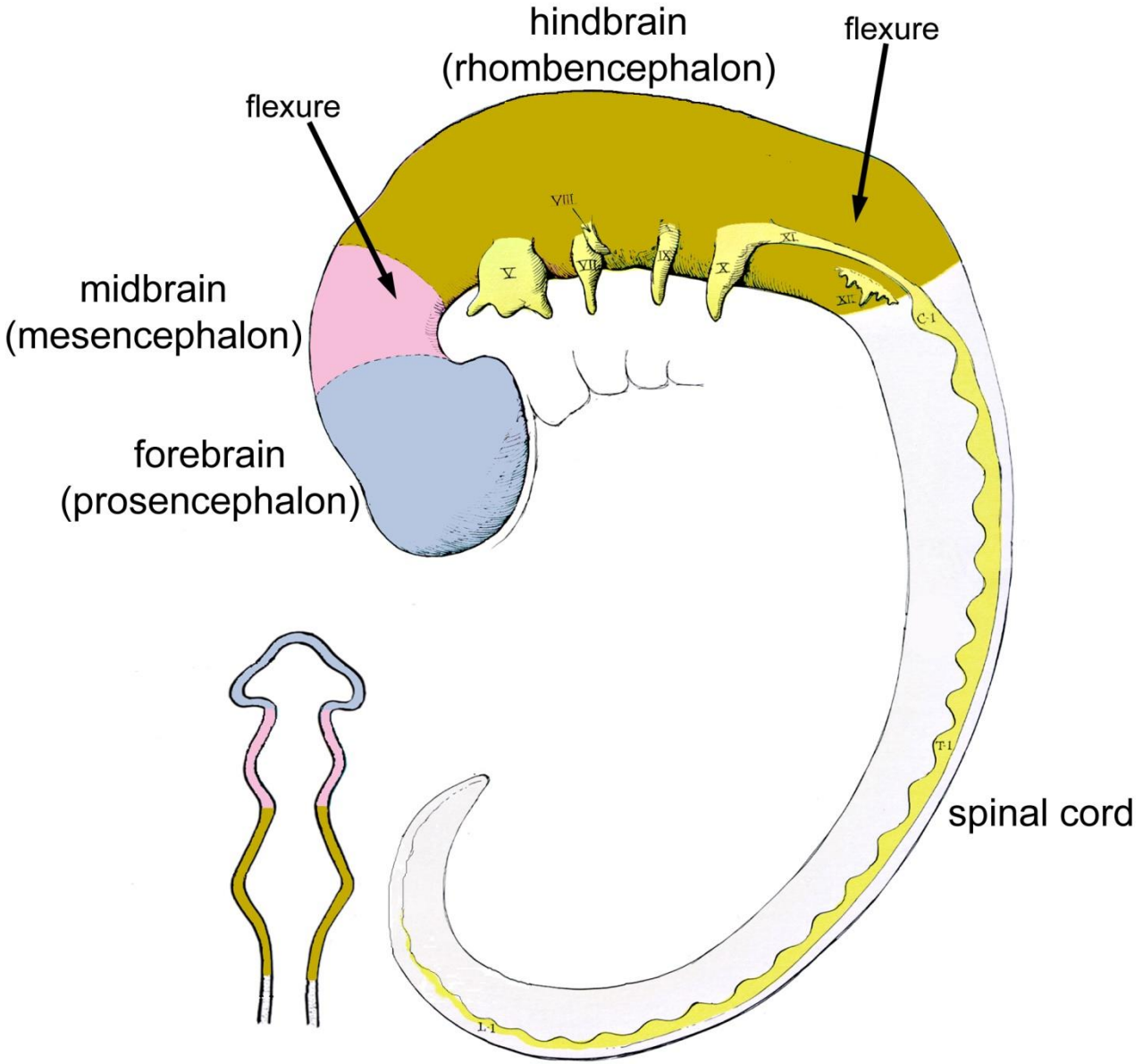
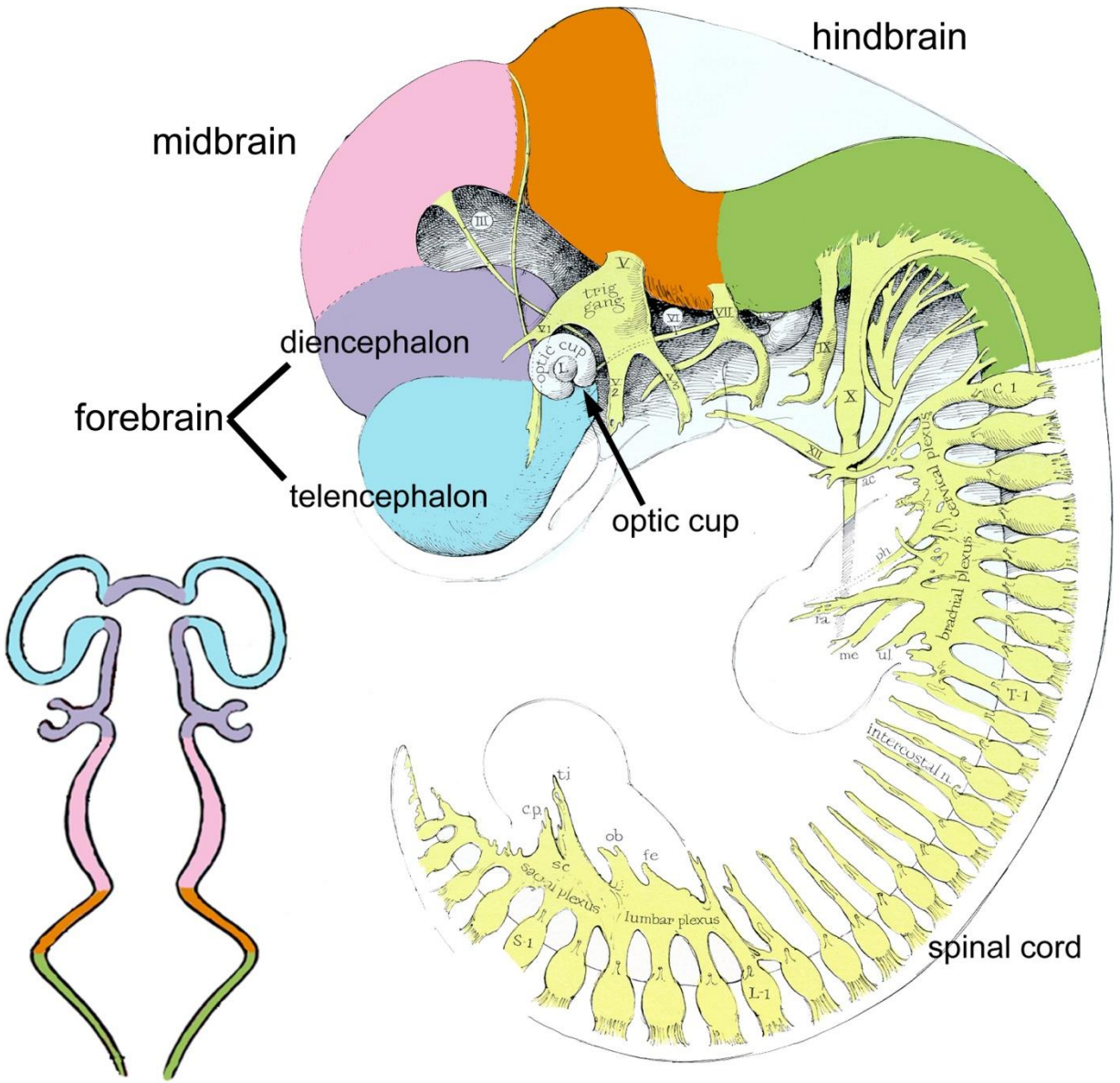
Forebrain

Steven McLoon
Department of Neuroscience
University of Minnesota

Three Primary Brain Vesicles

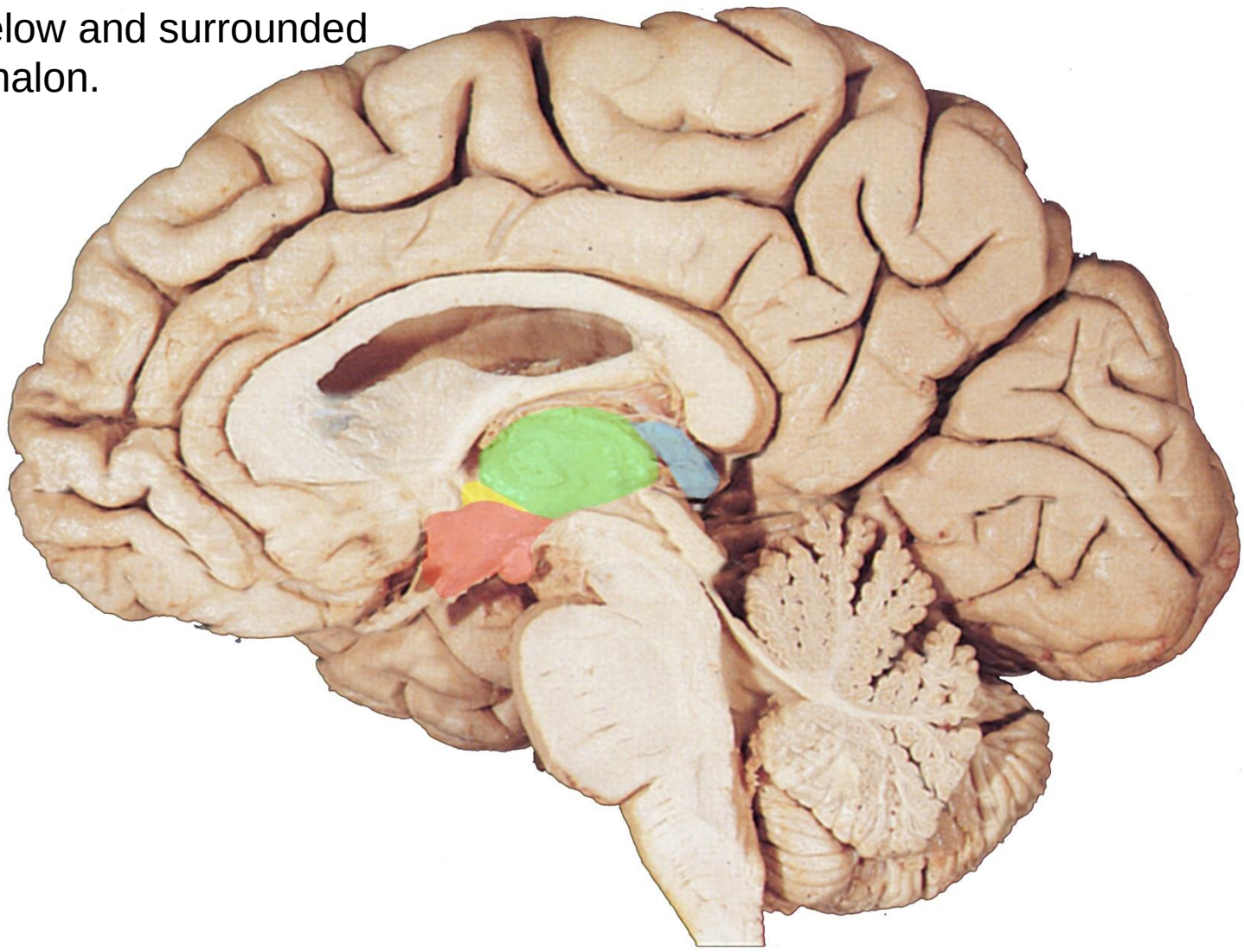


Forebrain gives rise to diencephalon, telencephalon and retina.



Diencephalon

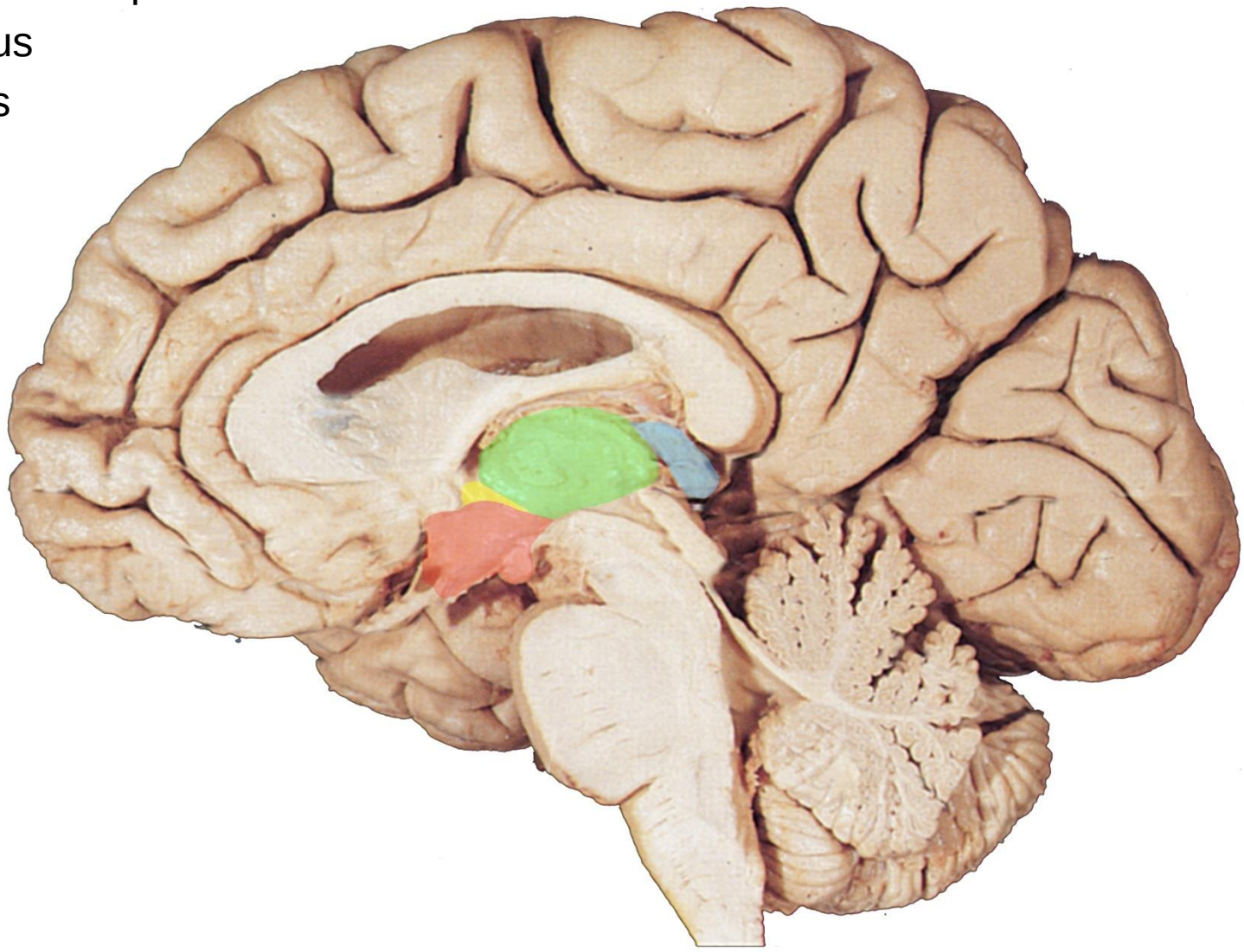
The diencephalon sits above the midbrain and below and surrounded by the telencephalon.



Diencephalon

The parts of the diencephalon are:

- Hypothalamus
- Subthalamus
- Thalamus
- Epithalamus



Diencephalon

The parts of the diencephalon are:

- Hypothalamus – controls autonomic and endocrine (hormone) systems
- Subthalamus – part of the basal ganglia, which has a role in the motor system
- Thalamus – gateway to the cerebral cortex
- Epithalamus – includes pineal gland, which regulates circadian rhythms

Hypothalamus

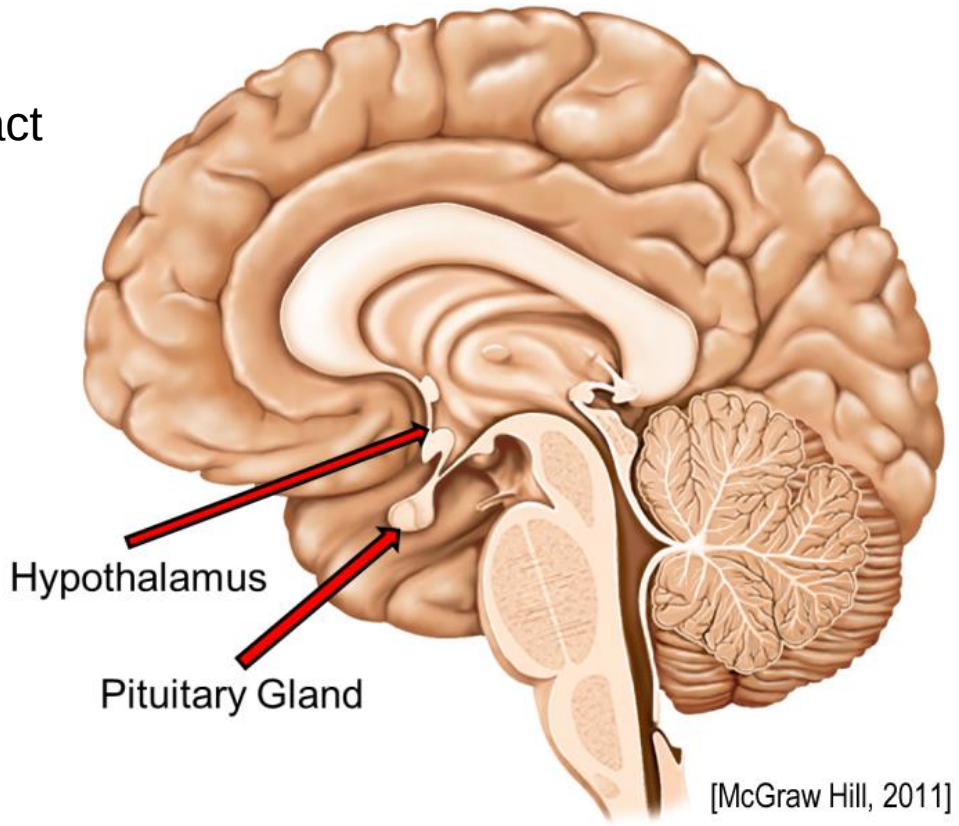
Participates in many functions including:

- temperature regulation
- circadian rhythms
- sexual activity
- feeding & drinking
- aggression & flight

Hypothalamus

Some neurons of the hypothalamus release hormones into the blood that act on the pituitary gland.

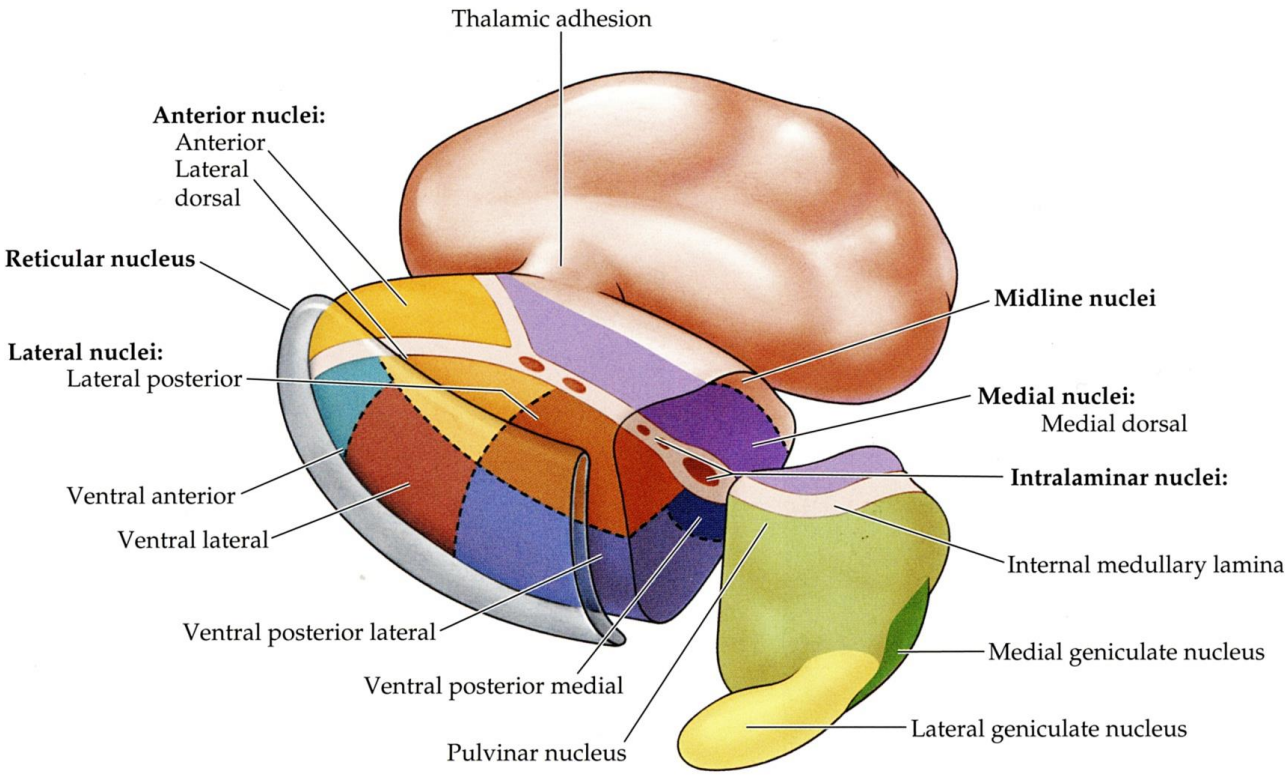
The pituitary gland is attached to the hypothalamus by the pituitary stalk.



Thalamus

The thalamus has two types of nuclei:

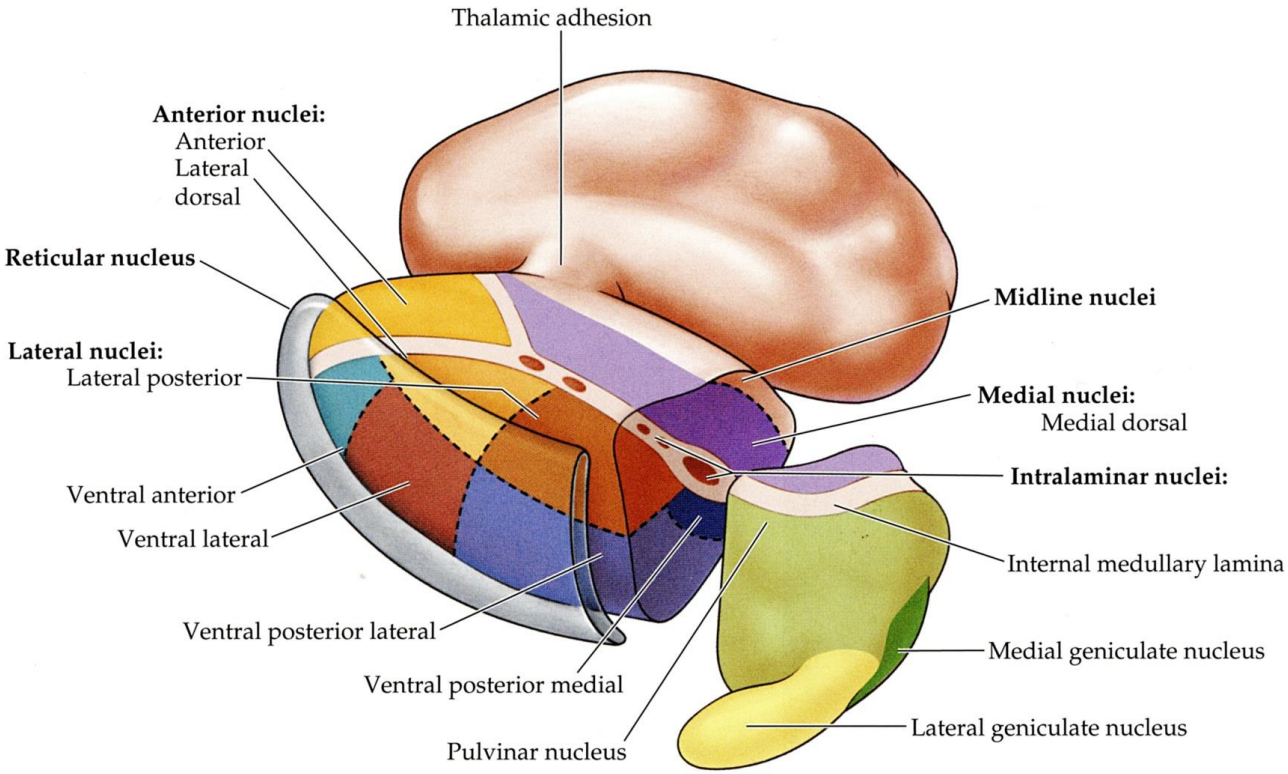
- Relay nuclei – relay specific sensory or motor information to specific regions of cortex
- Diffuse nuclei – have diffuse projections to cortex or thalamus



Thalamus

Diffuse nuclei …

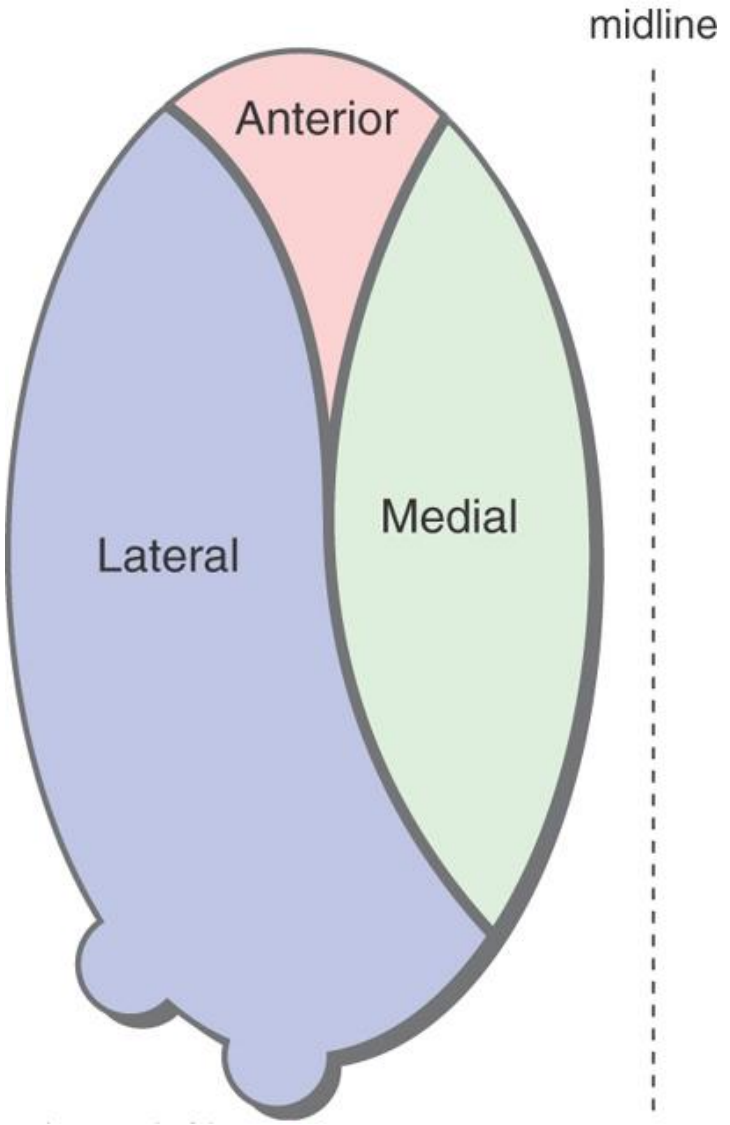
- are in the shell and intralaminar regions of the thalamus.
- are important for attention and arousal.
- include the reticular nucleus in the lateral shell region.



Thalamus

A sheet of myelinated axons, the internal medullary lamina, divides the thalamic relay nuclei into three major regions:

- Anterior (anterior nucleus)
- Medial (dorsomedial nucleus)
- Lateral (lateral group of nuclei)



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horizontal section

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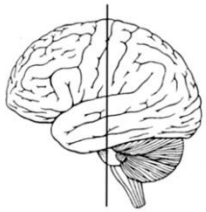
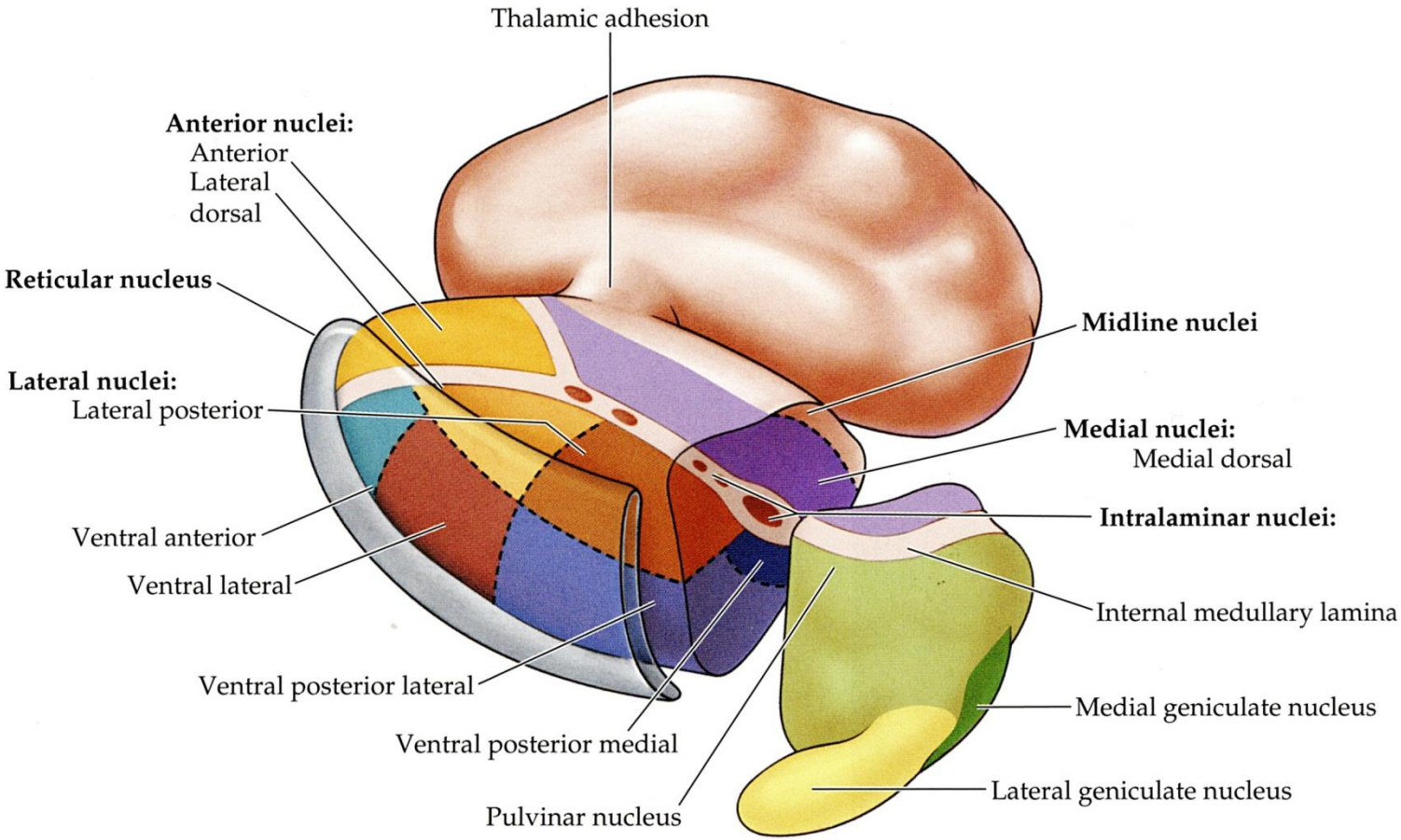


coronal section

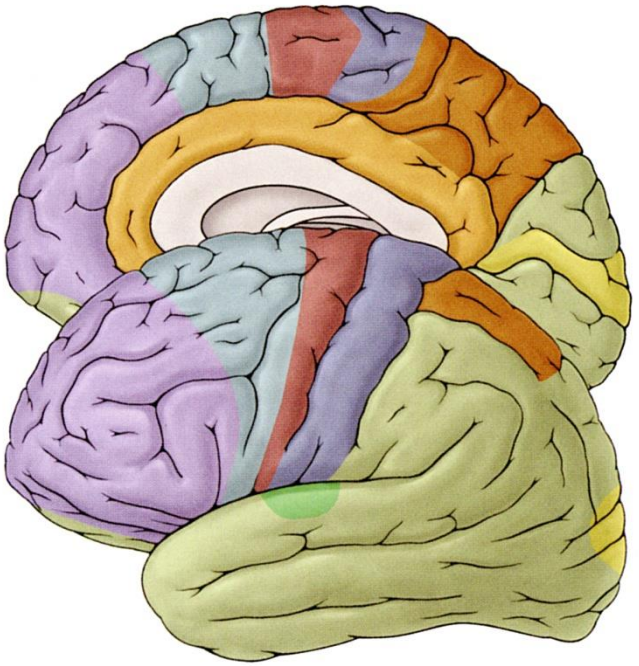
Thalamus

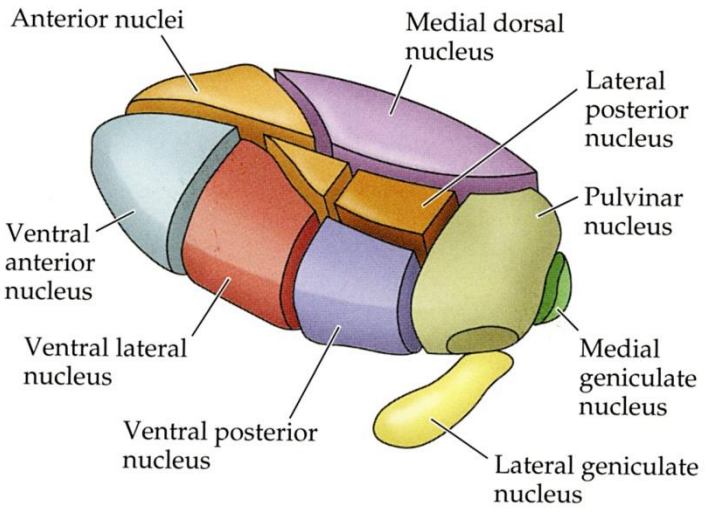
The lateral group of relay nuclei is further divided based on their connections (functions).



Thalamus

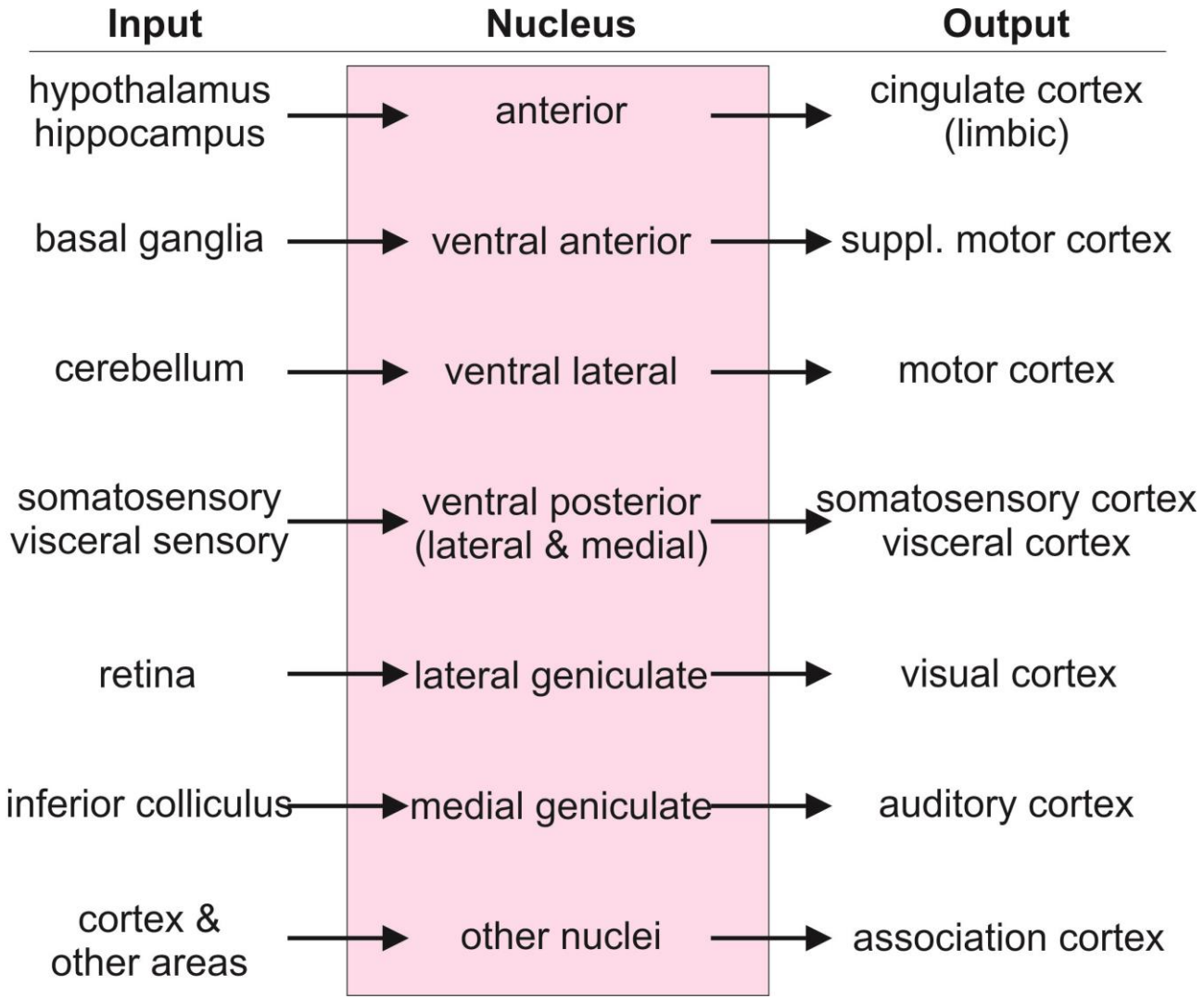
- Relay nuclei send axons to cortex.
- This projection is ipsilateral (to the same side).
- The pattern of the nuclei in thalamus approximately matches the pattern of their connections to cortex.





Thalamus

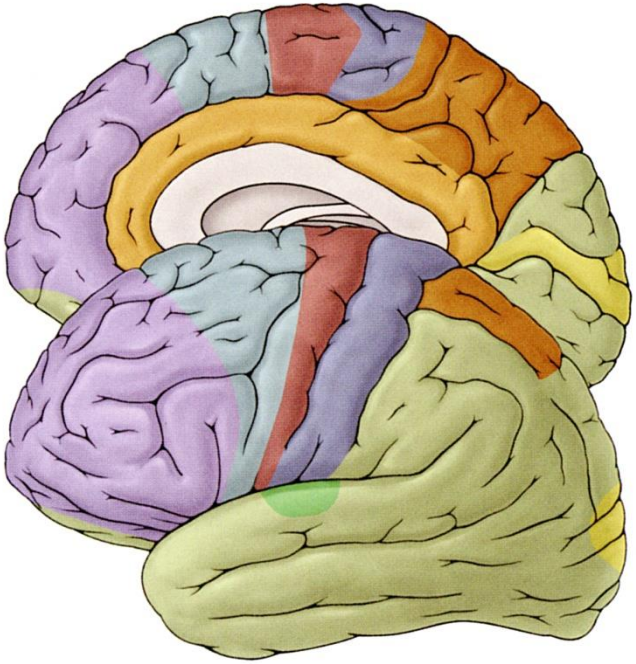
- Input and output relationships of the major relay nuclei:

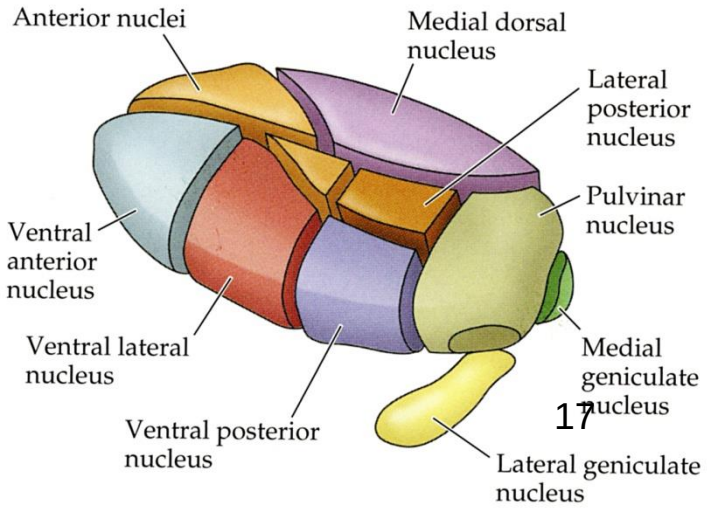


Thalamus

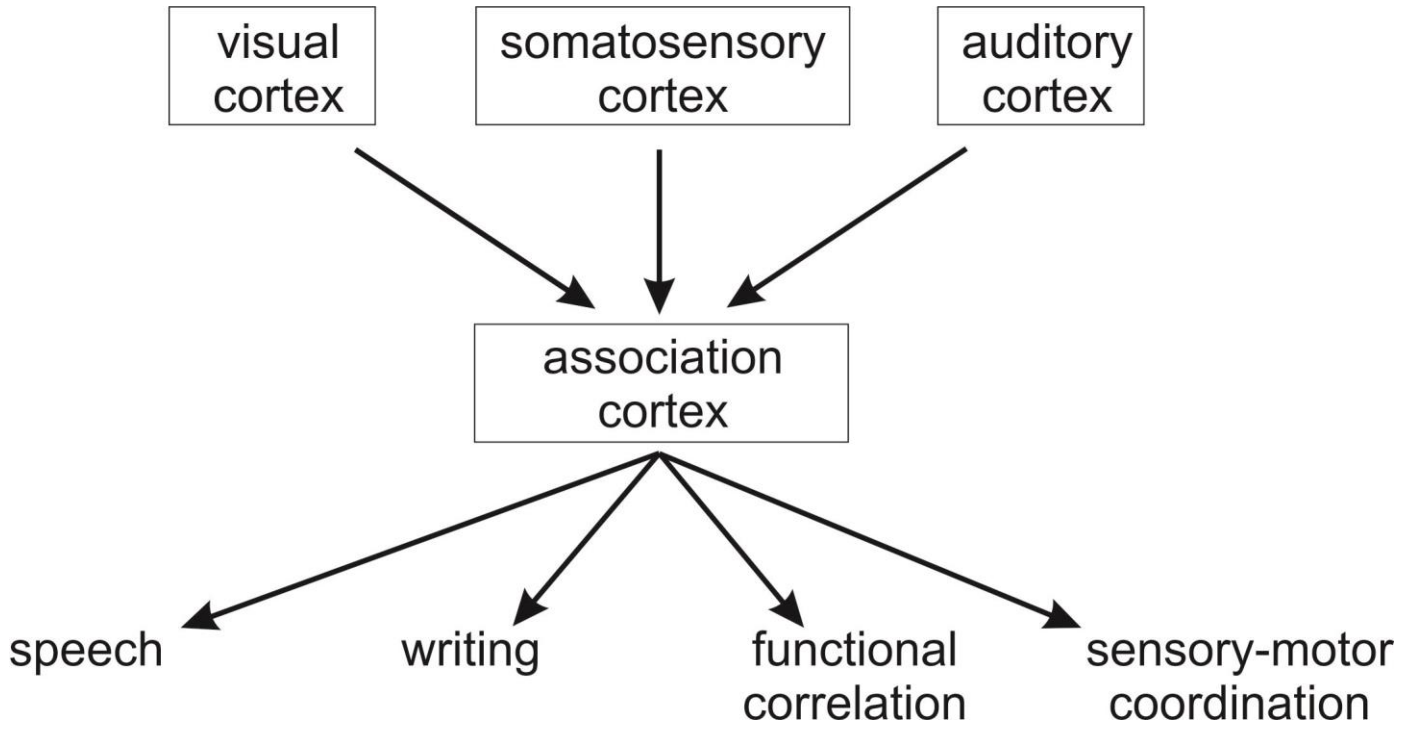
Other thalamic nuclei carry multiple modalities and project to association cortex. For example:

- dorsomedial nucleus → prefrontal association cortex
- pulvinar → parietal-occipital-temporal assoc. cortex





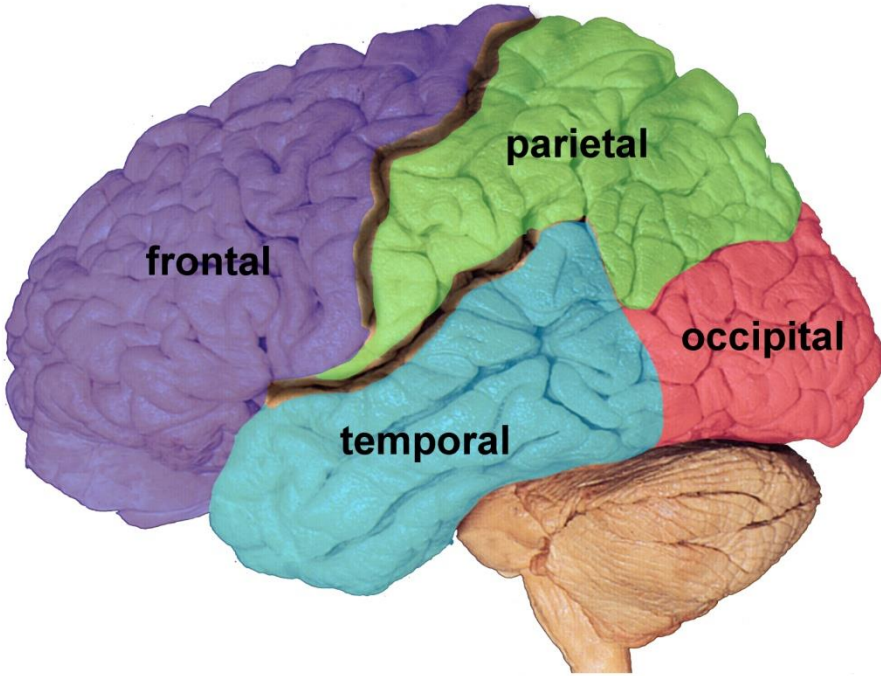
What is association cortex?

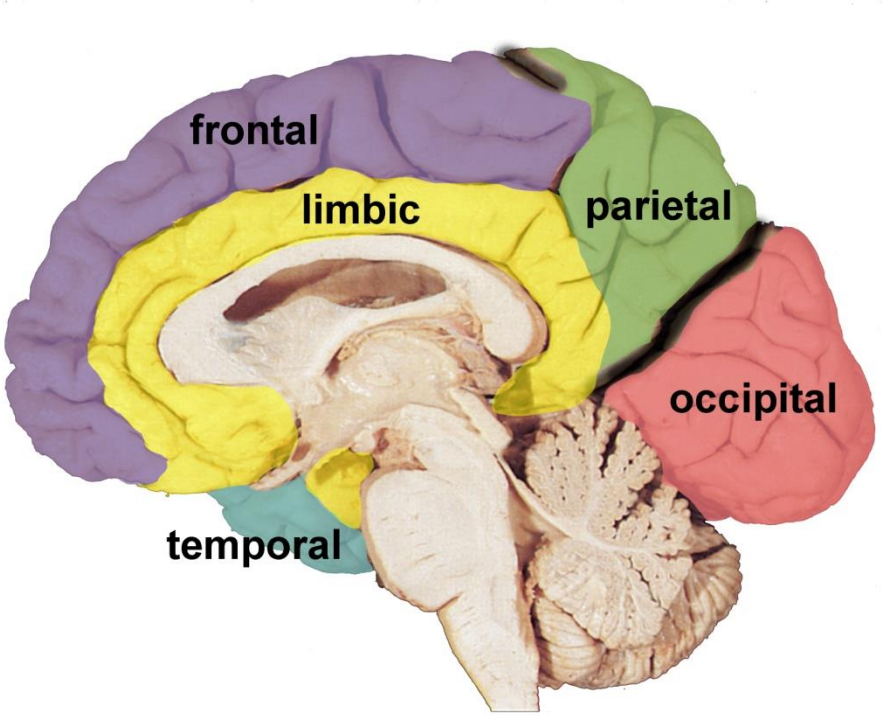


What is association cortex?

Association cortex is in three main areas:

- Parietal (parietal, temporal & occipital)
- Prefrontal
- Limbic (cingulate & orbitofrontal)

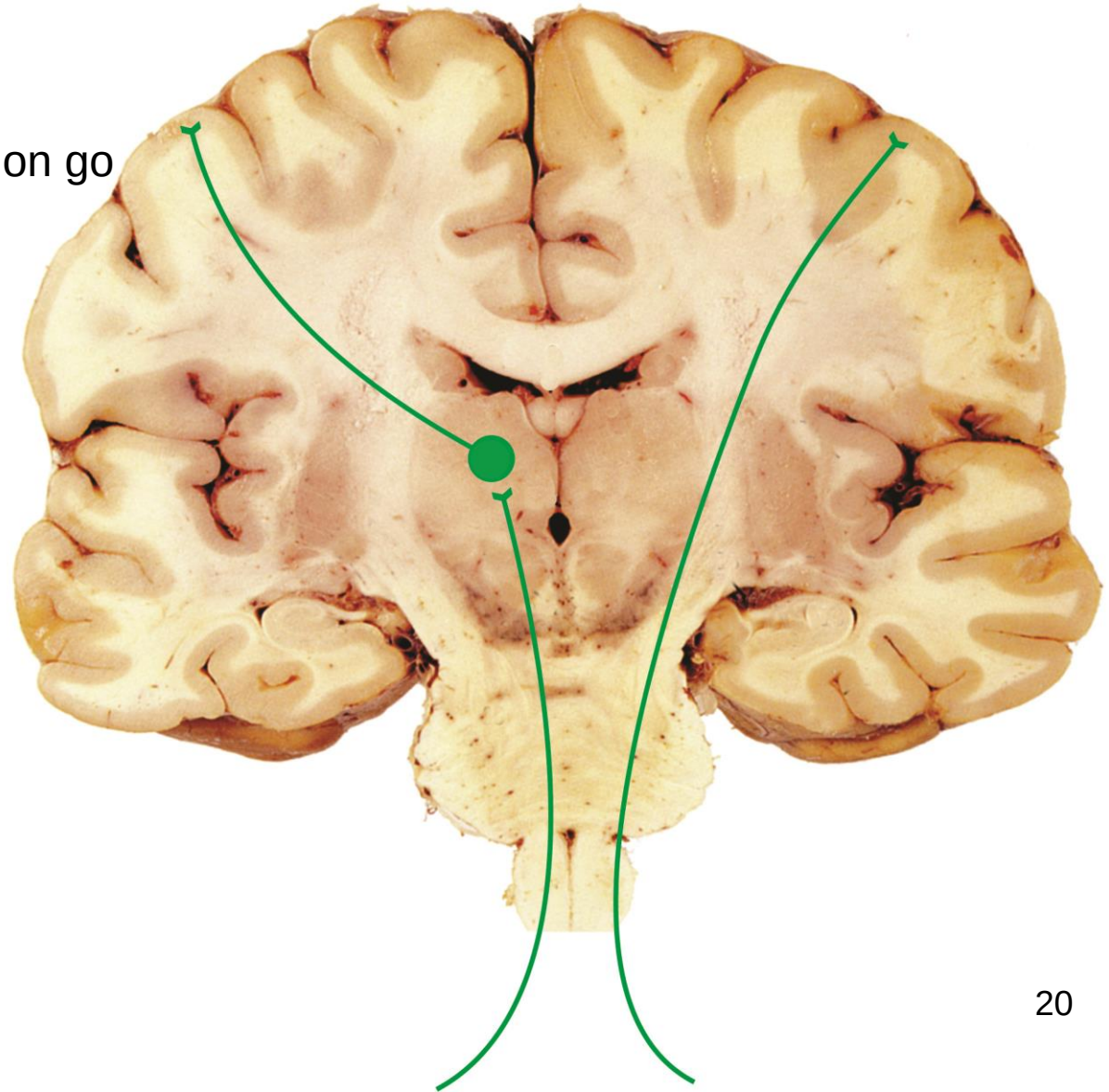




Thalamus

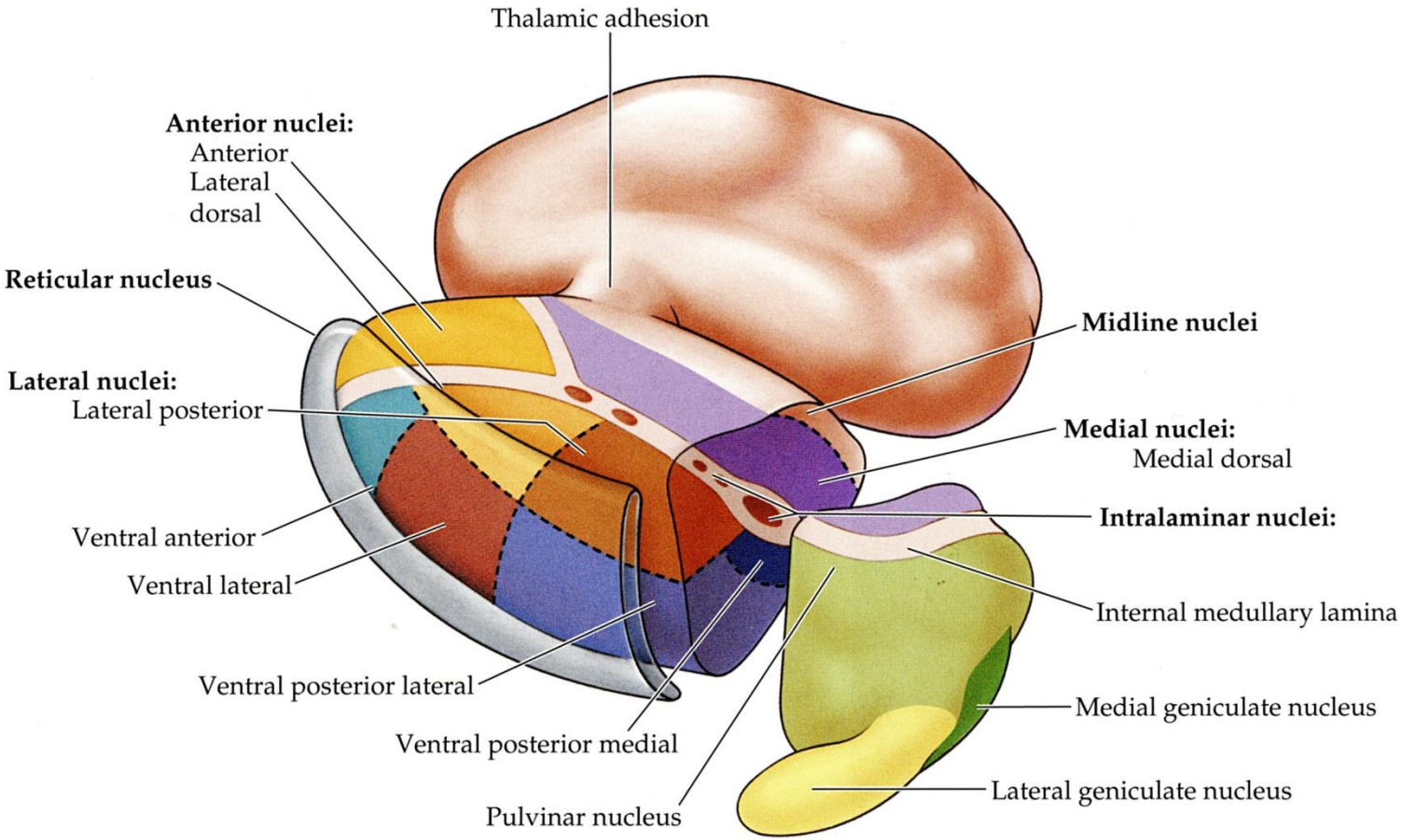
Why have a thalamus?

Why not have all information go straight to cortex without stopping in the thalamus?



Thalamus

The flow of information from the thalamus to cortex is gated by inputs from the brainstem reticular activating system and the cortex via the reticular nucleus of the thalamus.



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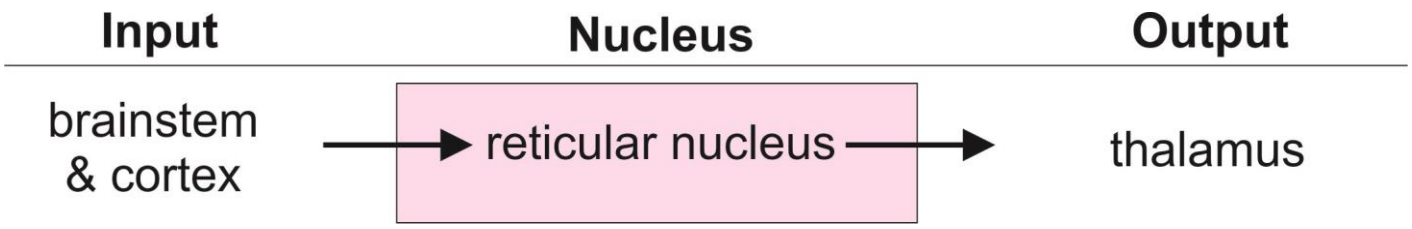


The reticular nucleus inhibits the output of other thalamic nuclei.

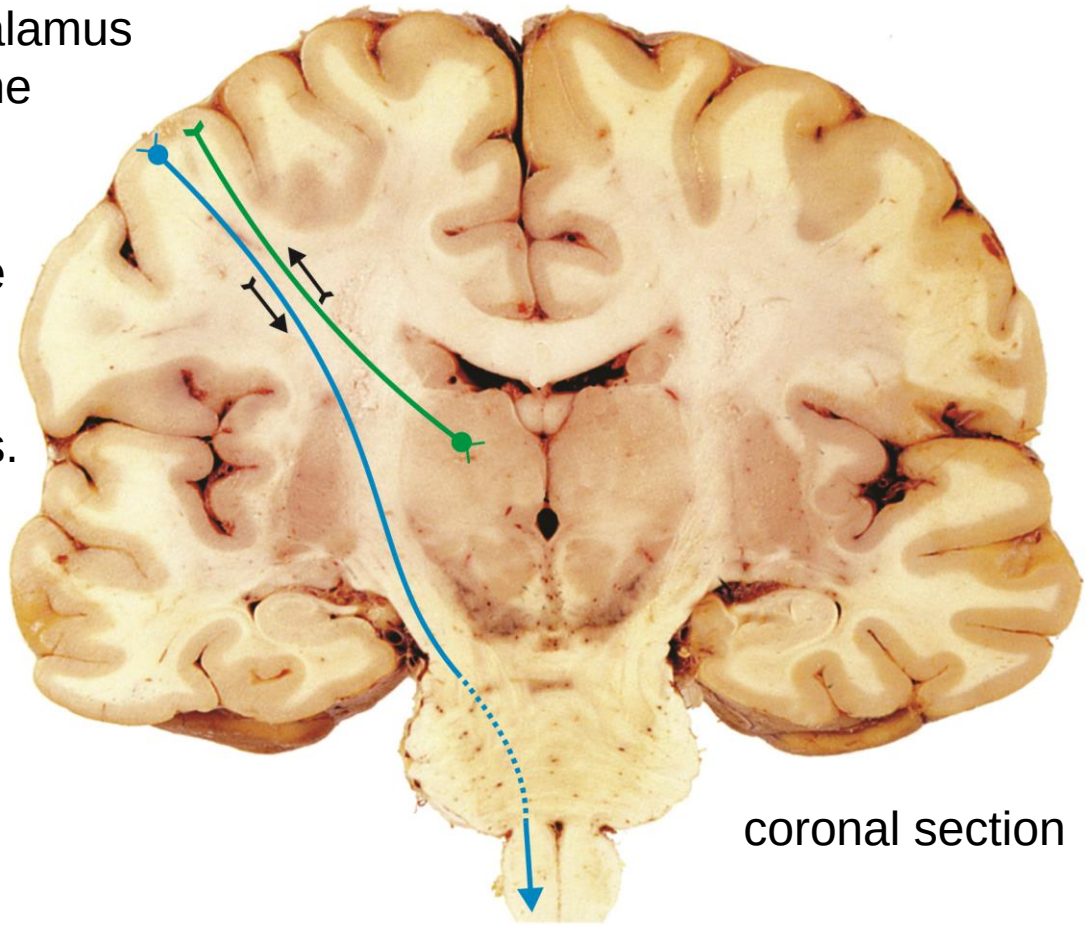
Gating is an important way to attenuate the flow of information when it is not needed such as during sleep or when concentrating on one thing for which other information would be distracting

Thalamus

We have a highly evolved system for focusing our attention on one thing at a time by gating in the thalamus. You might wish that you can text while driving, listening to a lecture or studying. However, you cannot unless you have a significant mutation!

Internal Capsule

- Axons from neurons in thalamus ascend to the cortex via the internal capsule.
- Axons from neurons in the cortex descend via the internal capsule and pass just lateral to the thalamus.

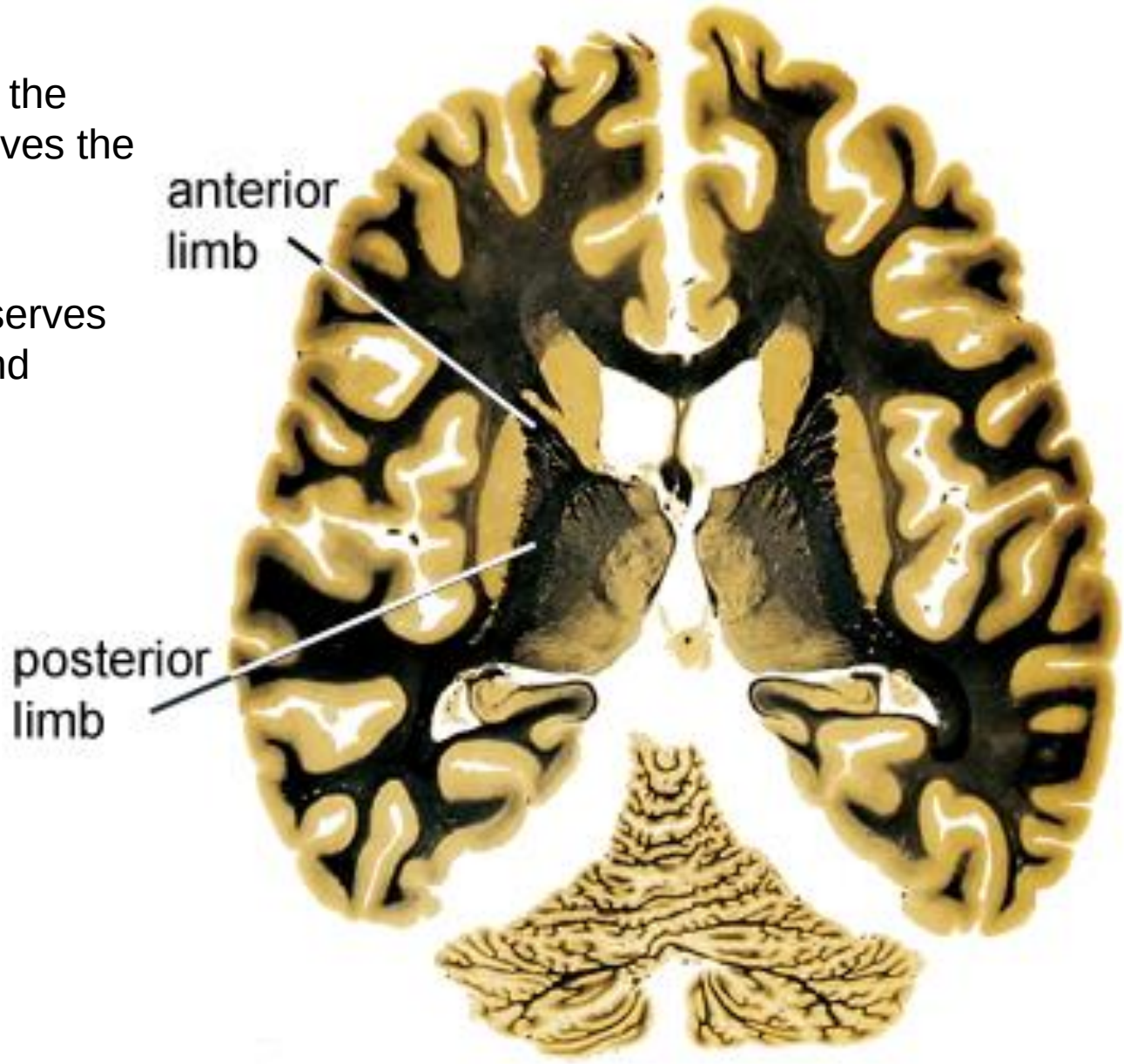


coronal section

Internal Capsule

Internal Capsule

- The anterior limb of the internal capsule serves the frontal lobe.
- The posterior limb serves parietal, occipital and temporal lobes.

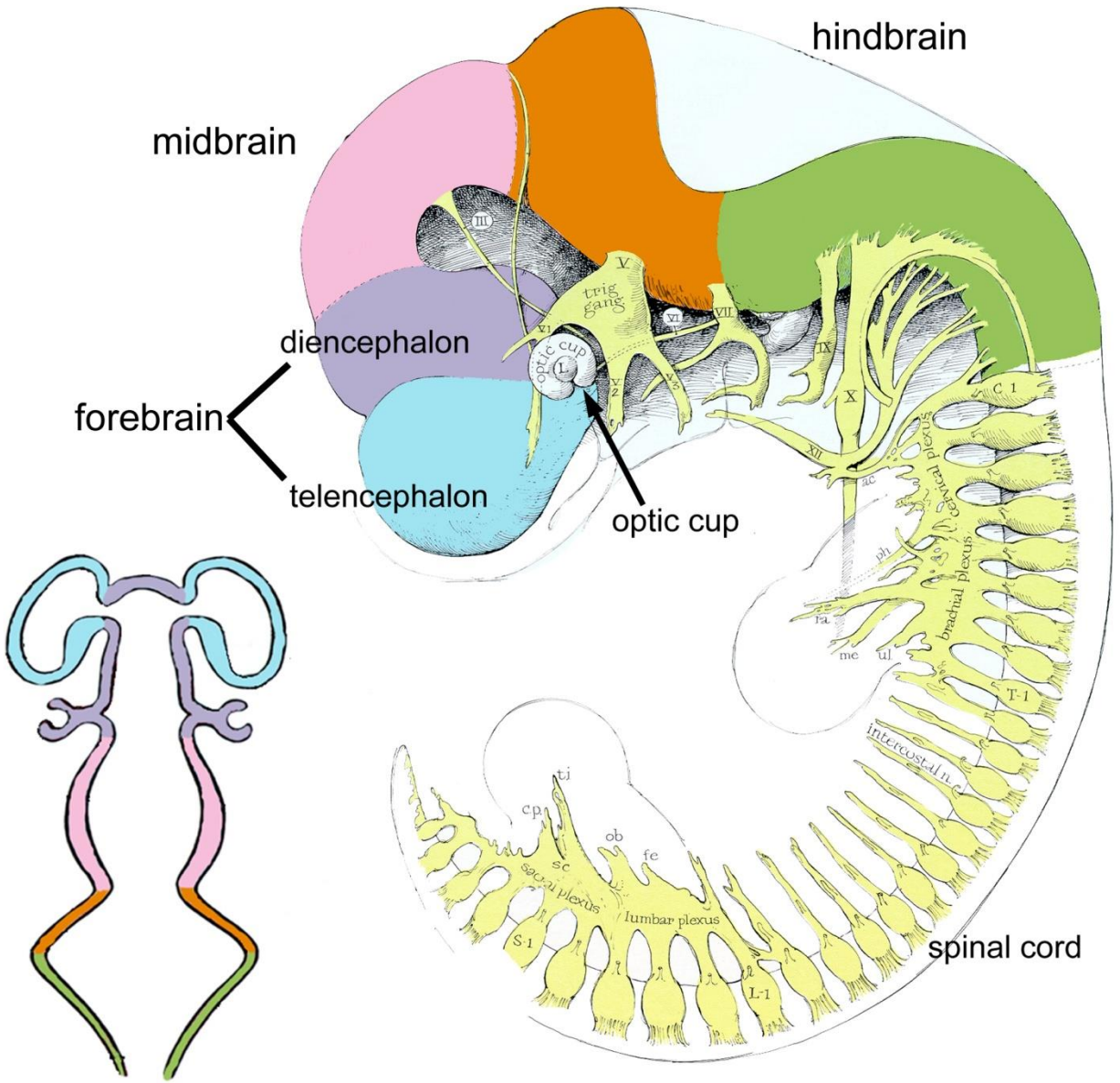


Telencephalon

It is convenient to think of telencephalon as having three parts that are highly interrelated:

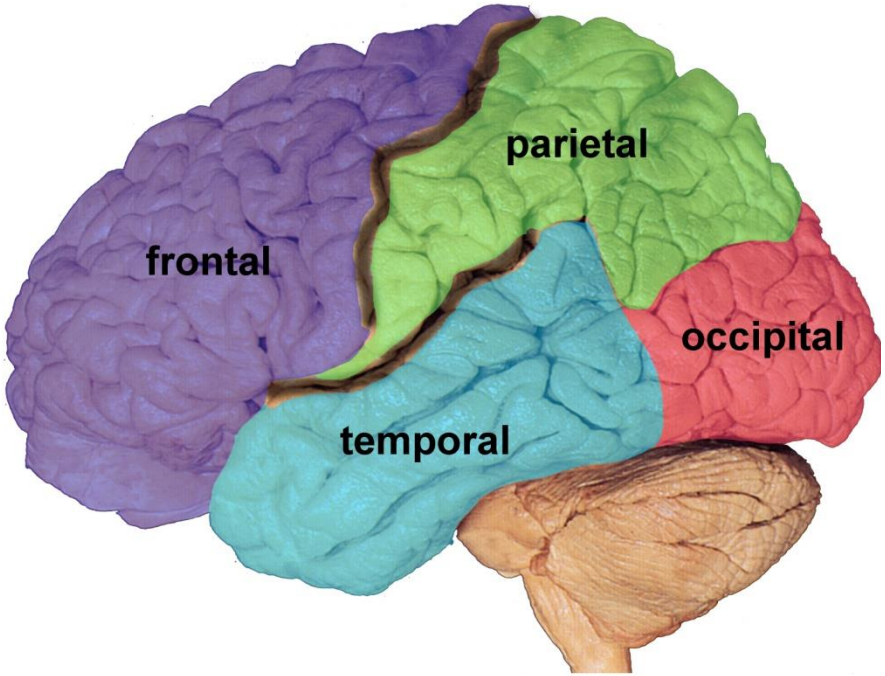
- Neocortex (cortex)
- Limbic & olfactory systems (partly allocortex)
- Basal ganglia

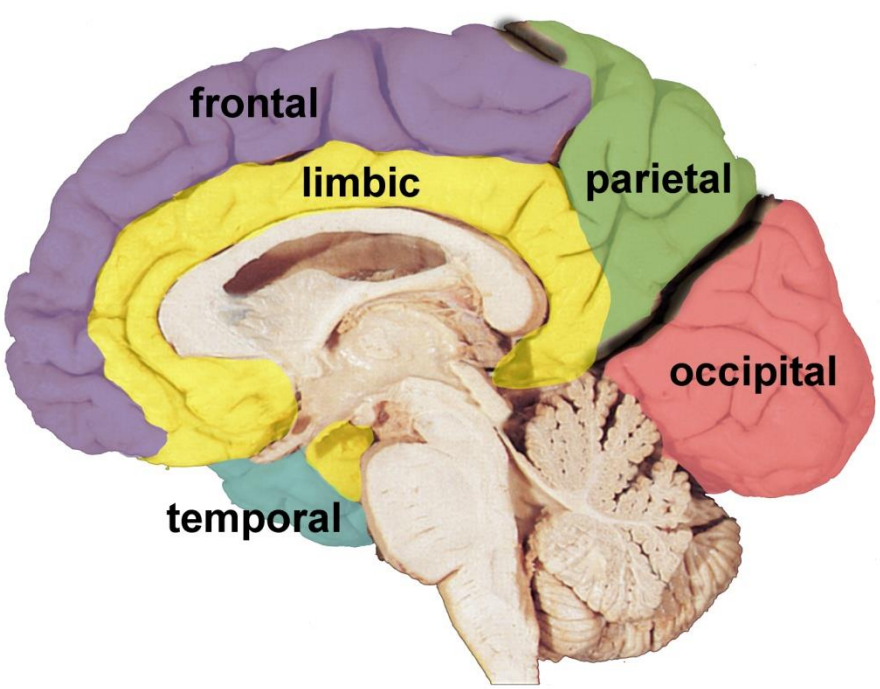
Telencephalon has two hemispheres.



Cerebral Cortex (Neocortex)

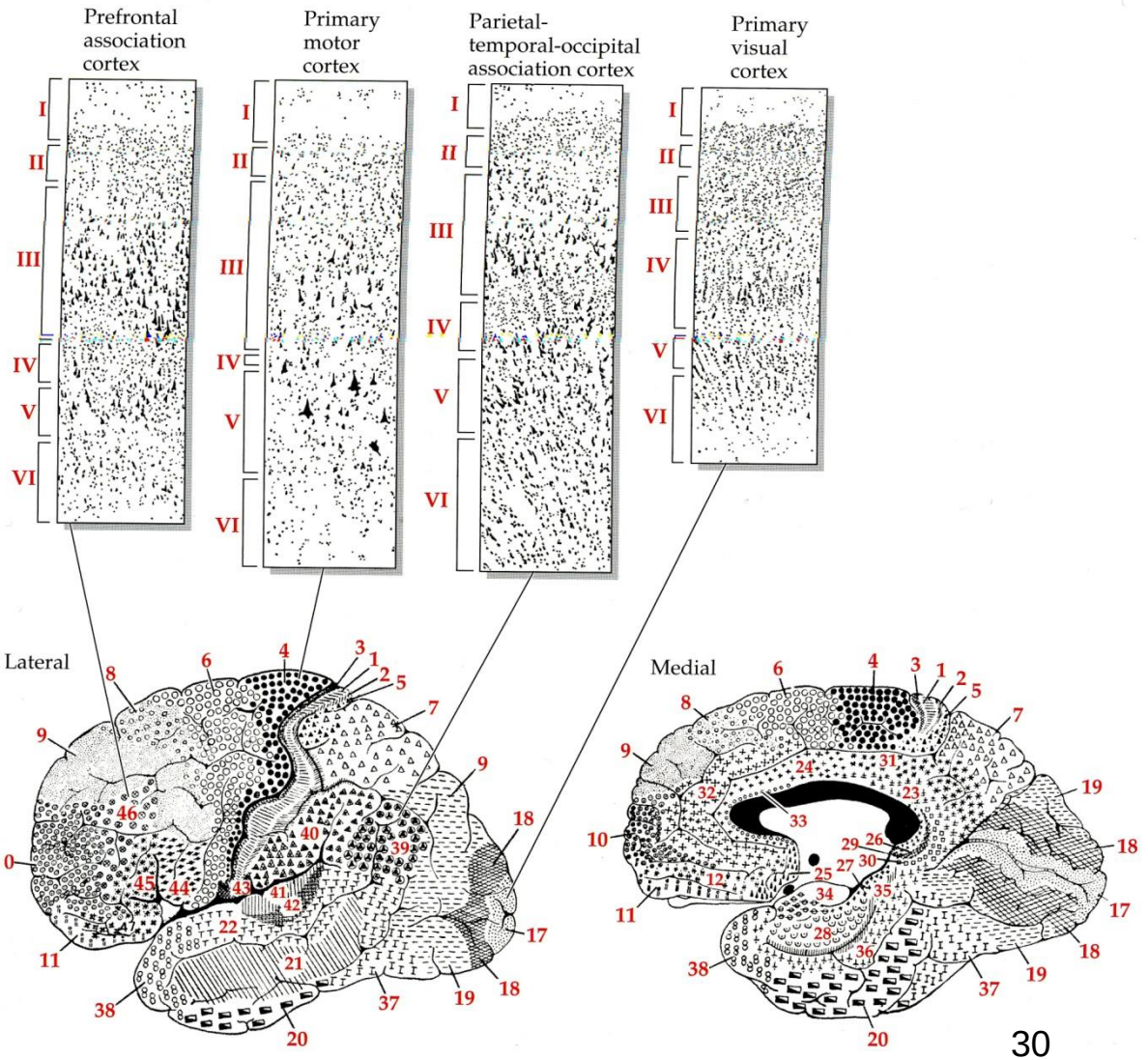
Cortex is divided into five major lobes (i.e. geographic regions).





Cerebral Cortex (Neocortex)

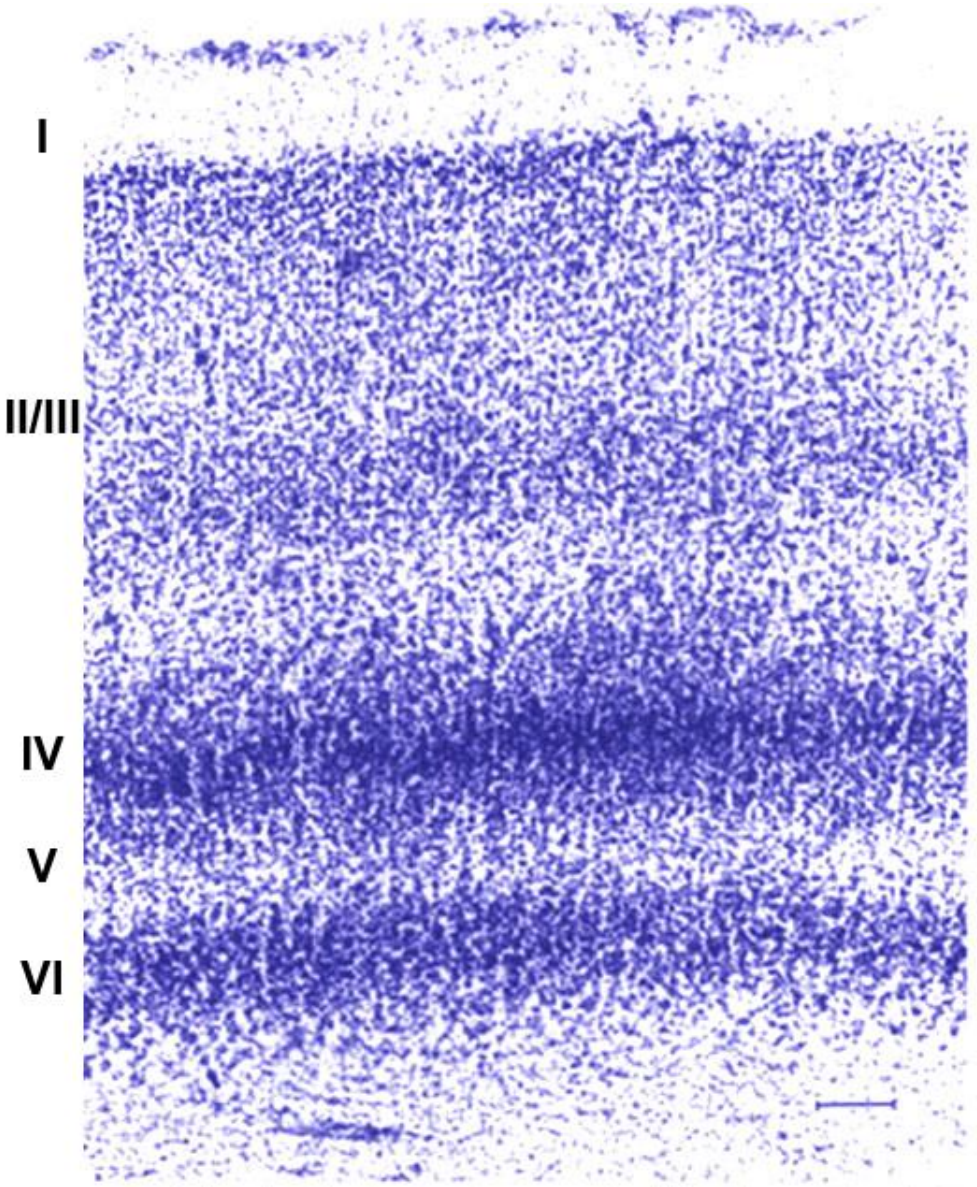
Brodmann identified over 50 areas based on histological characteristics, which have been shown to correspond to different functional domains.



Cerebral Cortex (Neocortex)

Neocortex – six cell layers

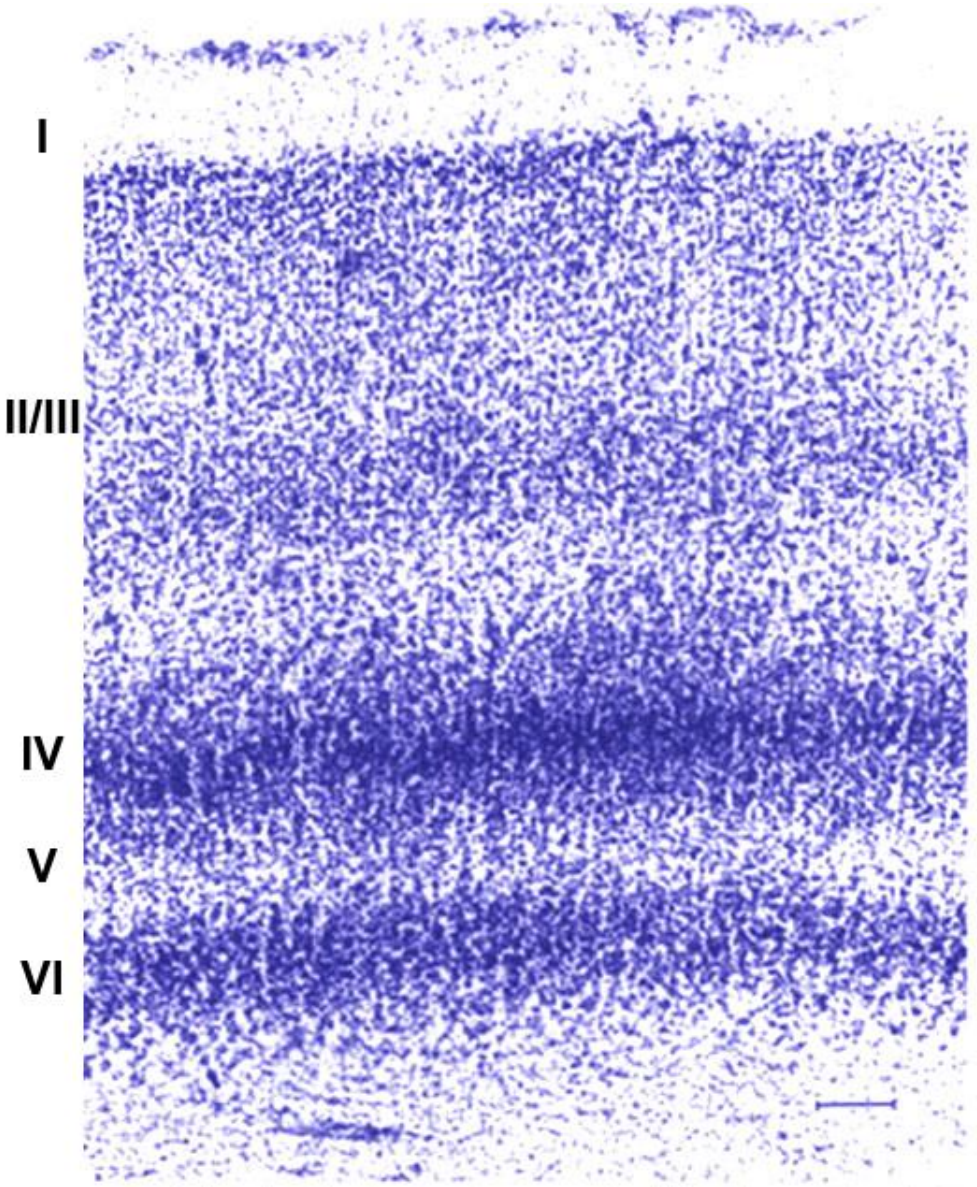
Allocortex – 3-5 cell layers
evolutionarily old
includes hippocampus



Cerebral Cortex (Neocortex)

Neocortex – six cell layers:

- Thalamus projects to layer IV.
- Layer IV projects to II & III.
- Layers II & III interconnect with other cortical areas.
- Layer VI projects to thalamus
- Layer V projects to lower CNS.



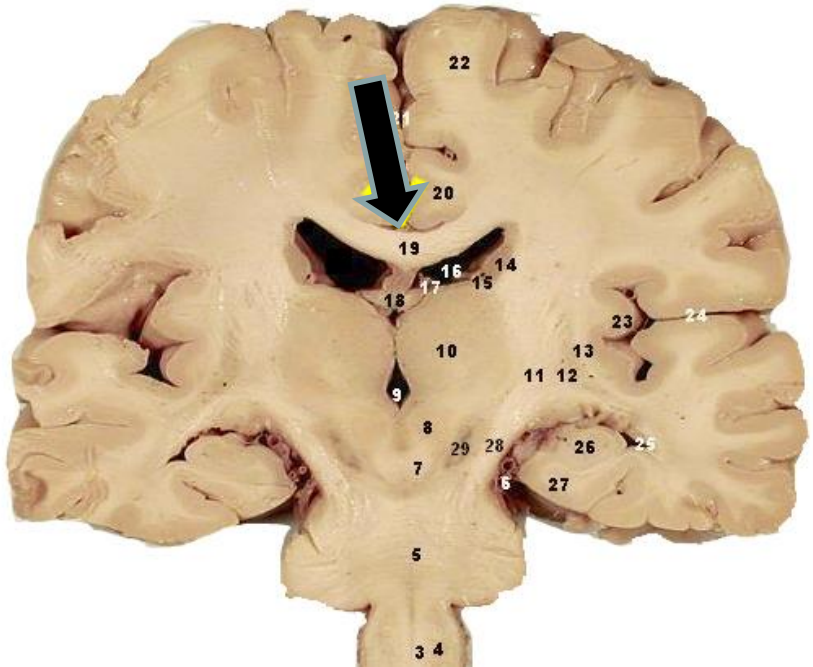
Cerebral Commissures

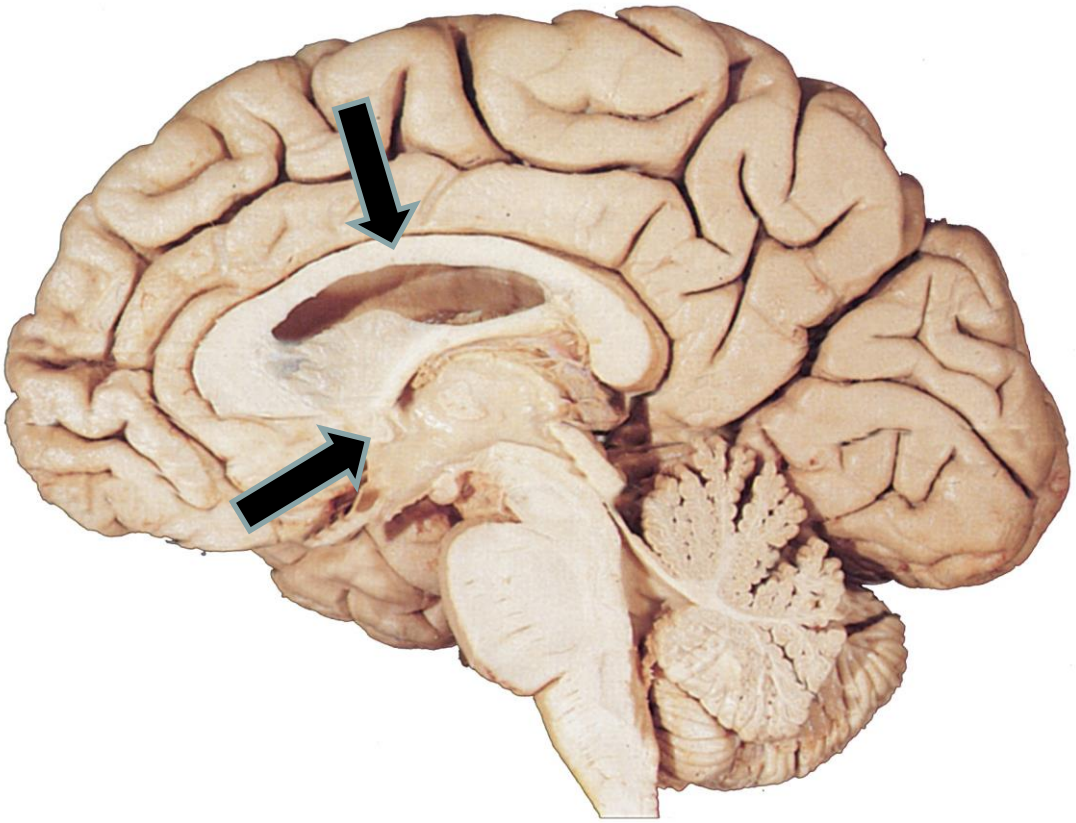
Commissures are discrete bundles of axons that cross the midline.

Typically, a region of cortex on one side of the brain communicates with the same region on the other side.

Two commissures interconnect the hemispheres of the cerebral cortex:

- Corpus callosum
- Anterior commissure





Cerebral Commissures

Epilepsy is characterized by seizures, that is the uncontrolled contraction of muscles.

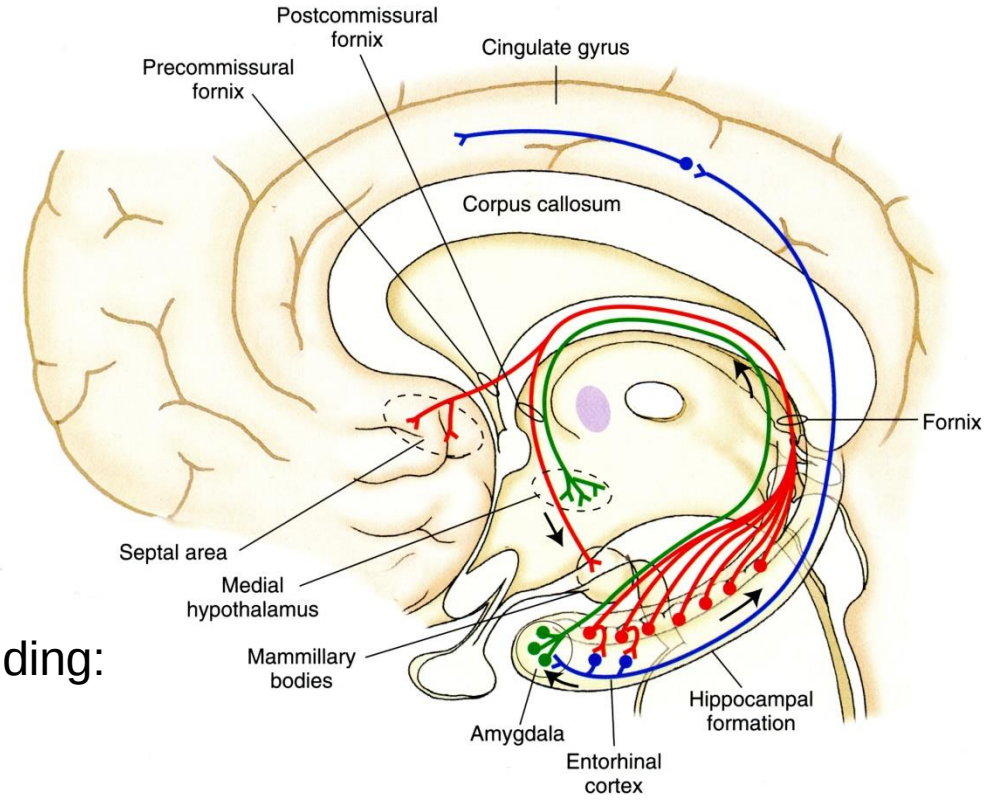
It is caused by synchronous excitatory activity in the cortex that spreads from a focal activation site.

In severe cases, portions of the corpus callosum can be surgically cut, which will prevent the spread of activity from one side of the brain to the other.

Limbic & Olfactory Systems

The limbic / olfactory systems include:

- Olfactory bulb & tract
- Hippocampus
- Septal area
- Amygdala
- Parts of many other structures including:
  - Prefrontal cortex
  - Cingulate gyrus
  - Anterior nucleus and other nuclei of the thalamus
  - Mammillary bodies and other nuclei of hypothalamus
  - Midbrain reticular formation



Limbic & Olfactory Systems

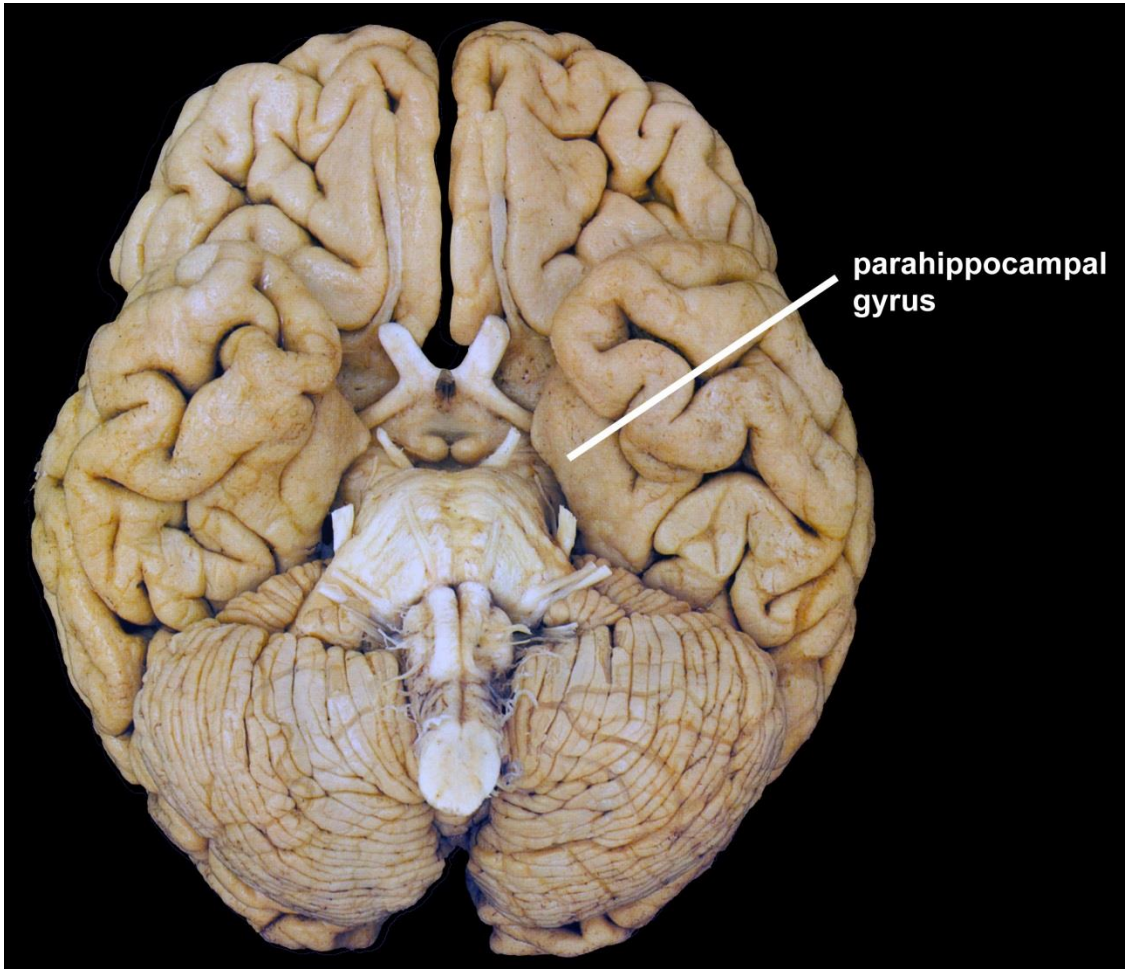
Much of the limbic and olfactory systems encompass allocortex (i.e. not neocortex). Allocortex is phylogenetically older than neocortex.

Allocortex has 3-5 cell layers:

- Hippocampus – 3 cell layers
- Amygdala – 3-4 cell layers

Limbic & Olfactory Systems

- Hippocampus is in the temporal lobe inside the parahippocampal gyrus.



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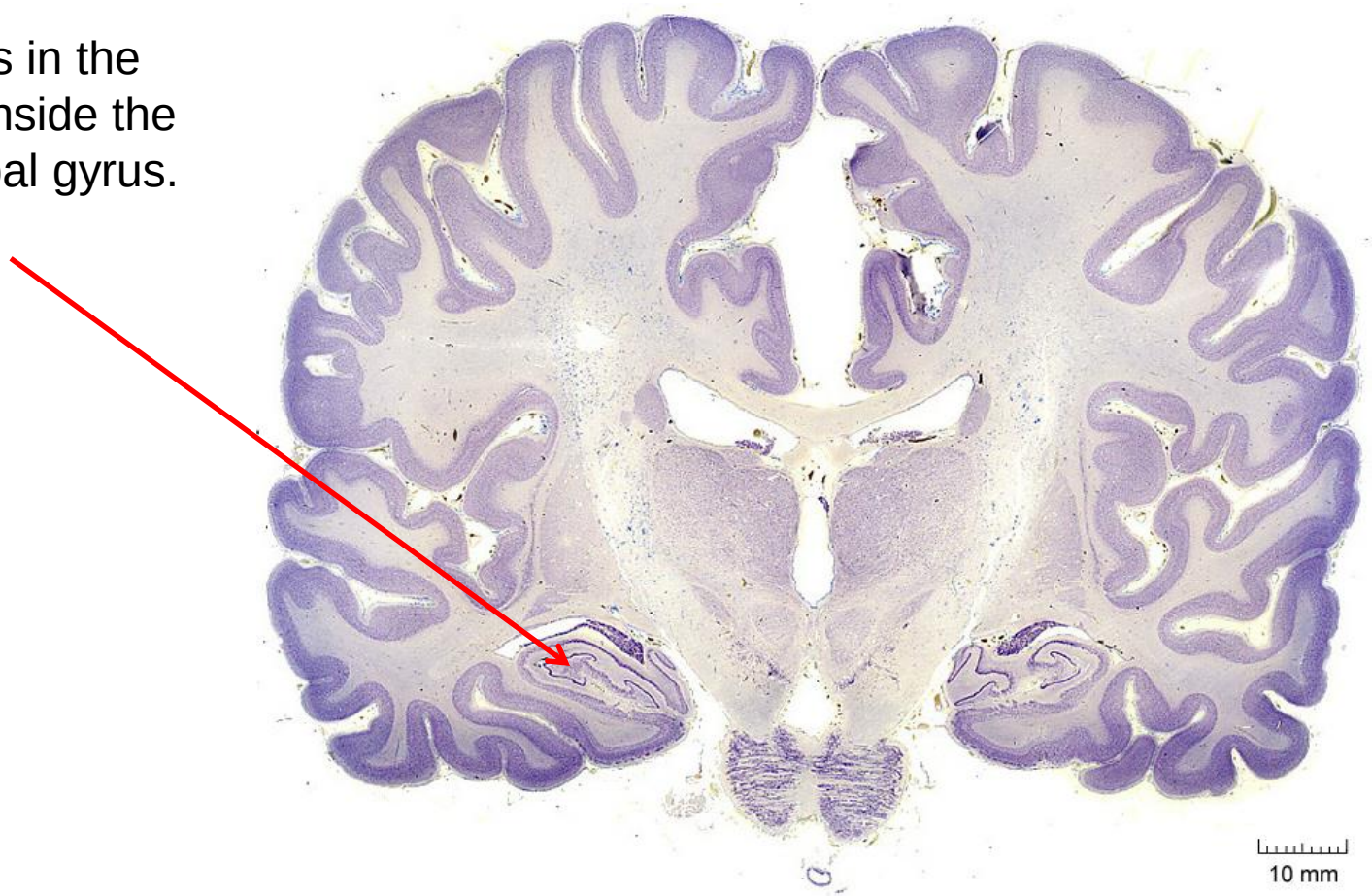
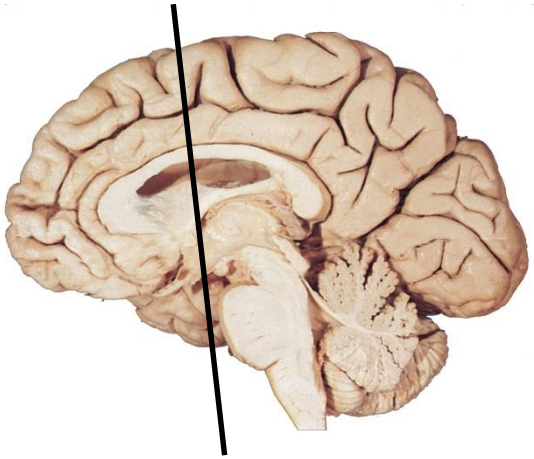
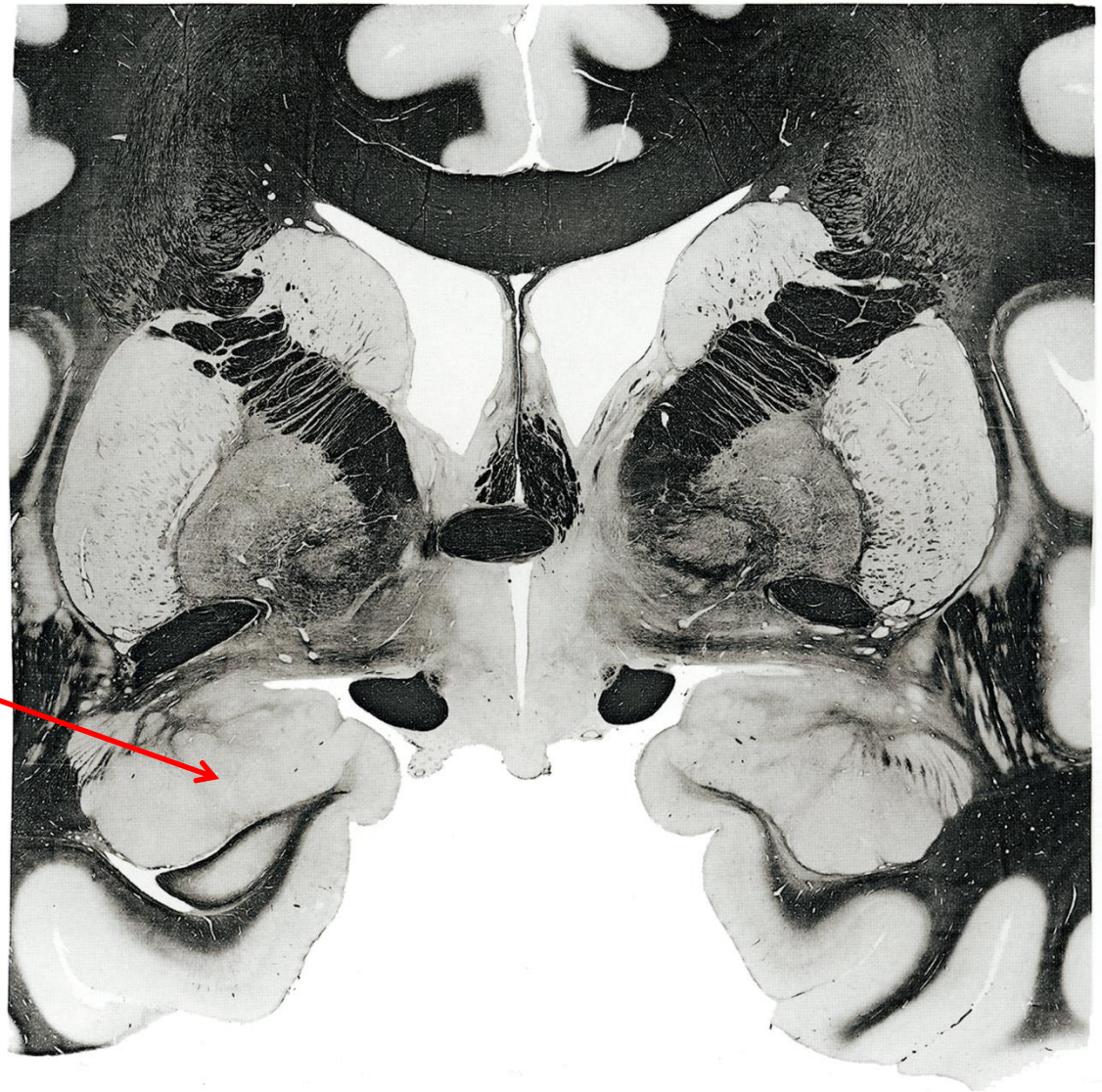


Limbic & Olfactory Systems



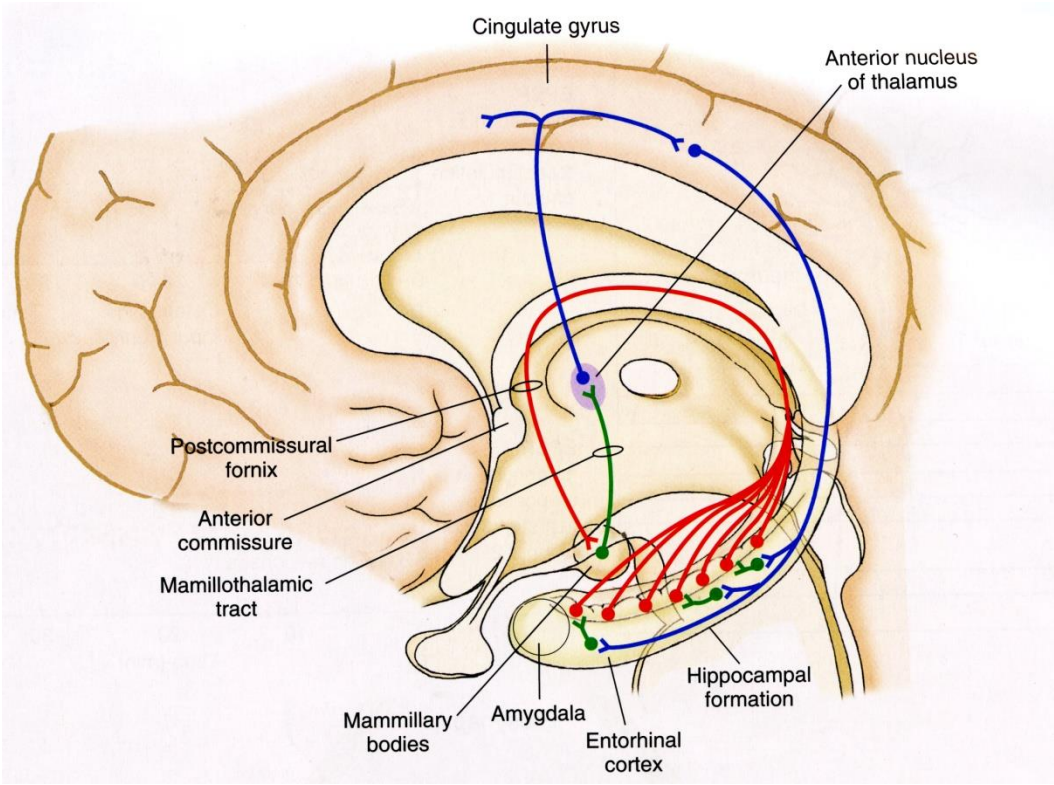
- Amygdala is in the front of the temporal lobe (at the front of the tail of the caudate nucleus)



Limbic & Olfactory Systems

Tracts of the limbic system include:

- Fornix – hippocampus to mammillary bodies
- Mammillothalamic tract – mammillary bodies to anterior nucleus of thalamus

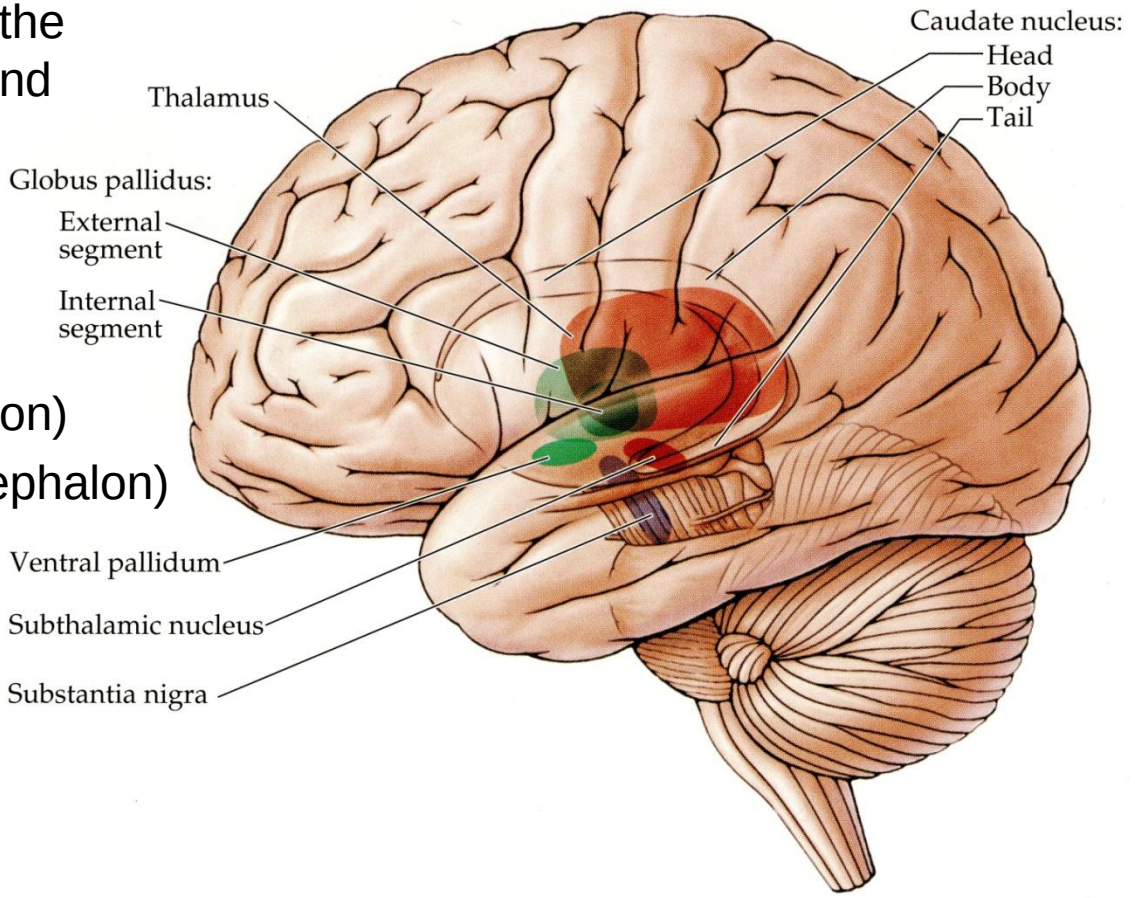


Basal Ganglia Anatomy

The basal ganglia consist of a number of nuclei in the basal region of the telencephalon, diencephalon and midbrain.

The largest nuclei are:

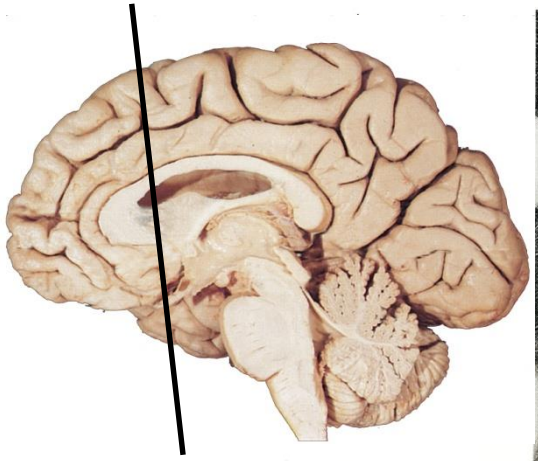
- Striatum (telencephalon)
- Globus pallidus (telencephalon)
- Subthalamic nucleus (diencephalon)
- Substantial nigra (midbrain)



Basal Ganglia Anatomy

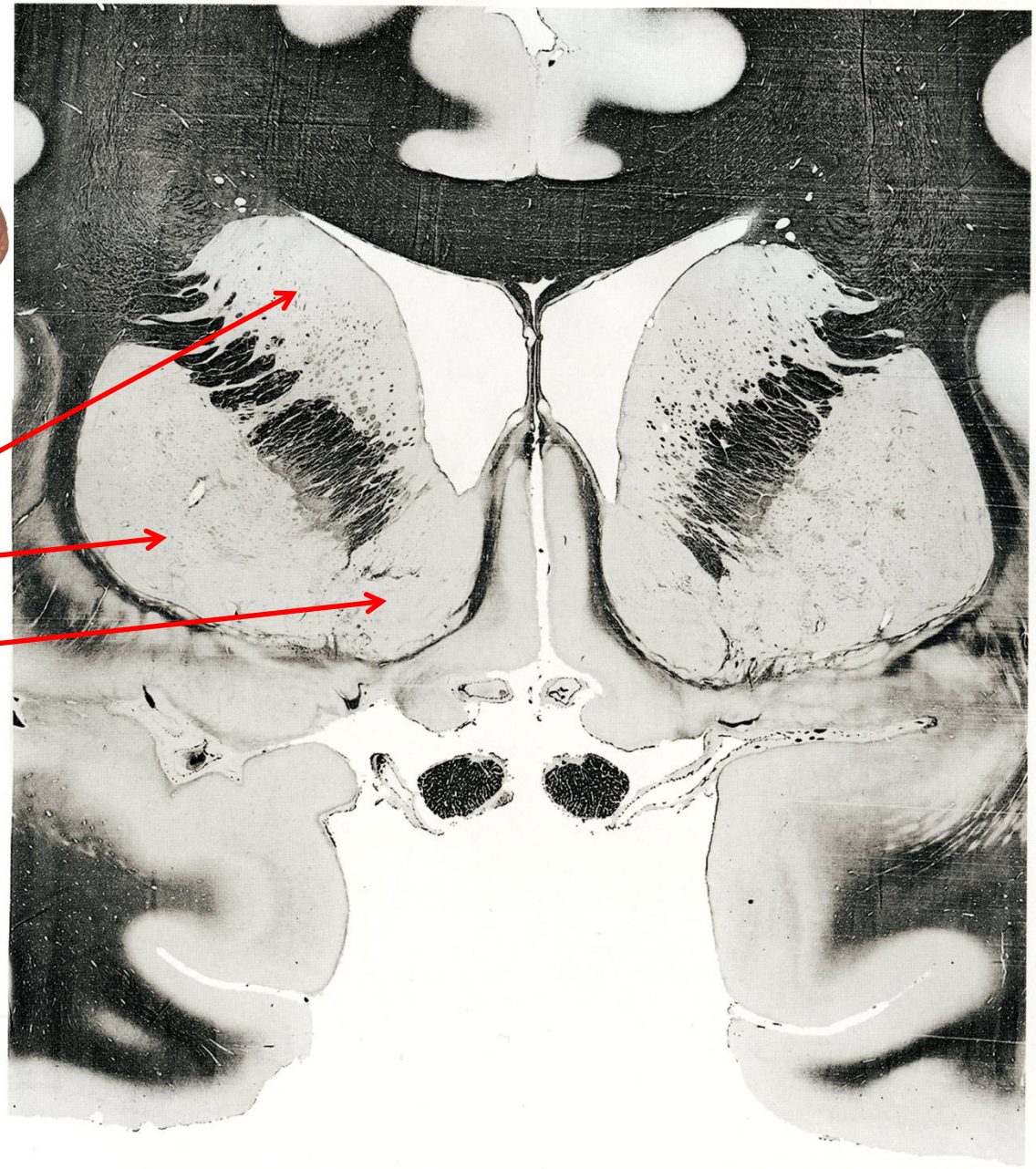
- The striatum is composed of three nuclei:
  - caudate nucleus
  - putamen
  - nucleus accumbens

- The striatum is more like one nucleus divided by the internal capsule, which comes together at the front of the internal capsule.



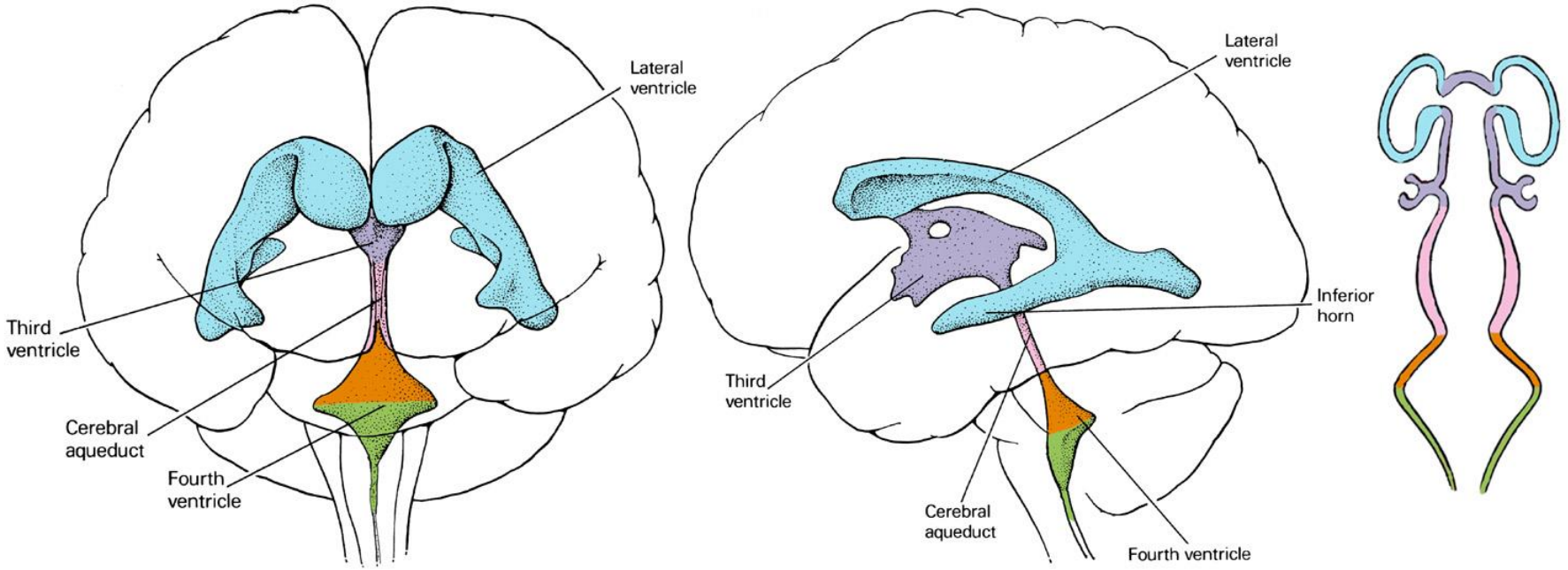
Striatum:

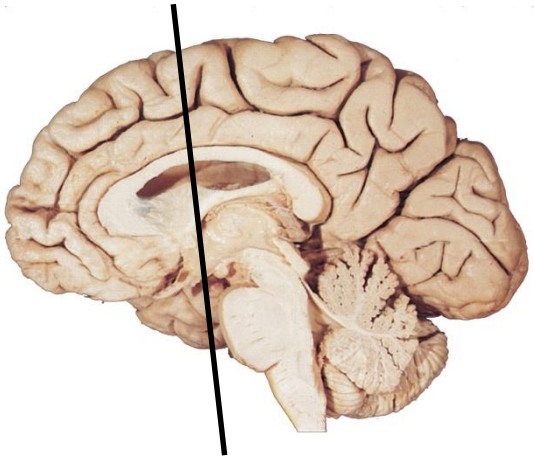
- caudate nucleus
- putamen
- nucleus accumbens

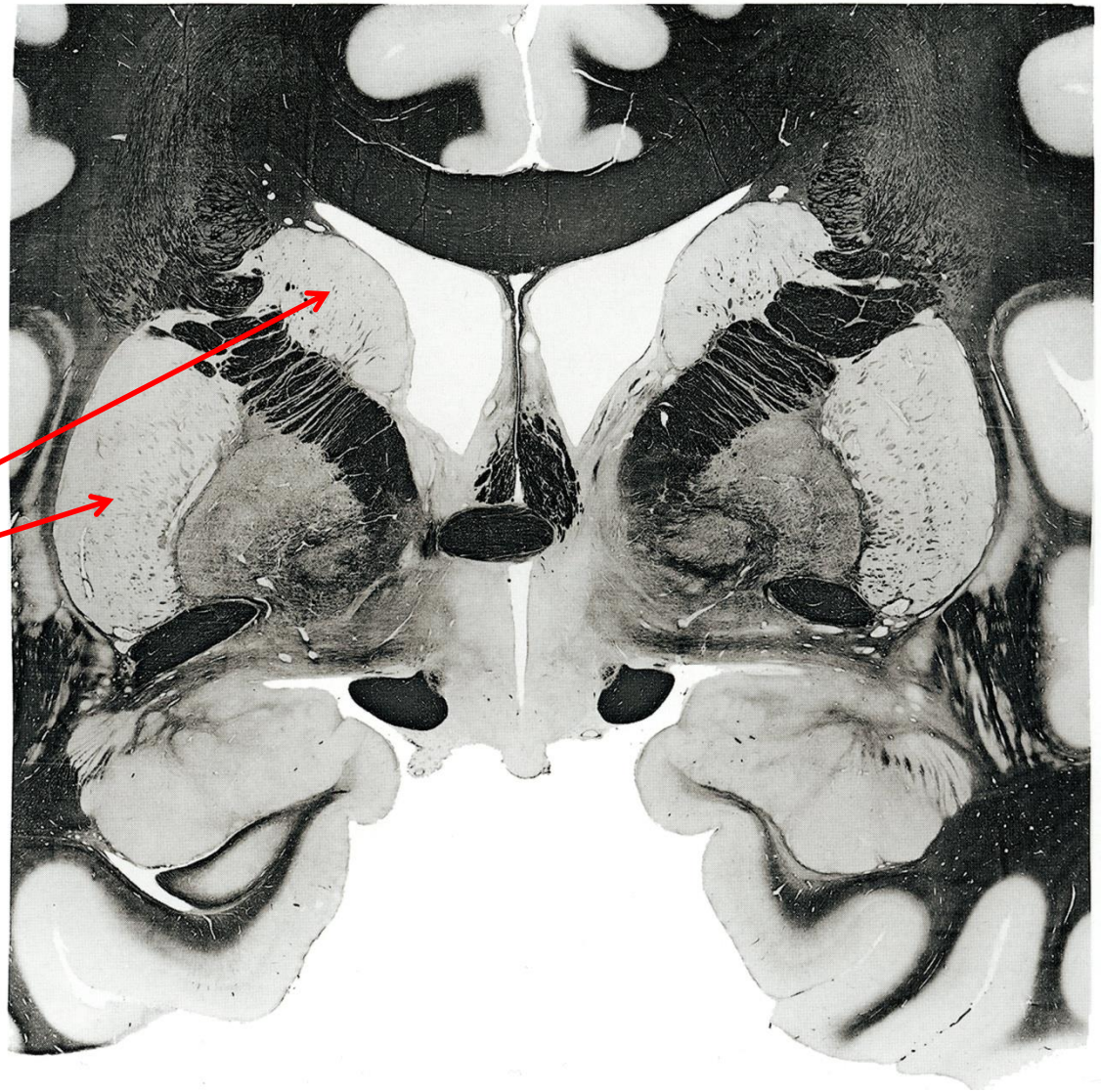


Basal Ganglia Anatomy

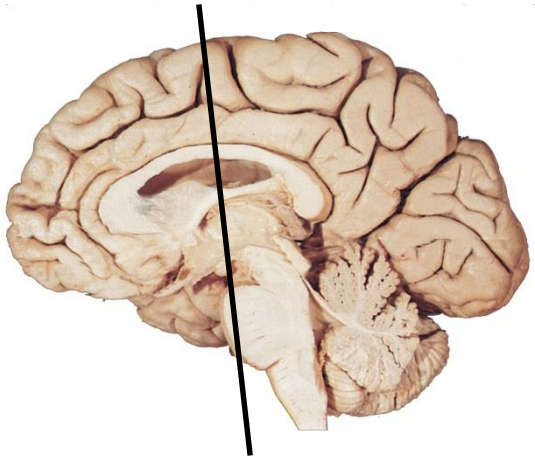
- The caudate nucleus follows the lateral ventricle.

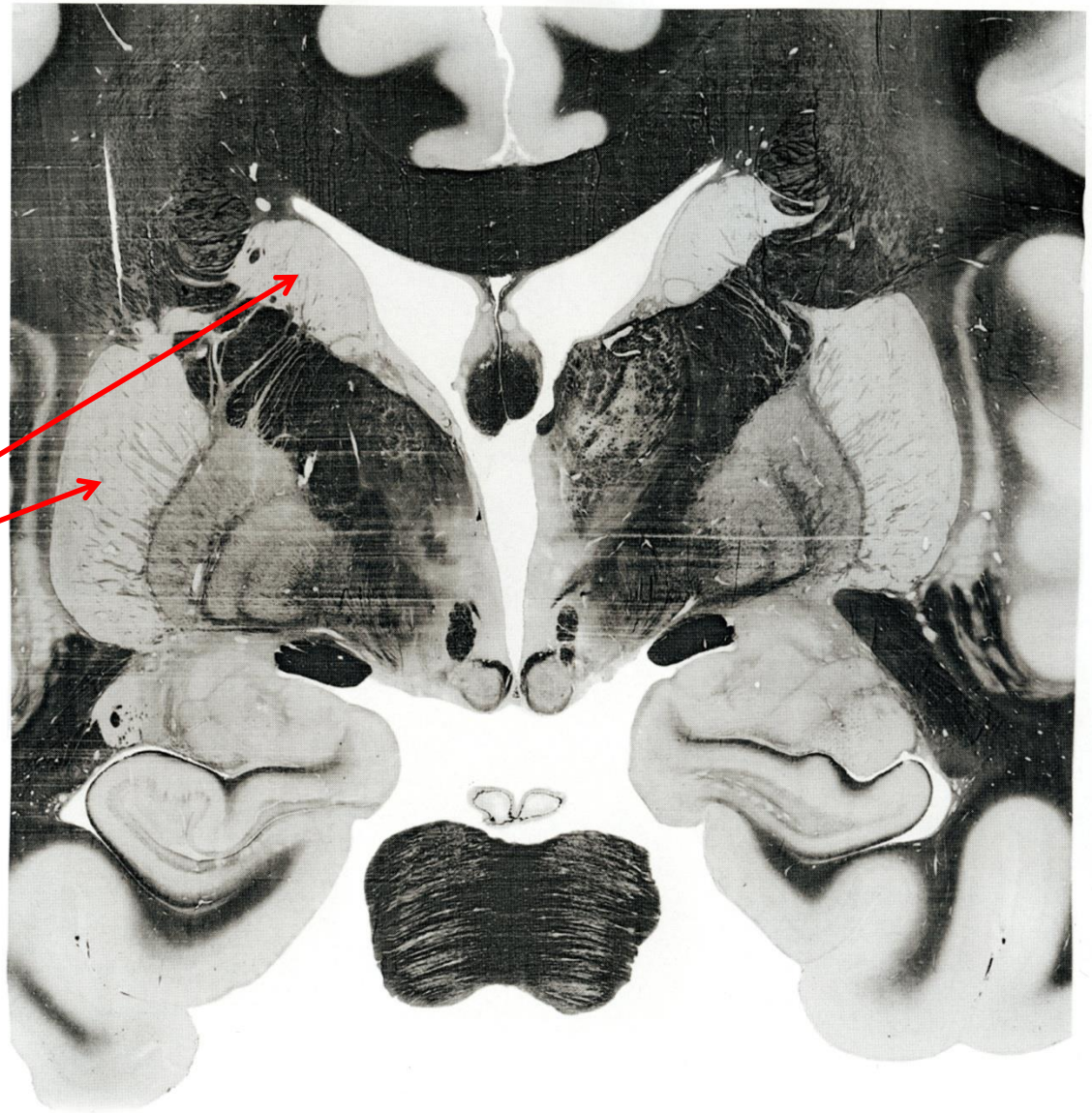






- caudate nucleus
- putamen





- caudate nucleus
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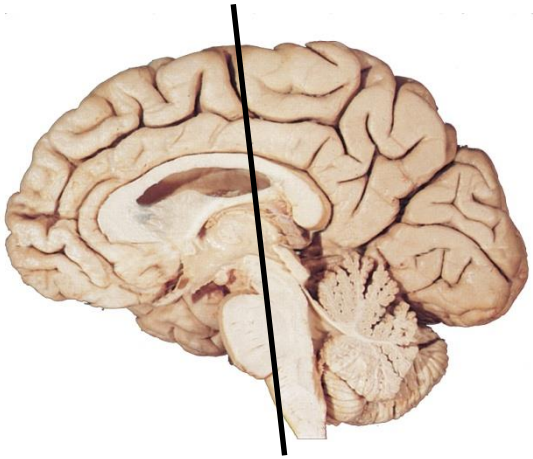
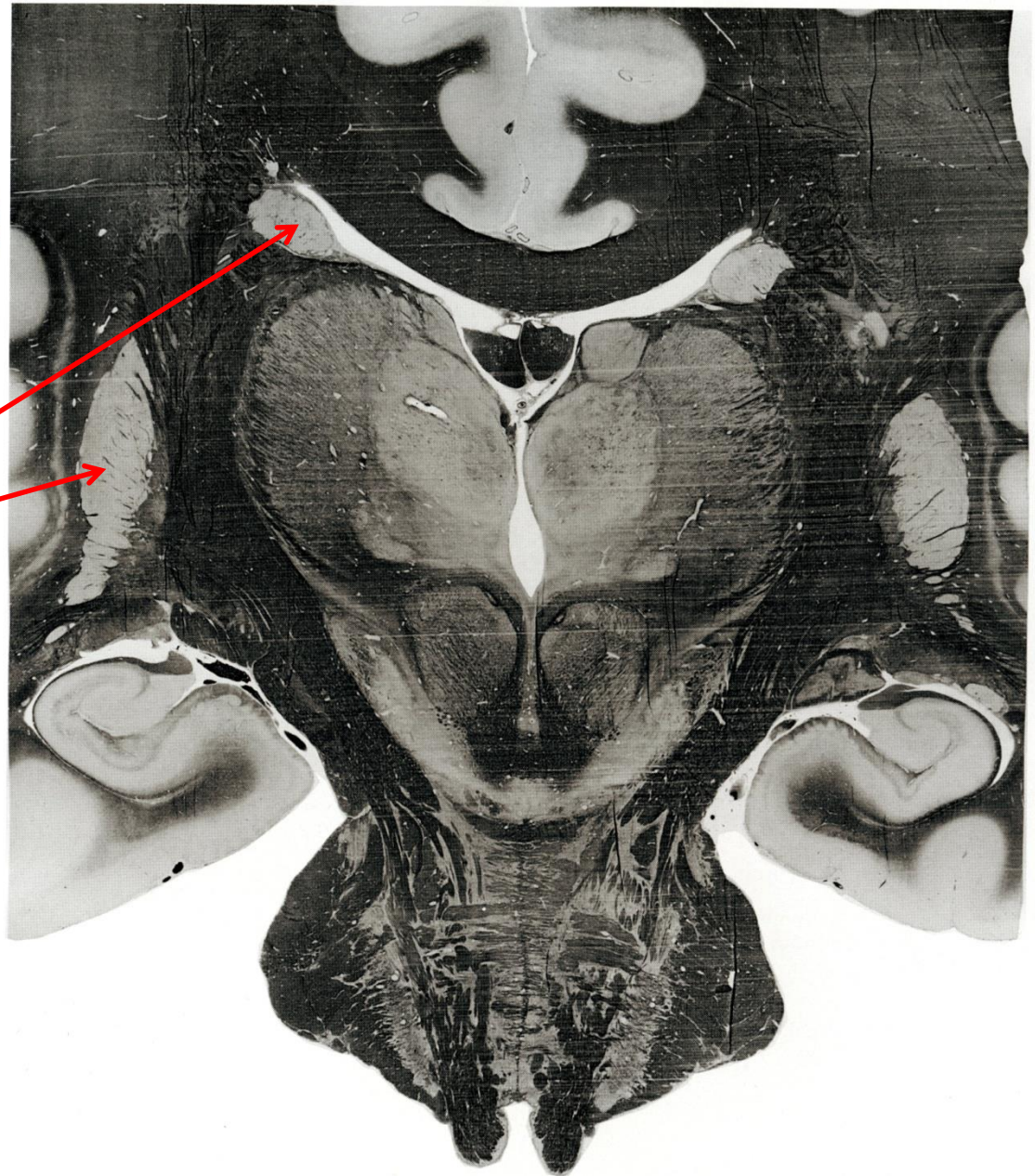
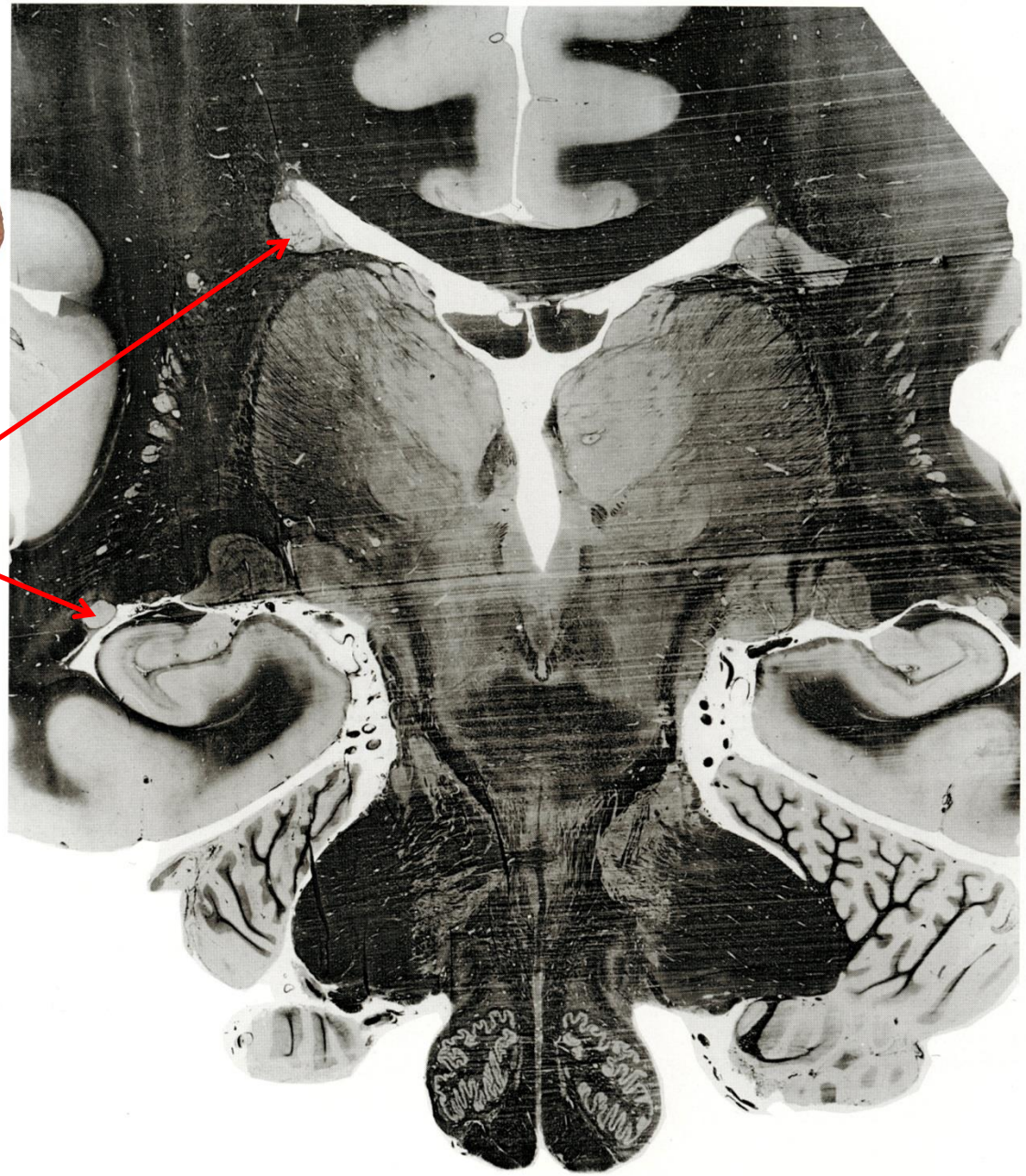




- caudate nucleus
- putamen

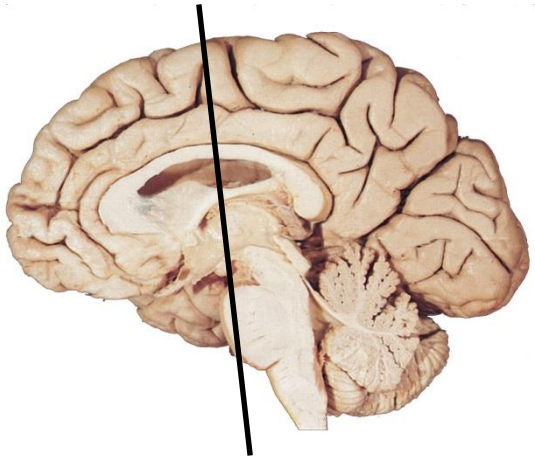


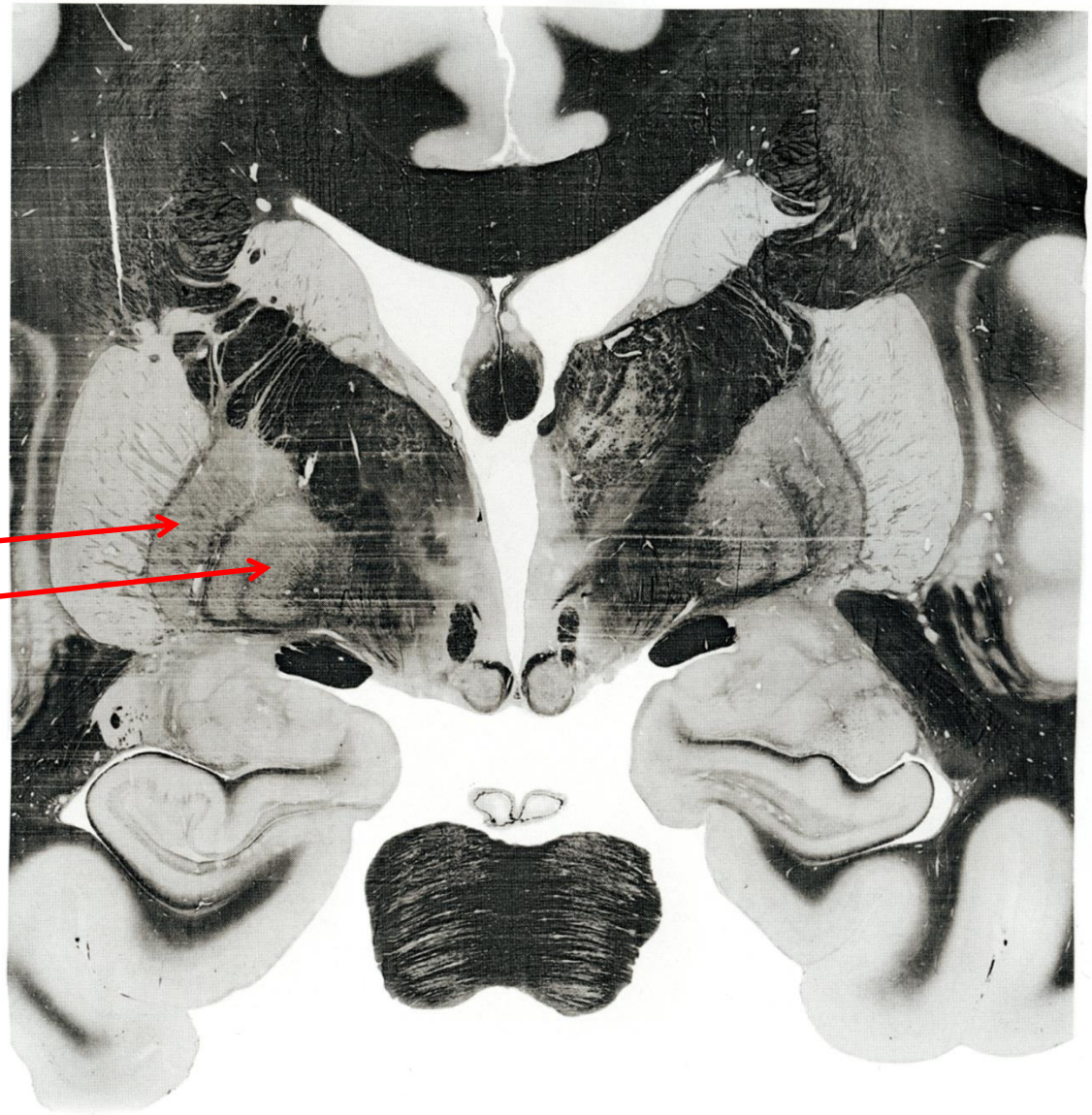
- caudate nucleus

Basal Ganglia Anatomy

- The globus pallidus is just medial to the putamen.

- The globus pallidus has two divisions:
  - external (GPe) – part of the internal circuitry
  - internal (GPi) – part of the output system

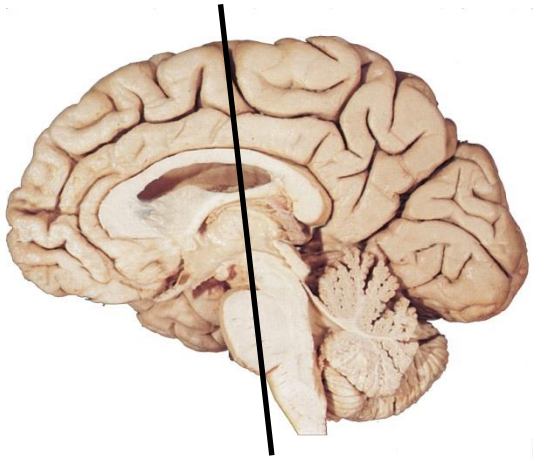




- GPe
- GPi

Basal Ganglia Anatomy

- The subthalamic nucleus is part of the diencephalon.
- The subthalamic nucleus is positioned just below the thalamus and above the midbrain.



- subthalamic nucleus

Learning and Memory

Many parts of the telencephalon are essential for learning and memory:

- Hippocampus for events and places
- Amygdala for emotional responses
- Striatum for procedures
- Neocortex for facts