

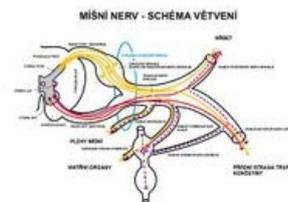


**Plexus Brachialis** (C4 – Th1) - innervation of the upper limb (for example radial nerve, ulnar nerve).

**Thoracic nerves** - passes inside the intercostal spaces, does not form any braids. They innervate the chest wall.

**Plexus lumbalis** (L1 – L5) - innervation of the skin and muscles of the abdomen, thighs and pelvis.

**Plexus sacralis** (S1 – S5) - innervates the back of the thigh, buttocks, leg and foot. The thickest nerve in the human n. ischiadicus belongs to this plexus.



Spinal nerve branching scheme

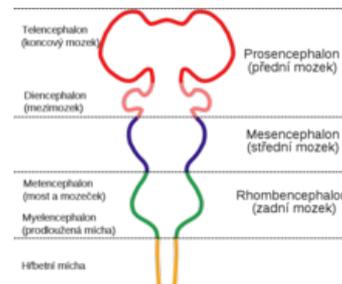
## Hindbrain (rhombencephalon)

The hindbrain, rhombencephalon, consists of the following parts: myelencephalon (*medulla oblongata*) and metencephalon (ie Varol's bridge and cerebellum).

### Medulla oblongata

Part of the hindbrain and brainstem connects to the spinal cord, 2 cm long, passes through a large occipital opening. It has anterior median fissure in the front and pyramids on the sides.

- **Sulcus anterolateralis** - next to the pyramids, XII. cranial nerve - nervus hypoglossus (sublingual).
- **Olivae** - bodies lying on the sides of the medulla oblongata.
- **Sulcus posterolateralis** - output IX., X. and XI. cranial nerves.
- Structure: **gray matter** (forms nuclei - huge number, grouping of neurons); **white matter** (nerve fibers).



### Varoli Bridge (pons Varoli)

Follows the medulla oblongata. White matter represents passing paths, gray forms nuclei. Output V. -VIII. cranial nerves. Together with the medulla oblongata, it forms the base of the fourth ventricle.

### Reticular formation

a formation that penetrates the medulla oblongata and the Varol Bridge to the midbrain. It has a networked appearance, it consists of multiple nuclei that are interconnected. Reticular formation is connected to other parts of the CNS.

Functions: activating and inhibiting (activating and suppressing), coordinating and connecting, the center of important reflexes (sucking, swallowing, coughing, vomiting), the center of control of vital functions (breathing, heart activity, blood pressure).

### Cerebellum

The cerebellum is located in the posterior cranial fossa, its average weight is 130-140 g. It consists of two hemispheres. The hemispheres are connected by a so-called worm (vermis). In the cross-section we can distinguish:

- **gray cortex** cerebellar;
- **white matter**, the so-called tree of life (arbor vitae).

Inside are the cerebellar gray nuclei. The cerebellum is connected to the medulla oblongata, the Varol Bridge and the midbrain, there comes information from the balance, auditory, visual system, muscles, tendons, joints and cortex, forming the ceiling of the 4th ventricle.

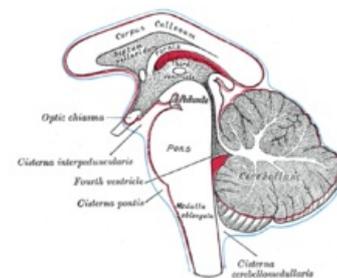
- Function: involved in the control of precise movements, coordination, spatial orientation, important for standing and walking.

**The cerebellum** is located in the posterior cranial fossa, dorsally from the medulla oblongata and the pons (brainstem).

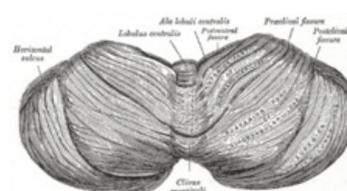
Rounded dorsally arched formation. Round, longitudinal, narrow middle band, separated by sagittal depressions from the lateral parts = **vermis cerebelli** (cerebellar worm). **Hemisphaeria cerebelli**: 2 lateral, larger, symmetrically arranged hemispheres. Cranial surface flatter, contact with a roof-like duplicate of the dura mater (**tentorium cerebelli**). Dorsal and caudal areas are arched; placed in the fossa of the occipital bone under the transverse arms of the eminentia cruciformis (fossae occipitales cerebellares). The **false cerebri** (from the crista occipitalis interna) intervenes between the hemispheres of the cerebellum.

From the brainstem, 3 pairs of stalks enter the cerebellum, the pedunculi cerebellares:

- **Inferiores (corpora restiformia)** - connect the medulla oblongata with the cerebellum; line the caudal part of the fossa rhomboidea.

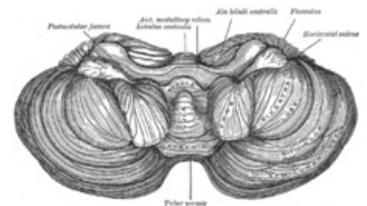


Cerebellum - sagittal section



Cerebellum - top view

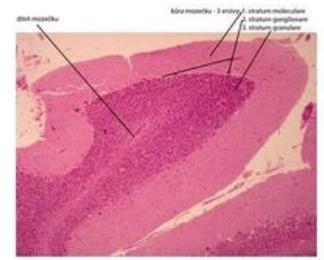
- **Medii (pontini; brachia pontis)** - connect the pons Varoli with the cerebellum; makes a boundary the fossa rhomboidea.
- **Superiores (brachia conjunctiva)** - connect the mesencephalic tegmentum with the cerebellum; makes a boundary the rostral part of the fossa rhomboidea.



The base of the cerebellum

All peduncles contain pathways going to and from the cerebellum. The upper medullare superius (**velum medullare superius**) (craniale) - front part of the ceiling IV. chambers, pulled into the apex called **fastigium**.

Numerous transverse furrows on the surface of the cerebellum - separate the individual sections on the vermis and hemispheres = **fissurae cerebelli**. The largest and deepest fissures separate 3 main sections: **lobi cerebelli**. The smaller fissures further divide these lobes into lobules: symmetrically placed on the hemispheres; correspond to an unpaired stretch of vermis. The smallest fissures separate the parallel strips of the cerebellar surface = **folia cerebelli**. The surface is covered with continuous gray matter: **cortex cerebelli**. Fissura prima - from the center on both sides, fissura horizontalis - dorsal pole, fissura posterolateralis - separates the nodule and flocculus.



Cerebellum - histological specimen

Inside the cerebellum white matter, corpus medullare. It extends in the shape of discs like laminae albae into the foils of the cerebellum. On the sagittal section, the vermis forms a tree-like pattern (**arbor vitae**, the tree of life).

Paired clusters of gray matter are deposited in the white matter: **nuclei cerebelli**:

- **Ncl. dentatus** - the largest of the cerebellar nuclei. It has two parts: dorsomedial (paleocerebellar) with fibers pointing to the ncl. ruber and ventromedial (neocerebellar) with fibers leading to the thalamus. The shape of a crumpled sac with a ventromedial opening against the mesencephalon. Vacuum opening = hilum (hilus) nuclei dentati. Hence the pathway contained in the superior cerebellar pedunculus.
- **Ncl. emboliformis** - elongated small nucleus, shape of blood clot. Stored sagittally at hilo ncl. dentatus.
- **Ncl. globosus** - in pairs, located medially to ncl. emboliformis. From several small spherical formations of gray matter.
- **Ncl. fastigii** - paired, located most medially at fastigii, near the midline.

Ncl. emboliformis, globosus and fastigii efferent to ncl. ruber, reticular nuclei, mesencephalon, pons Varoli and oblongata. All the cerebellar nuclei are the starting point of the pathways protruding from the cerebellum - through which the cerebellum is involved in the movement control system.

The nuclei contain bodies of multipolar neurons at which the axons of Purkinje cells terminate.

## Morphological division of the cerebellum

It is divided by transverse grooves into 3 lobes. Each lobe is separated by smaller grooves into smaller lobules (on the vermis and hemispheres). The morphological division enables topographic orientation on the cerebellum, but does not correspond to the developmental and functional division.

### Description of departments

**Upper surface** (from front to rear)

**Vermis** (anterior cerebral lobus)

- Lingula cerebelli - one to several foils based on velum medullare superius.
- Lobulus centralis - a square group of foils in the anterior incisure. (fissula precentralis).
- Monticulus - a larger part of the upper surface of the vermis, arched; transverse groove is divided into culmen and declive (fissura prima).
- Folium vermis - the only folium in the posterior cerebral incisure.

### Hemispheres

- Vinculum lingulae cerebelli - narrow white band.
- Ala lobuli centrales - a triangular group of foils in the anterior incisure.
- Lobulus quadrangularis - divided by a transverse groove into pars superior and inferior (pars inf. otherwise also called lobulus simplex).
- Lobulus semilunaris sup. - crescent shape.

**Lower surface** (separated from the upper surface by fissura horizontalis cerebelli)

### Vermis (posterior cerebral lobe)

- Tuber vermis - protrudes into the incisura cerebelli posterior (fissura horizontalis)
- Pyramis vermis - the widest part of the vermis (fissura prepyramidalis)
- Uvula vermis - elongated ridge of several foliage (fissura secunda)
- Nodulus vermis - attached to the uvula, rests on the velum medullare inf.

## Hemispheres

- Lobulus semilunaris inf - lobulus gracilis joins it.
- Lobulus biventer - bulging.
- Tonsila cerebelli - highly convex groups of horseshoe-shaped foils.
- Flocculus - a stalk group of foils with a curly edge; a rudimentary paraflocculus is attached at the posterior margin.

## Division of departments according to developmental relations

Vestibular cerebellum - the oldest part, the basis of development are the vestibular pathways. It consists of: flocculus, lingua and nodule.

Spinal cerebellum - the basis of development are the spinocerebellar pathways, it divides the vestibular cerebellum into anterior part (lingua) and posterior part (nodule and flocculus). It consists of the anterior: central bulbar, culmen, superior quadrangular lobule and posterior: pyramis, uvula, paraflocculus.

Vermis		Hemifolium	
Lingula	Arviculum lingulae	Lobus anterior s. rostralis	
Lobulus centralis	Ala lobuli centralis		
Culmen semilunare	Lobulus quadrangul. sup.		
Fissura prima			
Dective monticuli	Lobulus quadrangul. inf.	Lobulus simplex	
Folium vermis	Lobulus semilun. sup.		Lobus medius
Folium vermis	Lobulus semilun. inf.		
Pyramis	Fissura praepyramidalis	Lobulus complicatus	
Uvula	Lobulus biventer		
	Tonsilla		
	Nucleus accessorius	Lobus posterior s. caudalis	
Fissura nodulofloccularis			
Nodulus	Flocculus	Neri nodulofloccularis	

Cerebellum - Summary of anatomical developmental description

Cerebral cerebellum - develops by afferentation of the cortex, through the pontocerebellar tract. It occurs in the middle of the older parts of the cerebellum, collectively referred to as the palaeocerebellum. It is then called the neocerebellum (seu lobus medius).

The creasing of the cerebellum happens gradually.

The earliest sulcus primarius (fissura prima) is formed. It separates the part called the anterior lobus (rostralis). This includes the lingua and the anterior part of the spinal cerebellum. The following groove - fissura praepyramidalis defines the lobus medius and lobus caudalis in the vermis. Fissura nodulofloccularis - border between the caudal lobus and the nodulofloccular pars.

## Division including anatomical and developmental characteristics

- Lobus rostralis (anterior) - anterior rudiment of the vestibular cerebellum and anterior spinal cerebellum.
- Lobus medius - the largest part, includes the cerebral cerebellum.
- Lobus caudalis (posterior) - posterior spinal cerebellum.
- Lobus nodulofloccularis - part of the vestibular cerebellum not included in the lobus rostralis.

## Functional involvement of the cerebellum

Inlet pathways via the **pedunculi cerebellares** inferiores, media, superiores into the cerebellar cortex. From the cerebellar cortex the fibers exit, ending in the cerebellar nuclei.

The **cerebellar nuclei** send axons to the gray matter of the **stem** (mainly to the reticular formation, ncl. Ruber, to the thalamus). From the gray matter of the stem tracks into the spinal cord, which affect the cells that send their axons like motor fibers to the skeletal muscles. It controls movement activities and muscle tone, where the vermis participates in the coordination of the muscles of the torso and the hemisphere of the muscles of the equilateral limbs. [1]

## Cerebellar tracts

Afferent pathways predominantly lead to the cerebellar cortex. Efferentation begins with Purkinje cells (1st neuron) and continues after switching in the cerebellar nuclei (2nd neuron) into a centrifugal pathway going outside the cerebellum.

**Vestibulocerebellum** - lobus flocculonodularis and lingua vermis are connected to the vestibular nuclei of the rhombencephalon, from ncc. vestibulares a ncc. colliculi superiores and visual cortical areas, maintaining body balance, spatial orientation.

**Spinocerebellum** - lobus cerebelli posterior, anterior in addition to the rostral section of the lingua joins with the spinal cord, afferent fibers come from the trigeminal nerve, auditory and visual structures of the CNS and efferent nerves go to the motor nuclei of the brainstem, the function is to coordinate motor skills and respond to proprioceptive information.

**Cerebrocerebellum** - via the nuclei pontis associated with the cortex, af. fibers from the cerebral cortex via ncc. pontis, ef. they pass through the motor thalamus (nc. ventralis anterior and lateralis) and through the cerebral cortex, the function is coordination and timing of muscle movements.

A) Nodulofloccular pathways:

- Afferents from ncl. vestibulares as tr. vestibulocerebellares.
- The efferent points to the Deiters nucleus, according to its origin as tr. nodulovestibularis and flocculovestibularis. from ncl. fastigii goes more independently tr. fastigiovestibularis (Russel's bundle) along with the pedunculus cerebellaris inf. to the core of Deiters.

B) Tracks lobi rostralis and lobi caudalis

## Afferent tracks:

- Tr. spinocerebellaris post.: Stilling-Clark core - pedunculus cerebellaris inf. - cerebellar cortex (and cerebellar nuclei).
- Tr. spinocerebellaris ant. (Gowersi): crossing in the spinal cord - lateral spinal cords (ventrally from the tractus Spinocerebellaris post.) - through the pedunculi cerebellares superiores into the cerebellum.
- Tr. bulbo-cerebellares: from the nuclei of the posterior spinal cords - uncrossed as *fibrae arcuatae externae dorsales* or crosswise as *fibrae arcuatae externae ventrales* and *fibrae arcuatae internae* - via the pedunculus cerebellaris inf.
- Tr. nucleocerebellares: from the nuclei of sensitive cranial nerves.
- Tr. olivocerebellares: from the main olive (older part) and the secondary olive.
- Tr. tectocerebellaris: of gray matter under the colliculi superiores - velum medullare superius - cortex of the superior vermis.
- Tr. reticulocerebellaris: from the nuclei of the lateral nuclei RF - pedunculus cerebellaris inf. - vermis - into the equilateral hemisphere.
- Tr. rubrocerebellaris: after crossing tr. rubrospinalis turns into - pedunculus cerebellaris sup.

## Efferent paths:

- Tr. cerebellotegmentalis (dentatotegmentalis): from cerebellar nuclei (mainly dentatus) - pedunculus cerebellaris sup. - FR nuclei of the pons and mesencephalon.
- Tr. cerebellorubralis (dentatorubralis): via pedunculi cerebelli sup. do ncl. ruber (then using tr. rubrospinalis and rubroolivaris to olive).
- Tr. cerebelloolivaris: via pedunculi cerebelli inf. - contralateral to the main olive (older part) and the secondary olive.
- Tr. cerebellotectalis: via pedunculi cerebelli sup.
- Tr. cerebellothalamicus (embolothalamicus): through the central nuclei of the thalamus into the striatum.

## C) Tracks of lobus media

### Afferent tracks:

- Tr. pontocerebellares: from ncl. pontis where it crosses - pedunculi cerebelli medii - cerebellar cortex; the pathway is a continuation of the corticopontic pathway (tr. frontopontinus et tr. occipitotemporopontinus) and cross-connects the hemispheres of the forebrain and cerebellum.
- Tr. olivocerebellares: as with the lobi rostralis et caudalis pathways, however, it comes from the Neo-Olives (younger part of the Italian ciliaris).
- Tr. corticocerebellares: from the motor area of the frontal lobe - pedunculi cerebelli inf. - into the unilateral hemisphere of the cerebellum.

### Efferent paths:

- Tr. cerebellorubrales: guidance as for the eponymous track from the previous group of tracks.
- Tr. cerebrothalamici: from ncl. dentatus into the ventrolateral nuclei of the thalamus (here in after referred to as thalamocorticalis into areas 4 and 6).

## Middle brain (mesencephalon)

The middle brain / mesencephalon / is the most spacious part of the brainstem, it connects to the Varol Bridge.

It combines rhombencephalon with diencephalon. They measure to a length of about 2 cm. Practically the entire is covered by the hemispheres of the terminal brain, only its ventral part is visible as the so-called *crura cerebri* (partes anteriores pedunculi cerebri) - massive stems containing white matter. The **aquaeductus mesencephali** (Sylvii) runs through the middle brain - a narrow canal, leading to the cerebrospinal fluid, after leaving IV. chambers.



Localization of the midbrain

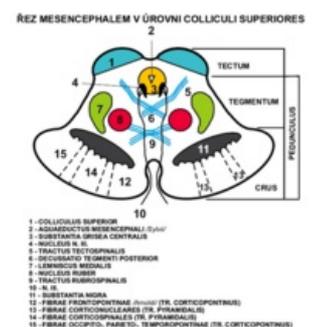
Aquaeductus mesencephali is lined with a layer of gray matter *substantia grisea centralis*.

The midbrain can be divided into several parts - the *tegmentum mesencephali* and the *pedunculus cerebri* (which consists of the *tegmentum mesencephali* and the *crura cerebri*).

*Pedunculus cerebri* is ventral to aquaeductus mesencephali.

**Crura cerebri** (partes anteriores pedunculi cerebri) - also part of the *pedunculus cerebri*. They are lateral and sink under the optic tract into the base of the brain.

Between the two stems is the **interpeduncular fossa**. Its surface is perforated by a series of vessels, so it is called **substantia perforata posterior** (interpeduncularis). Be careful not to confuse the *substantia perforata anterior*, which is part of the terminal brain!



Section of the midbrain at the level of the colliculi superiores

In the interpeduncular fossa, the oculomotorus III. protrudes medially from the pedunculus.

Ventrally from the interpeduncular fossa are the corpora mamillaria, which already belongs to the diencephalon. These cranial nerves leave the midbrain - III., IV. (II. already runs here as a pathway, not an optic nerve). The cranial ends of the reticular formation also extend here.

**Tectum**, in Czech four-bladed, lies dorsally from aquaeductus mesencephali. It contains two pairs of bumps - colliculi superiores et inferiores.

They are involved in the visual and auditory pathways and continue as the **brachium colliculi superioris et inferioris** into the **corpus geniculatum laterale and mediale** of diencephalon.

Caudally from the colliculi run pedunculi cerebellares superiores, another in a series of stem pathways. As with the inferiores cerebellares pedunculi, the velum, more precisely the velum medullare superius, forming the cranial part of the IV. chamber ceiling is unfolded here. Cranially from the tectum is the area pretectalis, which already belongs to the diencephalon.

### **Nuclei mesencephali of tectum:**

- mostly sensitive pathways (sight and hearing)

a) **Ncl. colliculi superioris** - retinal fibers both motor and somatosensitive

b) **Ncl. colliculi inferioris** - auditory cortical center

c) **Ncl. commissurae posterioris**

d) **Ncll. pretectales - ncl. optical tract**

**Tegmentum** (partes posteriores pedunculi cerebri) - ventrally from the tectum, part of the pedunculus cerebri.

The boundary between crura and tegmentum is formed by substantia nigra.

**Substantia nigra** - pigment in the pericarya, the outer part faces the crura and has a reticulate appearance (pars reticularis) and the inner part faces the tegmentum (pars compacta) produces **dopamine**.

It contains a number of important tracks and cores. A slight elevation is visible on the side - trigonum lemnisci, where the lemniscus medialis takes place.

### **Nuclei mesencephali of tegmentum:**

- predominantly motor pathways

1. **Ncl. ruber** - oval, large, reddish, between substantia nigra and aquaeductus, regulation of limb movements
2. **Ncl. nervi oculomotorii** - in aquaeductus, a set of several nuclei, sends somatomotor fibers to the oculomotor nerve, which innervate 4 of the 6 oculomotor muscles, controls the movements of the eyeball
3. **Ncl. accessorius n. oculomotorii** - dorsal from nc. oculomotor nerves, visceromotor parasympathetic fibers, ciliaris and sphincter pupillae, eyeball movements
4. **Ncl. interstitialis Cajal** - small, dorsal from nc. nervi oculomotorii, associated with the gray matter of the substantia grisea centralis and the rostral part of the formatio reticularis, part of the fasciculus longitudinalis medialis
5. **Ncl. Darkshevich** - small, cerebellum fibers, telencephal cortex, vestibular nuclei of rhombencephalon
6. **Ncl. nervi trochlearis** - small, at the substantia grisea centralis, caudally from n. III., somatomotor fibers innervate the obliquus superior bulbi muscle
7. **Ncl. mesencephalicus nervi trigemini** - long and slender, comes from the rhombencephalon, lateral to the aquaeductus, sensitive muscular and articular receptors of the masticatory muscles, artic. temporomandibularis and oculomotor muscles

### **Mesencephalon pathways:**

- afferent to ncll. collicules superiores from the retina, from the spinal cord, rhombencephalon, from the visual cortex

- to colliculi inferioris from ncll. cochleares

## **Forebrain (prosencephalon)**

The forebrain (prosencephalon) includes two brain structures: the midbrain (diencephalon) and the terminal brain (telencephalon).

### **Diencephalon**

The diencephalon or midbrain consists of five functionally and morphologically distinct parts. Dorsoventrally they are: epithalamus, thalamus, metathalamus, subthalamus and hypothalamus.

## **Anatomy**

The midbrain connects to the upper end of the brainstem. It is located **between the hemispheres of the terminal brain**, so it is not clearly visible. The only visible structure lies on the ventral surface of the brain, and that is the **hypothalamus**. The posterior border is formed by the upper end of the interpeduncular fossa, or two humps, the corpora mamillaria. It ends in the area of **chiasma opticum**.

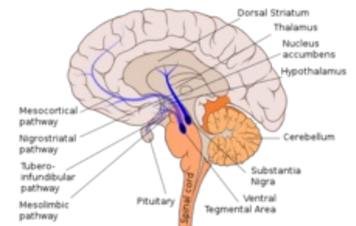
The diencephalon is formed by further development of the **anterior cerebral sac (prosencephalon)**, in which the **original division** into **alar** and **basal discs** is evident. The thalamus (**sensitive structure**) and basal hypothalamus (**visceromotor structure**) develop from the alar plates.



Diencephalon

## Description

The most conspicuous part of the midbrain are the two arches, which are the thalamus that form the lateral walls of **III. cerebral ventricles**. Furthermore, the fibrous bodies of the choroidea ventriculi tertii protrude from the thalamas, forming the ceiling of III. cerebral ventricles. The place of attachment of the body of the choroid is called taenia thalami. Diencephalon contains **III. cerebral ventricle**, which is a continuation of **aquaeductus mesencephali**, leading from **IV. cerebral ventricles**. It then flows into the foramina interventricularia, through which it enters the **lateral ventricles** (between the hemispheres of the terminal brain).



Description of the brain

The medial wall of the diencephalon (side walls of the third ventricle) is divided by a pair of grooves - sulcus hypothalamicus (corresponds to the sulcus limitans of the neural tube). This structure divides the diencephalon into **dorsal and ventral parts**. The dorsal part includes the thalamus, metathalamus and epithalamus, which are mostly **sensitive**. The ventral part includes the subthalamus and hypothalamus, whose functions are mainly **motor**.

## Epithalamus

Dorsocaudal part of the diencephalon, which consists of **habenular nuclei** and corpus pineale. The habenular nuclei are contained in the trigonum habenulae, which is formed by the extension of the bundle of white matter fibers (stria medullaris thalami). Both trigons together form a **habenula**, within which the **fibers of the stria medullaris thalami cross**. At the junction, the corpus pineale (**pineal gland**) extends from the epithalam.

### Nuclei

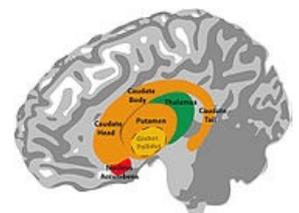
Inside the habenula there are **habenular nuclei** (nucleus habenularis medialis et lateralis). Their activity is **somatomotor and visceromotor**, allowing reactions of olfactory and limbic arousal. Habenula is a functional part of the limbic system.

### Tracks

The **posterior commissura** connects the posterior nuclei of the thalamus, the colliculi superiores and the pretectal nuclei of both sides. It contains fibers emerging from the ncl. interstitialis, from ncl. Darkshevich, from pretectal nuclei and part of **habenulotectal fibers**.

## Thalamus

Paired part of diencephalon, **oval** in shape. The **anterior part** narrows into the anterior tuberculum and the **posterior rounded part** is called the pulvinar. The two parts of the thalamus are connected to each other through the adhesio interthalamica.



Thalamus

## Metathalamus

Occipitally follows the thalamus. It consists of the corpus geniculatum laterale, which is located under the pulvinar and mediale. The metathalamus is involved in the **visual and auditory pathways**, receiving signals from the **mesencephalon**.

### Nuclei

Ncl. corporis geniculati lateralis belongs to the **visual tract** and ncl. corporis geniculati medialis belongs to the **auditory pathway**.

## Subthalamus

It lies ventrally from the thalamus and laterally from the hypothalamus.

## Hypothalamus



helping to drain liquor into the venous system.

## Pia mater encephali

It clings firmly to the surface of the brain. Between the arachnoidea and the pia mater, blood vessels run and sink into the brain tissue.

## Links

### Reference

Wikiskripta: centrální nervový szstém

### Related articles

- Mozek
- Obaly mozku
- Vývoj mozku
- Atlas histologických preparátů/Nervová soustava

### External links

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