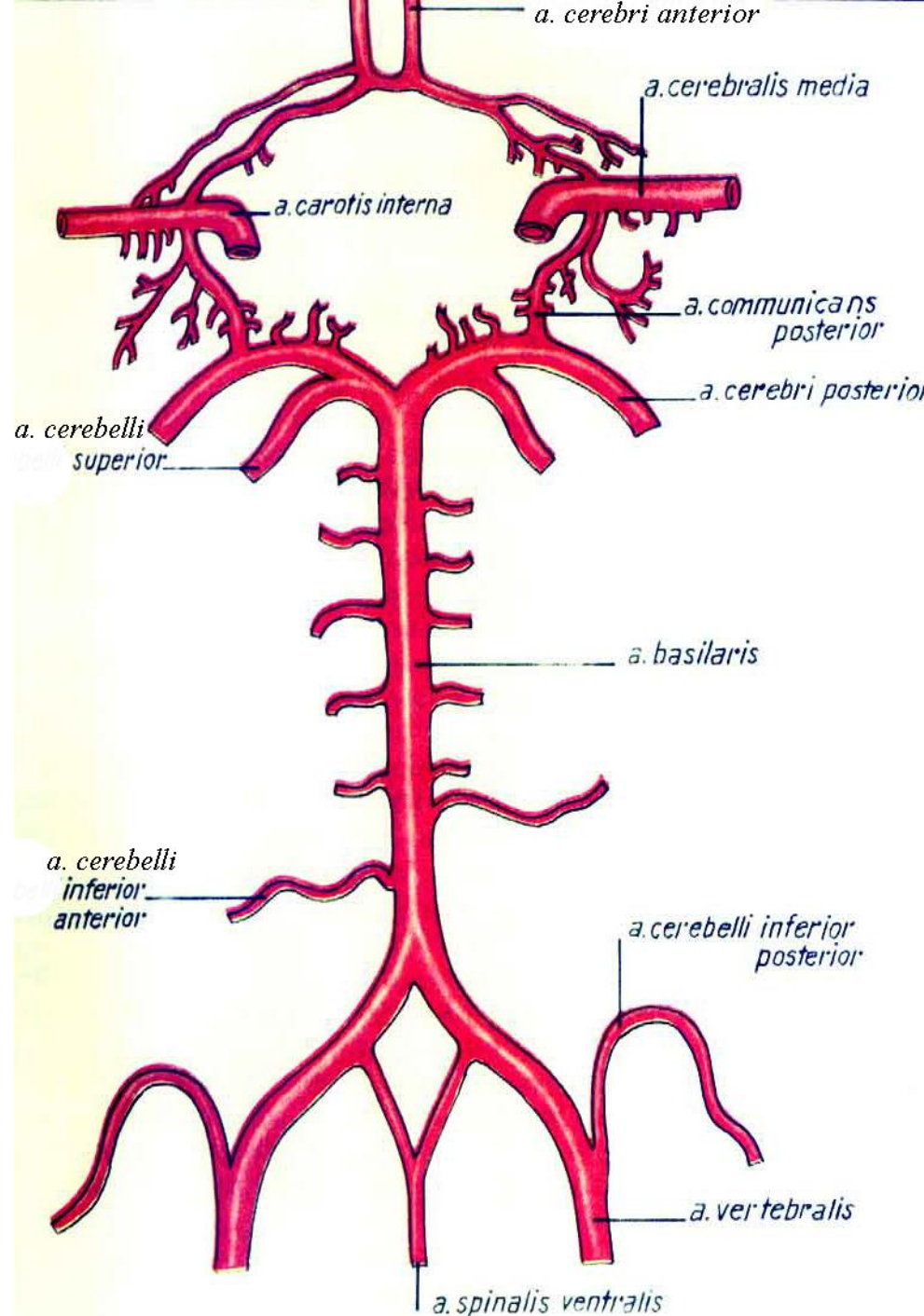
One peculiar feature is the presence of anastomosis in the form of the arterial circle /circle of Willis/.

it is formed:

anteriorly by the anterior communicating artery,
posteriorly by the basilar artery as it divides into the right and left posterior cerebral arteries,
on each side by the anterior cerebral, internal carotid, posterior communicating and posterior cerebral arteries.

It lies in the interpeduncular subarachnoid cistern.

It equalizes pressure in the arteries of the two sides.

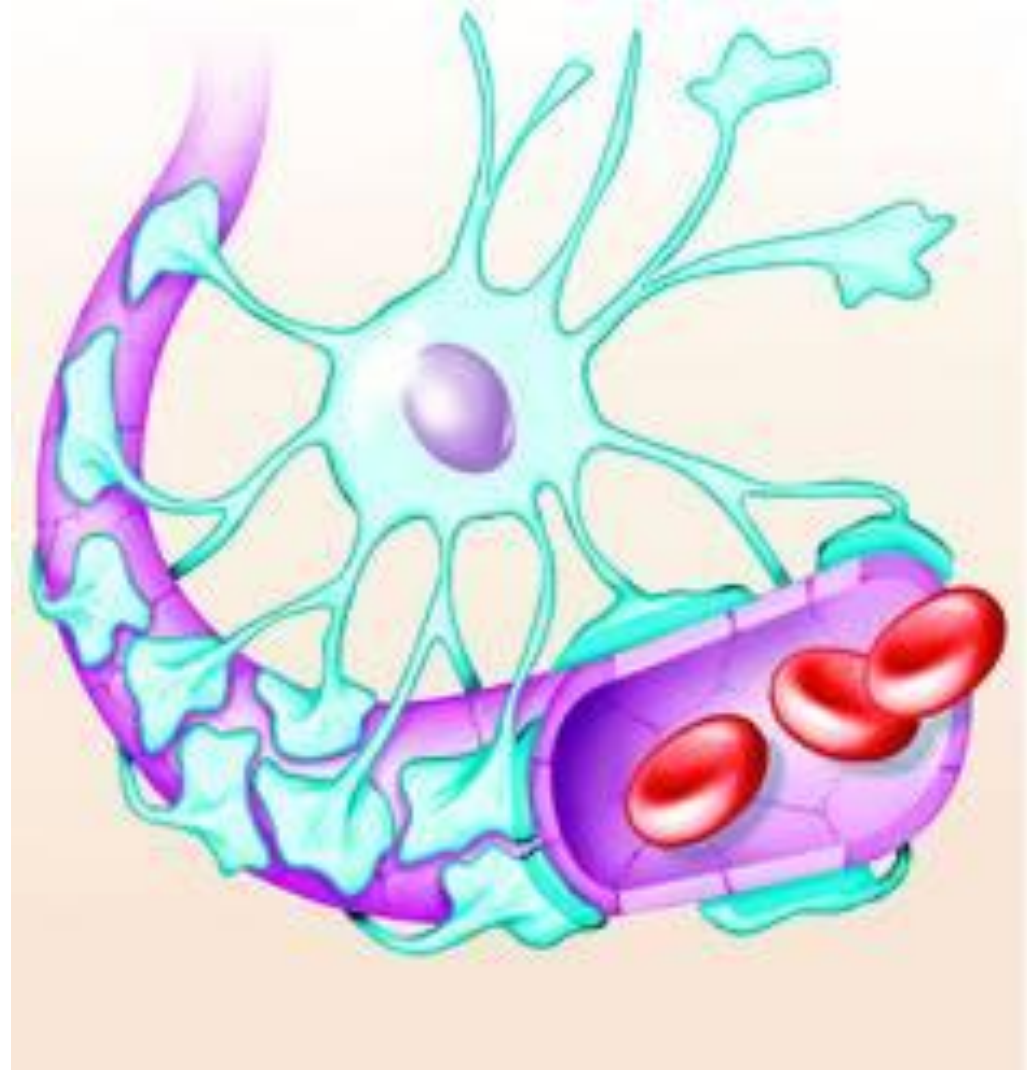


The second peculiarity is
the existence of a
„blood-brain” barrier
formed by structures
between the blood and
nerve cells of the brain.

This barrier is made up of:

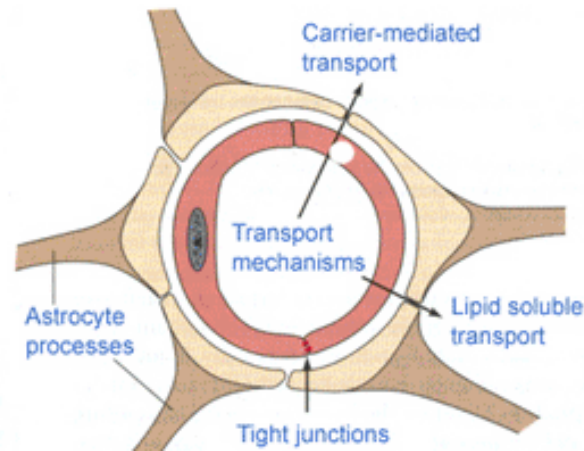
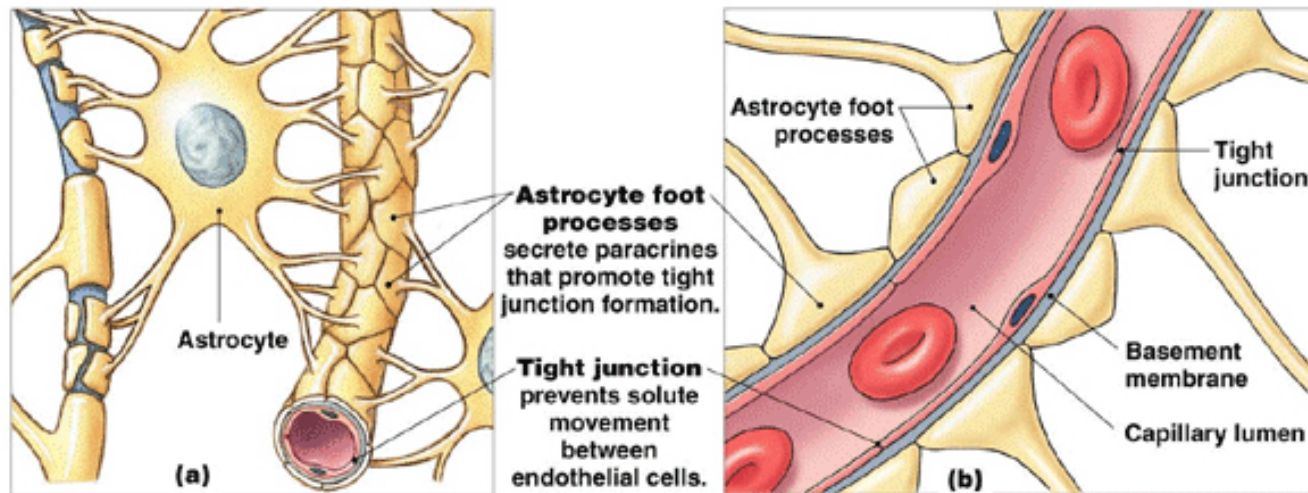
- the vessel wall;
- the neuroglia;
- the ground substance of the brain.

- The barrier, at the capillary level, is reduced merely to the capillary endothelium with neuroglia and ground substance.
- Toxic and harmful substances are ordinarily prevented from reaching the brain.



The blood-brain barrier (BBB)

- It is a separation of circulating **blood** and tissue of the **central nervous system** (CNS).
- It occurs along all capillaries and consists of tight junctions around the capillaries that do not exist in normal circulation.
- **Endothelial cells** restrict the diffusion of microscopic objects (e.g. **bacteria**) and large or **hydrophilic** molecules into the CSF, while allowing the diffusion of small **hydrophobic** molecules (O₂, hormones, CO₂).
- Cells of the barrier actively transport **metabolic** products such as glucose across the barrier with specific proteins.



Blood-Brain Barrier

*Protective mechanism that helps maintain a stable environment for the brain

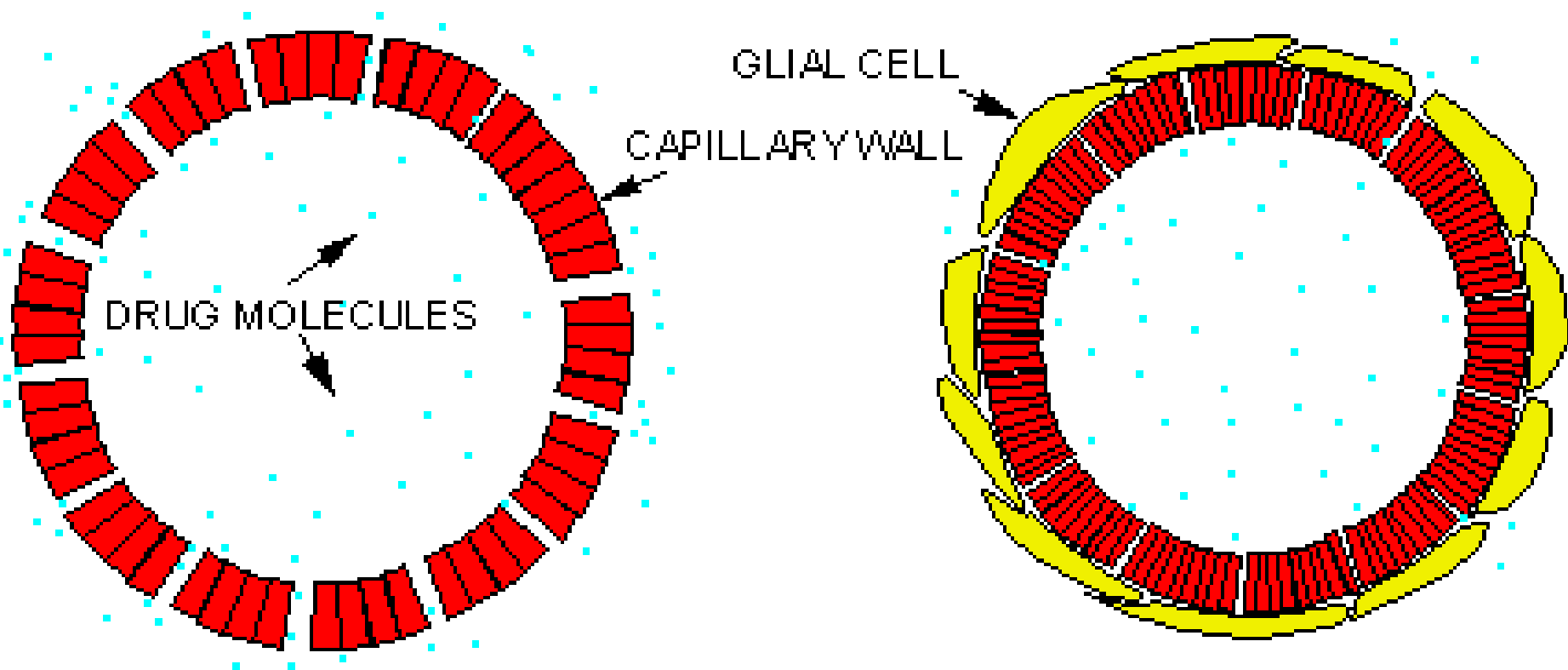
*Blood borne substances in brain capillaries are separated from neurons by:

- Continuous endothelium of capillary walls
- Relatively thick basal lamina
- Bulbous feet of astrocytes

Least permeable capillaries in the body due the nature of the tight junctions between endothelial cells

Blood-Brain Barrier: Functions

- *Selective barrier that allows nutrients to pass freely**
- *Is ineffective against substances that can diffuse through plasma membranes (fats, gasses, alcohol)**
- *Absent in some areas (vomiting center and the hypothalamus), allowing these areas to monitor the chemical composition of the blood**



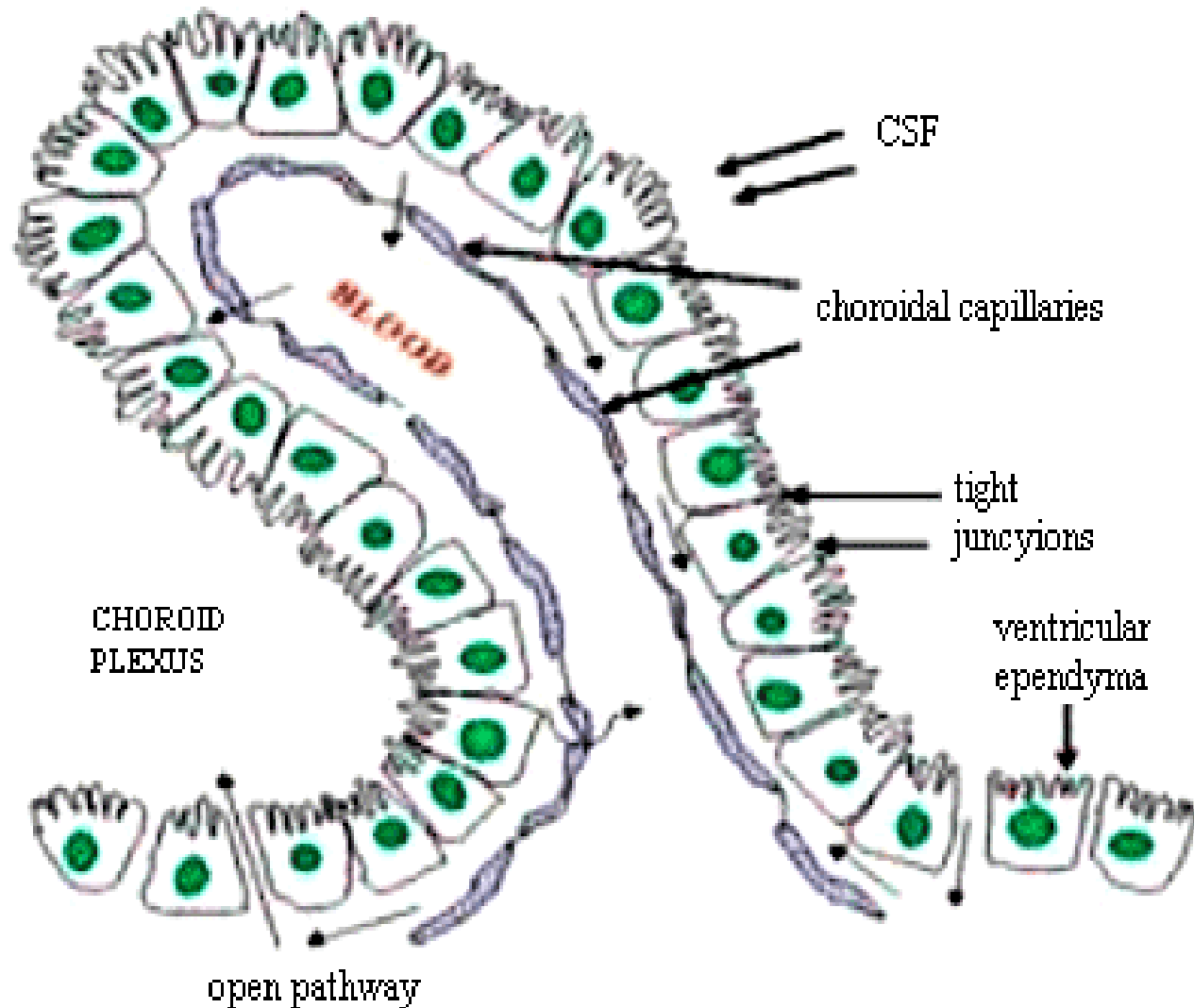
General body capillaries allow drug molecules to pass freely into the surrounding tissue.

Brain capillaries have a dense-walled structure and are surrounded by glial cells (lipid). This prevents many drug molecules from entering the surrounding tissue.

This barrier is made up of:

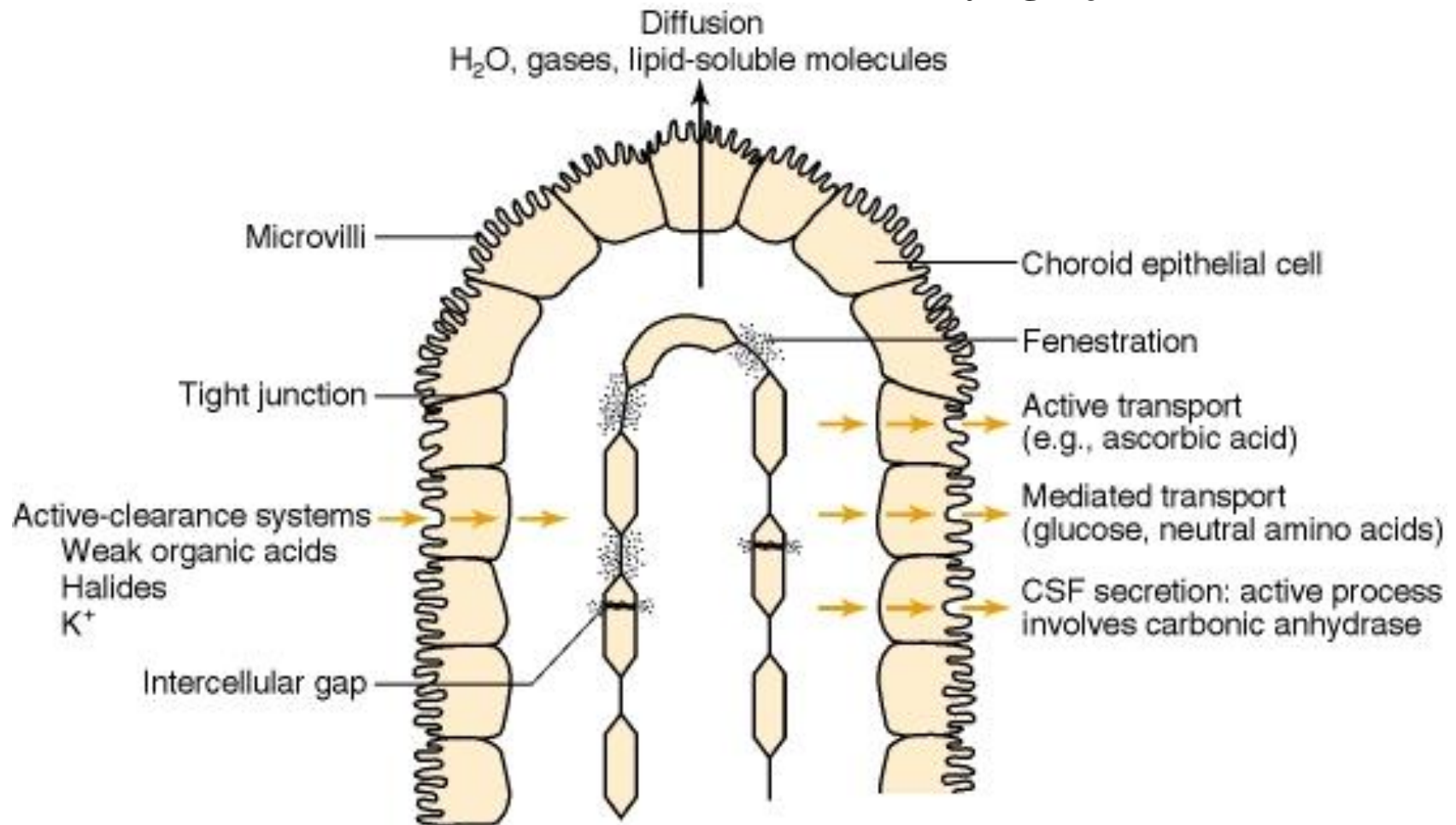
- the arachnoid layer of the perivascular sheath;
- the perivascular space;
- the pial layer of the perivascular sheath

The **BBB** is distinct from the quite similar **blood-cerebrospinal fluid barrier**, which is a function of the choroidal cells of the **choroid plexus**, and from the **blood-retinal barrier**, which can be considered a part of the whole realm of such barriers. Several areas of the human brain are not "behind" the BBB. These include the **circumventricular organs**. One example of this is the **pineal gland**, which secretes the hormone **melatonin** "directly into the systemic circulation" as this hormone can pass through the blood-brain barrier.

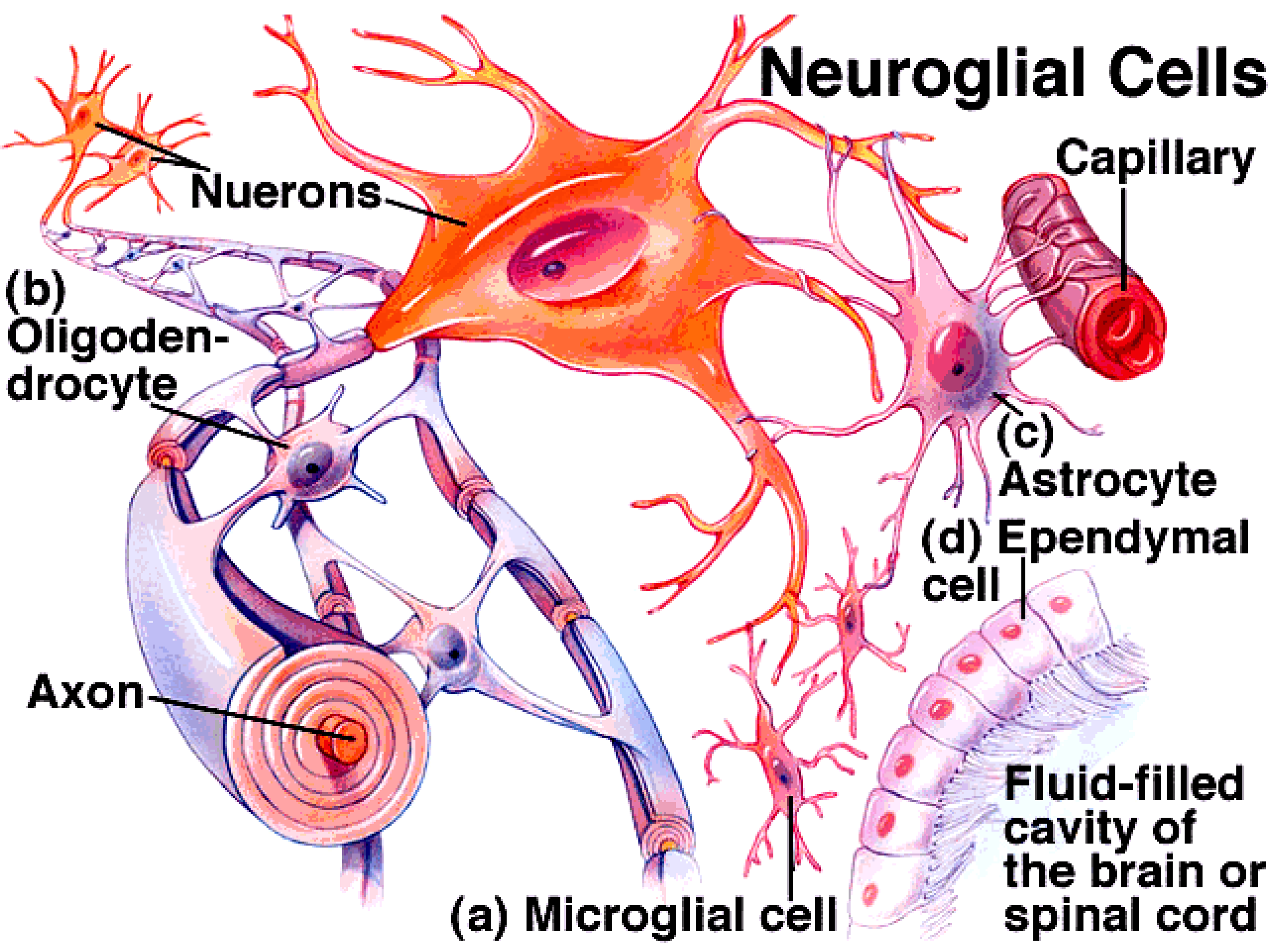


Unlike the capillaries that form the blood—brain barrier, **choroid plexus capillaries are fenestrated and have no tight junctions**. The endothelium, therefore, does not form a barrier to the movement of small molecules. Instead, the blood—CSF barrier at the choroid plexus is formed by the epithelial cells and the tight junctions that link them. The other part of the blood—CSF barrier is the arachnoid membrane, which envelops the brain.

The cells of this membrane also are linked by tight junctions.



Neuroglial Cells



Neurons

Capillary

(b) Oligodendrocyte

(c) Astrocyte

(d) Ependymal cell

Axon

Fluid-filled cavity of the brain or spinal cord

(a) Microglial cell

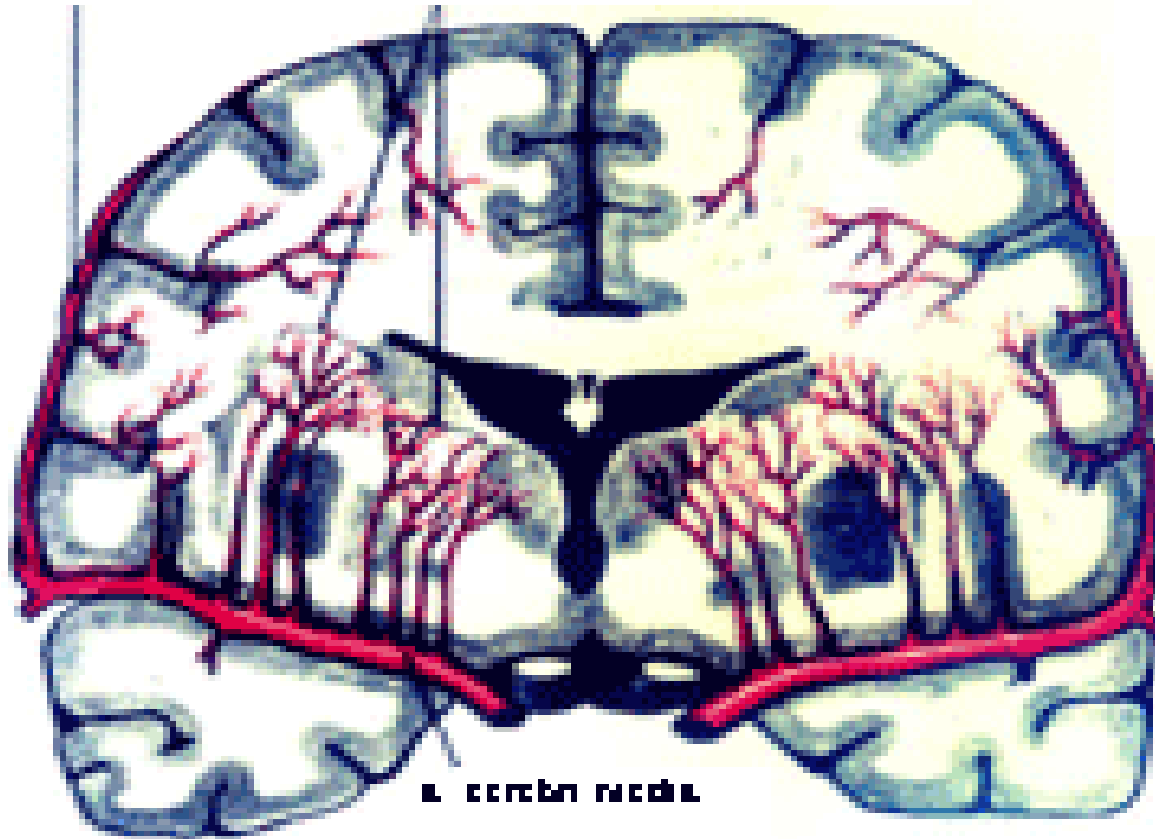
The third significant fact is that central branches of cerebral arteries are end arteries. An end artery is an artery that is the only supply of oxygenated blood to a portion of tissue.

End arteries are also known as terminal arteries.

Thrombosis of any one of them, invariably causes infarction.

The cortical branches establish very poor anastomoses with each other: the anastomoses cannot compensate for any loss of blood supply to a particular area of the cortex.

anastomoses in cerebral arteries



anastomoses in cerebral arteries

**The types of
end arteries are:**

Anatomic (True) End Artery:
they do not undergo
anastomoses

Functional End Artery:
arteries with ineffectual
Anastomoses

End artery one which undergoes progressive branching without development of channels connecting with other arteries, so that if occluded it cannot supply sufficient blood to the tissue depending on it.

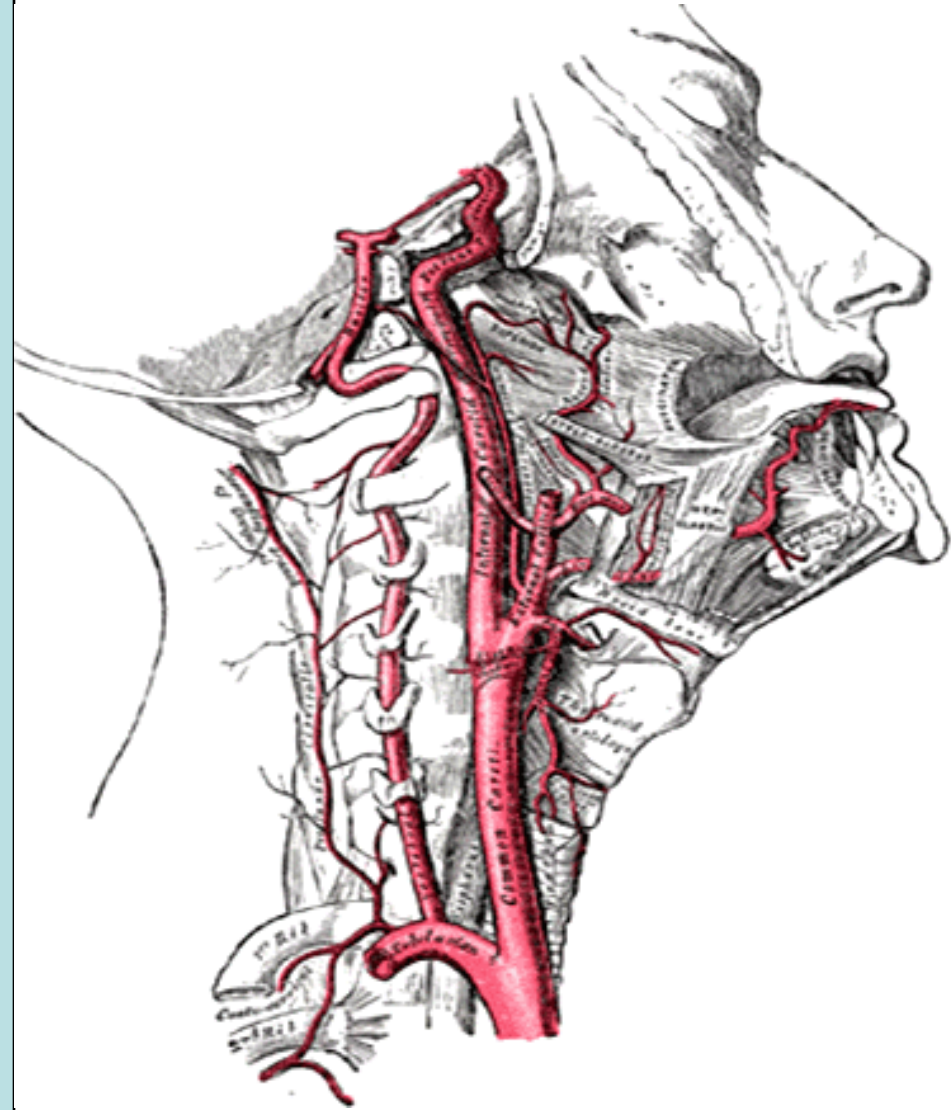
Arterial vessels of the brain

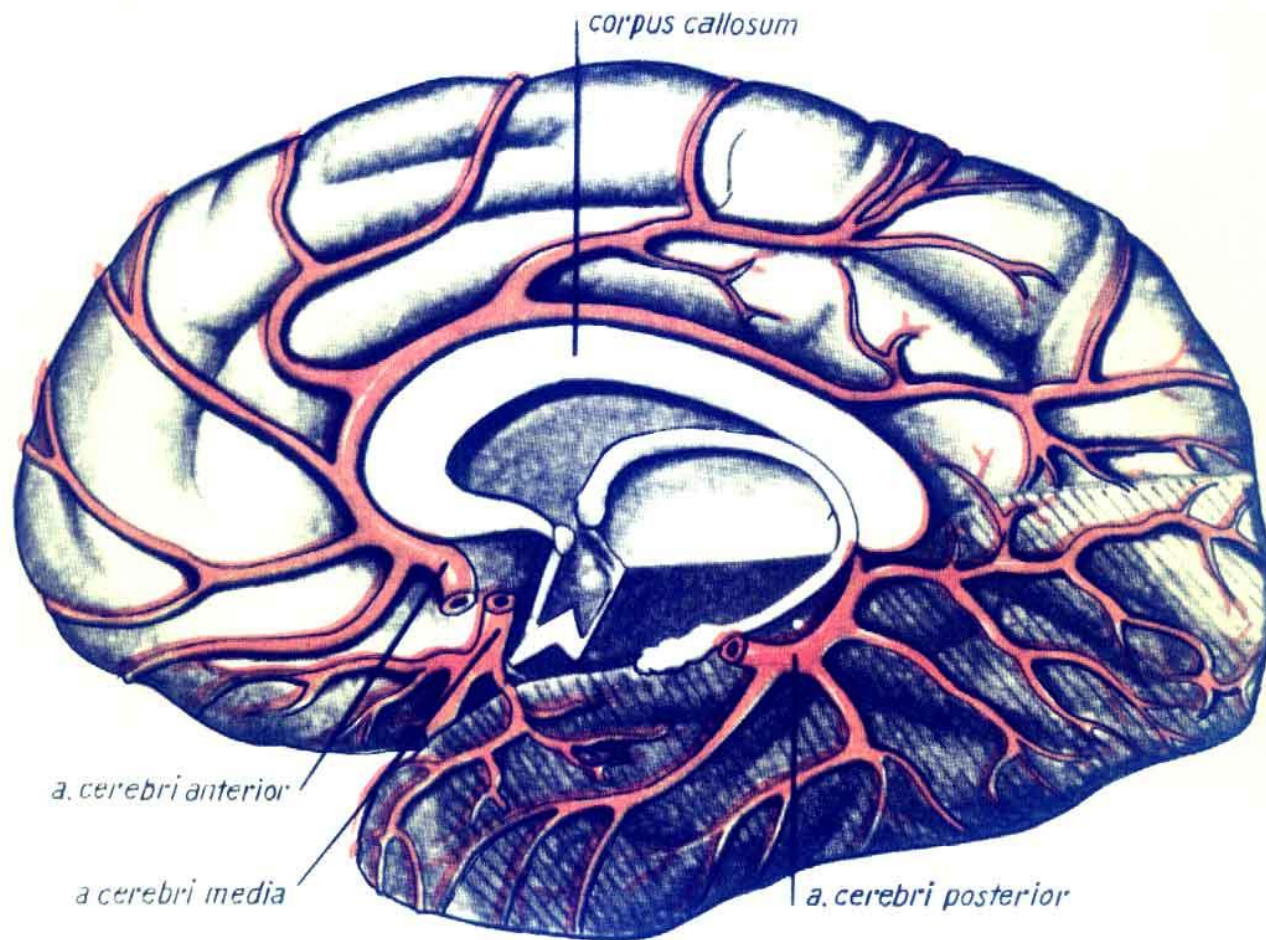
The brain is supplied by 2 systems of blood vessels:

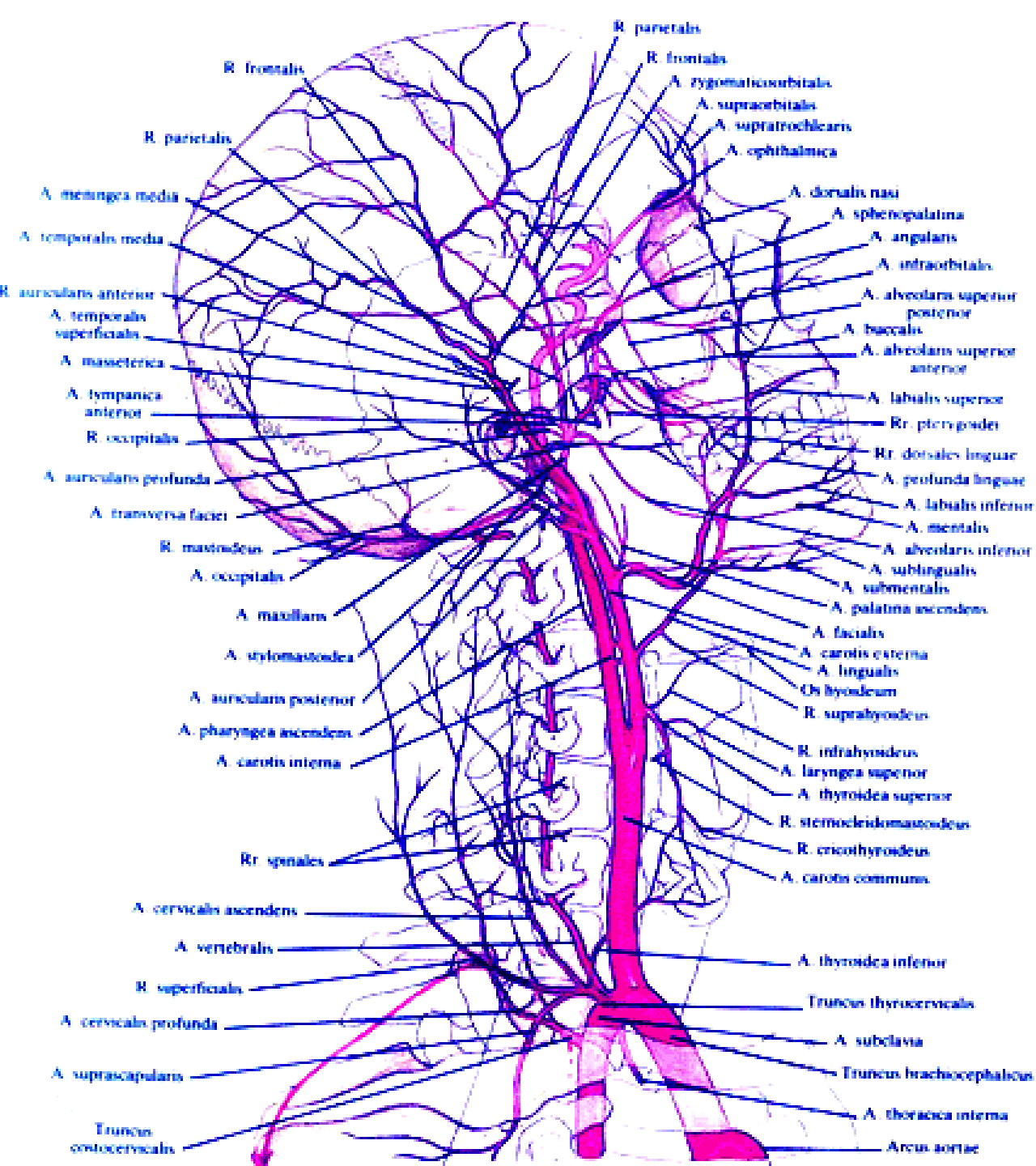
- * ***Internal carotid aa.*** with diameter 4-5 mm;
- * ***Vertebral aa.*** with diameter 2-3 mm, which give off cerebral arteries.

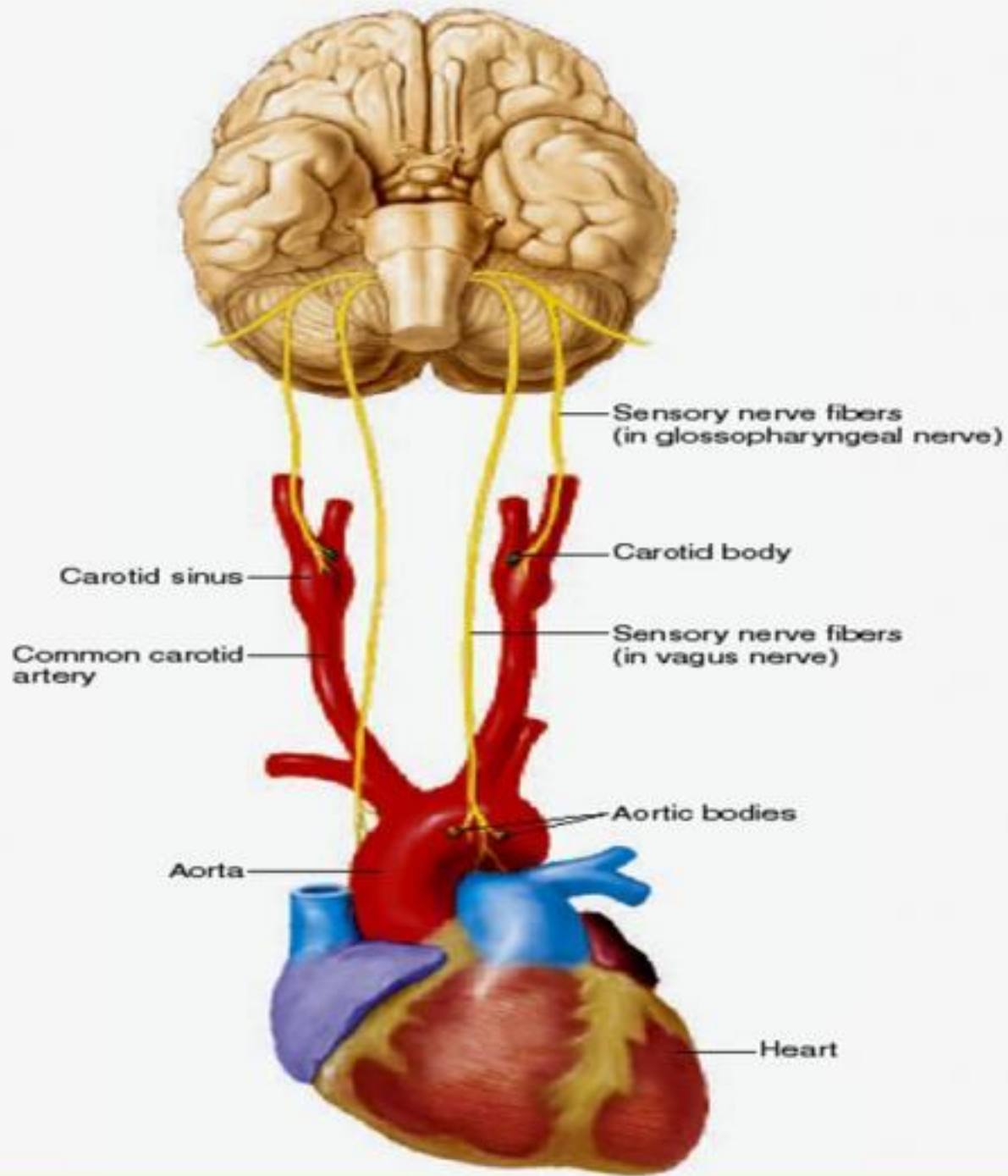
Prezence of two systems of vascularization of the brain is very important.

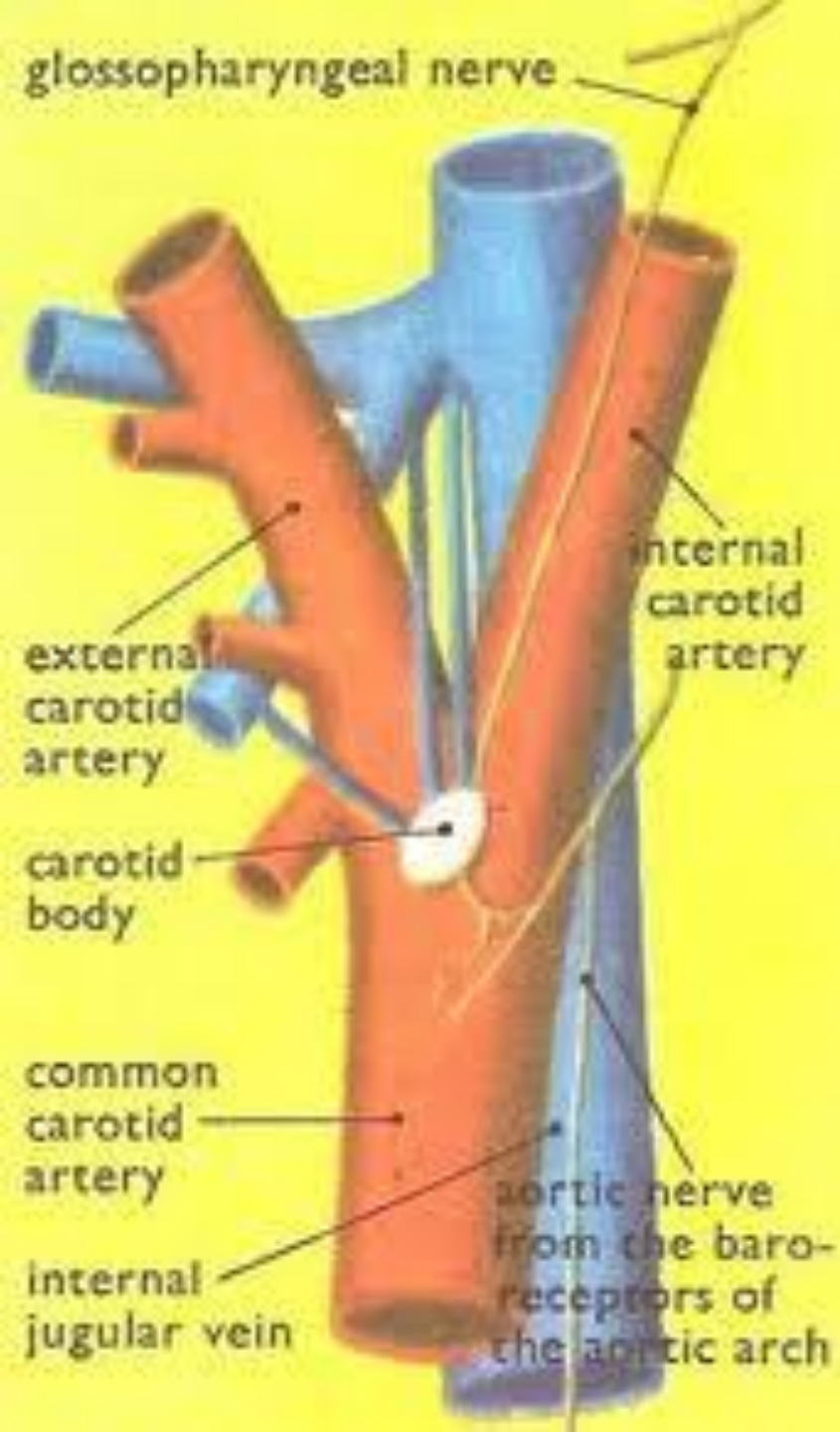
Blood torrent of different arteries changes during the head movements:
in extention of the head the vertebral a. practic is closed at the level of the vertebra C3,
during rotation - 1/2 of the lumen of this vessel on the opposite side is reduced. !!!











The carotid body (*carotid glomus* or *glomus caroticum*) is a small cluster of chemoreceptors and supporting cells located near the fork (bifurcation) of the carotid artery (which runs along both sides of the throat).

The carotid body detects changes in the composition of arterial blood flowing through it, mainly the partial pressure of oxygen, but also of carbon dioxide. Furthermore, it is also sensitive to changes in pH and temperature.

The carotid body is made up of two types of cells, called glomus cells: glomus type I (chief) cells, and glomus type II (sustentacular) cells.

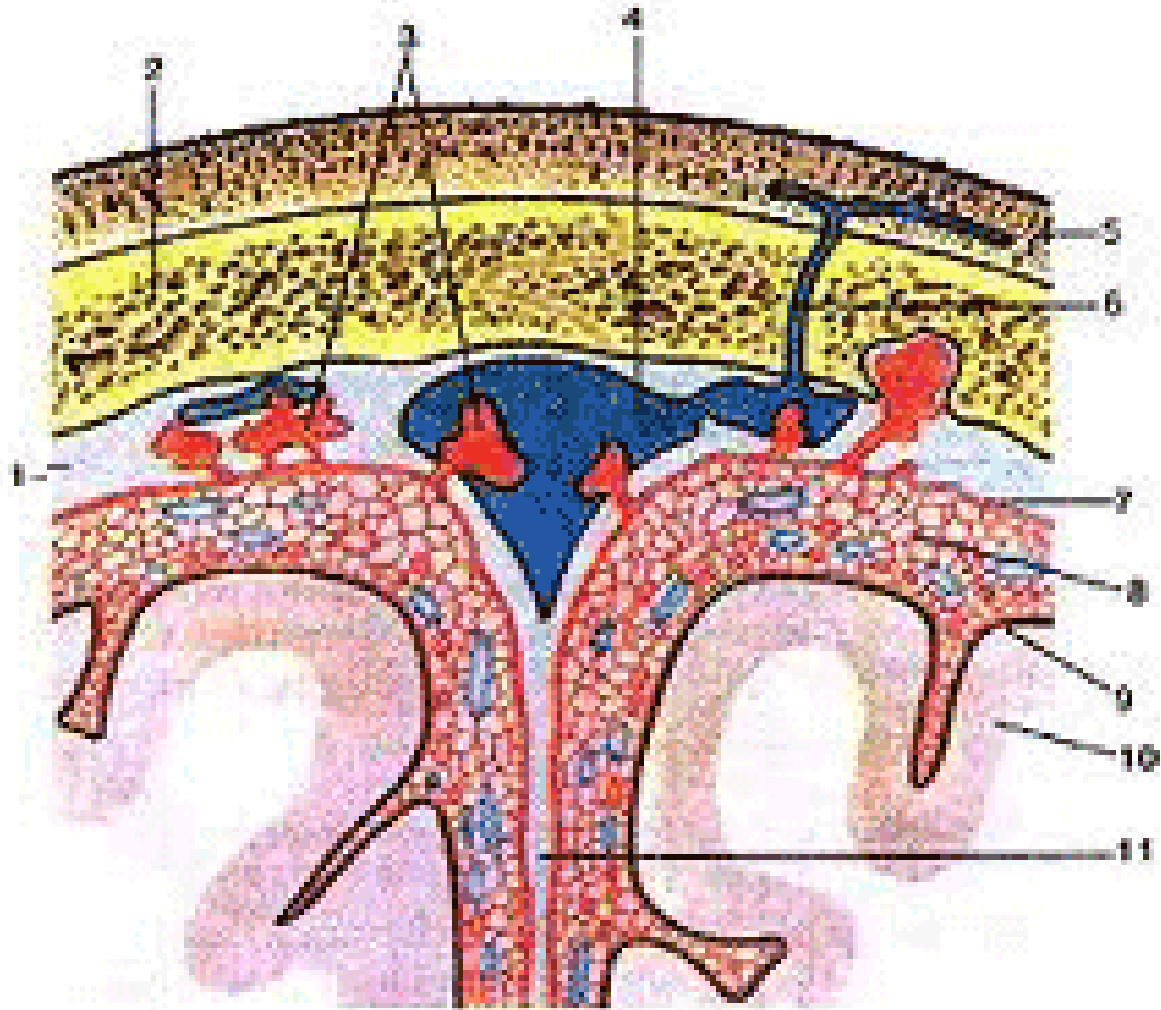
- Glomus type I/chief cells are derived from neural crest, which, in turn are derived from neuroectoderm. They release a variety of neurotransmitters, including acetylcholine, ATP, and dopamine that trigger EPSPs in synapsed neurons leading to the respiratory center.
- Glomus type II/sustentacular cells resemble glia, they act as supporting cells.

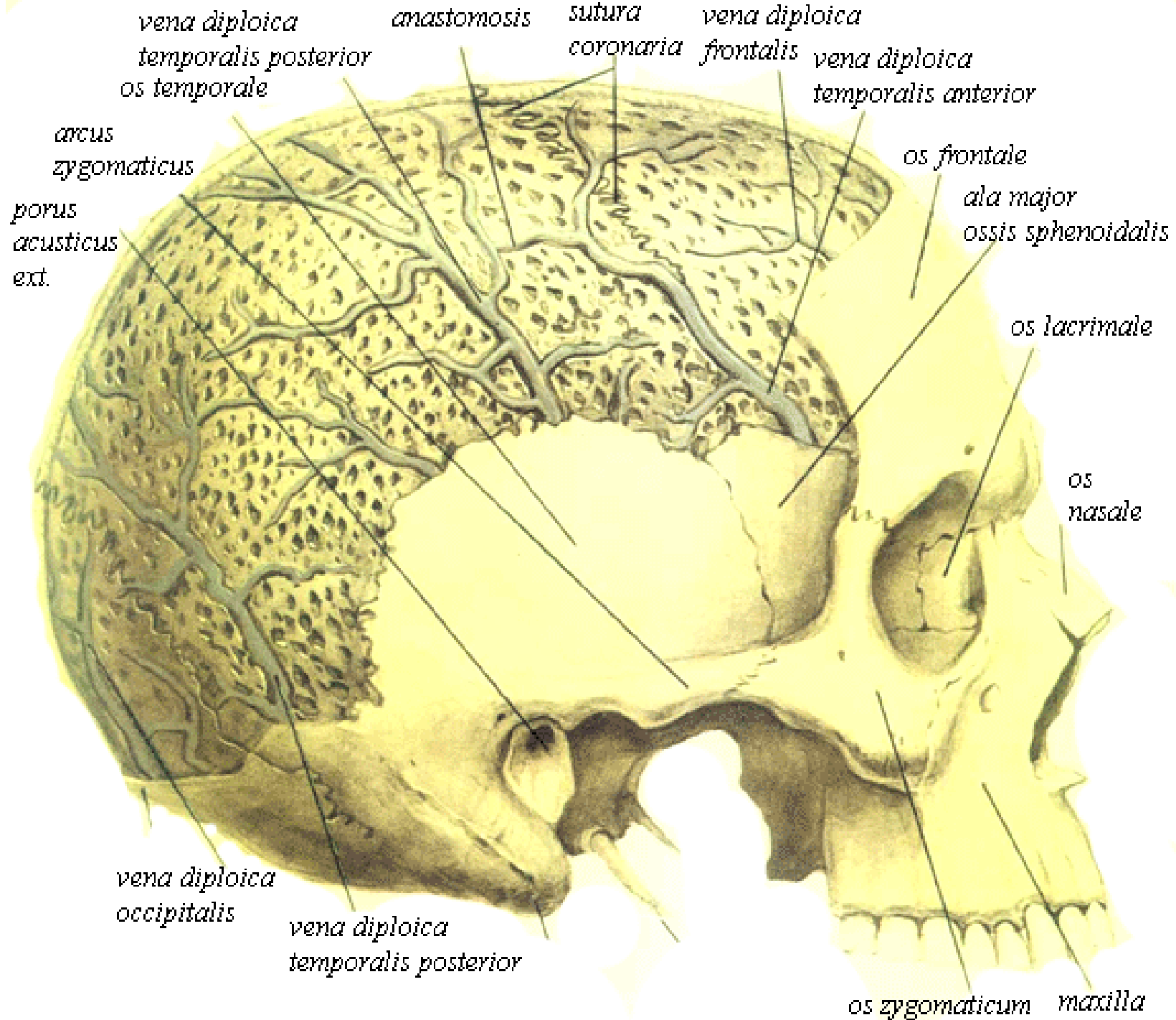
The carotid body contains the most vascular tissue in the human body.

Anatomical peculiarities of the cerebral veins

- form anastomoses with the diploic and extracranial veins;
- multiple ways of the drainage;
- the walls are devoid of muscles;
 - the veins have no valves;
- in order to maintain patency, some of them open into the venous sinuses against the direction of blood flow in the sinus;
- pachimeningeal sinuses don't collapse and cause the hemivacuum.

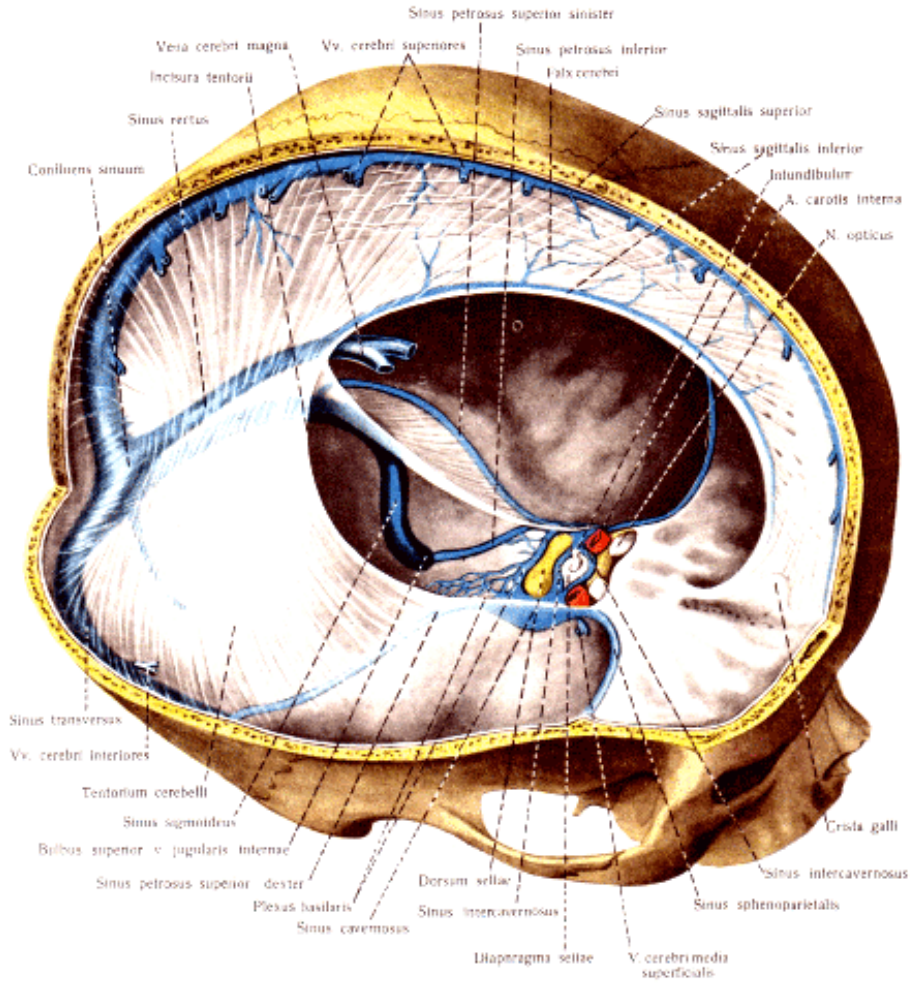
All these peculiarities maintain constant blood pressure and pressure of the cerebrospinal fluid.







Multiple ways of the drainage

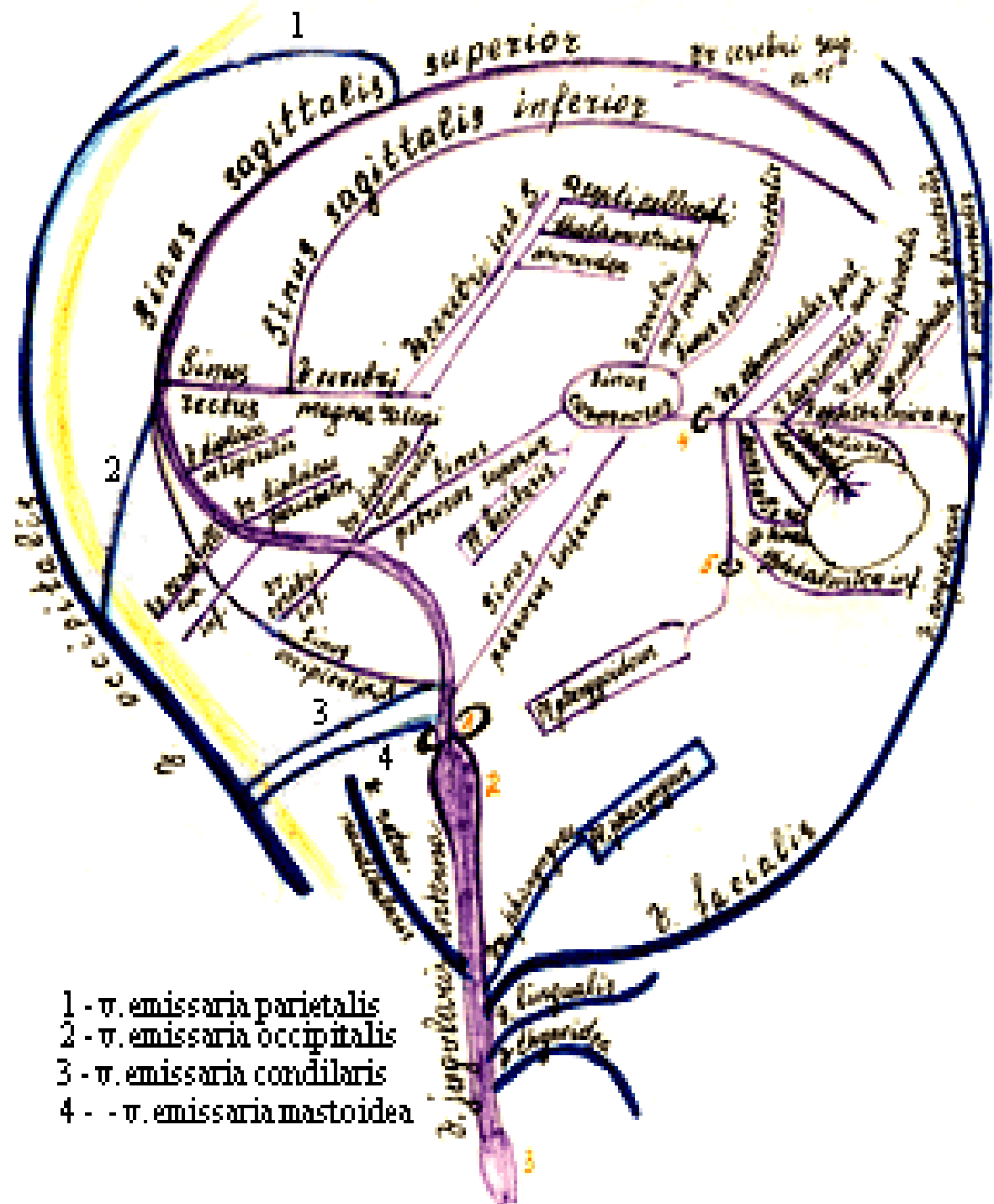


Some of veins open into the venous sinuses against the direction of blood flow in the sinus

The **emissary veins** are valveless **veins** which normally drain external veins of the **skull** into the **dural venous sinuses**. However, because they are valveless, pus can flow into the skull through them as well, making them a possible route for transmission of extracranial infection to get into the skull.

One important *emissary vein* communicates from outside the skull through the **sphenoidal emissary foramen** inferior to the **zygomatic arch** with the **cavernous sinus** on the inside of the skull.

This is an important route for spread of infection because **cranial nerves** III, IV, V1, V2, and VI and the **internal carotid** pass through the cavernous sinus. Subsequent infection or inflammation in the cavernous sinus can result in damage to any of the cranial nerves that pass through it or **meningitis**. Also, rupturing the emissary veins will result in a **subdural hematoma** which will compress the brain.



- 1 - v. emissaria parietalis
- 2 - v. emissaria occipitalis
- 3 - v. emissaria condilaris
- 4 - v. emissaria mastoidea

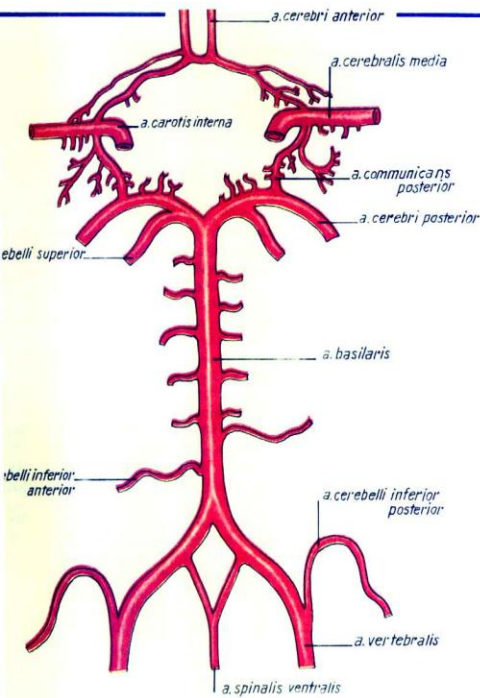


Fig. 149. Schema principalelor surse arteriale ale encefalului.

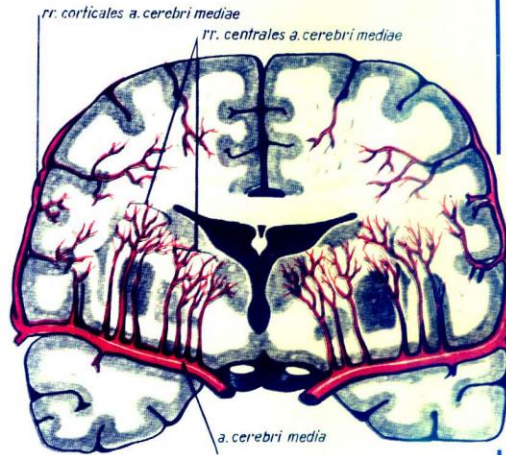


Fig. 150. Artera cerebrală medie – teritoriul.

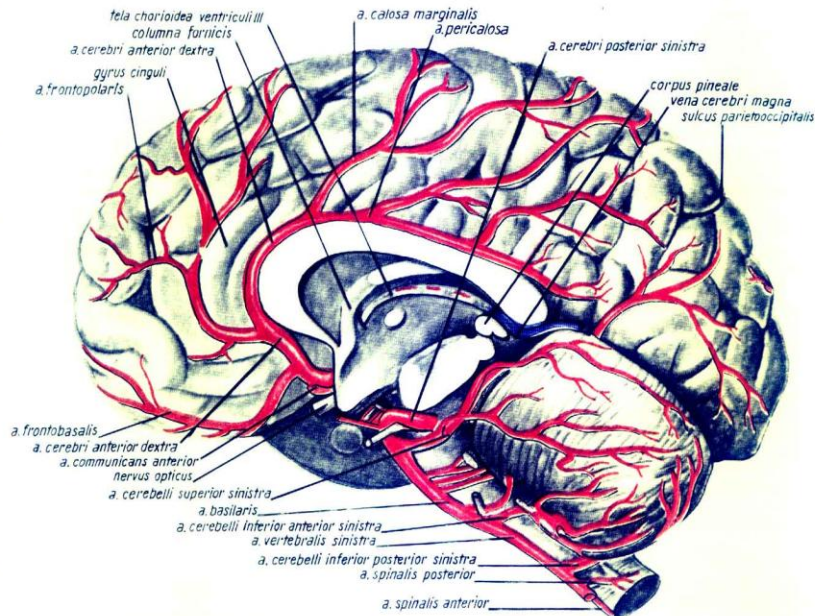
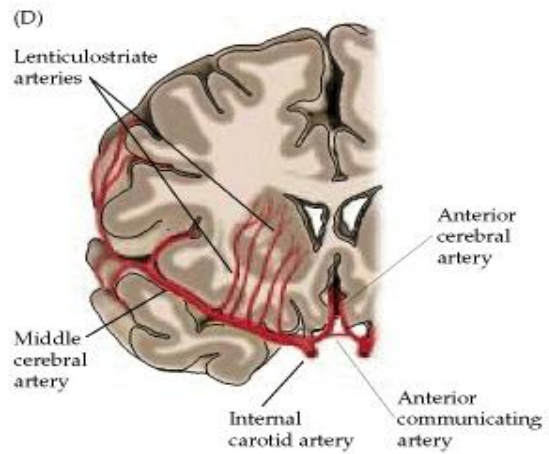
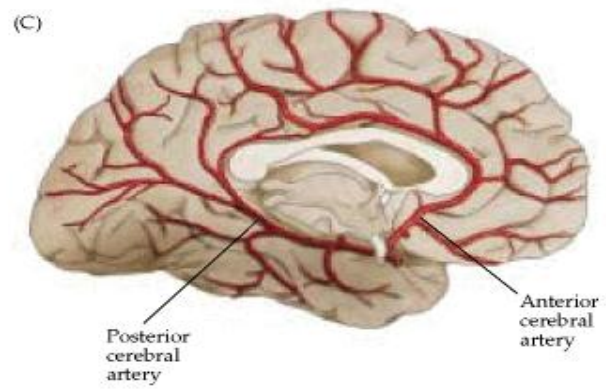
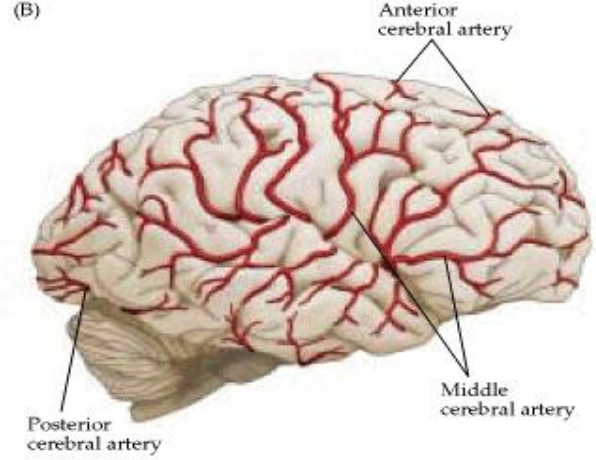
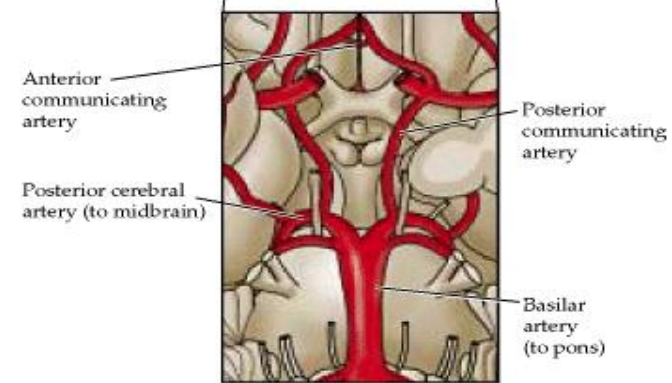
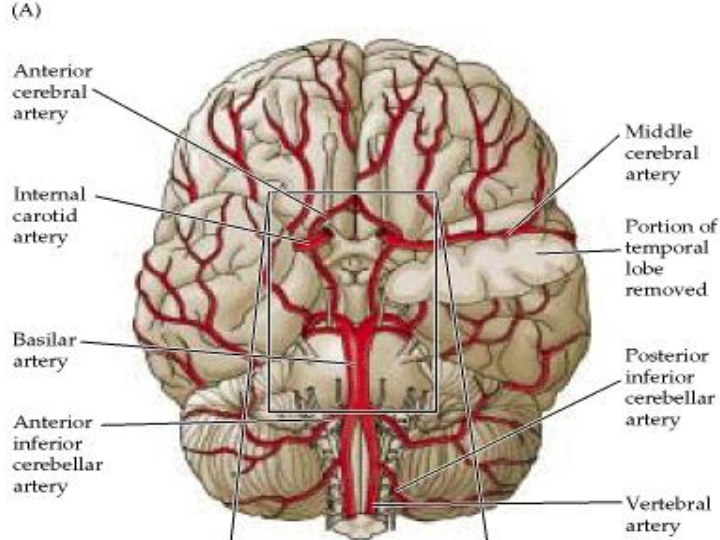


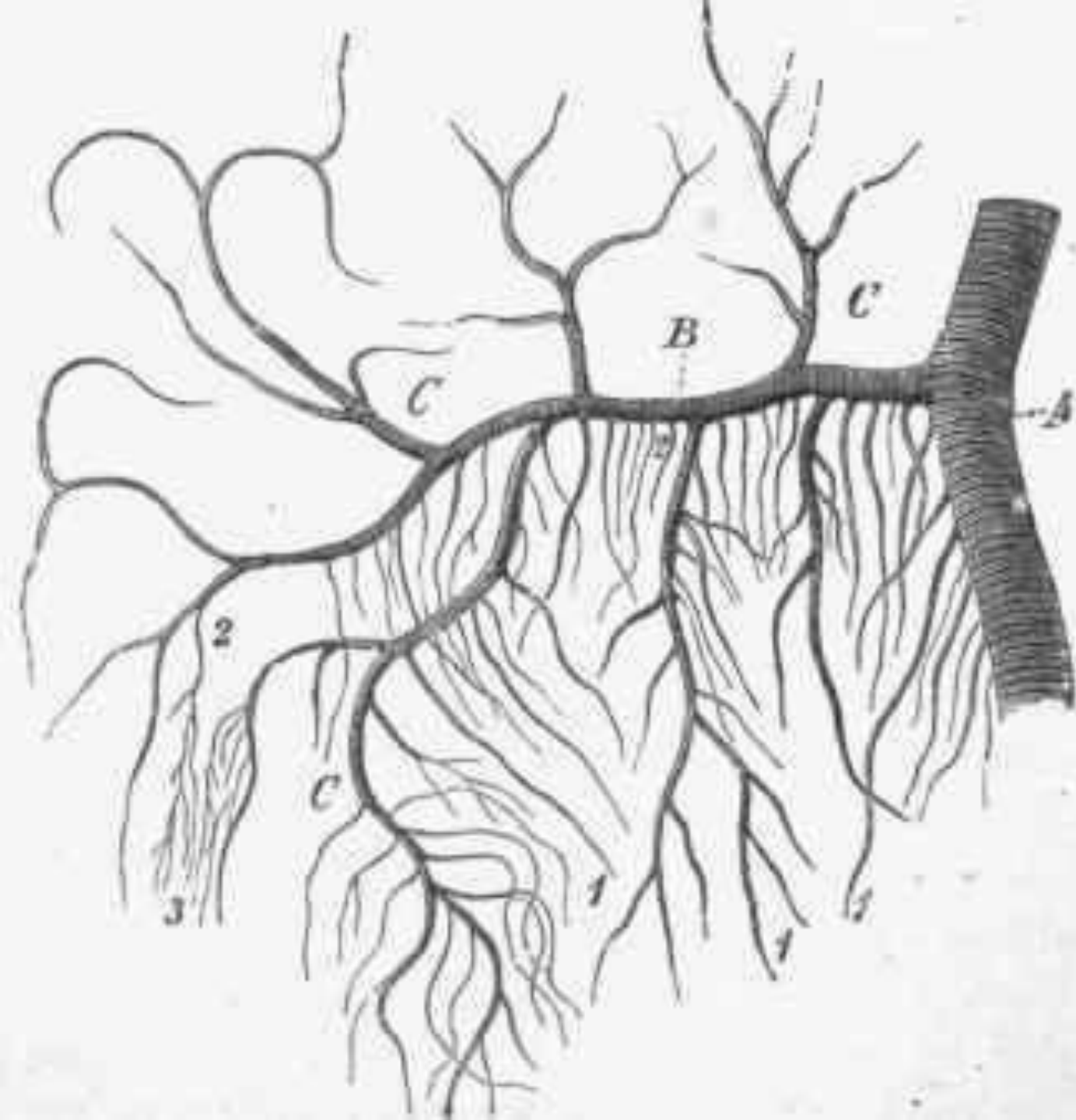
Fig. 151. Irigația encefalului (fața medială a emisferului cerebral cu păstrarea trunchiului cerebral și cerebelului pe preparatul realizat).

Cerebral aa. and their branches form **2 systems of the blood supply of the brain**, which have of principle different structure.

1. Arterial network of the pia mater from which short and long branches start to the cortex and adjacent white mater.

2. Vascular system of the subcortical structures, diencephalon and stem brain made up of the branches given off by the initial parts of the cerebral arteries.

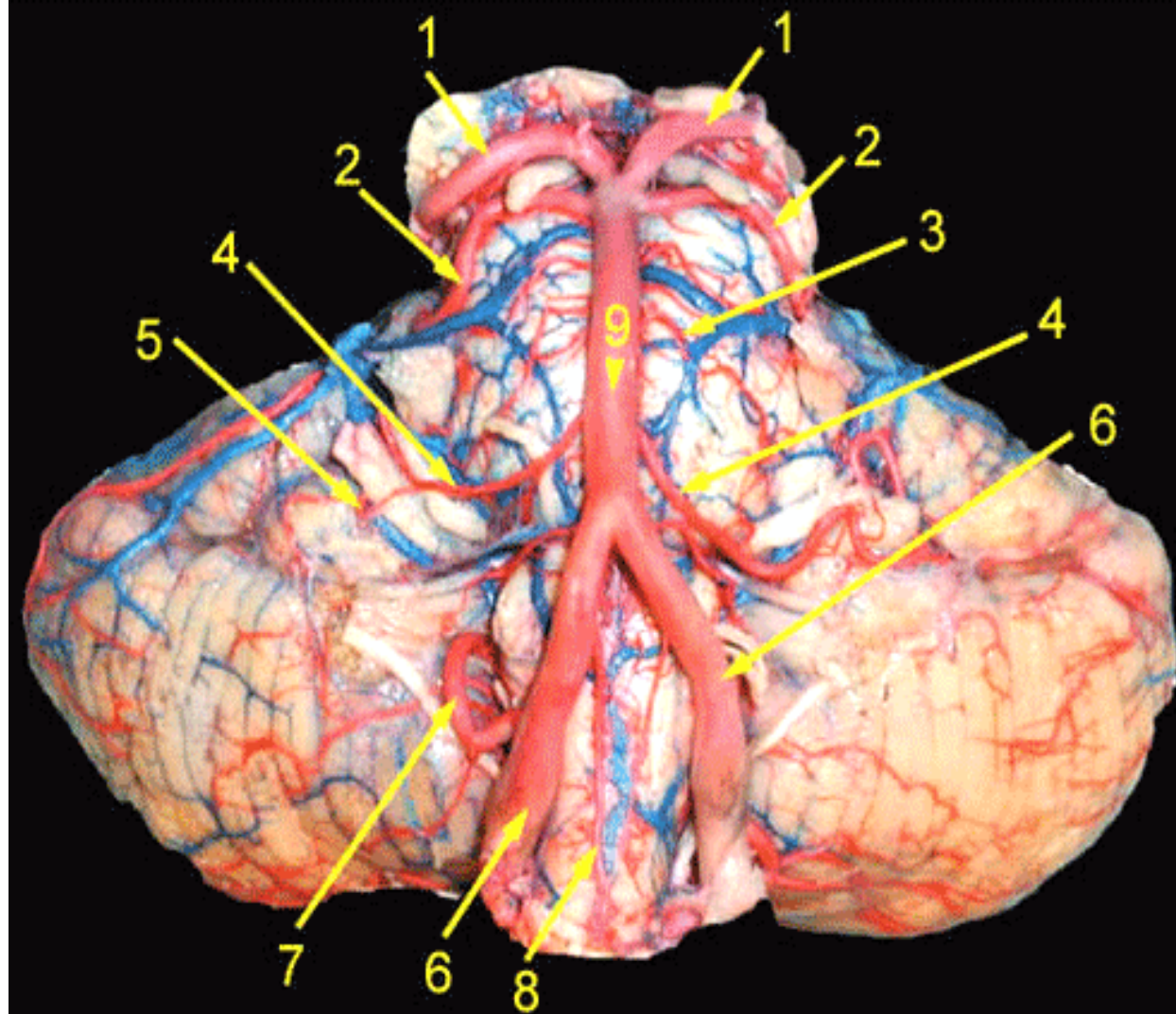




End
arteries

Arterial system of the brain stem

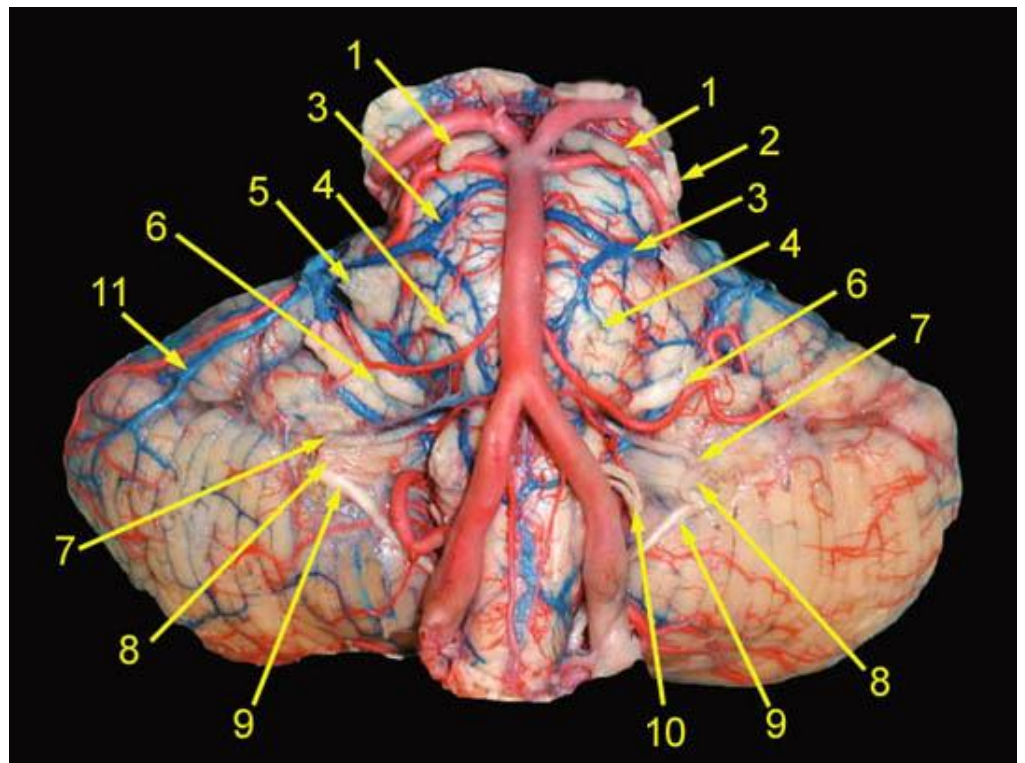
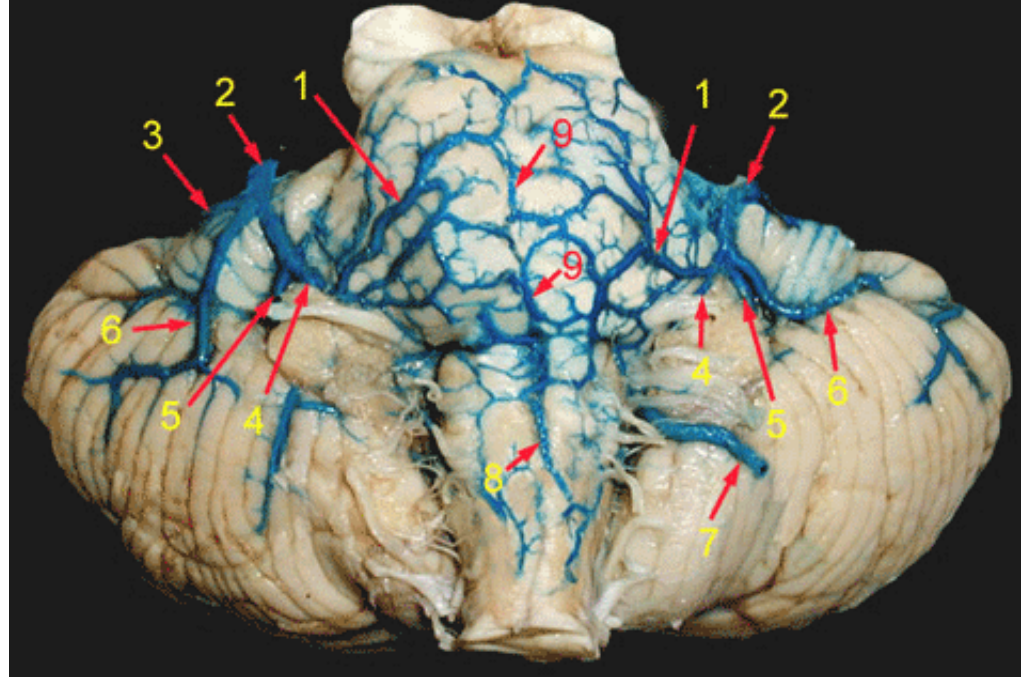
- doesn't form the superficial network, but due the multiple anastomoses it is not interrupted;
- its vessels represent the branches of the basilar and vertebral arteries;
- anastomoses of the arteries of the opposite sides form the arterial rings surrounding the brain stem, from which the intratrunkal branches are given off.



Blood of this system drains into the superficial veins of the leptomenings.

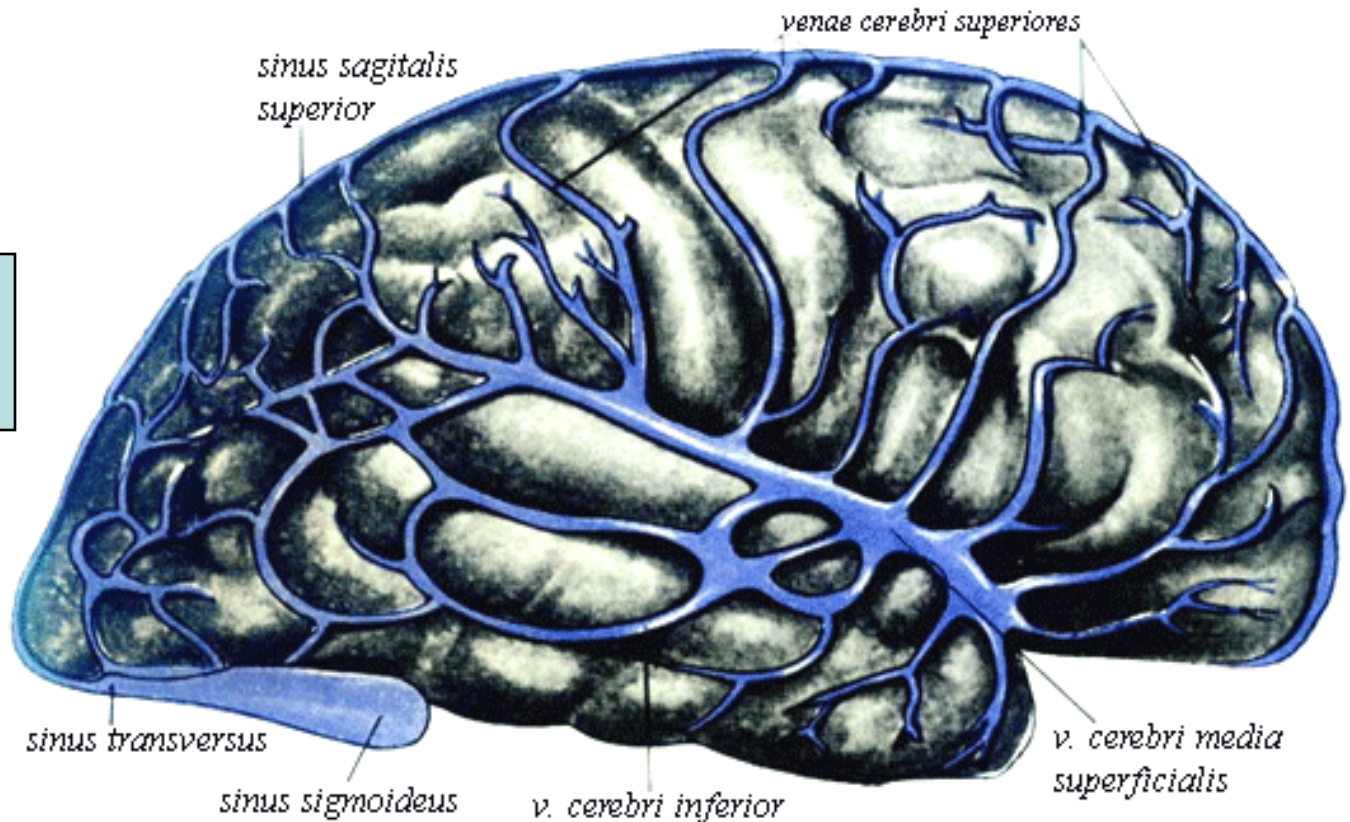
Blood of subcortical structures flows into the deep cerebral veins.

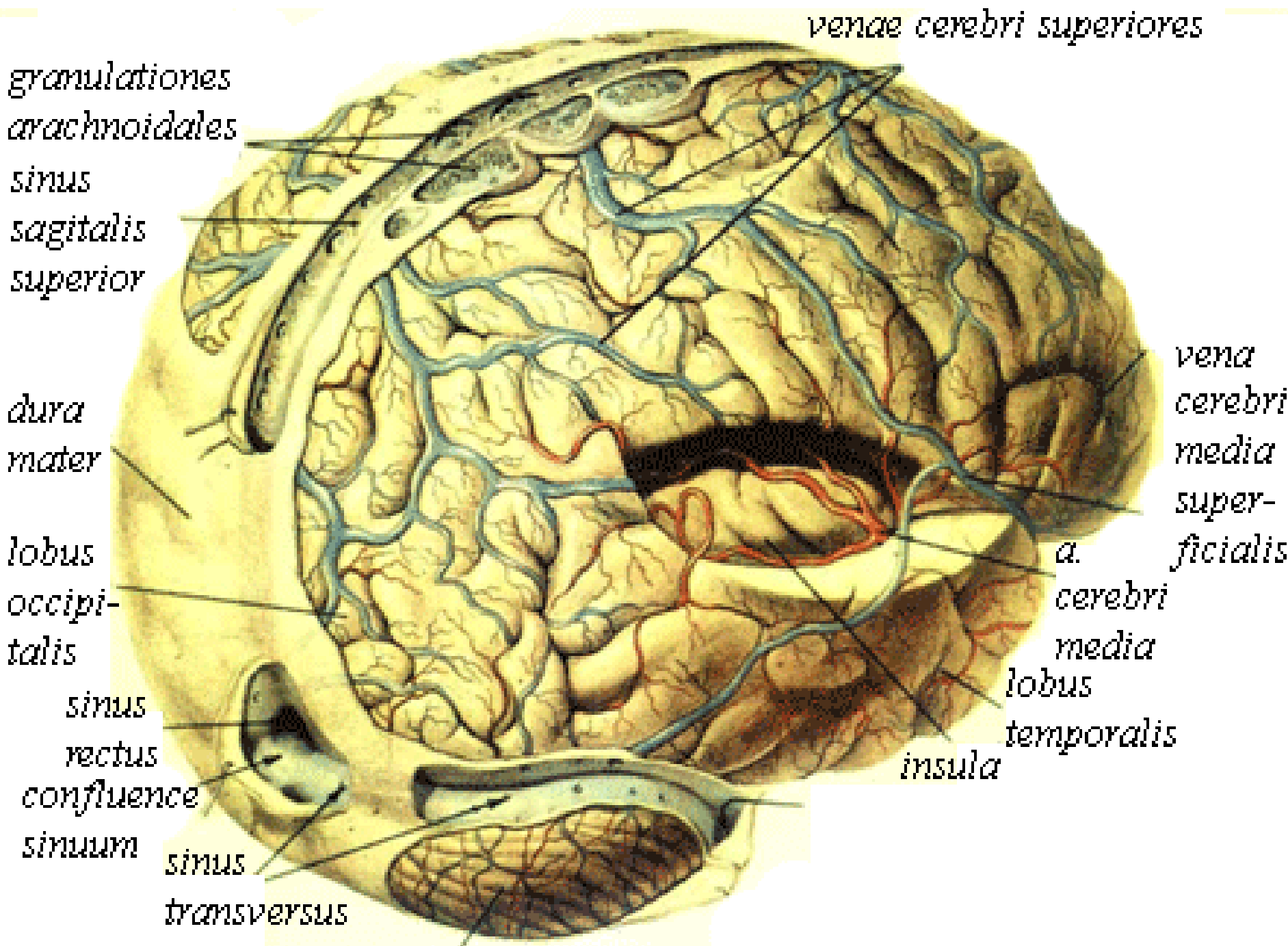
Uterior, blood flows into the pahimeningeal sinuses, after that – into the internal and, partially, external jugular vein.



<i>Veins</i>	<i>Region of drainage</i>	<i>Termination</i>
<i>The superior cerebral vv. /6-12/</i>	Superolateral surface of the hemisphere	The superior sagittal sinus
<i>The superficial middle cerebral v.</i>	The area round the posterior branch of the lateral groove	The cavernous sinus or The sphenopalatine sinus
<i>The deep middle cerebral v.</i>	Surface of the insula	The basal vein
<i>The inferior cerebral vv.</i>	The orbit The temporal lobe	The superior cerebral vv. The superior sagittal sinus The cavernous or neighbouring sinuses
<i>The anterior cerebral vv.</i>	The corpus callosum The anterior part of the medial surface of the hemisphere	The basal vein

Extracerebral veins





venae cerebri superiores

*granulationes
arachnoideales*

*sinus
sagittalis
superior*

*dura
mater*

*lobus
occipi-
talis*

*sinus
rectus
confluence
sinuum*

*sinus
transversus*

*vena
cerebri
media
super-
ficialis*

*a.
cerebri
media*

*lobus
temporalis*

insula

End veins

The great cerebral v.

- it is a single median vein,
- it is formed by union of 2 internal cerebral veins,
- it terminates in the straight sinus,
- its tributaries

- basal vv.
- vv. from the pineal body
- vv. from the colliculi
- vv. from the cerebellum
- vv. from the adjoining part of the occipital lobe

Basal vein

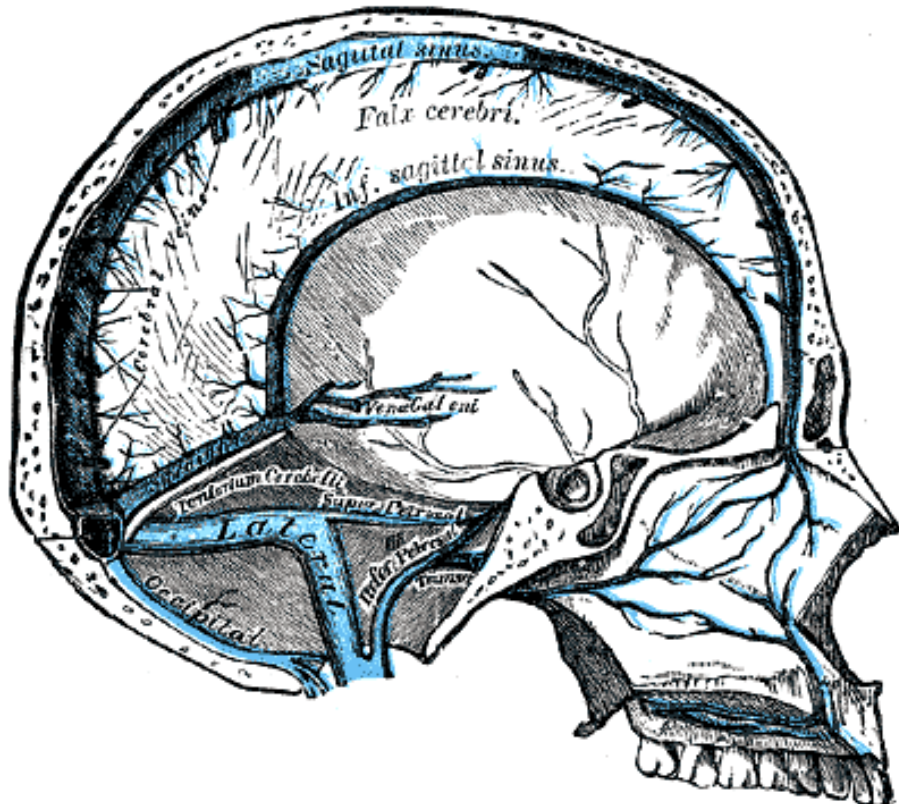
- there is one vein on each side,
- it is formed by the union of the deep middle cerebral v., the anterior cerebral vv., the striate vv.

•it runs posteriorly, winds round the cerebral peduncles,

•terminates by joining the great cerebral v,

•its tributaries:

- vv. from the cerebral peduncles,
- vv. from the interpeduncular structures,
- vv. from the tectum of the midbrain
- vv. from the parahippocampal gyrus

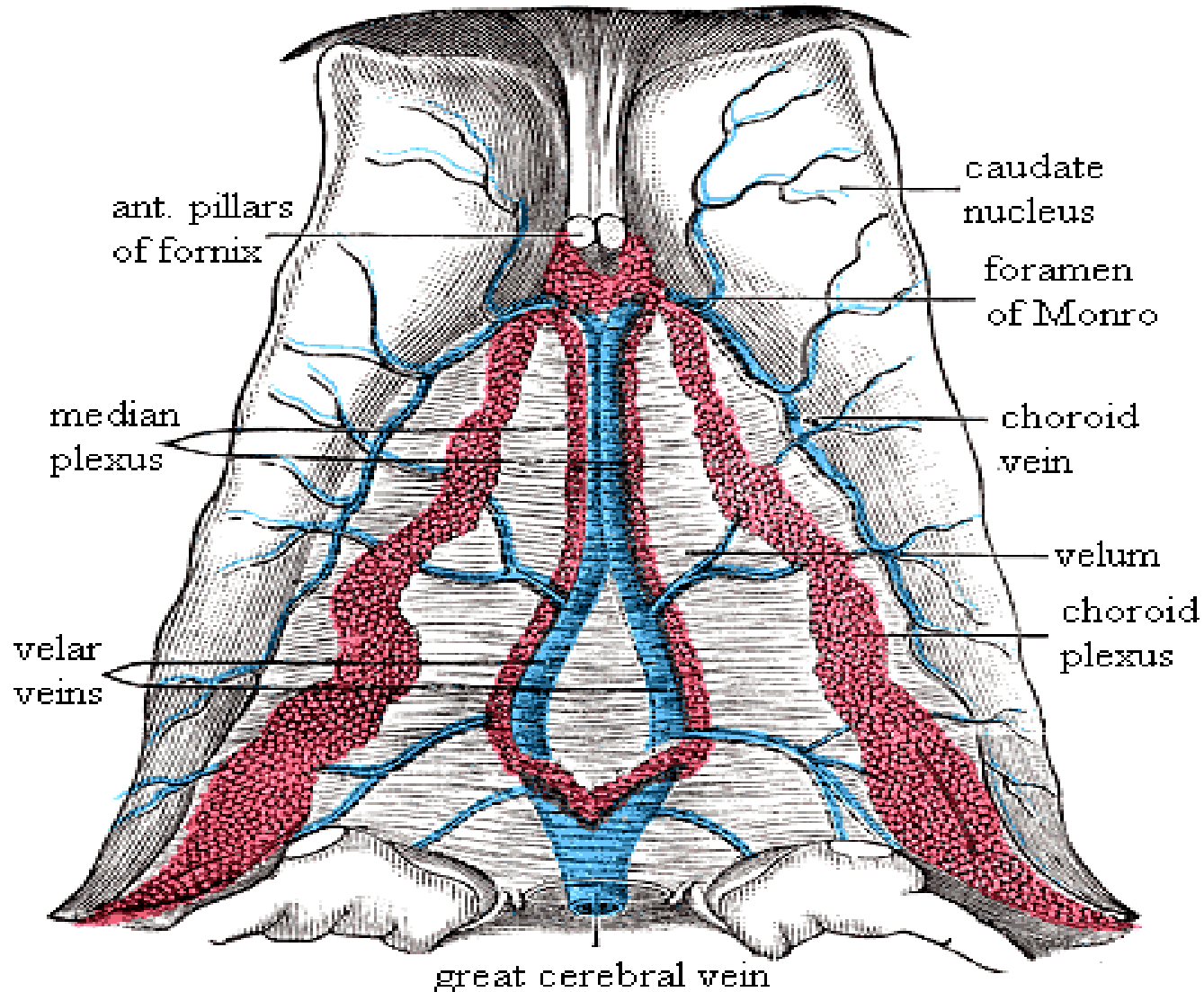


Ultimately all veins drain into the various venous sinuses which, in turn, drain into the internal jugular v.

Internal cerebral veins (vein of Galen): There is one vein on each side,

•It is formed by the union of the thalamostriate and choroidal vv.,

•The *right and left cerebral vv. /velar veins/* run posteriorly parallel to each other in the tela choroidea of the III ventricle, unite together to form the *great cerebral veins* below the splenium of the corpus callosum.



The basal vein /Rosenthal/ is formed at the anterior perforated substance by the union of

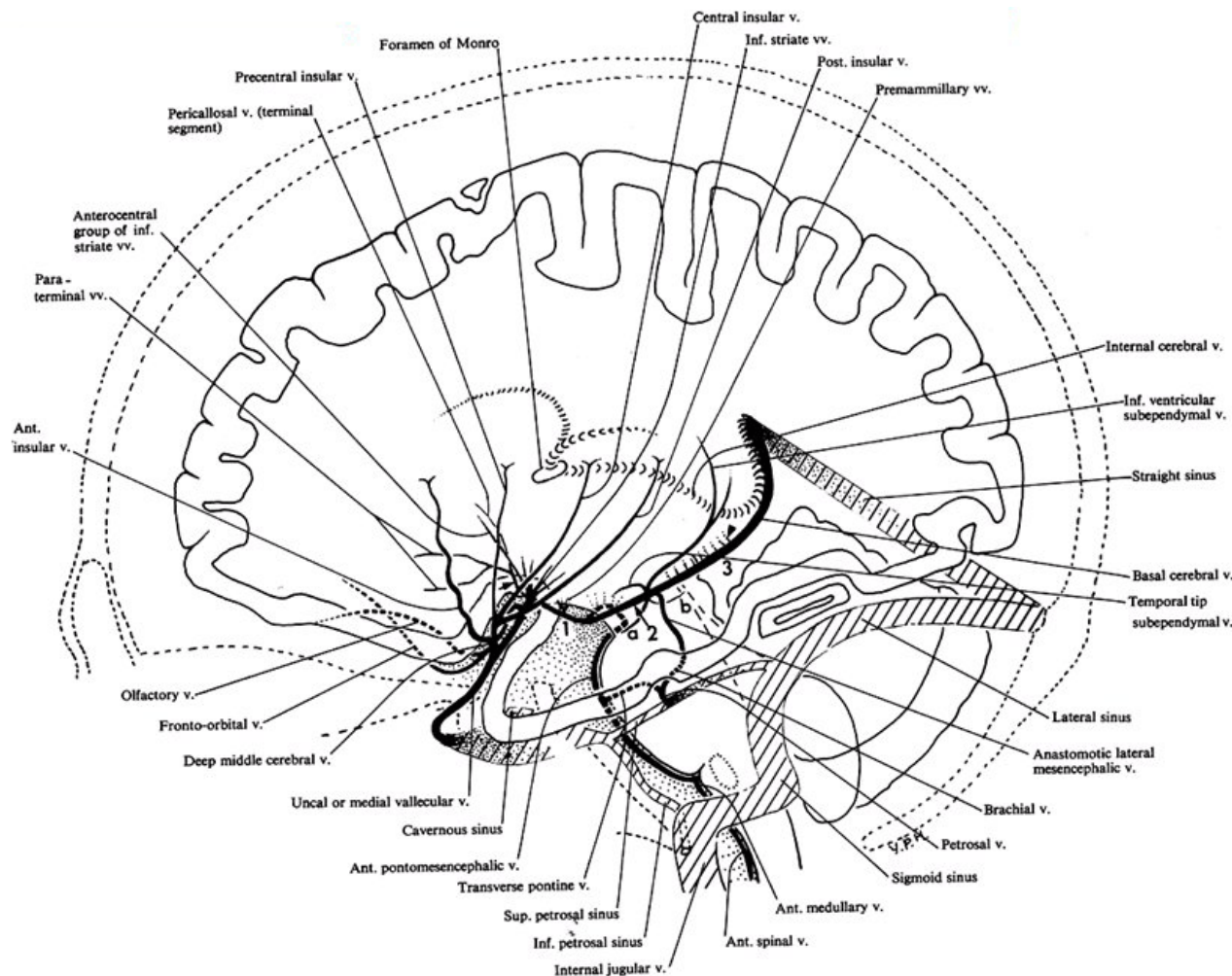
(a) a *small anterior cerebral vein* which accompanies the anterior cerebral artery

(b) the *deep middle cerebral vein (deep Sylvian vein)* /from the insula and neighboring gyri/,

(c) the *inferior striate veins* /leave the corpus striatum through the anterior perforated substance/.

The basal vein ends in the internal cerebral vein (vein of Galen); it receives tributaries from the interpeduncular fossa, the inferior horn of the lateral ventricle, the hippocampal gyrus, and the mid-brain.

The BVR open into the great vein of Galen in 87.8%, but the anastomoses between the first and second segments were not confirmed in 36.9% of this type. The first segments with hypoplastic or a plastic anastomoses flowed into the cavernous sinus or the sphenoparietal sinus. Therefore, typical BVRs with these anastomoses accounted only for 55.4% of all sides. More than one fourth of the typical type also entered the anterior veins such as the cavernous sinus. Drainage was to the lateral mesencephalic vein in 5.6%, peduncular vein in 1.6%, and lateral or medial tentorial sinus in 5.0%.



The **basal vein of Rosenthal** originates on the medial surface of the temporal lobe and runs posteriorly and medially.

It passes lateral to the midbrain to drain into the vein of Galen.

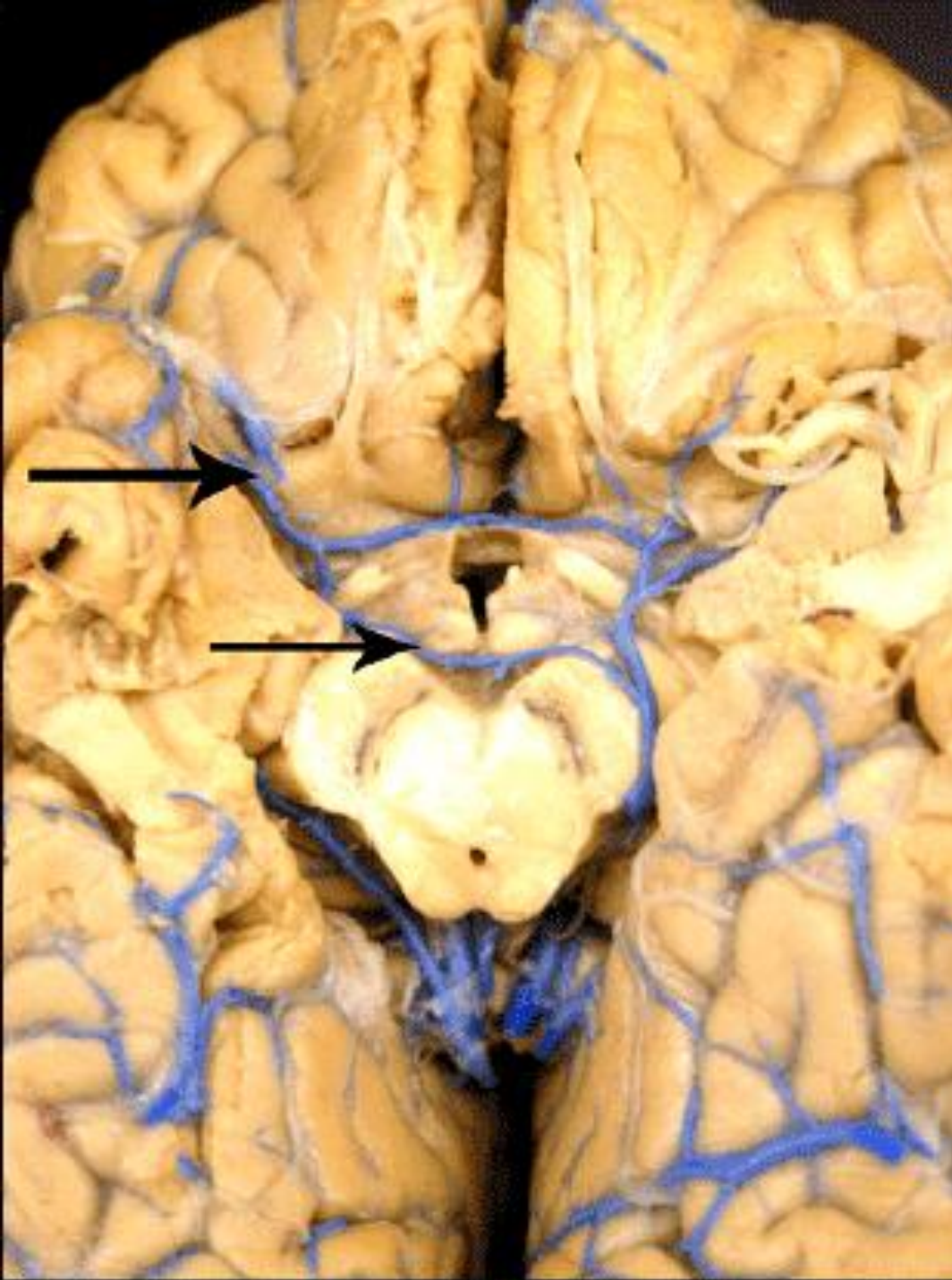
It is closely related to the posterior cerebral artery (PCA).

A **venous anastomotic network /circle Trolard/** at the base of the brain closely resembles the vicinal arterial circle of Willis.

This venous polygon is composed of the

- anterior cerebral and
- communicating veins,
- the basal vein of Rosenthal ,
- the posterior communicating,
- lateral mesencephalic veins.

This venous circle might cause bleeding with such procedures as an endoscopic third ventriculostomy. This information regarding venous circle may be useful to neuroradiologists or neurosurgeons operating at the base of the brain.



Venous circle /Trolard's/ of the brain

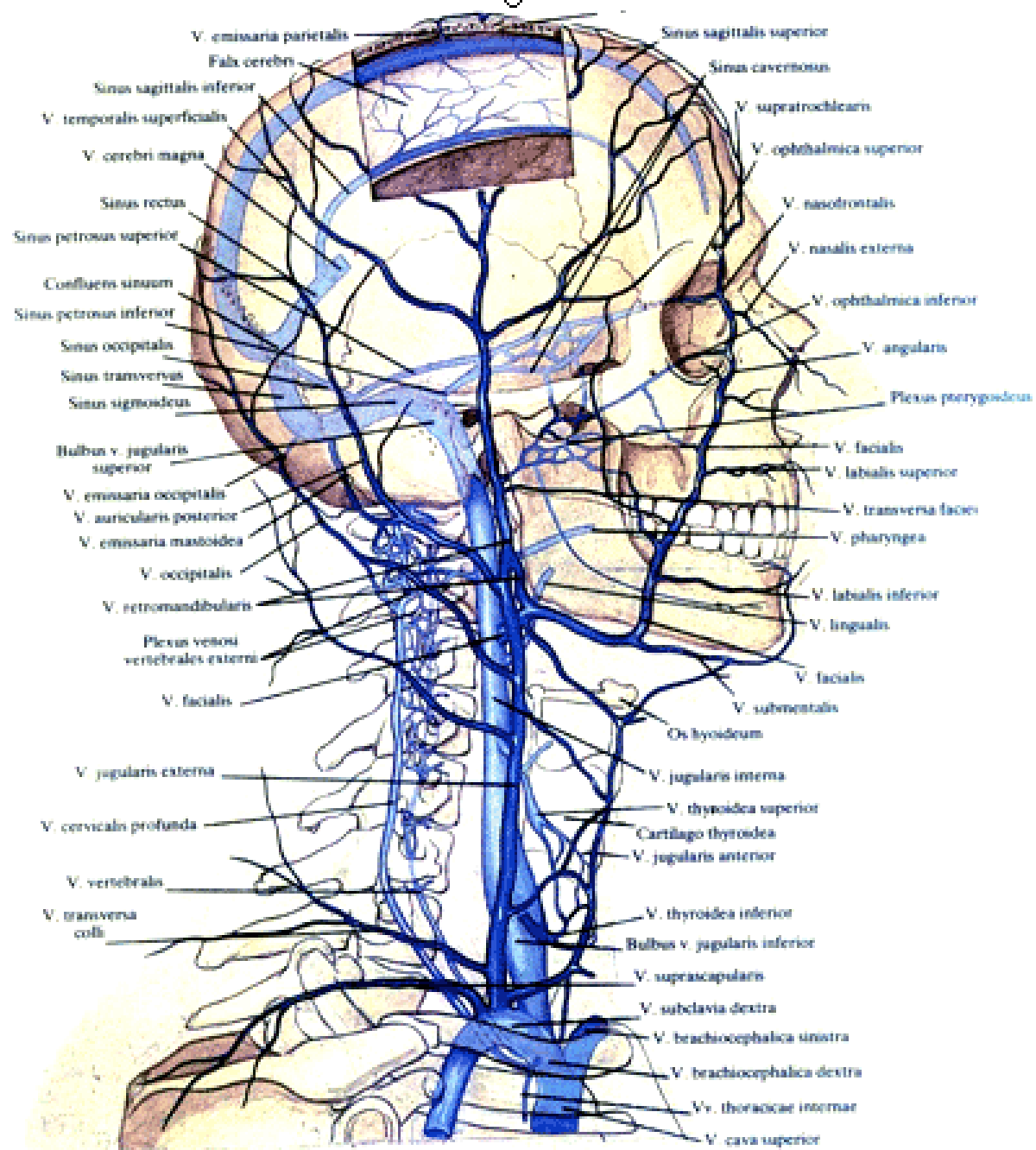
For reference, note the olfactory tracts and midbrain cross section.

Note the venous ring encircling the mamillary bodies and floor of the third ventricle.

The anterior cerebral veins are seen leaving the longitudinal fissure.

Note the anterior communicating vein between the two anterior cerebral veins and deep Sylvian vein */upper arrow/*.

An anastomotic vein */lower arrow/* is seen linking the basal vein of Rosenthal just posterior to the mamillary bodies.



**Intracranial
tributaries
of the internal
jugular vein**

**Extracranial
tributaries
of the internal
jugular vein**

Veins of head and neck; right aspect (semischematic representation).

Vascular anastomoses of the head and neck

They are very important for blood redistribution, for unsurement of compensation in the cerebral blood system /intrasystemic & extrasystemic/.

Classification of the anastomoses in the region of the head & neck:

-Intracranial

-Extracranial

-Extraintracranial

- Intrasystemic

- Intersystemic

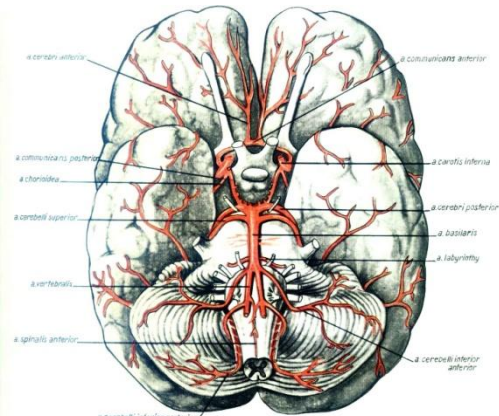
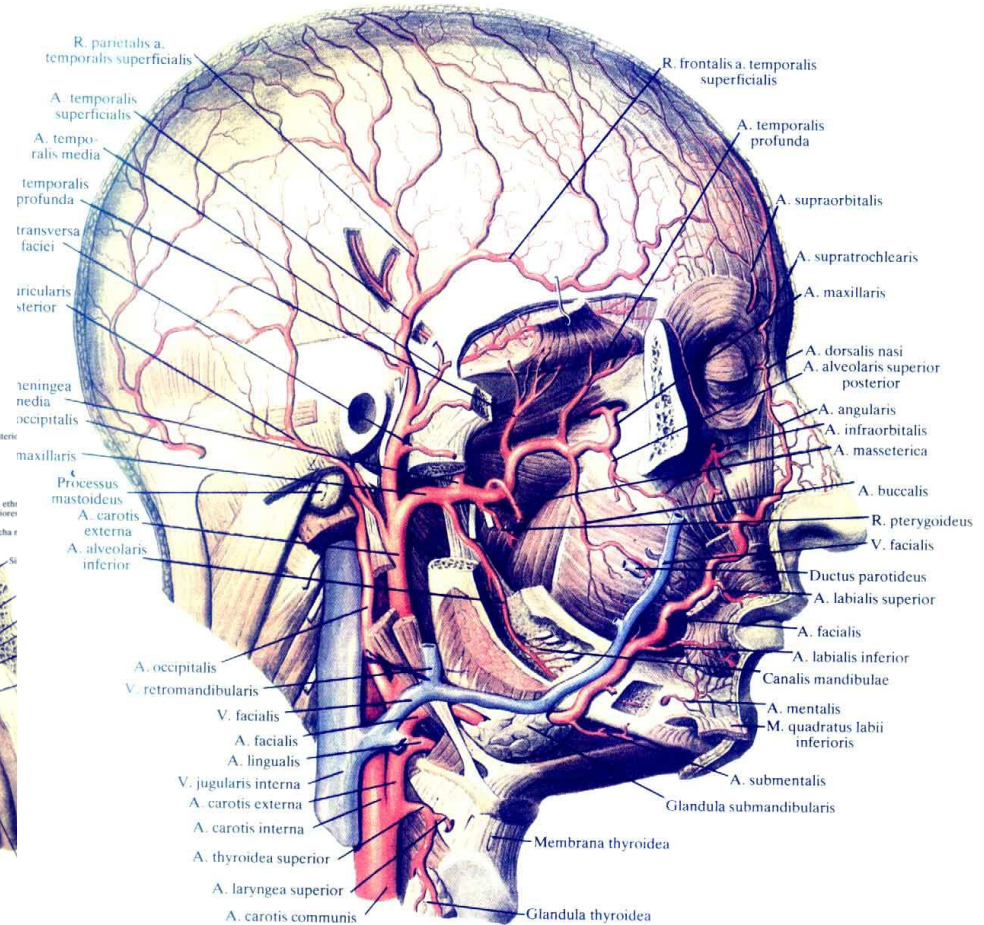
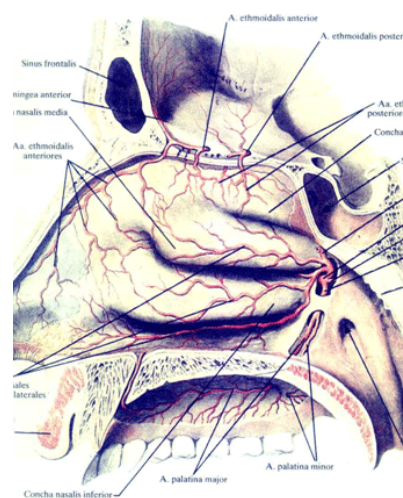
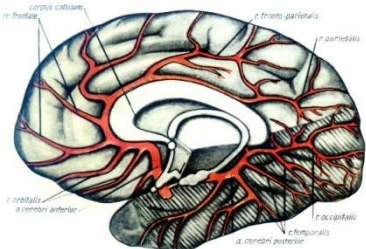
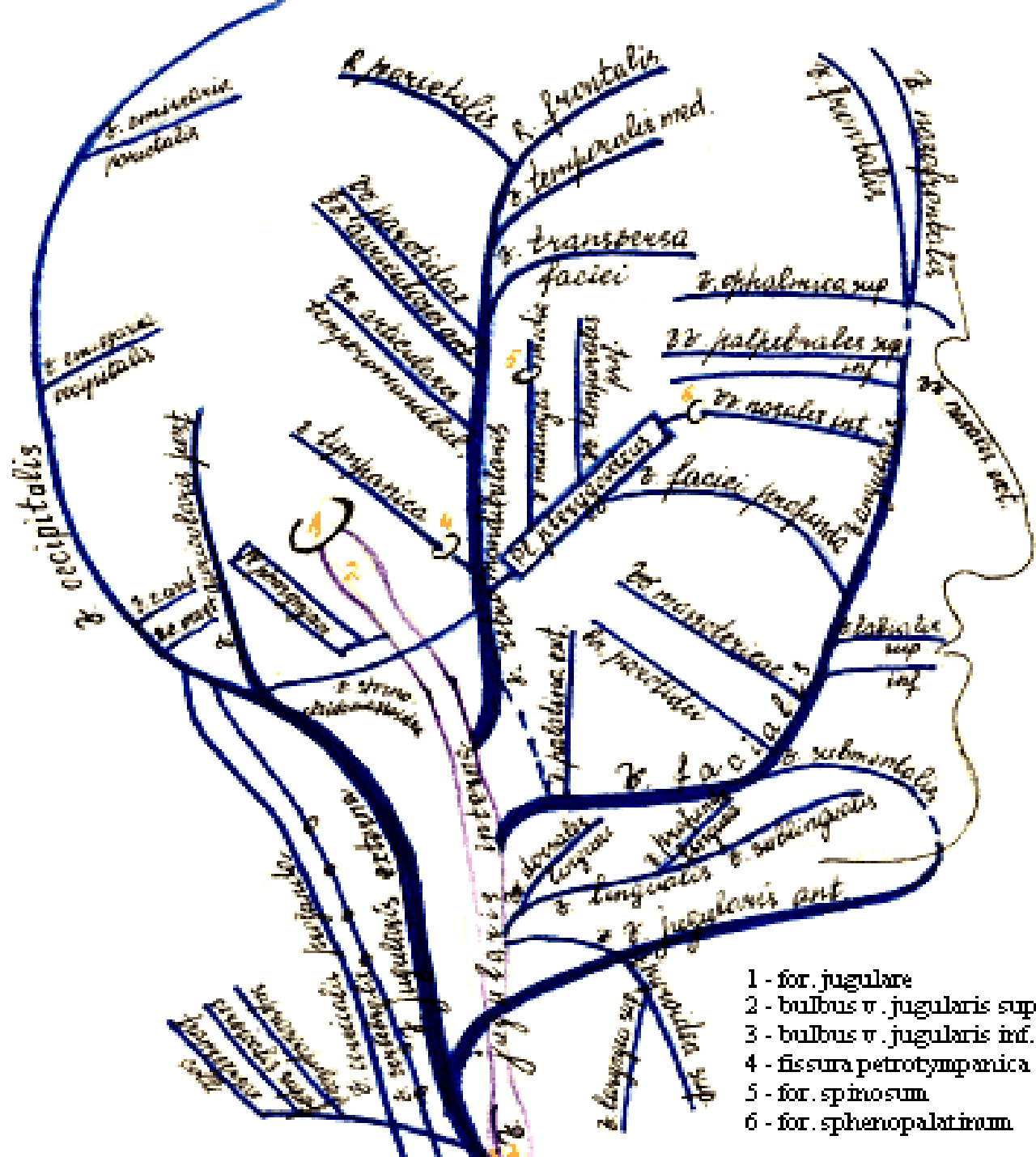
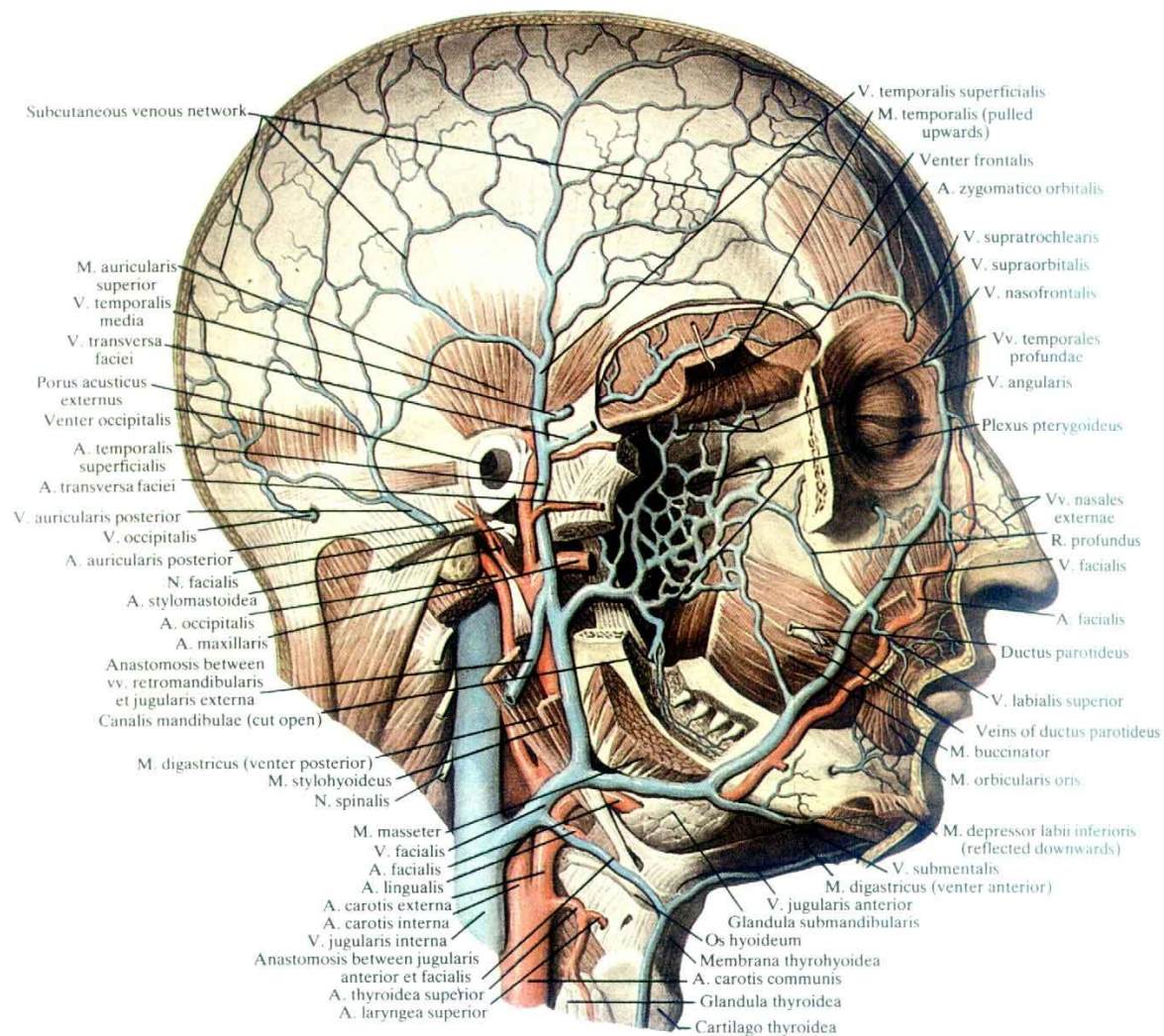


Fig. 152. Ligatura arterială a encefalului – fața inferioară.



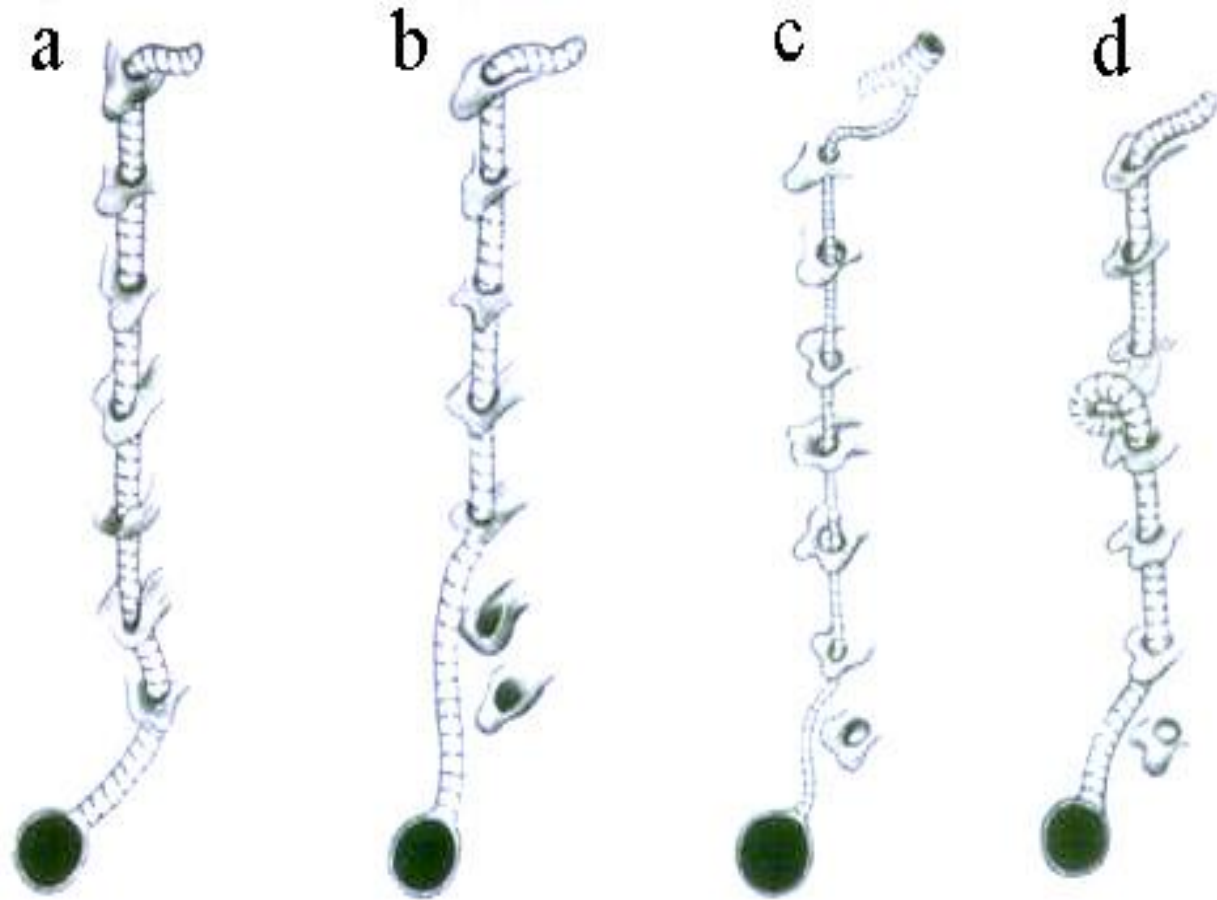
Extracranial veins





Classification of the vascular anomalies

- of the origin
- of the traject
- of the branching



a,b - variants of traject of the vertebral artery;
c - hypoplasia; d - arterial loop .

VARIANTS OF THE VESSELS OF THE HEAD AND NECK :

- 1. Lack of brachiocephalic trunk - right common carotid and subclavian artery have separate origin**
- 2. A. laryngea superior starts from a. carotis externa, not on a. thyroidea superior**
- 3. The presence of a common arterial trunk of the facial-lingual arteries**
- 4. Variations of the location of the diploic veins**
- 5. Unilateral v. jugularis anterior**
- 6. Variants of the confluence of v. jugularis externa – into the venous angle or the internal jugular vein.**

Anomalies of the blood vessels of the head and neck

- 1. Anomalies of the vertebral artery - can enter the spinal canal at the level of CIII-CIV, sometimes - duplication of vertebral artery**
- 2. Asymmetric arrangement**
- 3. Hypoplasia (underdevelopment)**
- 4. Double a. basilaris.**
- 5. Dystopia a. basilaris**
- 6. The presence of the membrane that divides a. basilaris into 2 halves**
- 7. Anomalies of the circle of Willis - hypoplasia or aplasia of the communicating arteries**
- 8. Congenital cutaneous capillary hemangioma**
- 9. Arterio-venous fistulas**

Anomalies of the basilar artery

**lateropositon,
existence of the septum,
plexiform type,
high fusion of the vertebral arteries**

**multiple superior cerebellar arteries
tortuous course of basilar artery**

Anomalies of the arterial circle of the brain

**hypoplasia of the communicating arteries,
diversity of the structure, size and location of the arteries,
absence, doubling or triplet of the anterior communicating a. ,
doubling of the anterior cerebral a. starting from the ACI „anterior triplet”
in 1-7%,
anterior cerebral a. starts from the anterior communicating a. ,
“triplet of the ACI”: posterior cerebral a. starts from the ACI,
diameter of the anterior communicating is equal with the posterior cerebral
a.**

Internal carotid artery

Origin of occipital artery

Cervical internal carotid loops or coils

Recurrent artery of Heubner/medial lenticulostriate arteries

Origin of ascending pharyngeal artery

Aberrant petrous portion

Cavernous ophthalmic artery origin

Origin of posterior cerebral artery, "fetal origin"

External carotid artery

Ophthalmic origin from middle meningeal

Origin of posterior meningeal artery

Basilar artery

Multiple superior cerebellar arteries

Tortuous course of basilar artery

Vertebral artery

Isolated posterior inferior cerebellar artery

Inferior thyroid artery origin

Absent vertebral artery

END