B. Puder, Ph.D.

Objectives

At the end of this laboratory session you should be able to;

1. **Identify nuclei and tracts associated with the Diencephalon**

2. **List signs/symptoms that will occur when specific diencephalic nuclei and associated tracts are lesioned.**

3. **Identify nuclei and tracts associated with the basal nuclei, cerebellum, limbic system.**

4. **List signs/symptoms or disease names that result from lesions in the basal nuclei, cerebellum and limbic system.**

5. **Identify corticospinal tracts and describe the sign/symptoms that occur when these tracts are lesioned.**

General information regarding the transition from brainstem to diencephalon

There is a transition form the rostral midbrain of the brainstem to the diencephalon. This transition can be seen in an aproximately 2mm olbique section. The principal morphological changes from midbrain to diencephalon include a diminished size of the ***superior colliculi***, the presence of bits of the ***medial and lateral geniculate nuclei*** of the ***dorsal thalamus***, ***pineal gland***, a large and then diminished size of the ***red nucleus***, and an eventual enlargement of the **ventricular system.**

Recall that the ***midbrain*** becomes continuous with the diencephalon through the incisura. Remember that the uncus is the medial part of the parahippocampal gyrus in the temporal lobe, and is superior to the incisura and in close proximity to the ***cerebral peduncles*****.** The **posterior cerebral artery,** passes from the posterior fossa through the incisura between the midbrain and the temporal lobe. An increase in intracranial pressure in the anterior or middle cranial fossae, due to a neoplasm, hemorrhage, hematoma, abscess or edema, very often causes the uncus to press against the midbrain. The ***uncus*** may actually herniate through the incisura occluding the **posterior cerebral artery** and inducing ischemia of the entire midbrain.

The ***posterior commissure*** crosses the midline just rostral to the ***superior colliculi*****.** Many fibers of the ***posterior commissure*** are derived from the ***medial longitudinal fasciculus*** which crosses the midline through this structure. Identify the ***substantia nigra*** and ***cerebral peduncles***.

The caudal boundary of the diencephalon can be seen by drawing an imaginary line from the ***posterior commissure*** to the caudal aspect of the ***mammillary bodies***. The rostral boundary of the diencephalon can be seen by drawing an imaginary line from the ***interventricular foramen***, lamina terminalis, and the ***optic chiasm***.

The four major divisions of the diencephalon include: dorsal thalamus, hypothalamus, sub-thalamus, and epithalamus.

TThe expanded posterior portion of the ***dorsal thalamus*** that overhangs the ***midbrain i***s known as the **pulvinar**. Attached to the ventral surface of the **pulvinar** are the ***medial and lateral geniculate bodies (nuclei).*** The two geniculate bodies often are referred to as the metathalamus.

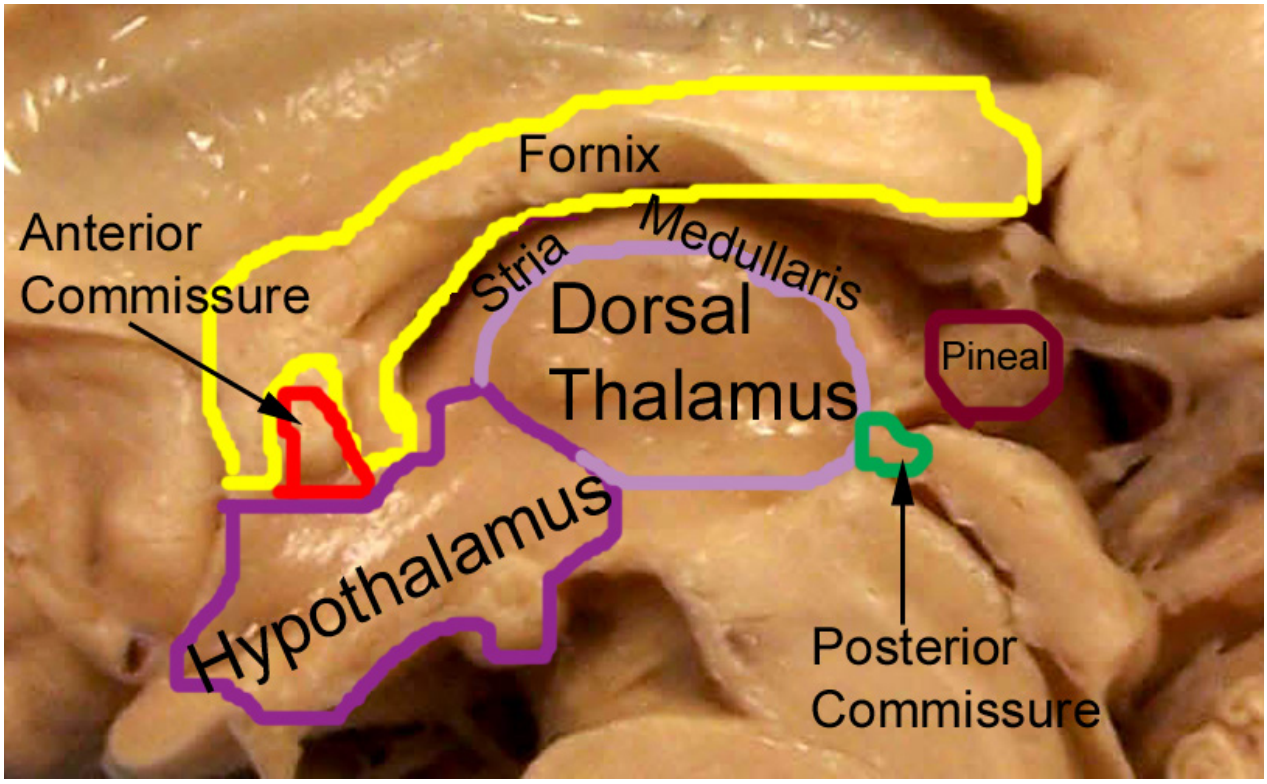
The Thalamus
Use a mid sagittal section to view the ***thalamus (dorsal thalamus)*** and note that it is separated from the ventrally placed ***hypothalamus*** by the hypothalamic sulcus - an embryologic structure that was an extension of the sulcus limitans.
Anterior to the ***dorsal thalamus*** is the ***interventricular foramen***. The ***third ventricle*** is situated between the 2 **dorsal thalami**. Some remnants of the thin roof of the ***third ventricle*** may still be attached to the dorsal medial surface of the thalamus. This tissue is composed, in part, of a portion of the ***choroid plexus***, branches of the posterior choroidal arteries and the internal cerebral veins. The paired internal cerebral veins join just after piercing the roof of the ***third ventricle*** near the root of the ***pineal gland*** to form the ***great cerebral vein (Galen***). None of the nuclei composing the dorsal thalamus can be seen on this medial view; however, the massa intermedia maybe observed on most brains (80%). The massa intermedia (interthalamic adhesion) contains no neurons or nerve tracts.

The Hypothalamus
The ***hypothalamus*** lies ventral to the hypothalamic sulcus. Its anterior boundaries are the lamina terminalis, which is the anterior wall of the third ventricle, the ***optic chiasm*** and the floor of the third ventricle. The medial wall of the diencephalon forms the lateral wall of the ***third ventricle***.

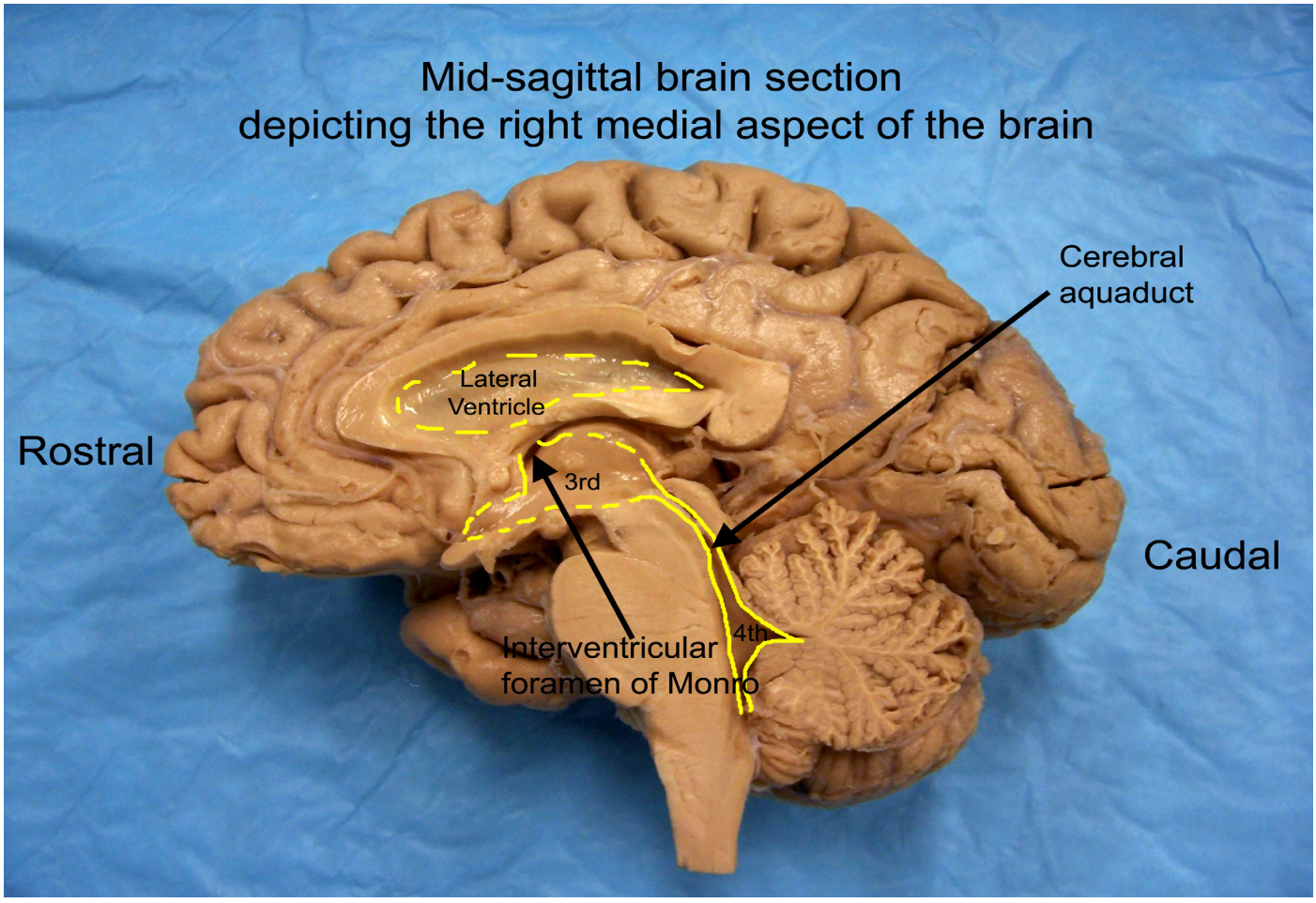
Gross anatomy of the Diencephalon

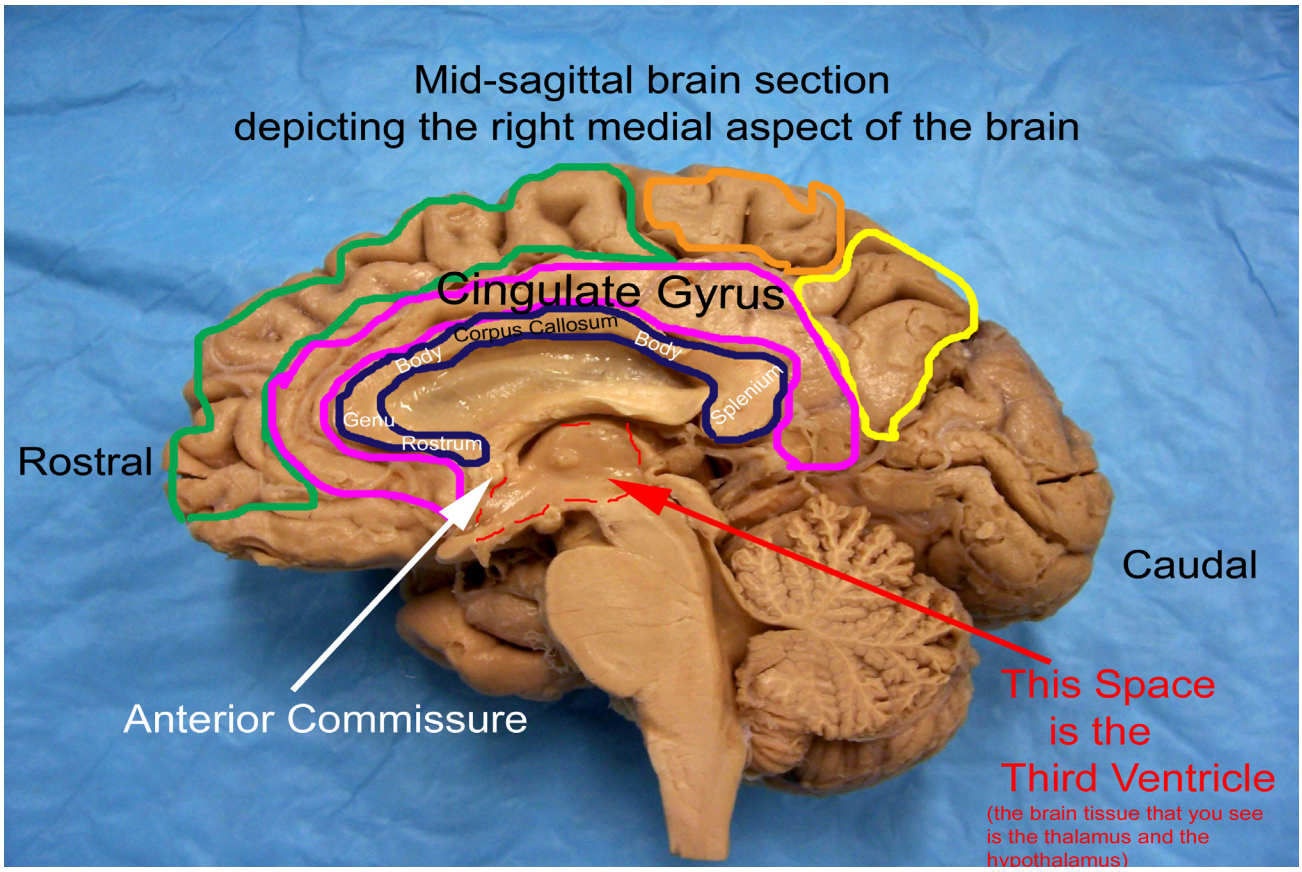
Identify the following diencephalic structures on the gross specimens:
Thalamus
Hypothalamus
Mammillary bodies (a Hypothalamic nucleus)
Stria medullaris thalami (Epithalamus)
Posterior commissure (Epithalamus)
Pineal gland (Epithalamus)

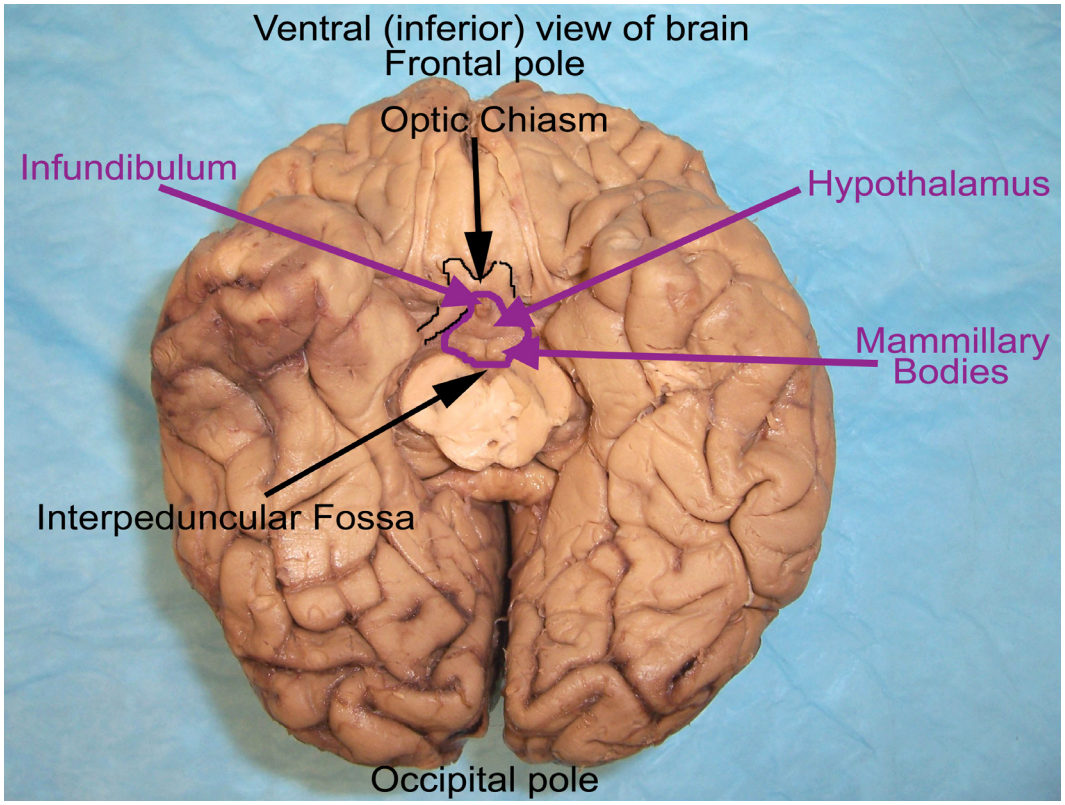
Identify the following structures that are not part of the diencephalon on gross specimens:
Lateral ventricle - anterior, body, posterior, and inferior horns
Interventricular foramen (of Monro)
Third ventricle
Internal capsule - anterior limb, genu, and posterior limb
Corpus callosum - genu, body, and splenium
Fornix
Anterior commissure
Optic nerve, optic chiasm, and optic tracts



High magnification view of some of the diencephalic structures on a mid sagittal section




Mid-sagittal brain section
depicting the right medial aspect of the brain
Cingulate Gyrus
Corpus Callosum
Body
Body
Genu
Rostrum
Splenium
Rostral
Caudal
Anterior Commissure
This Space
is the
Third Ventricle
(the brain tissue that you see
is the thalamus and the
hypothalamus)


Ventral (inferior) view of brain
Frontal pole
Optic Chiasm
Infundibulum
Hypothalamus
Mammillary
Bodies
Interpeduncular Fossa
Occipital pole

Intrinsic Morphology of the Coronal and Horizontal Brain Sections

Myelin stained "coronal" sections

The "coronal" sections start in the posterior aspect of the diencephalon and proceed rostrally. The problem with the "coronal" sections is that most of them are oblique sections, and the first 2 digital images are almost horizontal sections.

There are 9 "coronal" sections. We will start in the posterior diencephalon and work our way forward (rostrally/anteriorly).

Make sure you can identify all the bold faced terms in this lab manual.

Image 1: Transition from the midbrain to the diencephalon

This image depicts the transition of the ***midbrain*** to the diencephalon. In addition to the midbrain structures that you have identified in previous labs, you can now see the ***subthalamic nucleus*** - an almond shaped group of cell bodies located posterior to the cerebral peduncles. If the ***subthalamic nucleus is lesioned, the patient will exhibit contralateral hemiballism.*** The ***substantia nigra. is also present***. Recall that both the ***subthalamic nucleus*****(STN)** and the ***substantia nigra*** are both functionally part of the basal nuclei circuitry.
A lesion in the substantia nigra will cause Parkinson's disease.

The ***mammillary bodies*** (one of the hypothalamic nuclei) are in the interpeduncular fossa (the space between the cerebral peduncles).

Rostral to the ***mammillary bodies*** is the rest of the ***hypothalamus*** and the space spearating the ***hypothalamus*** is the ***third ventricle*.**

The ***optic chiasm*** is anterior to the ***hypothalamus***.
The ***optic tracts*** are lateral to the ***hypothalamus*** and continue posteriorly to synapse onto the ***lateral geniculate nucleus*** of the thalamus.

The ***medial geniculate nucleus*** (auditory information) is medial to the ***lateral geniculate nucleus*** (visual information).

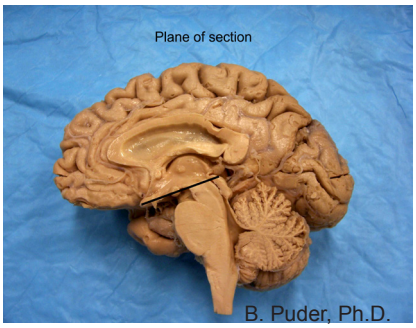
The **pulvinar** (one of the thalamic nuclei) is located posterior to the geniculate nuclei.

Make sure you can still identify the midbrain structures:

superior colliculus
cerebral aquaduct
periaquaductal gray
red nucleus
substantia nigra
cerebral peduncles

Image 1: Transition from midbrain to the diencephalon

Identify the following structures:
Hypothalamus
Mammillary bodies = MB
Third ventricle = 3V
Optic chiasm
Optic tracts = OT
Cerebral peduncles
Substantia nigra
Subtthalamic nucleus = STN
Red nucleus
Cerebral aquaduct
Periaquaductal gray = PAG
Superior colliculus = SC
Medial and Lateral geniculate nuclei = MGN and LGN
Corticospinal Tracts = CST



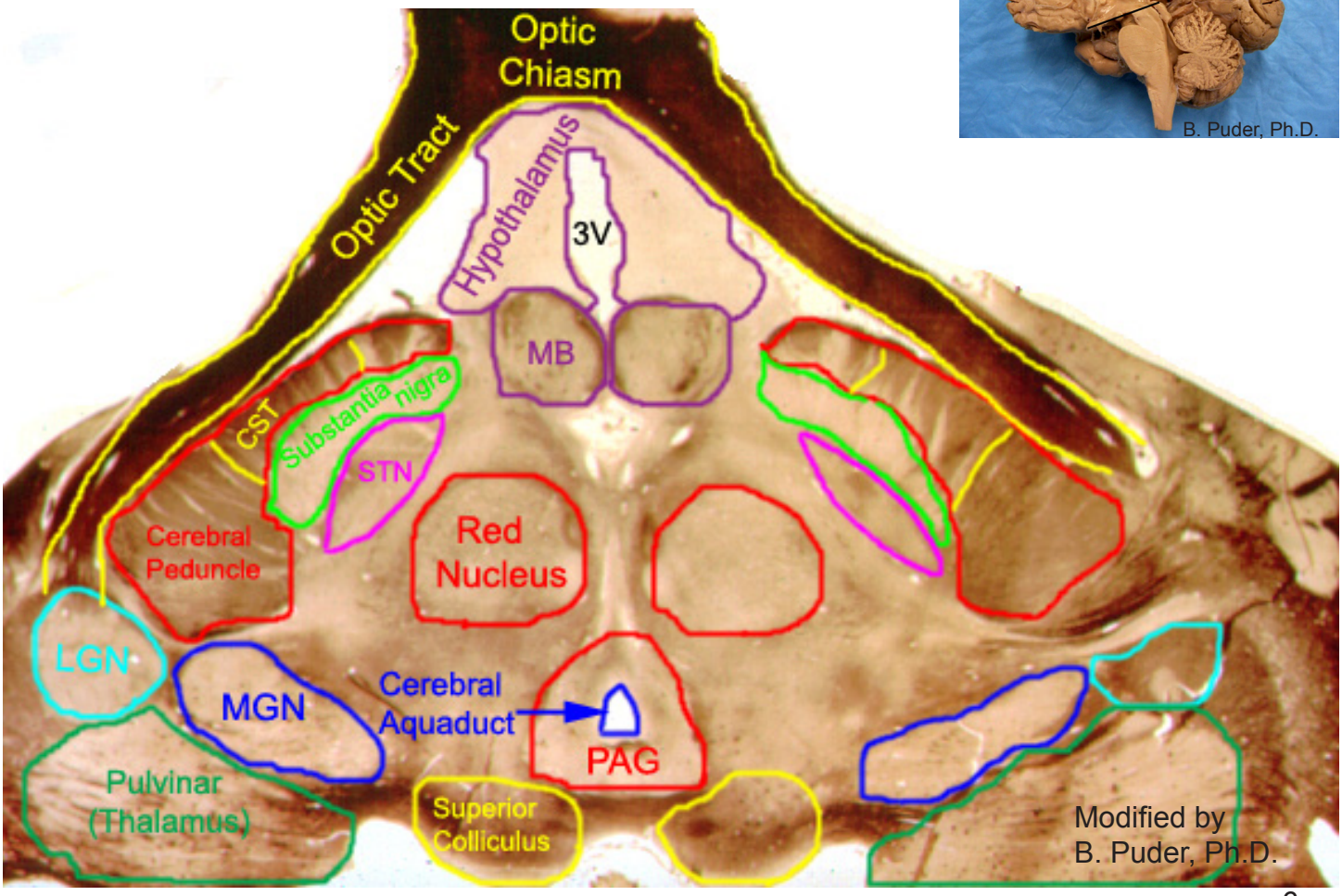
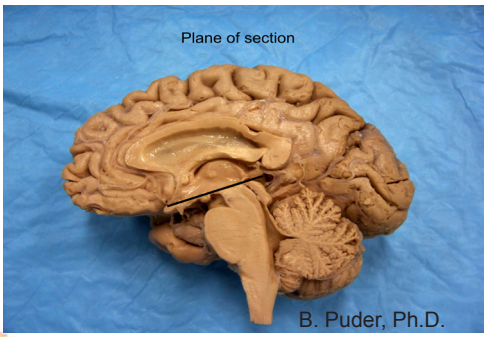


Image 2: Transition from the midbrain to diencephalon

This section is slightly superior to the previous image such that only the **pulvinar** of the thalamus can be seen.
The ***pineal gland*** is located superior and posterior to the ***superior colliculus.***
The ***subthalamic nucleus*** is present, but not the substantia nigra.
The ***posterior commissure*** can be seen medial to the ***superior colliculi.***

Still present in this image:
Red nucleus
Subthalamic nucleus = STN
Cerebral peduncles
Mammillary bodies = MB
Hypothalamus
Optic chiasm
Optic tracts
Third ventricle = 3V
Cerebral peduncles
Corticospinal tracts = CST
Red nucleus
Superior colliculus = SC



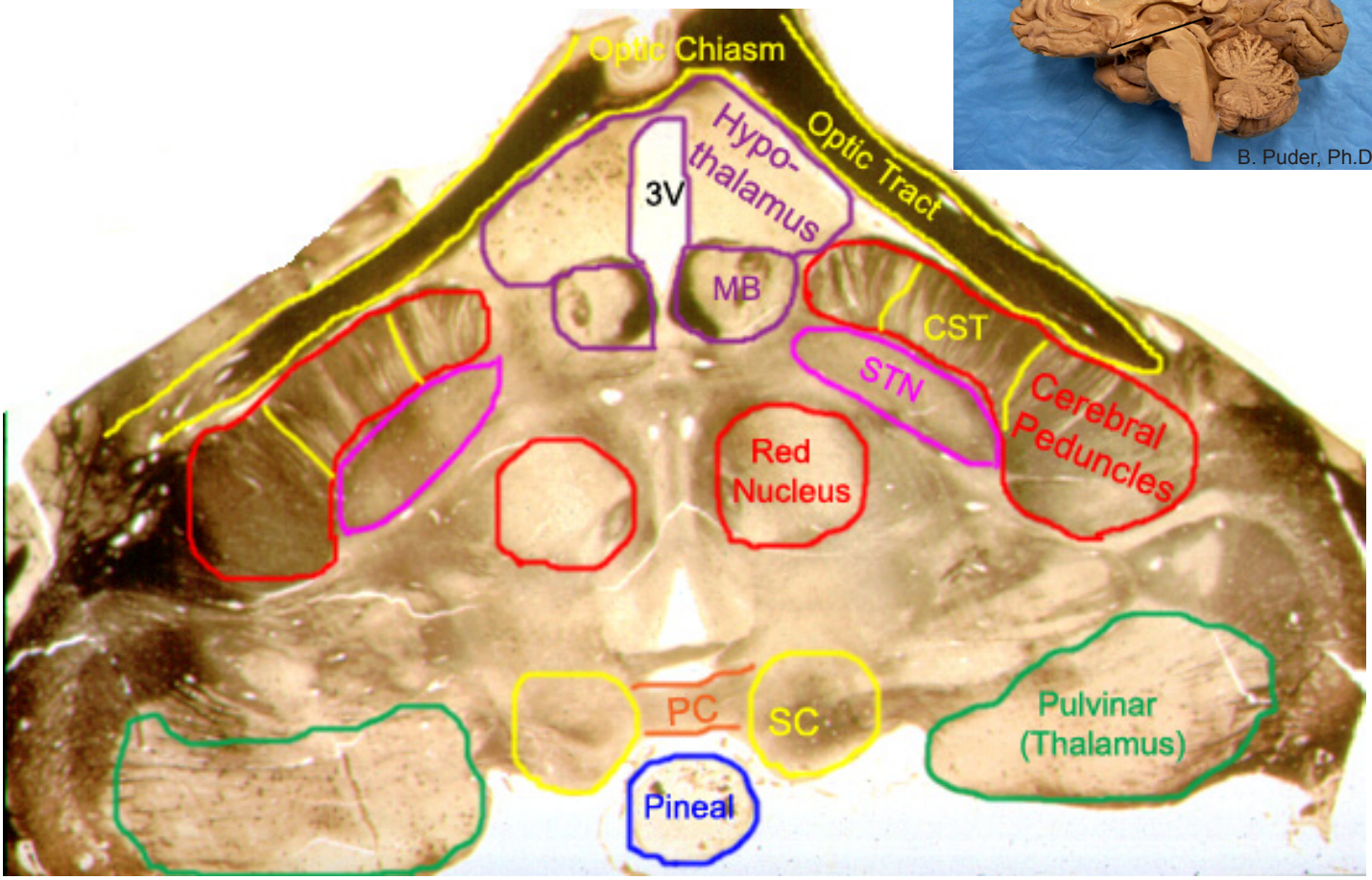


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Image 3: Posterior thalamus

Image 3 depicts the posterior aspect of the ***dorsal thalamus*** and the ***body of the caudate nucleus* (BCN) located** superior and lateral to the **dorsal thalamus**.
The ***posterior limb of the internal capsule*** is located lateral to the ***thalamus.***
The posterior limb of the internal capsule contains ascending and descending axons of the body.

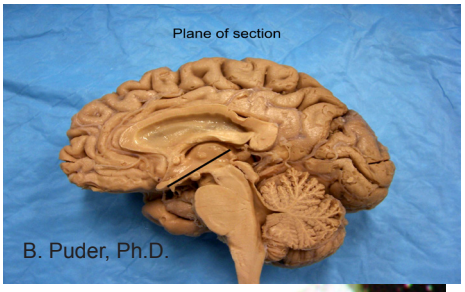
Lateral to the ***posterior limb of the internal capsule*** is the ***globus pallidus*** and the ***putamen***.

Medial to the ***thalamus*** is the ***habenular nucleus*** and ***habenular commissure***. Both structures are part of the epithalamus. ***Habenula -*** receives olfactory/limbic information.

Ventral (inferior) to the ***thalamus*** is the subthalamus and one structure within the subthalamus is the ***subthalamic nucleus. A lesion to the subthalamic nucleus results in Contralateral Hemiballism.***
Also Inferior to the ***thalamus*** is also the ***hypothalamus.***

The space superior to the ***thalamus*** is the ***body of the lateral ventricle***.

Identify the following structures:
Habenula = HA ***Habenular commissure***
Body of the lateral ventricle ***Third ventricle = 3V***
Putamen ***Globus pallidus***
Stria terminalis - Axons that connect the hypothalamus and amygdala
Posterior limb of the internal capsule
Body of the caudate nucleus = BCN
Subthalamic nucleus =STN
Hypothalamus = H
Thalamus



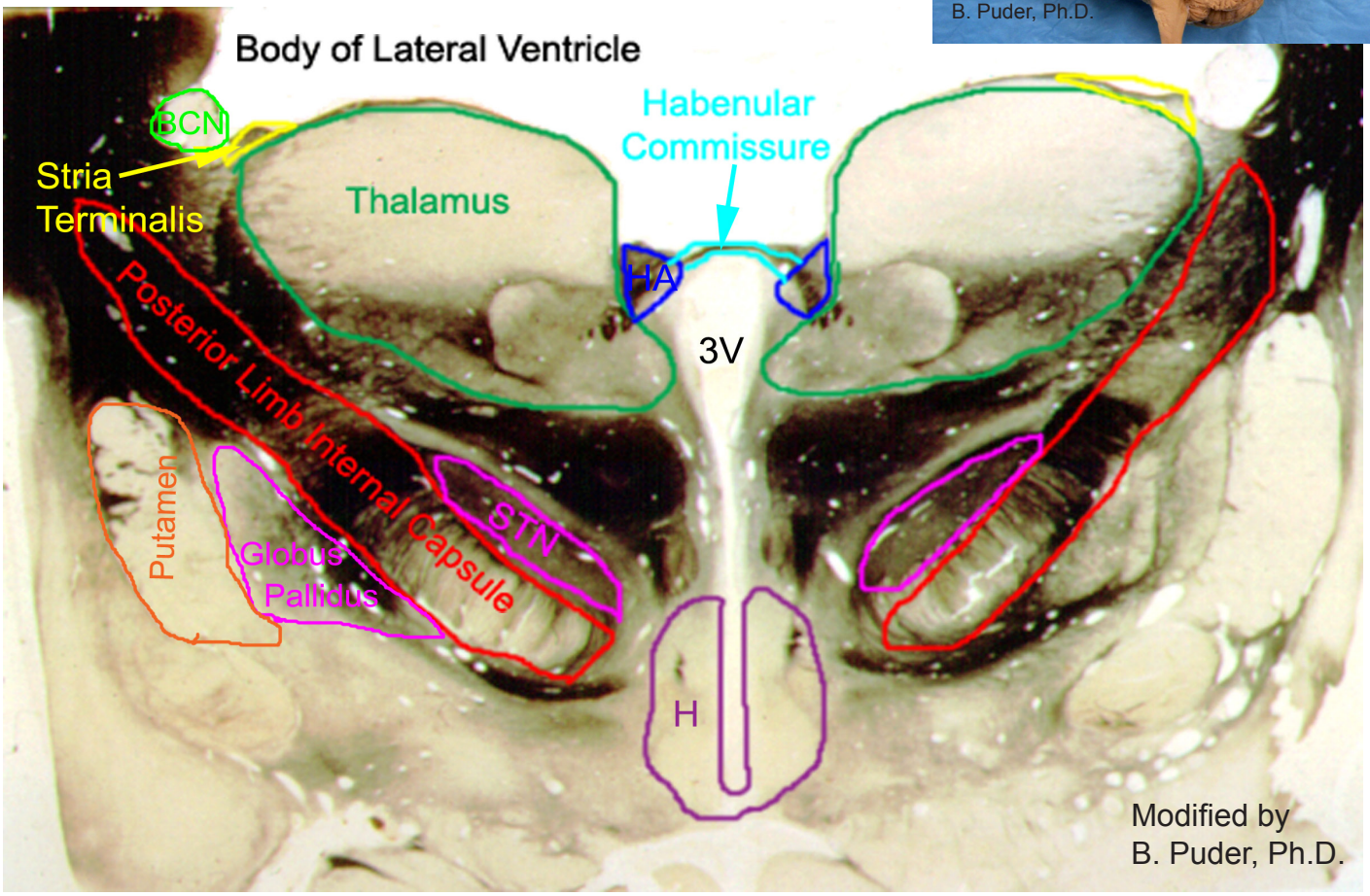


Image 4: Medial thalamus

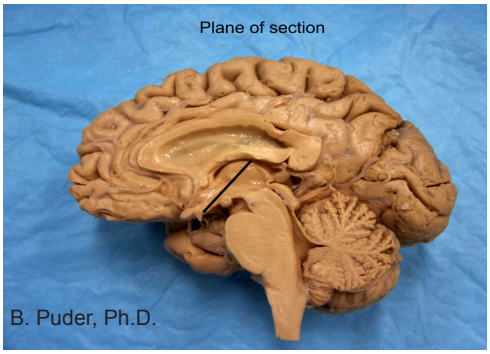
Image 4 once again depicts the ***body of the caudate nucleus, putamen and globus pallidus.*** Their positions have not changed.

Stria Medullaris thalami - Axons that will synapse on the habenular nuclei relaying emotional olfactory limbic information. (The cell bodies are in the septal nuclei located anteriorly).The stria medullaris thalami can be seen as a "black dot" on each of the medial aspects of the thalamus.

There is also a "black dot" in each side of the ***hypothalamus.*** These black dots are axons that are called the fornix and are part of the limbic system.

Hypothalamus with ***fornix fibers*** within it
The fornix is composed of axons that project from the hippocampus to the mammillary bodies of the

Identify the following structures:
Stria medullaris thalami
Body of the lateral ventricle
Third ventricle = 3V
Stria terminalis
Posterior limb of the internal capsule
Body of the caudate nucleus = BCN
Putamen
Globus pallidus
Hypothalamus = H
Fornix = F
Thalamus



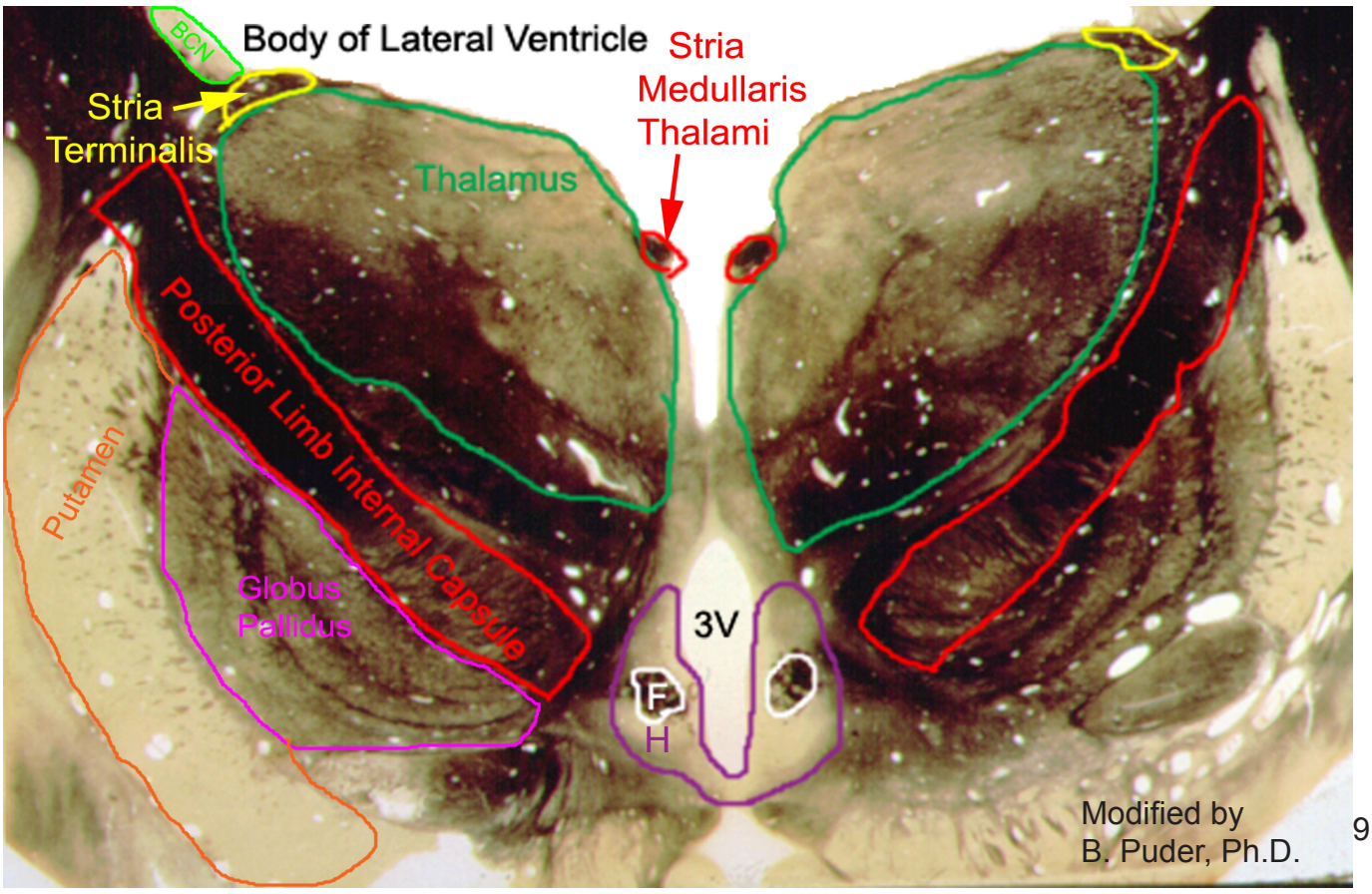


Image 5: Medial thalamus

Once again, the ***body of the caudate nucleus***, ***putamen***, **and** ***globus pallidus*** are present.
The ***substantia nigra*** and ***subthalamic nucleus*** **(STN)** are present as well.
The Temporal lobe is also present in this section.

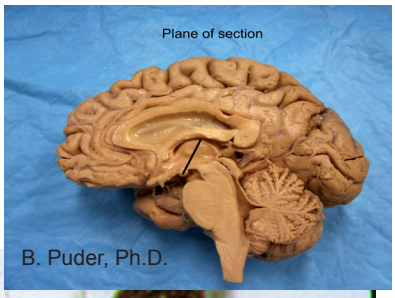
Posterior limb of the internal capsule - note that the ***posterior limb of the internal capsule*** becomes continuous with the ***cerebral peduncles.*** This makes sense as some of the axons of the posterior limb are the **corticospinal tracts** which are descending from the cortex through posterior limb through ***cerebral peduncles*** and through pyramids of the medulla to the spinal cord as the lateral corticospinal tracts to synapse on lower motor neurons in the anterior horn of the spinal cord.

The **fornix** fibers appear as "black dots/lines" floating superior to the ***thalamus*** in the ***lateral ventricles.*** This is because the ***fornix*** fibers originate in the temporal lobe and ascend from posterior and then superior to the ***thalamus***. Once the ***fornix*** fibers are anterior to the ***thalamus***, they descend into the ***hypothalamus*** to synapse on the ***mammillary bodies***. Thus depending on the section, you may see ***fornix*** superior to the ***thalamus***, or within the ***hypothalamus***.

Amygdala - located in the uncal portion of the parahippocampal gyrus in the temporal lobe

Identify the following structures:

Amygdala
Body of the lateral ventricle
Stria terminalis
Body of the caudate nucleus = BCN
Globus pallidus
Subthalamic nucleus = STN
Fornix = F
Stria medullaris thalami
Third ventricle = 3V
Posterior limb of the internal capsule
Putamen
Mammillary bodies = MB
Substantia nigra



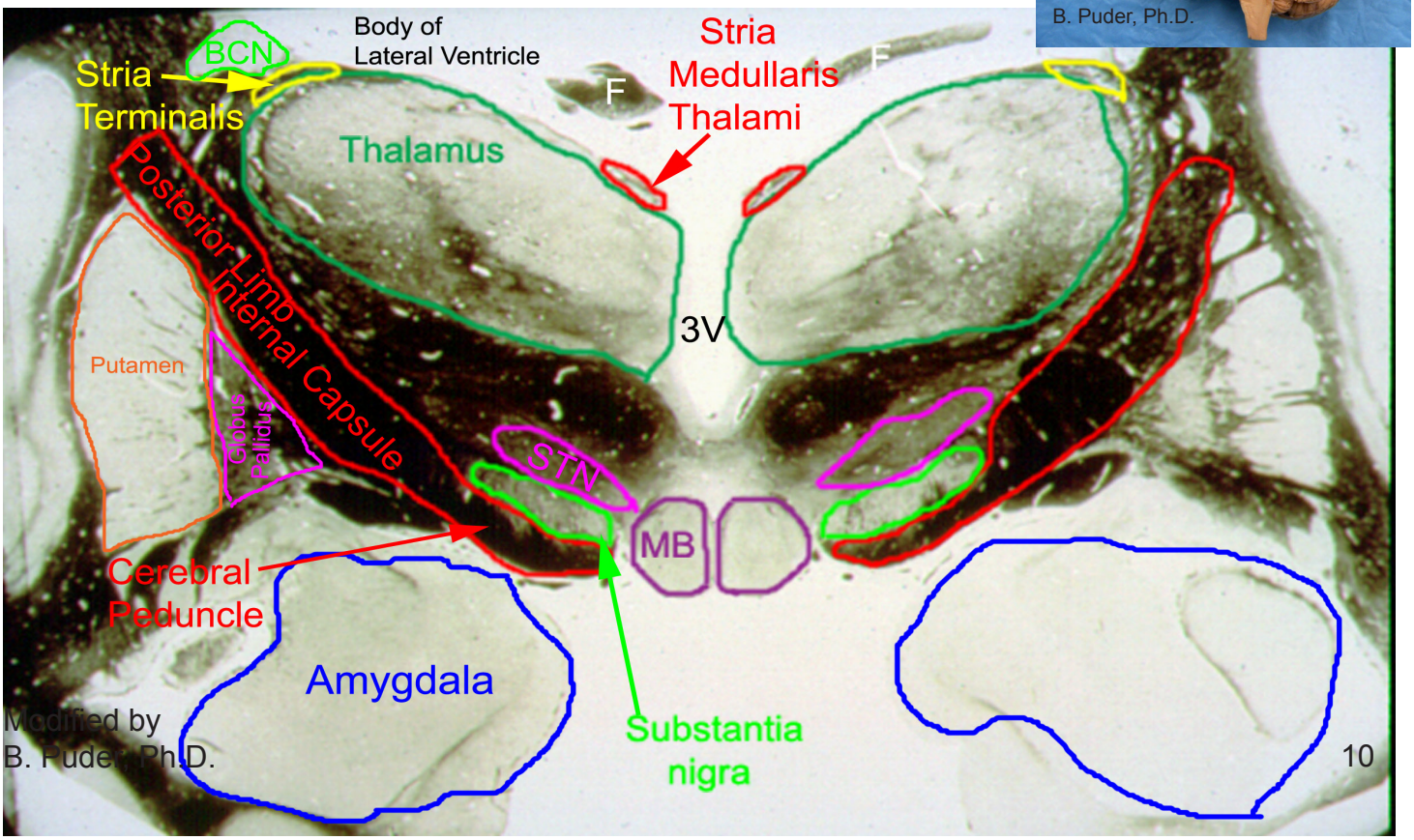


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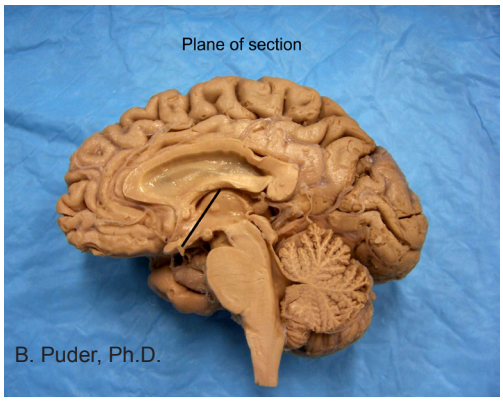
Image 6: Medial thalamus
The **hypothalamus** has **fornix** fibers "black dots" within it in this section
The **fornix** can also be seen superior to the **thalamus** in the **bodies of the lateral ventricles**.
The **optic tracts** are lateral to the **hypothalamus**.
Note: Don't confuse the **optic tracts** in this section with the **cerebral peduncles in image 5**.
Two ways to differentiate between the 2 structures is the **posterior limb of the internal capsule** will be continuous with the cerebral peduncles, or look at the **hypothalamus**: if **mammillary bodies** (which sit in the interpeduncular fossa), are present, then the cerebral peduncles will be lateral, if there is ***hypothalamus with no mammillary bodies***, then the ***optic tracts*** are seen laterally.

Image 6 also depicts the ***body of the caudate nucleus, putamen, globus pallidus***.

Identify the following structures:
Stria medullaris thalami
Body of the lateral ventricle
Third ventricle = 3V
Stria terminalis
Posterior limb of the internal capsule
Body of the caudate nucleus = BCN
Putamen
Globus pallidus
Hypothalamus = H
Fornix = F (in 2 places)
Amygdala
Thalamus
Optic Tracts



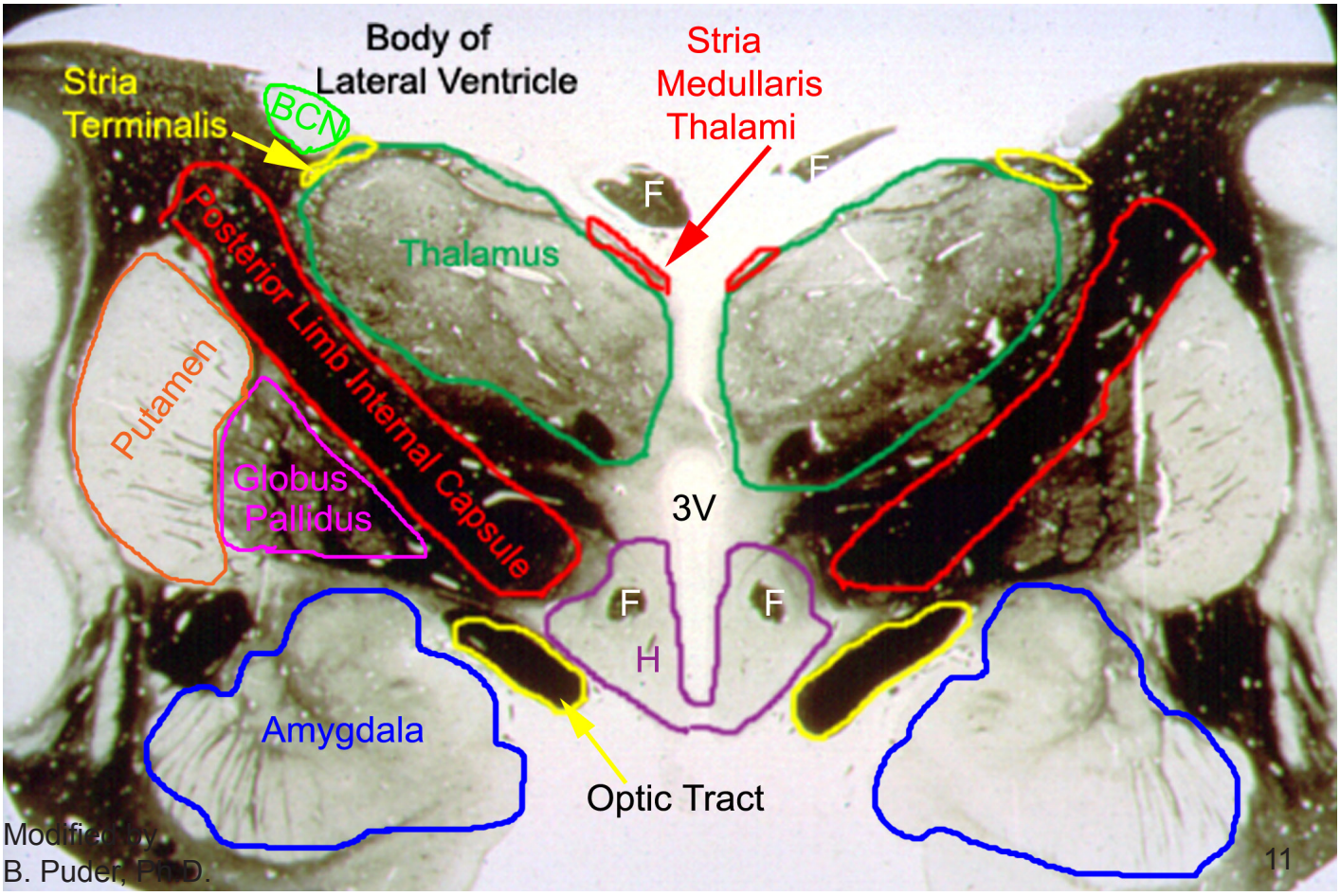


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Image 7: Anterior thalamus

The ***mammillothalamic tracts*** can be seen on this image. The neuronal cell bodies are located in the ***mammillary bodies*** and their axons project as the ***mammillothalamic tracts*** to synapse upon the anterior nucleus of the ***thalamus.*** This is part of the limbic system pathways.

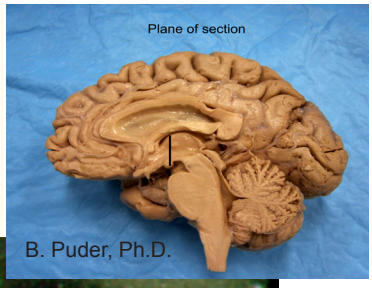
Identify the following structures:

Body of the caudate nucleus = BCN
Globus pallidus
Substantia nigra
Thalamus
Body of the Lateral Ventricle
Stria Medullaris thalami
Mammillary bodies = MB
Putamen
Subthalamic nucleus = STN
Posterior Limb of the Internal Capsule
Third Ventricle = 3V
Cerebral Peduncle
Stria terminalis
Fornix = F - now seen superior to the thalamus

Mammillothalamic tracts = MTT = axons that project from mammillary bodies to anterior thalamic nuclei

Hippocampus - located posterior to yhe amygdala in the parahippocampal gyrus in the temporal lobe
Axons leaving the ***hippocampus*** are called the ***fornix*** and these axons will synapse on the ***mammillary bodies*** of the ***hypothalamus*** or on the ***septal nuclei.***
A lesion to the ***hippocampus*** will interfere with learning and memory.

Amygdala - lesion here results in Kluver-Bucy syndrome



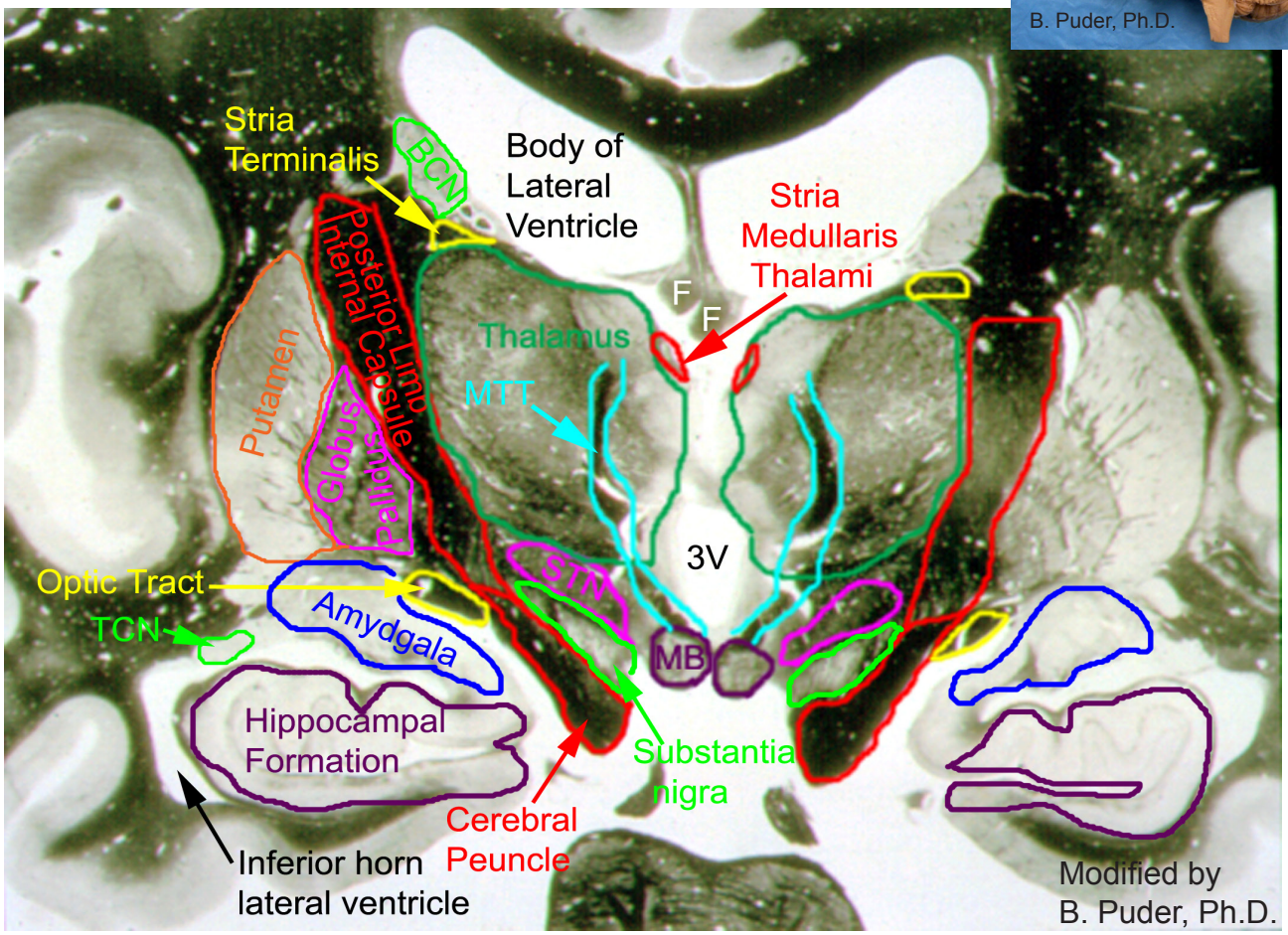


Image 8: Anterior to the thalamus/Anterior commissure

Image 8 is a coronal section anterior to the dorsal thalamus. Many changes occur here and most of them have anterior in their name.

Identify the bold italic terms:

The ***Head of the caudate nucleus*** replaces the body of the caudate nucleus, the ***anterior horn of the lateral ventricle*** is present and not the body of the lateral ventricle. The ***anterior limb of the internal capsule*** is now present. (We have no coronal images that depict the genu of the internal capsule.)

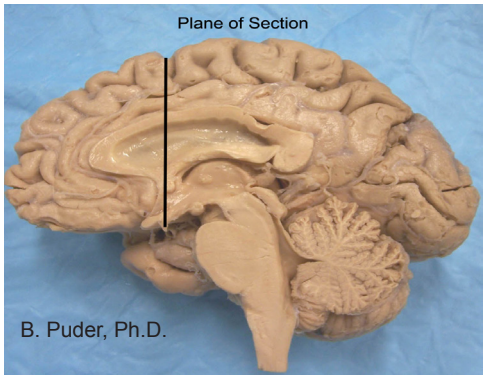
The anterior commissure is the myelin stained structure traversing this image from one side to the other.

The ***putamen and globus pallidus*** are still present.

Limbic system structures include:

Septal nuclei - cell bodies here project their axons as the stria medullaris thalami

Nucleus Basalis of Meynert - one of the first areas to undergo neuronal cell death during Alzeheimer's disease.



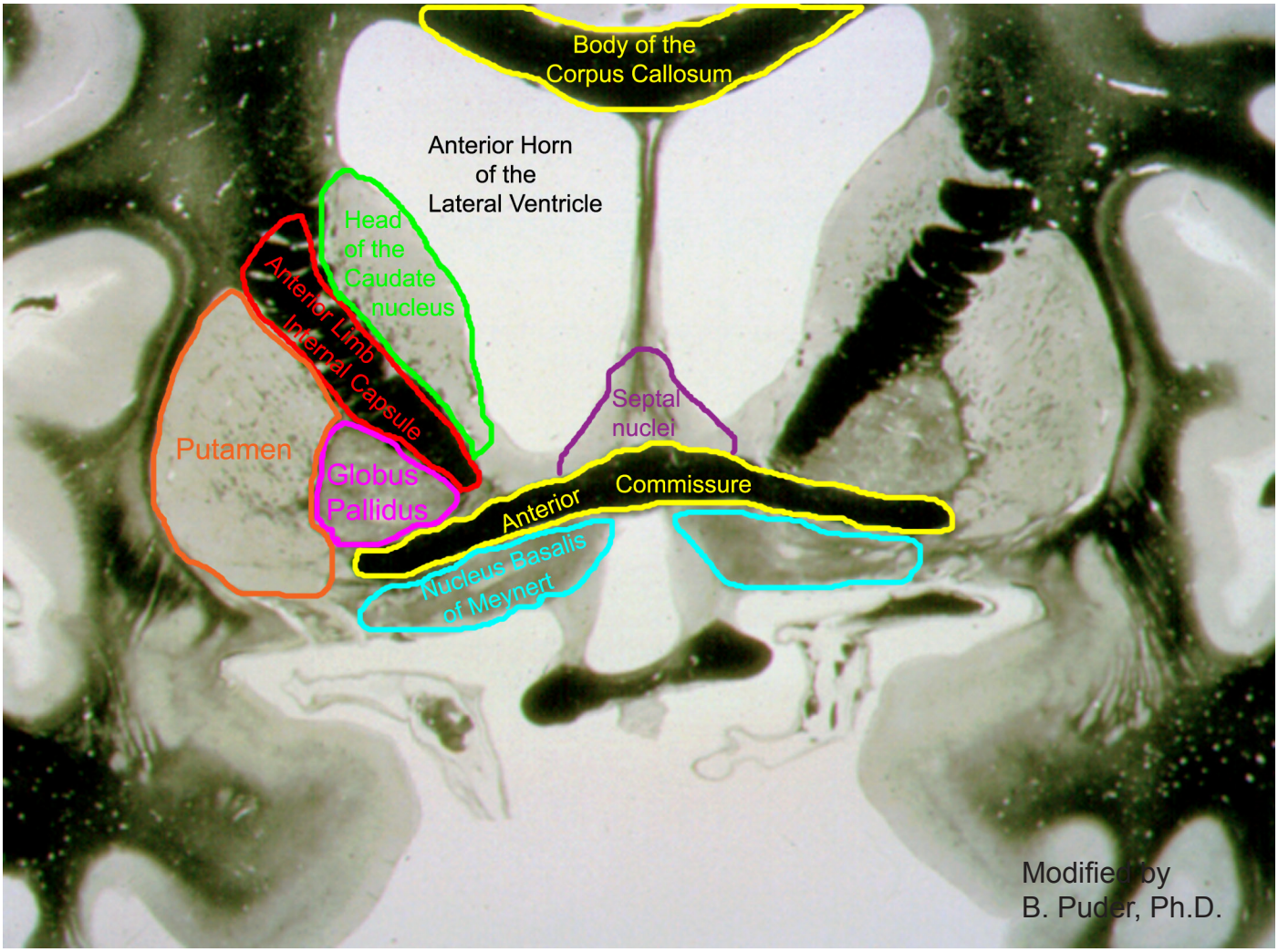
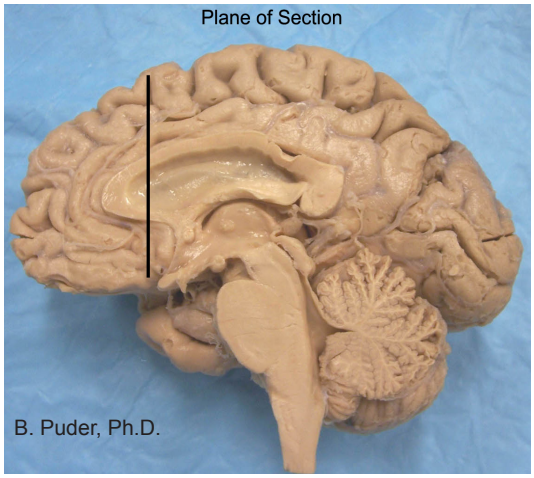
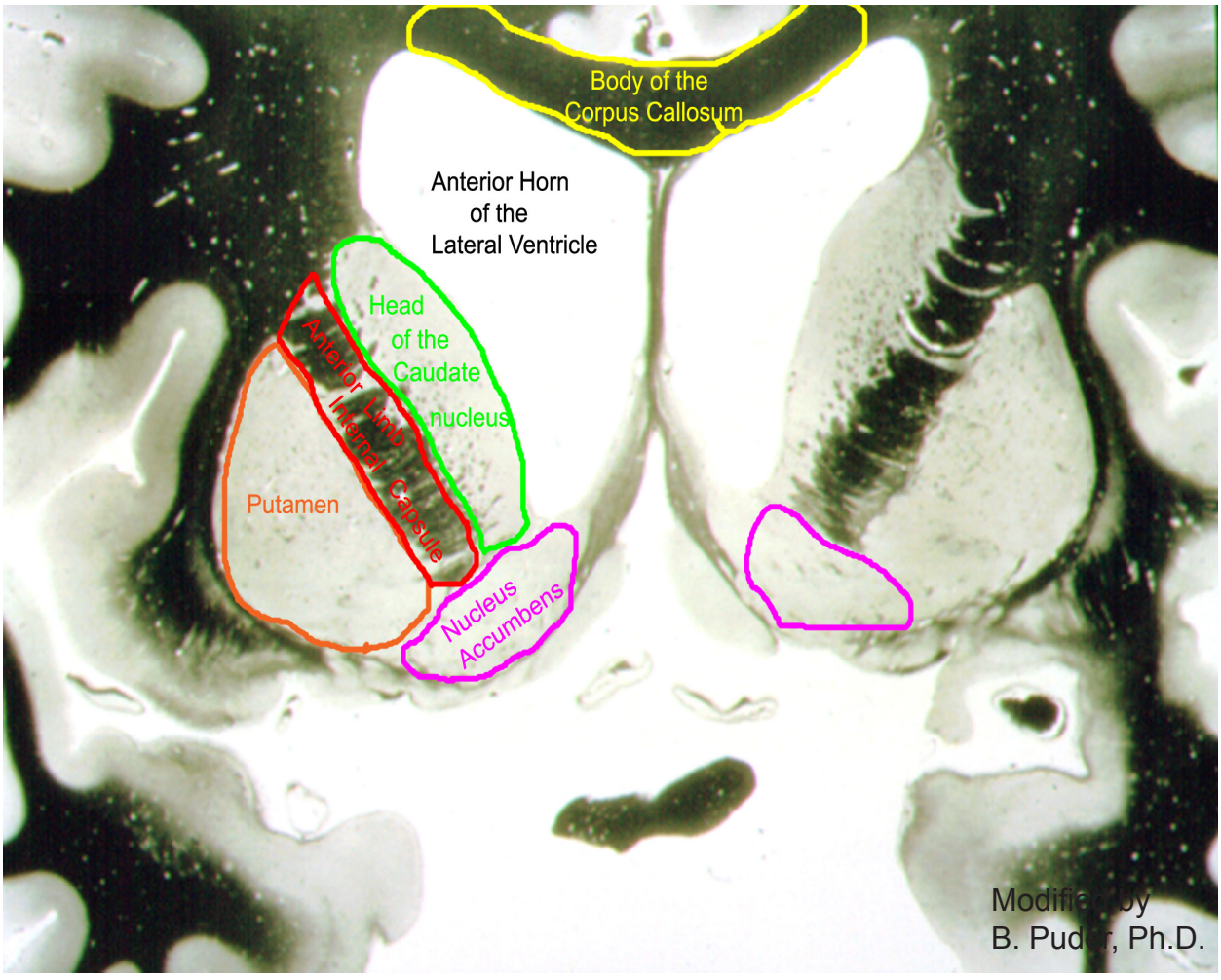


Image 9: Anterior coronal section (Anterior to the Anterior Commissure)

This image is the most anterior coronal section.
Identify the following structures present on this image:
head of the caudate nucleus
anterior horn of the lateral ventricle
anterior limb of the internal capsule
putamen
Limbic structure:
Nucleus Accumbens - plays a role in addictive behaviors, is considered the "pleasure center"





Myelin stained horizontal sections

There are 7 myelin stained horizontal sections. We will not be be looking at these sections with as much detail as the coronal sections.

We will start superiorly and move inferiorly through the images..

Image 1: Superior image - the "Body" image

This horizontal image depicts alot of "bodies":

Identify:

Body of the corpus callosum

Body of the lateral ventricle

Body of the caudate nucleus

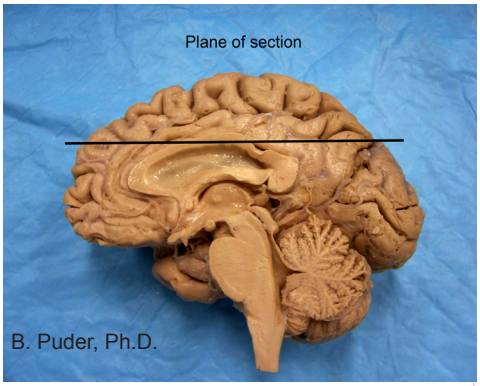


Image 2

Identify:

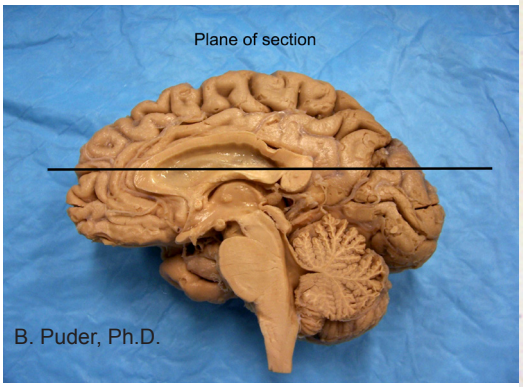
Genu and splenium of the corpus callosum

Body of the lateral ventricles

Anterior and posterior horns of the lateral ventricles

Body of the caudate nucleus

Putamen (P) (just a tiny bit of it)



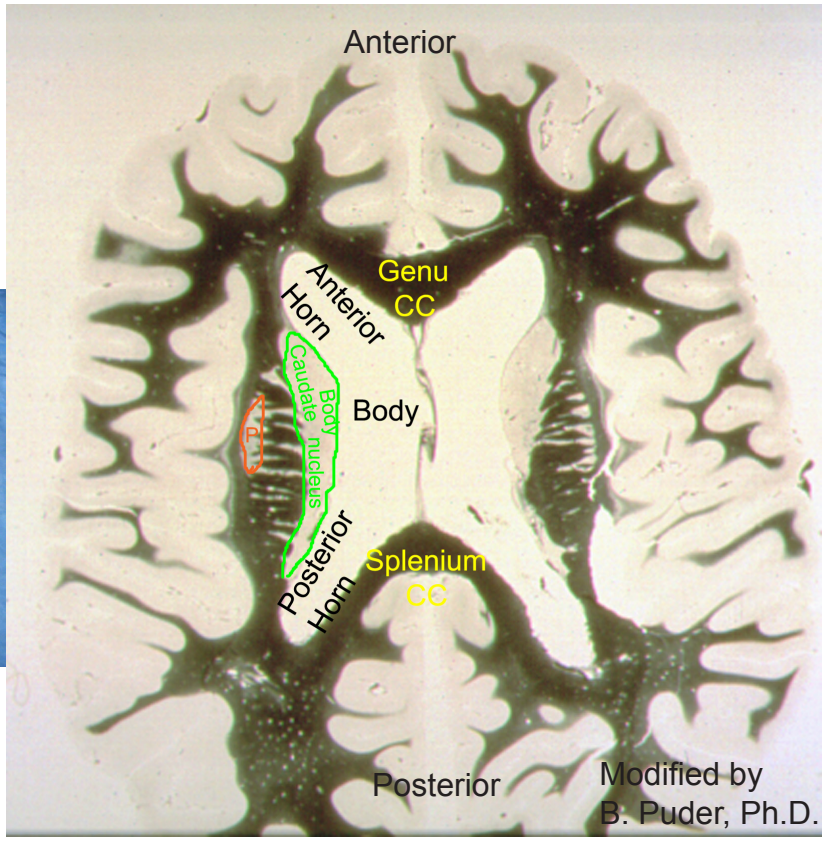
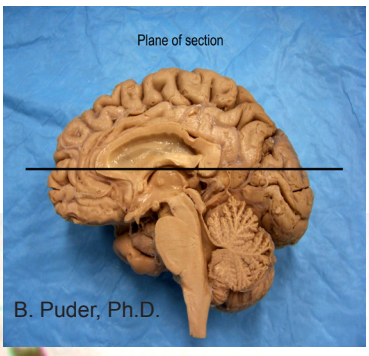


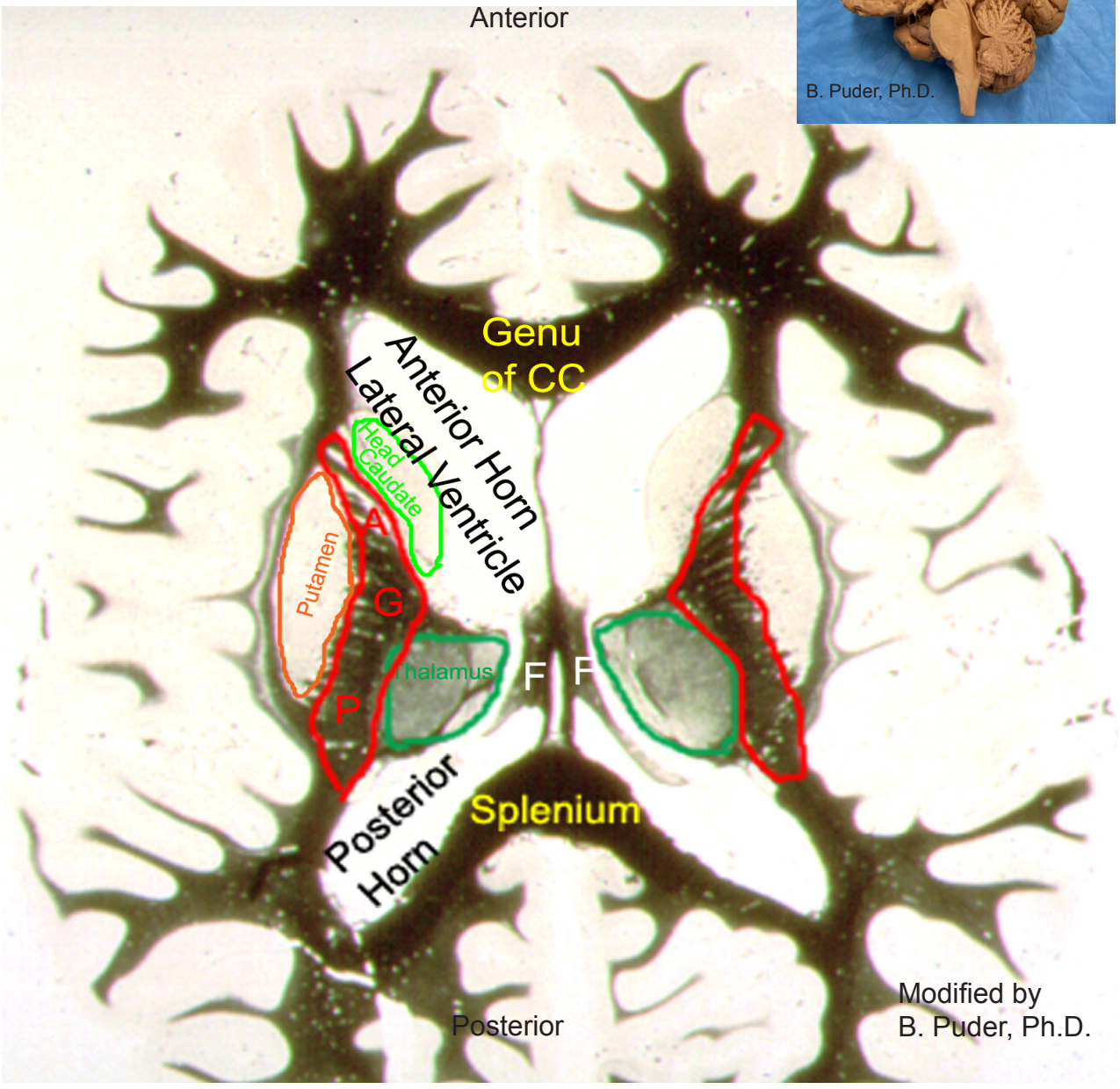
Image 3: Dorsal aspect of the thalamus

Now that the ***dorsal thalamus*** is present, the body of the caudate nucleus - which is in a superior section to the thalamus, is now gone. Recall that the caudate nucleus is "C" shaped, so now in this section, the ***Head of the caudate nucleus*** is anterior to the dorsal thalamus.

Also present is then entire internal capsule.
The anterior limb of the internal capsule = A (anterior to the thalamus) related to the limbic system
genu of the internal capsule = G (ascending and descending face pathways)
posterior limb of the internal capsule = P (ascending and descending body pathways)

Identify the following structures in this image:
Genu and splenium of the corpus callosum
Anterior and posterior horns of the lateral venricles
Head of the caudate nucleus
Thalamus
Anterior, genu and posterior limbs of the internal capsule
Putamen
Fornix = F



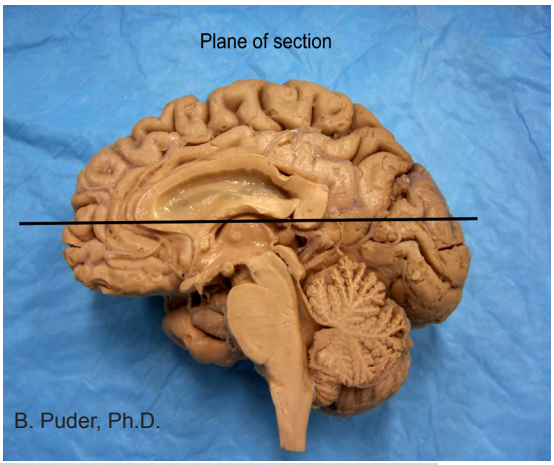


Modified by
B. Puder, Ph.D.

Image 4: Dorsal and medial aspect of the thalamus

The ***globus pallidus*** is now present in this image

Identify the following structures in this image;
Genu and splenium of the corpus callosum
Anterior and posterior horns of the lateral venricles
Head of the caudate nucleus
Thalamus
Anterior, genu and posteior limbs of the internal capsule
Putamen
Globus pallidus (GP)
Fornix (F)
Third ventricle (3V)



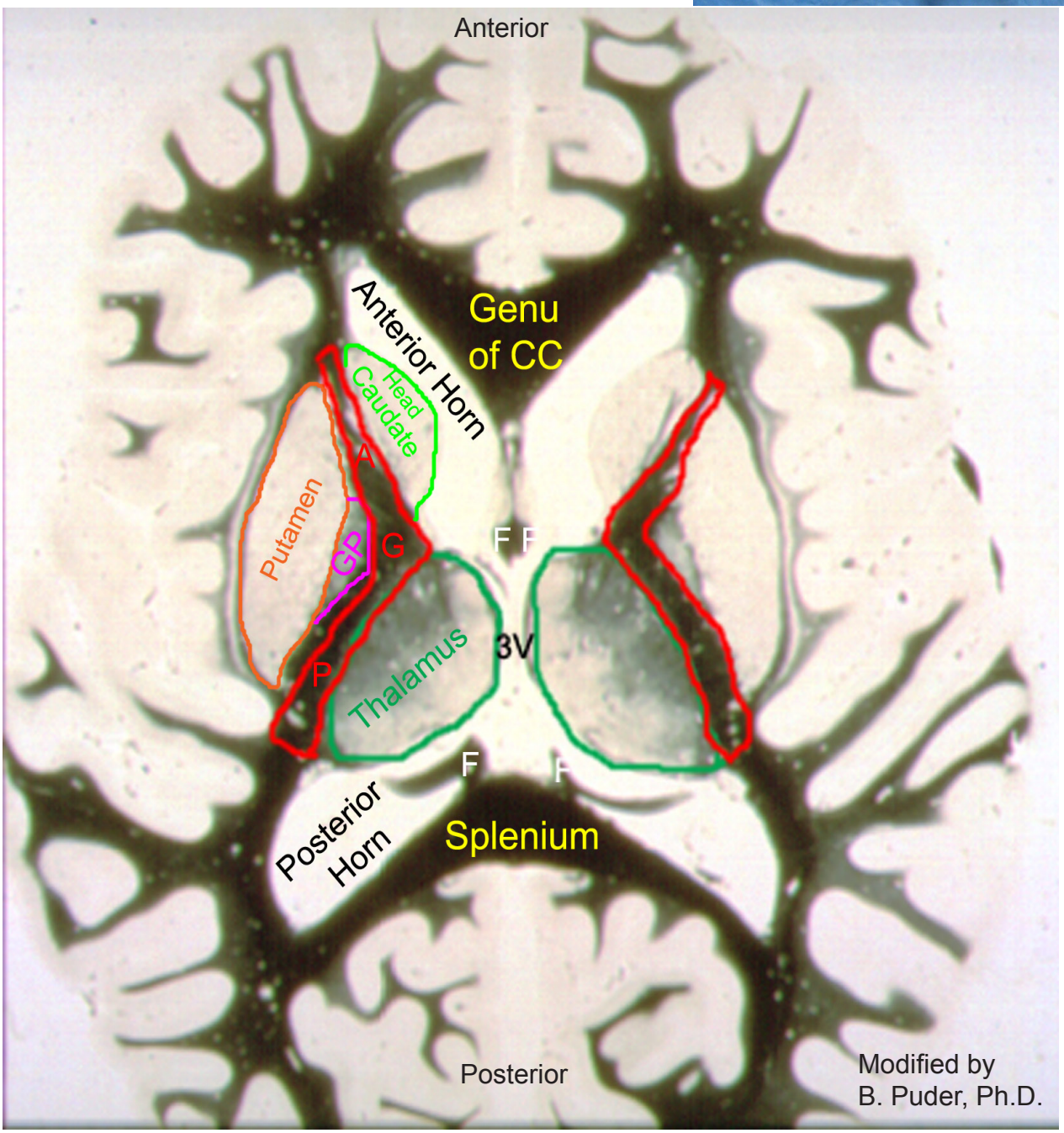
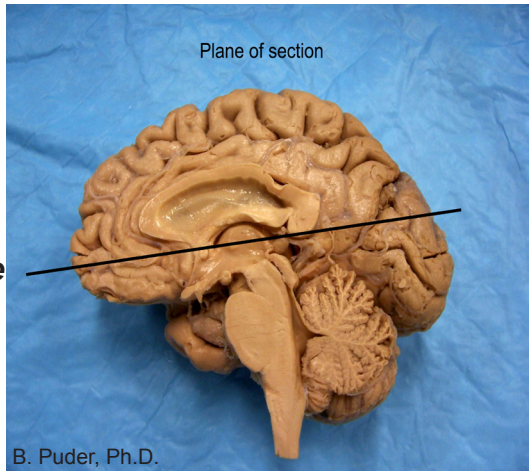


Image 5:
The ***anterior commissure*** is the new structure in this image.



Identify the following structures in this image:
Head of the caudate nucleus
Putamen
Globus pallidus
Anterior limb, genu, and posterior limb of the internal capsule
Thalamus
Third ventricle (3V)
Fornix = F
Anterior commissure

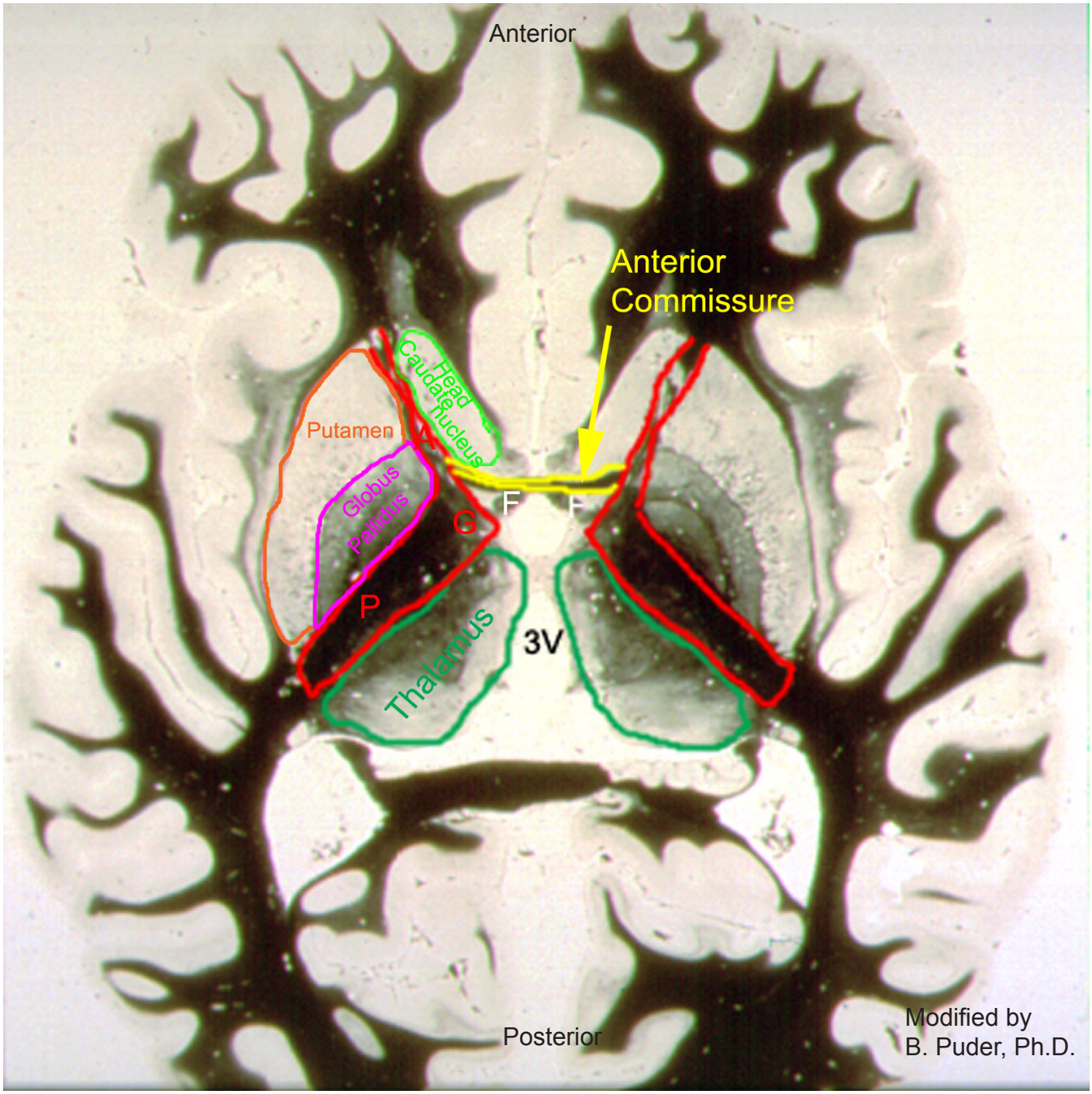
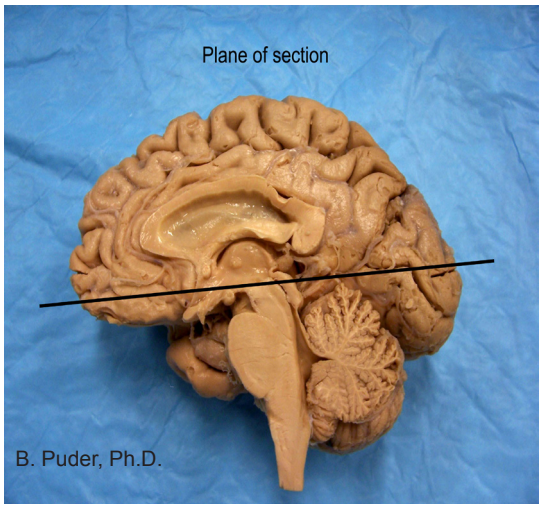


Image 6: Transition to the brainstem

Identify the following structures in this image:

Hypothalamus (H)
Third ventricle (3V)
Optic tracts (OT)
Cerebral peduncles (CP)
Substantia nigra (SN)
Red nucleus (RN)
Cerebral aquaduct
Periaquaductal gray (PAG)
Superior colliculus (SC)
Medial and lateral geniculate nuclei (MGN and LGN)
Amygdala
Hippocampus



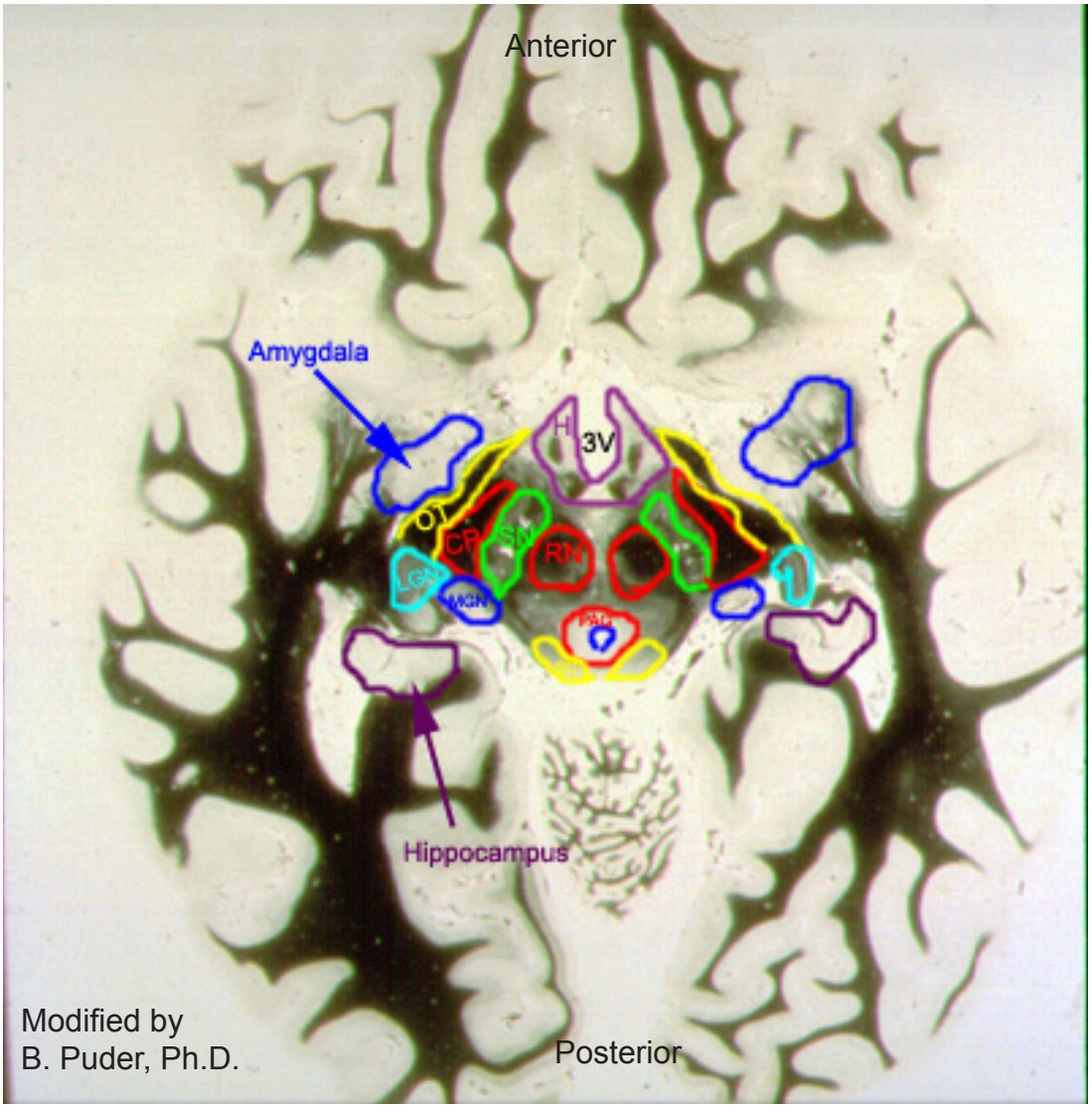
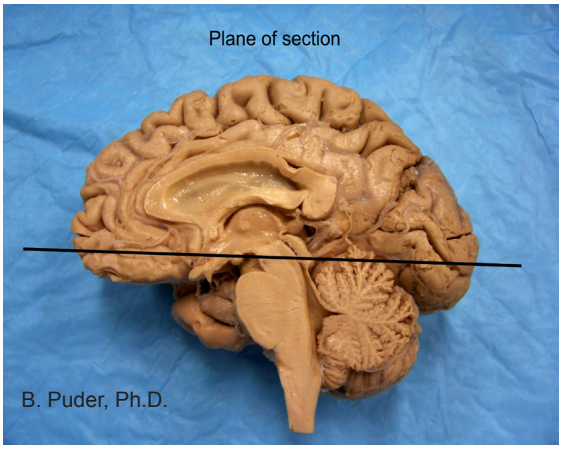
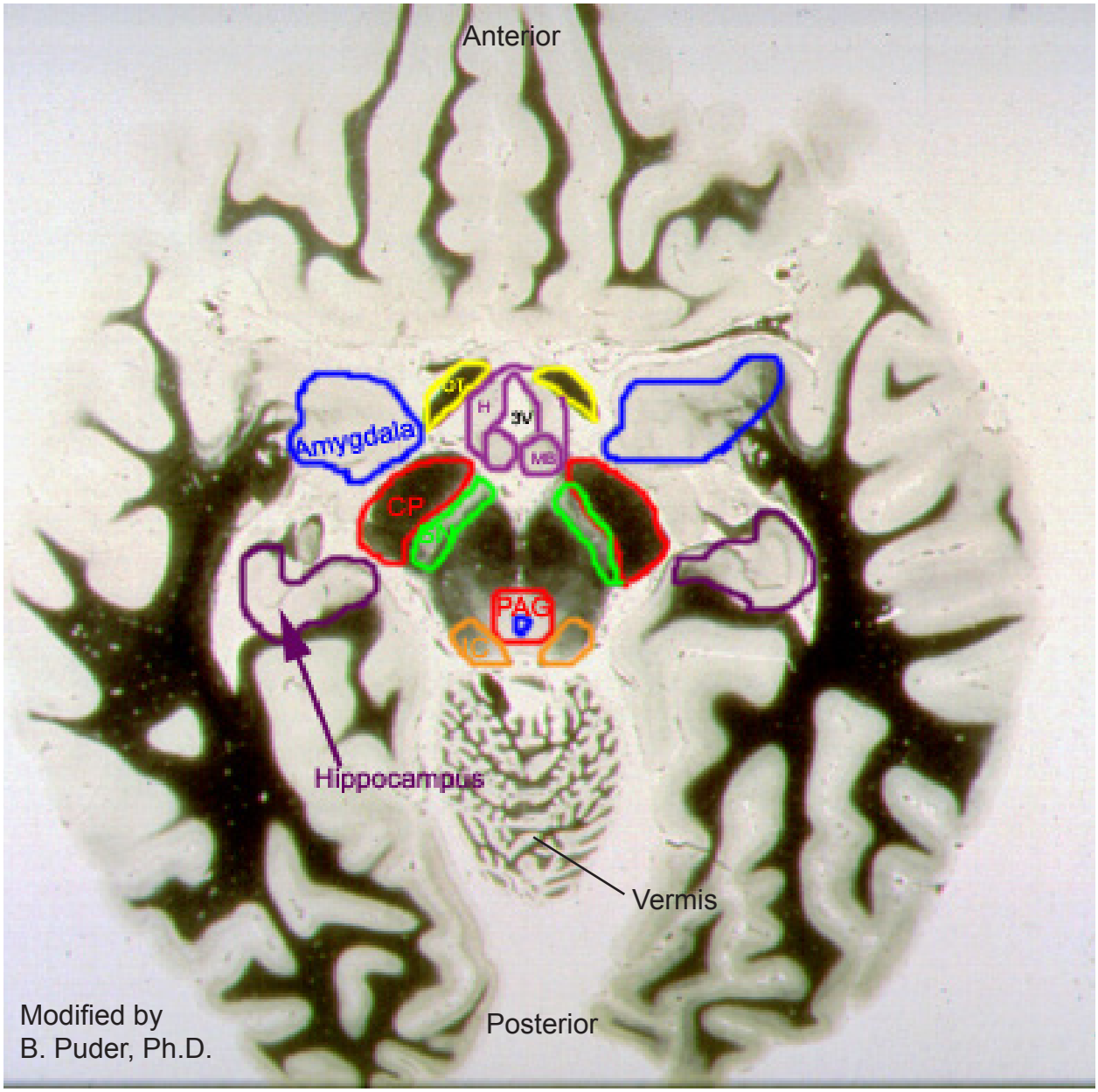


Image 7: Transition to the brainstem

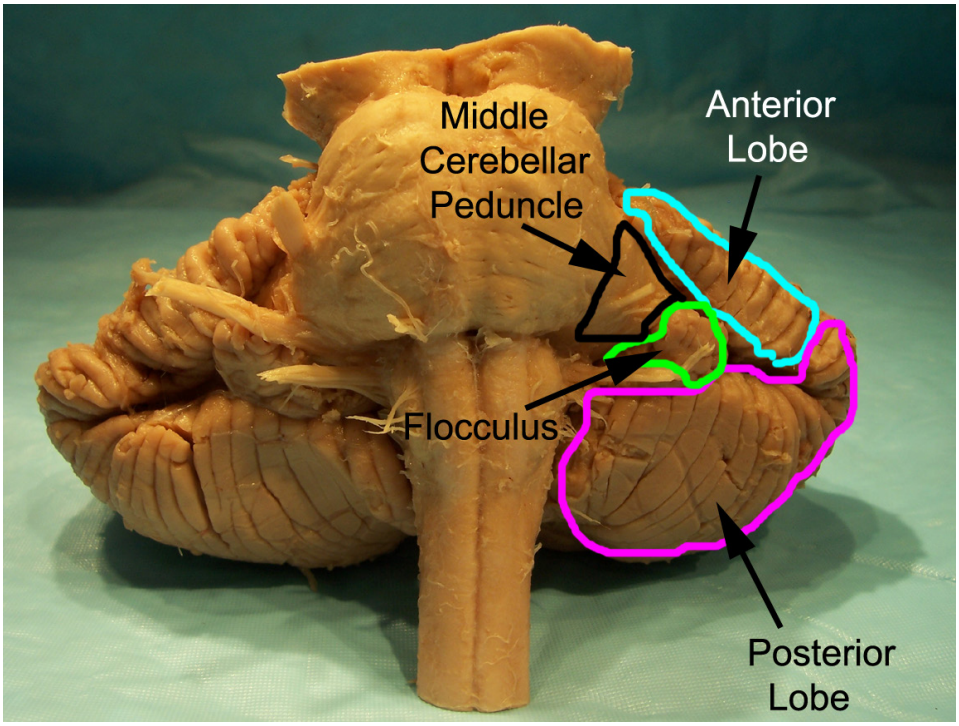
Identify the following structures in this image:
Hypothalamus (H)
Mammillary bodies (MB)
Third ventricle (3V)
Optic tracts (OT)
Cerebral peduncles (CP)
Substantia nigra (SN)
Cerebral aquaduct
Periaquaductal gray (PAG)
Inferior colliculus (IC)
Vermis of the cerebellum
Amygdala
Hippocampus



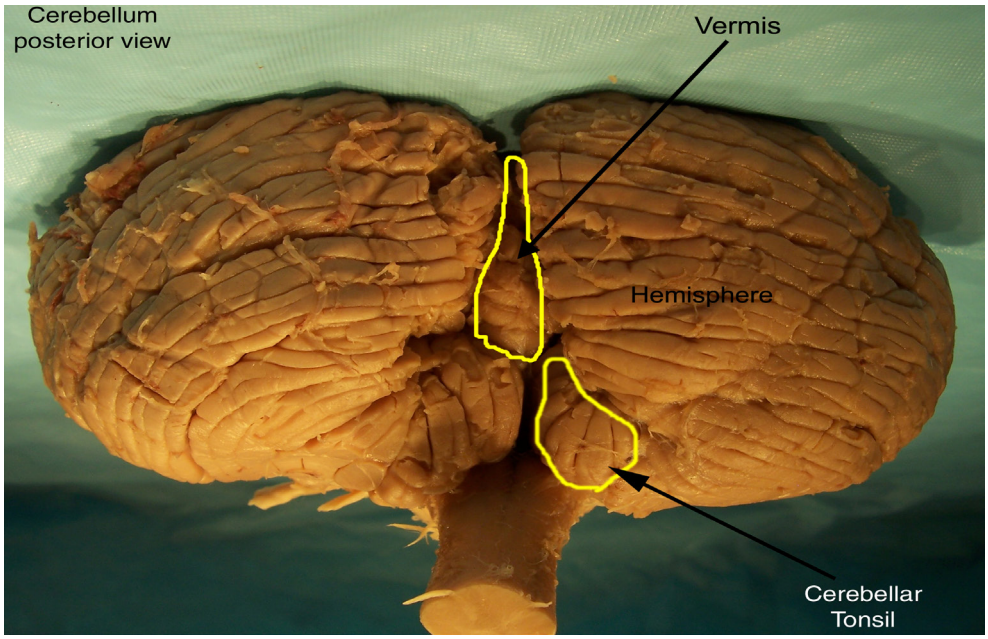


The Cerebellum
Gross anatomy of the cerebellum

Use a whole and half brain to identify the following gross anatomical cerebellar structures.
middle cerebellar peduncles
flocculus
anterior and posterior lobes
vermis
tonsils



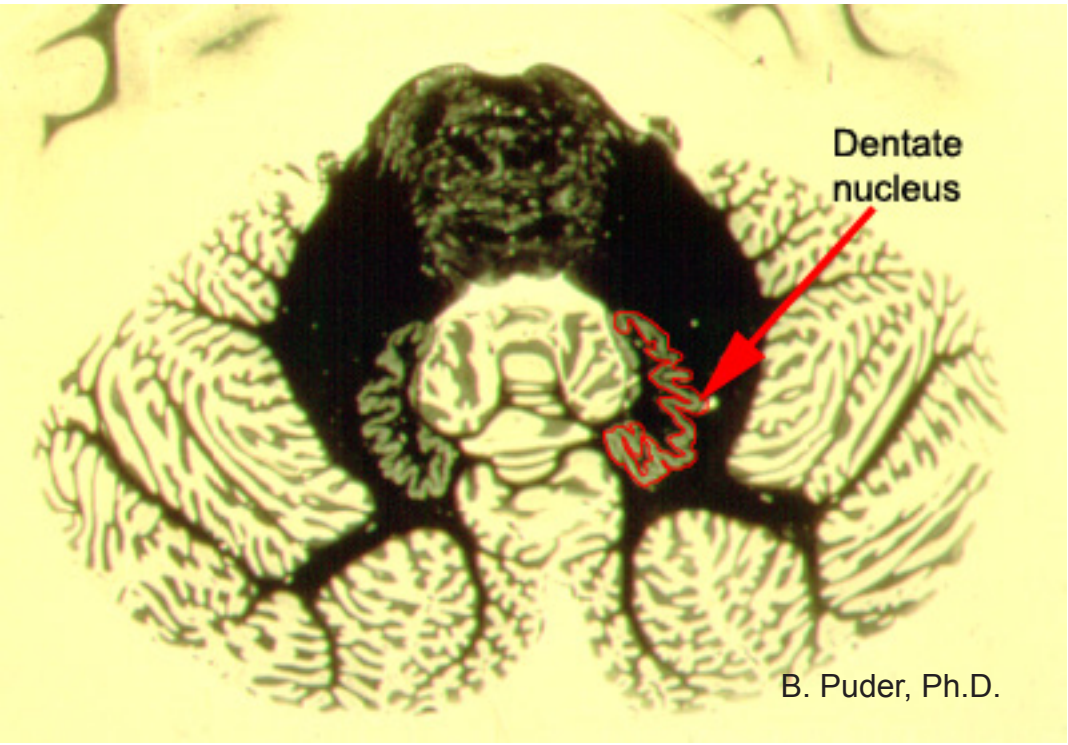
Anterior view of the brainstem and cerebellum



Posterior view of the cerebellum

Myelin stained cerebellar section
Materials: 1 myelin stained cerebellar section, lab guide, lab atlas

There is only 1 section that depicts a section through the cerebellum.
The ***dentate nucleus i***s the only 1 of the 4 deep cerebellar nuclei that are visible in this section.



Coronal section through the mid cerebellum depicting the ***dentate nucleus*** - one of the four deep cerebellar nuclei. The ***dentate nucleus i***s located in the lateral zone which is the pontocerebellum functionally.

FUN READING on the CEREBELLUM - you will NOT be tested on the 2 histological images on this page or on the information on this page.

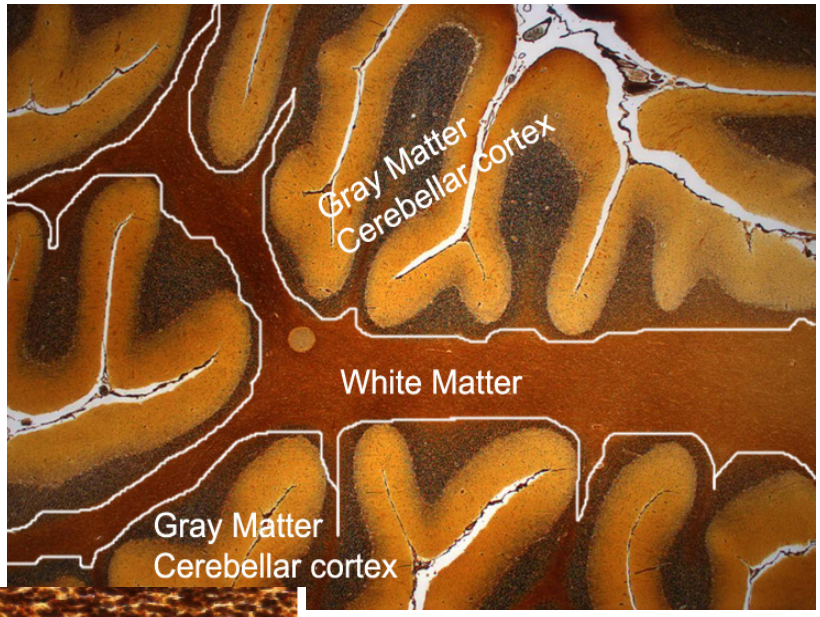
A note on function

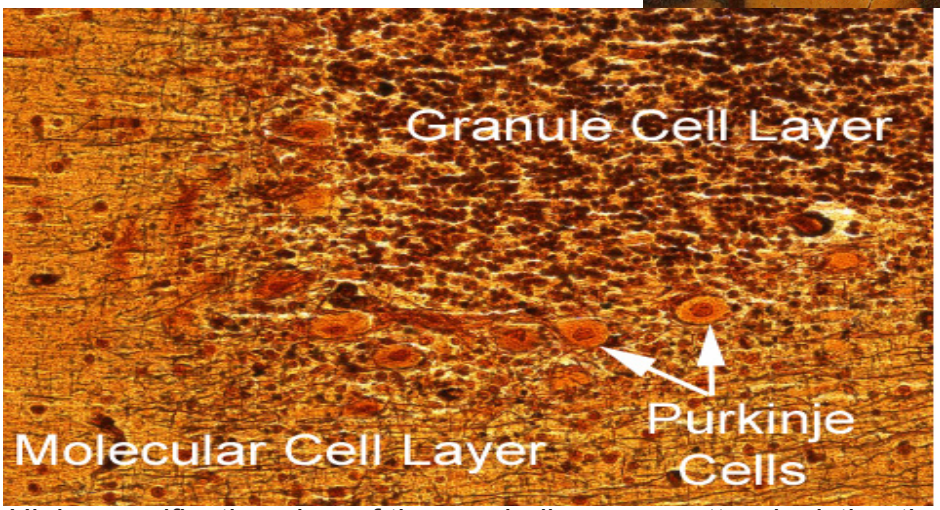
The middle cerebellar peduncle consists of fibers which inform the cerebellum of motor patterns which have been initiated by the cerebral cortex. The superior cerebellar peduncle is the principal outflow pathway from the cerebellum to motor centers in the mid-brain, diencephalon and ultimately the cerebral cortex. By means of this circuit the cerebellum exerts a correcting and coordinating influence over ongoing motor activity. Briefly, the cerebellum receives information initiated by the cerebral cortex. It compares this pattern with the pattern of sensory information derived from muscle spindles, tendon organs and other muscle sensory structures via the spinocerebellar pathways and the inferior cerebellar peduncles. The neuronal circuitry in the cerebellar cortex compares the motor pattern initiated by the cerebral cortex with sensory information regarding the position of the extremities, muscle tone, tendon tension and body orientation with respect to gravity (via the vestibulocochlear nerve). Muscle units that should not be contracting - those that are counterproductive to the cortically initiated movement pattern - are inhibited by the neuronal circuitry of the cerebellar cortex. The result is that the impulses that are allowed to flow out of the cerebellum via the superior cerebellar peduncle to the midbrain, diencephalon and cerebral cortex are only those impulses that facilitate the neuronal pathways controlling the muscle units required to carry out the movement originally initiated by the cerebral cortex.

Cerebellar cortex histology

Identify the following structures on the histological sections:

gray matter
white matter
granule cell layer
purkinje cell layer/purkinje cells
molecular cell layer





High magnification view of the cerebellar gray matter depicting the three cellular layers