



Windows to the Brain: Introduction to Neuroanatomy

Overview

Planes of Section
Radiographic Perspective
Major Divisions

Cortical

Lobes, Gyri & Sulci
General Functions
Brodmann's Areas
Basal Forebrain

Subcortical

Structures
Symptoms

Cerebellum

Structures
Symptoms

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Source: <http://www.mirecc.va.gov/visn6/Tools-Tips.asp>

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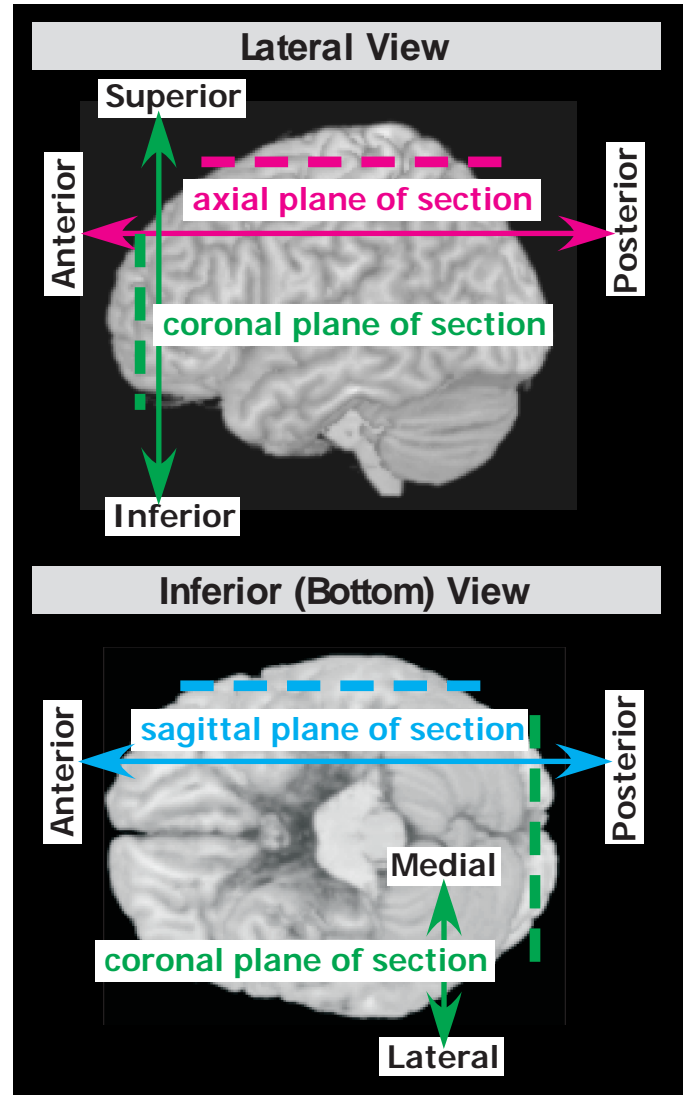
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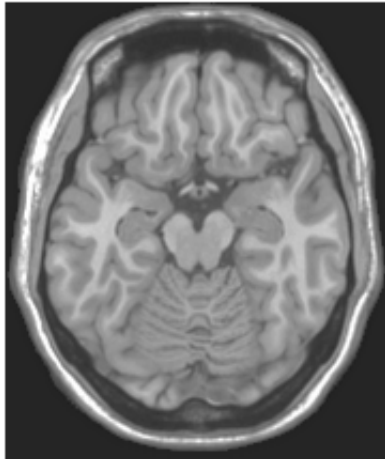
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Planes of Section

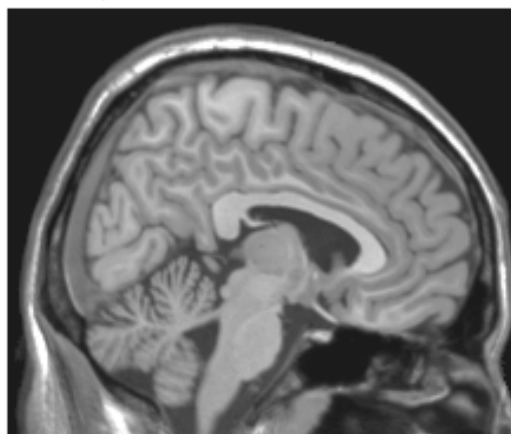
In medical practice the most common way to view the brain is the two dimensional sections provided by magnetic resonance imaging (MRI) and computed tomography (CT). While it is possible to image the brain in virtually any orientation, the **axial** plane of section is used most often as it allows the entire brain to be captured in the fewest number of sections. Anatomists prefer the **coronal** plane of section because many structures, particularly small ones, are more easily recognized. Note that both the **axial** and **sagittal** planes of section go from the front (anterior) to the back (posterior) of the brain. **Axial** goes from one side to the other (medial to lateral). **Sagittal** goes from top (superior) to bottom (inferior).



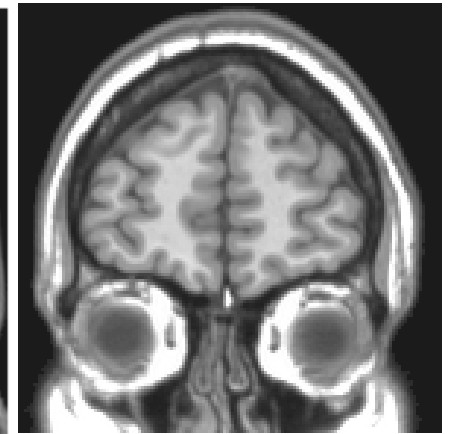
axial plane of section



sagittal plane of section



coronal plane of section



Radiographic Perspective

Clinical images are displayed in the radiographic perspective. Most teaching and reference materials use the anatomic perspective.

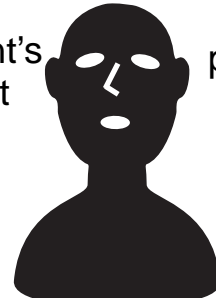
All radiographic images are displayed using a single set of conventions:

patient is lying on his/her back (supine)



viewer is at patient's feet
looking toward the
patient's head

patient's
right



patient's
left

viewer

There are **2 key differences** between the radiographic perspective and the anatomic perspective that are important to remember when viewing clinical brain images.

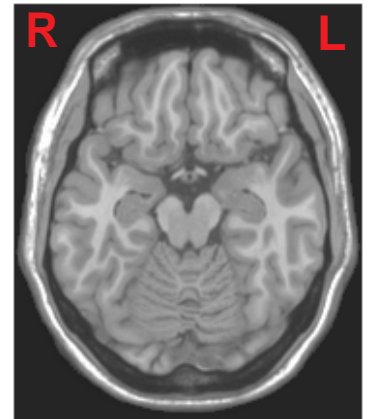
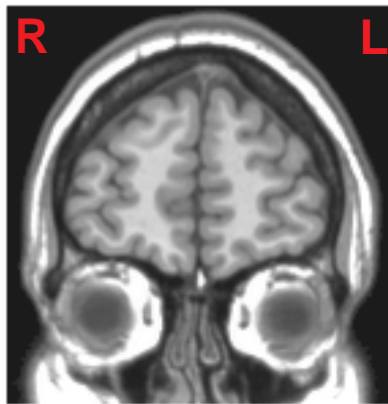
[1] The left side of an axial or coronal brain image is the right side of the brain:

patient's
right

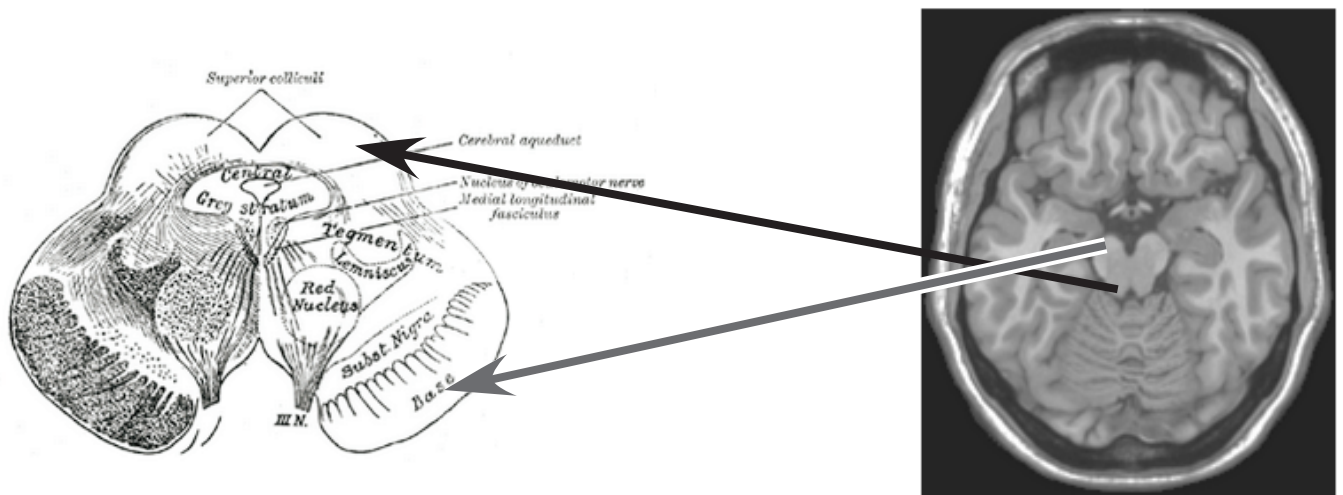


patient's
left

viewer

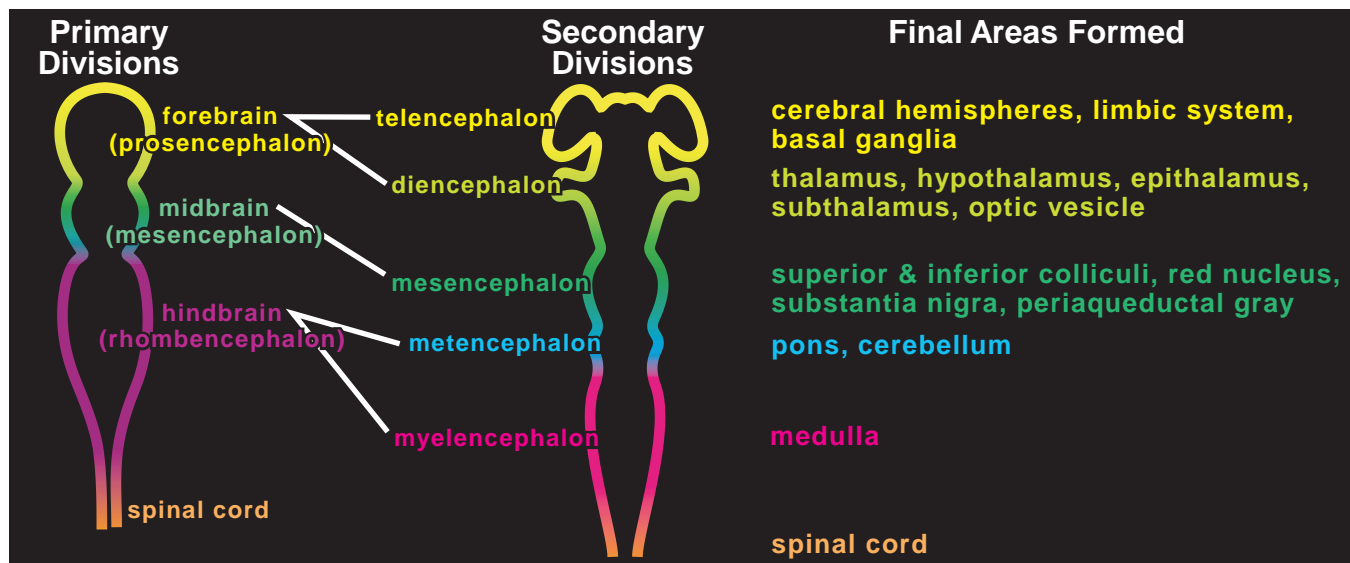


[2] On axial images brainstem and spinal cord will be inverted compared to how they are displayed in most teaching and reference materials:



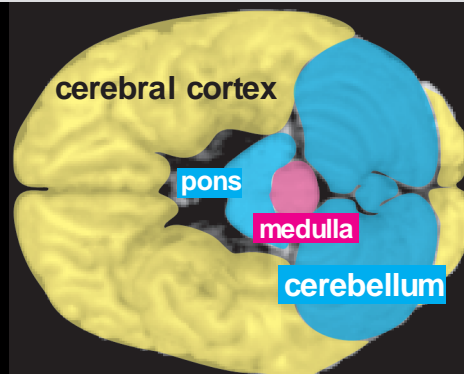
Major Divisions

The neural tube (illustrated in schematic form) expands locally to form the 3 primary divisions or vesicles: forebrain (prosencephalon, yellow), midbrain (mesencephalon, green), and hindbrain (rhombencephalon, purple). These in turn form the 5 secondary divisions. The forebrain vesicle subdivides into telencephalon (yellow) and diencephalon (light green). The hindbrain vesicle subdivides into the metencephalon (blue) and myelencephalon (pink). *

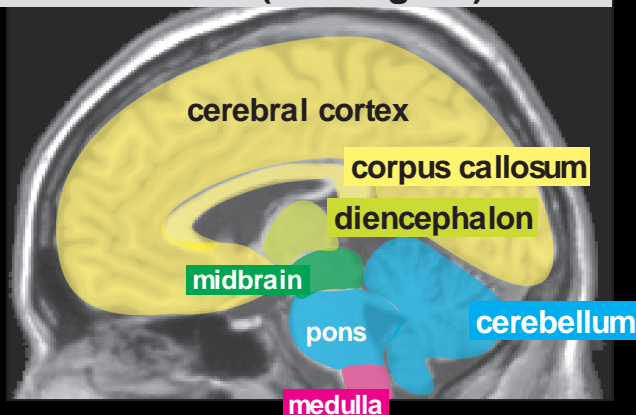


The 5 secondary divisions are color-coded onto magnetic resonance images to provide overall orientation.

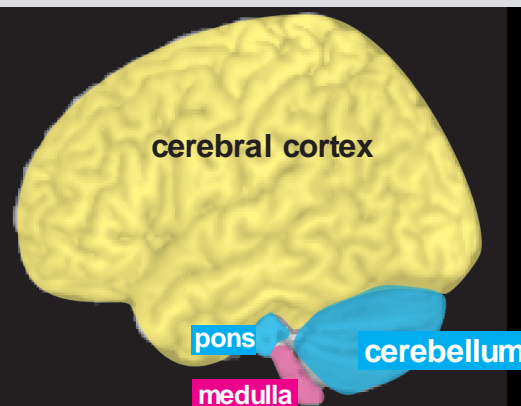
Inferior (Bottom) View



Midline Medial (Parasagittal) View



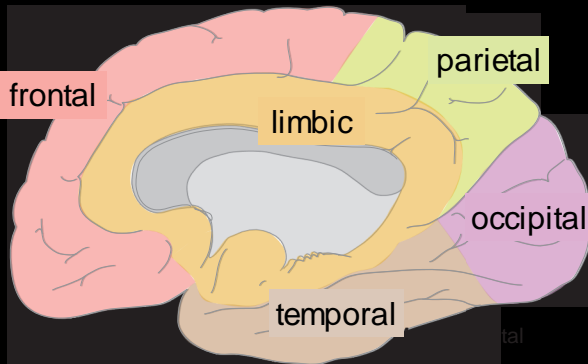
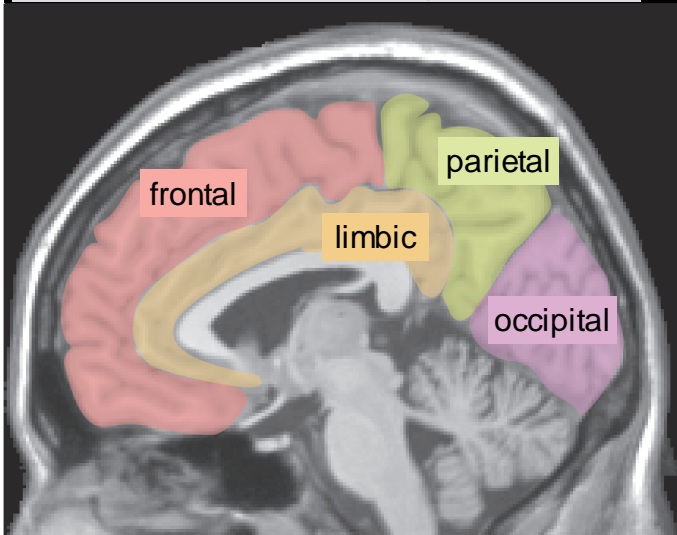
Lateral View



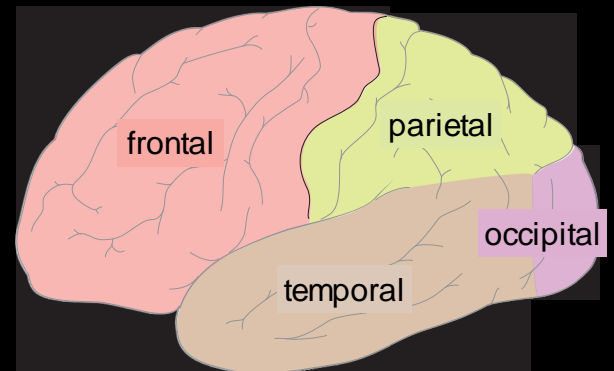
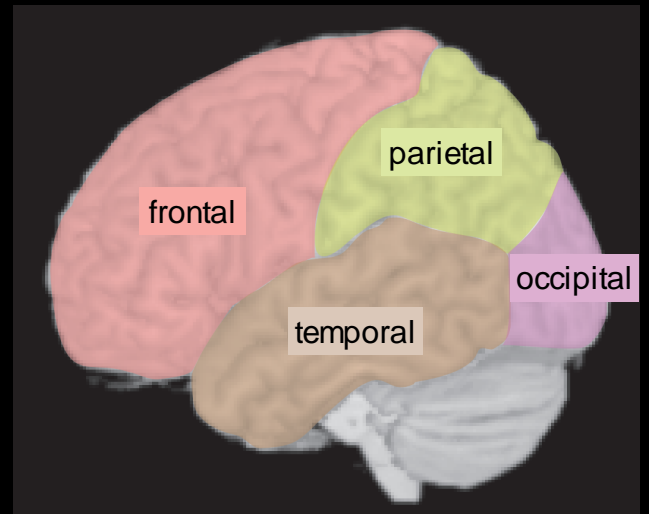
*Taber KH, Salpekar J, Wong AHC, Hurley RA. J Neuropsychiatry Clin Neurosci 2011;23(1): 1-5.

Cerebral Cortex - Lobes

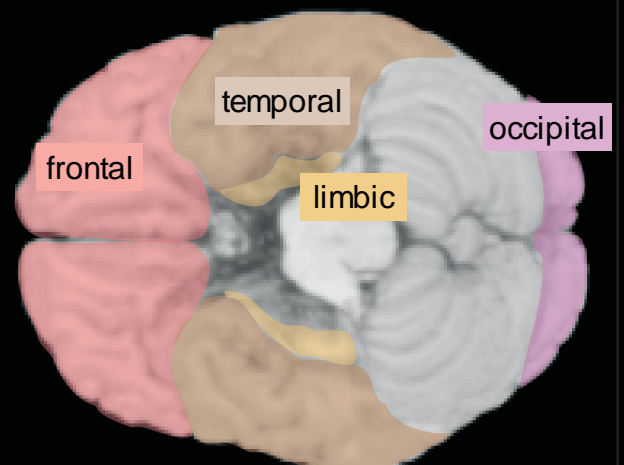
Midline Medial (Parasagittal) View



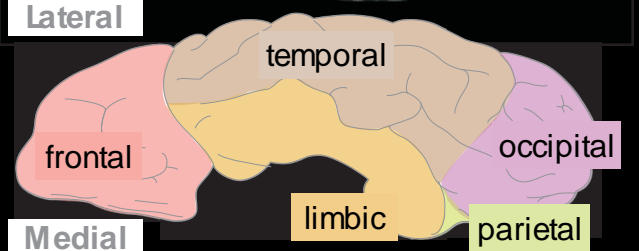
Lateral View



Inferior (Bottom) View



Lateral

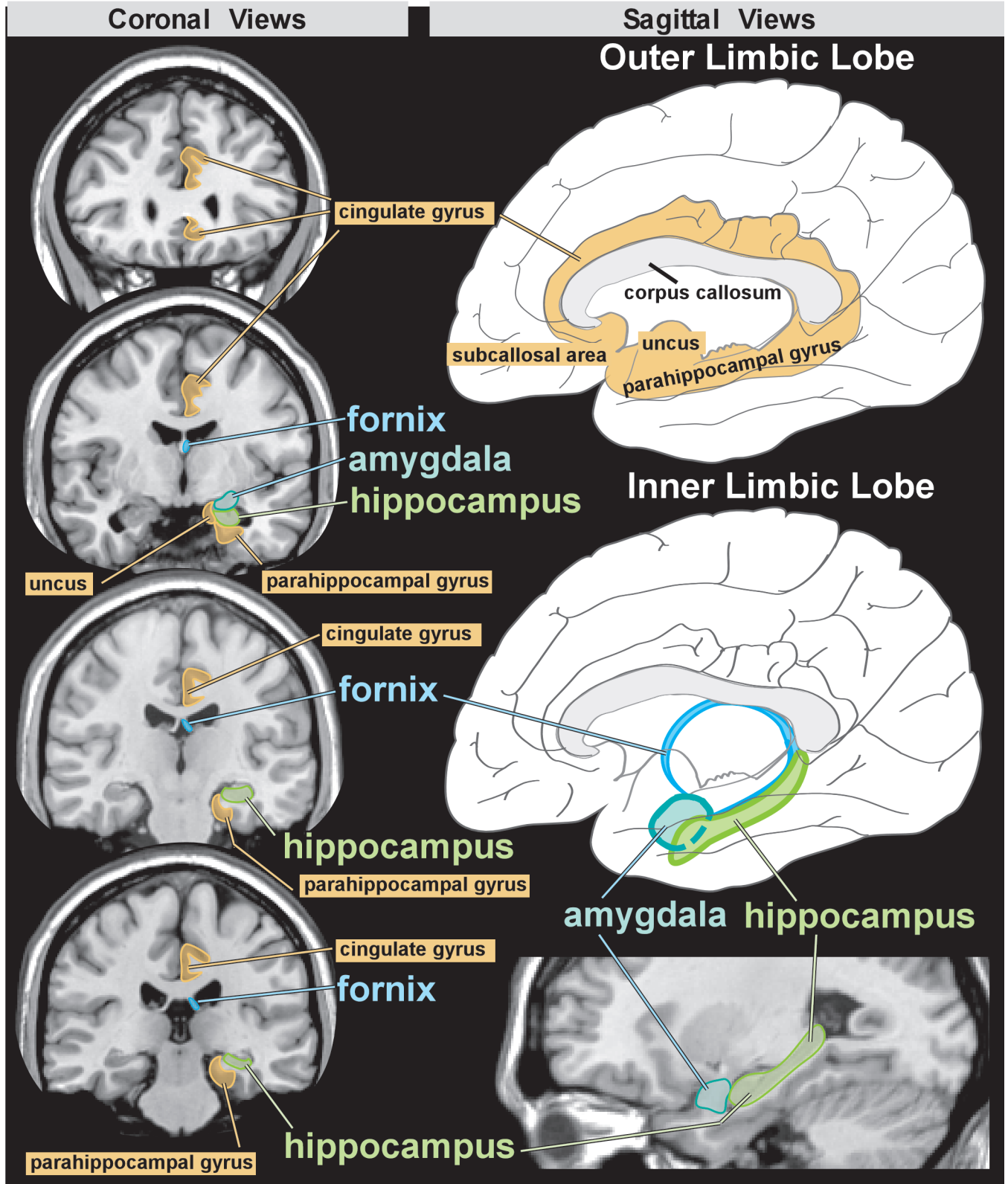


Medial

The highly in-folded cerebral cortex is the largest single division of the human brain. Anatomists commonly divide it into four sections or lobes - the frontal, temporal, parietal and occipital lobes. Some consider the limbic areas of cortex to comprise a fifth lobe, whereas others include these areas in the frontal and temporal lobes and diencephalon. Note that the medial and posterior inferior surfaces of the temporal lobe can only be seen on the drawings of the medial and inferior surfaces of the brain. This is because the brainstem and cerebellum have been omitted on the drawings.

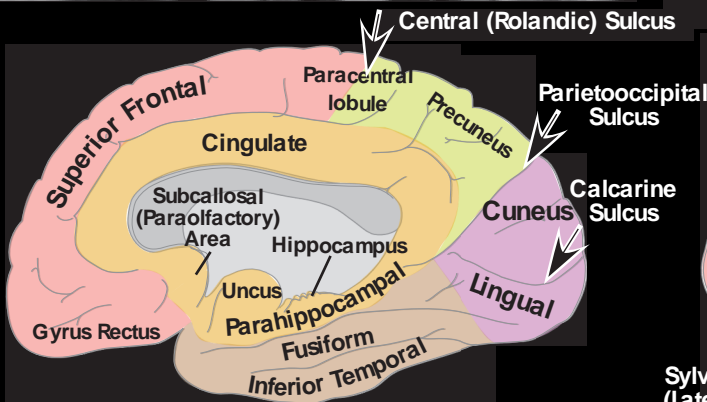
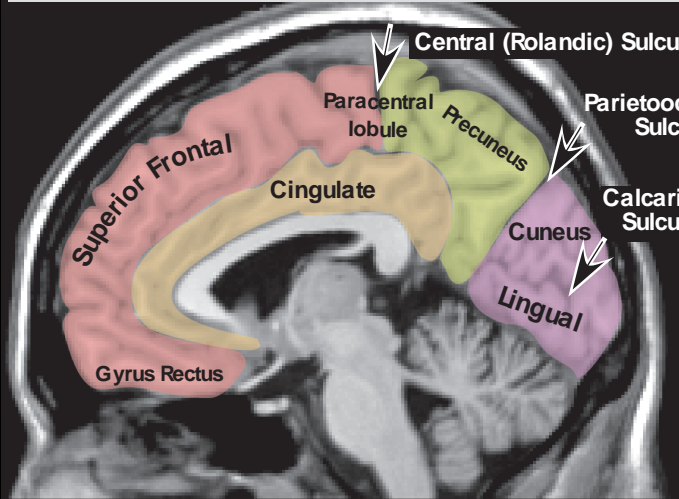
Outer & Inner Limbic Lobes

The location and names of the structures that make up the outer (surface of brain) and inner (deep structures) limbic lobes are illustrated on schematic diagrams of the medial surface of the right cerebral hemisphere. Structures are color-coded to match the summary of subcortical structures and the sectional atlases.



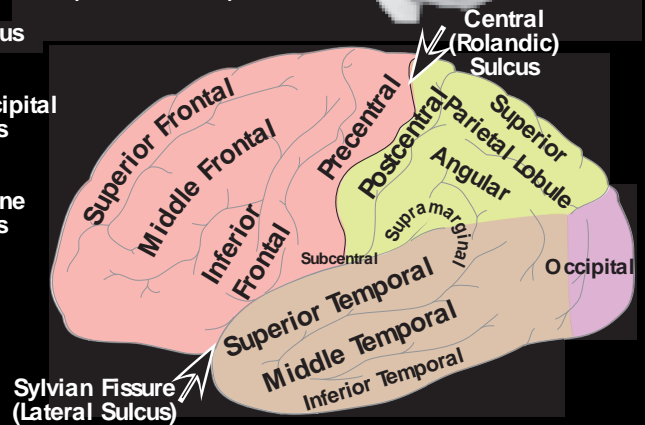
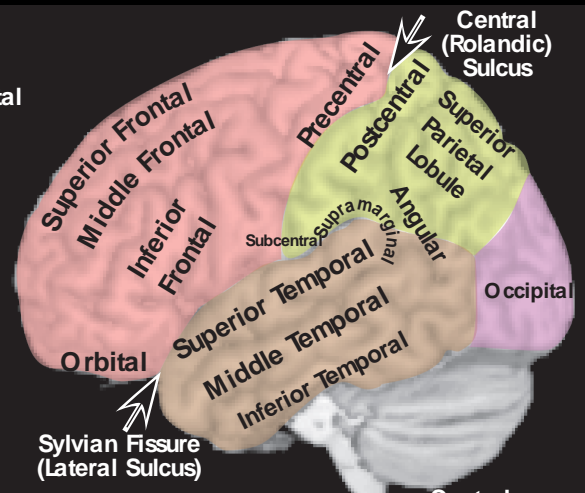
Major Gyri & Sulci

Midline Medial (Parasagittal) View

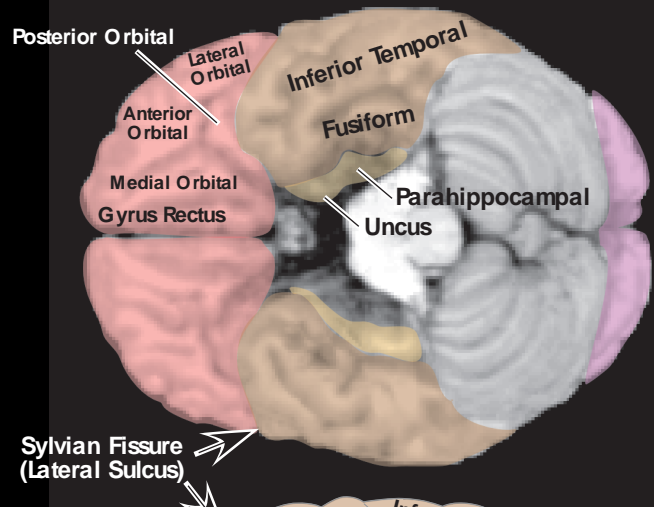


frontal | temporal | parietal | occipital | limbic

Lateral View



Inferior (Bottom) View



Lateral

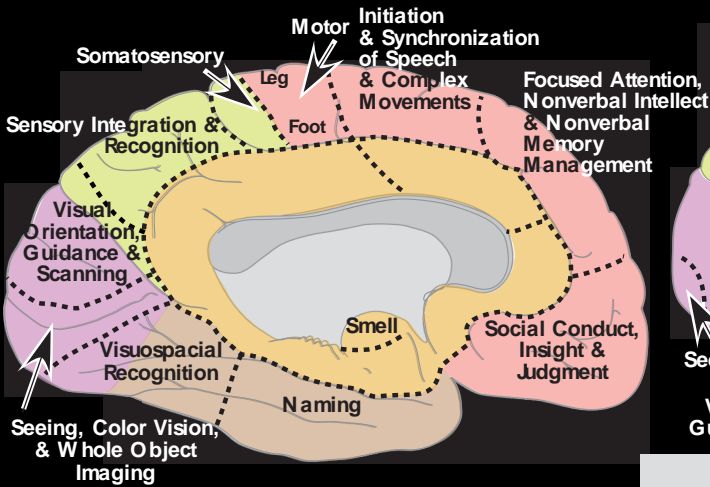
Medial

An outfolding of the cerebral cortex is called a gyrus (plural is gyri), an infolding is called a sulcus (plural is sulci). Some very large sulci are called fissures. Although major gyri and sulci are present in all normal brains, they can vary considerably in both extent and location. Many areas have considerable normal variation in the folding patterns.

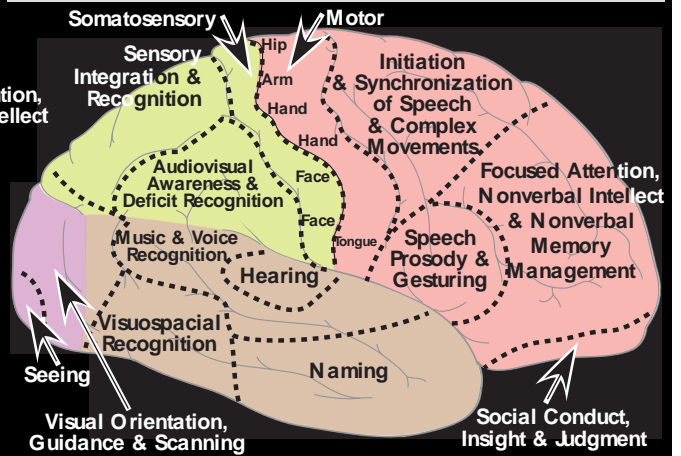
Major Functions

Right Hemisphere

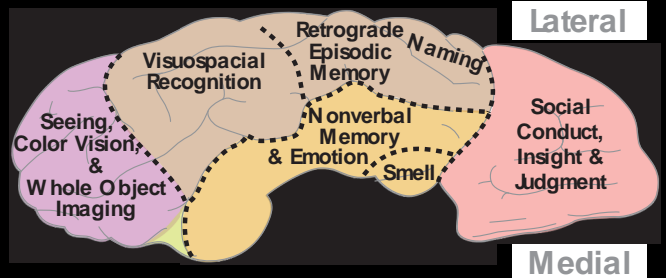
Medial (Parasagittal) View



Lateral View



Inferior (Bottom) View

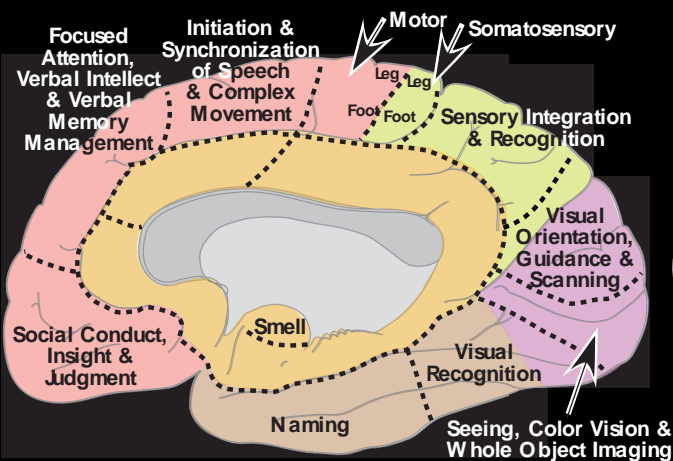


Right Hemisphere - In most individuals, the processing of nonverbal information, such as music or visuospatial information, occurs primarily in the right hemisphere.

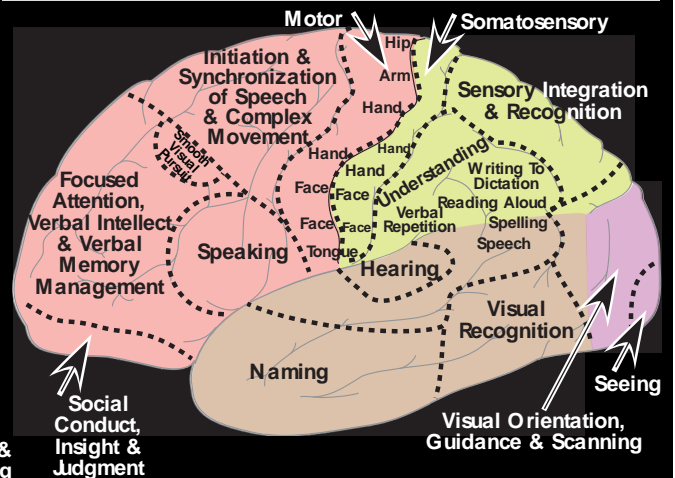
frontal | temporal | parietal | occipital | limbic

Left Hemisphere

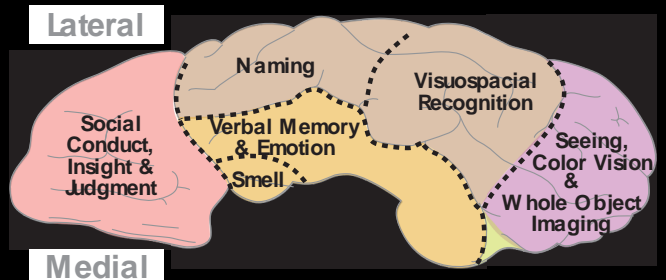
Medial (Parasagittal) View



Lateral View



Inferior (Bottom) View

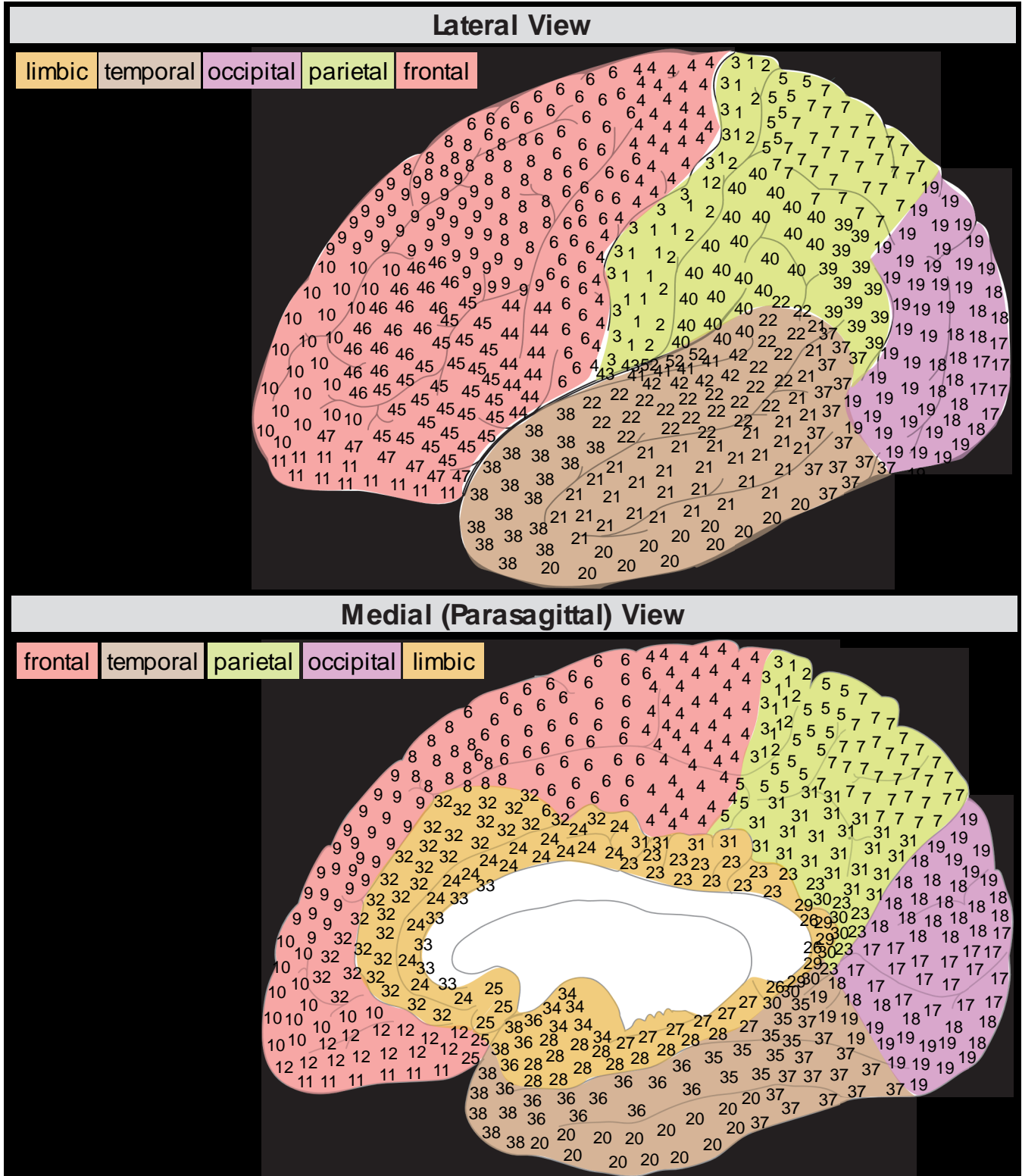


Left Hemisphere - In most individuals, the processing of verbal information, including language, occurs primarily in the left hemisphere.

frontal | temporal | parietal | occipital | limbic

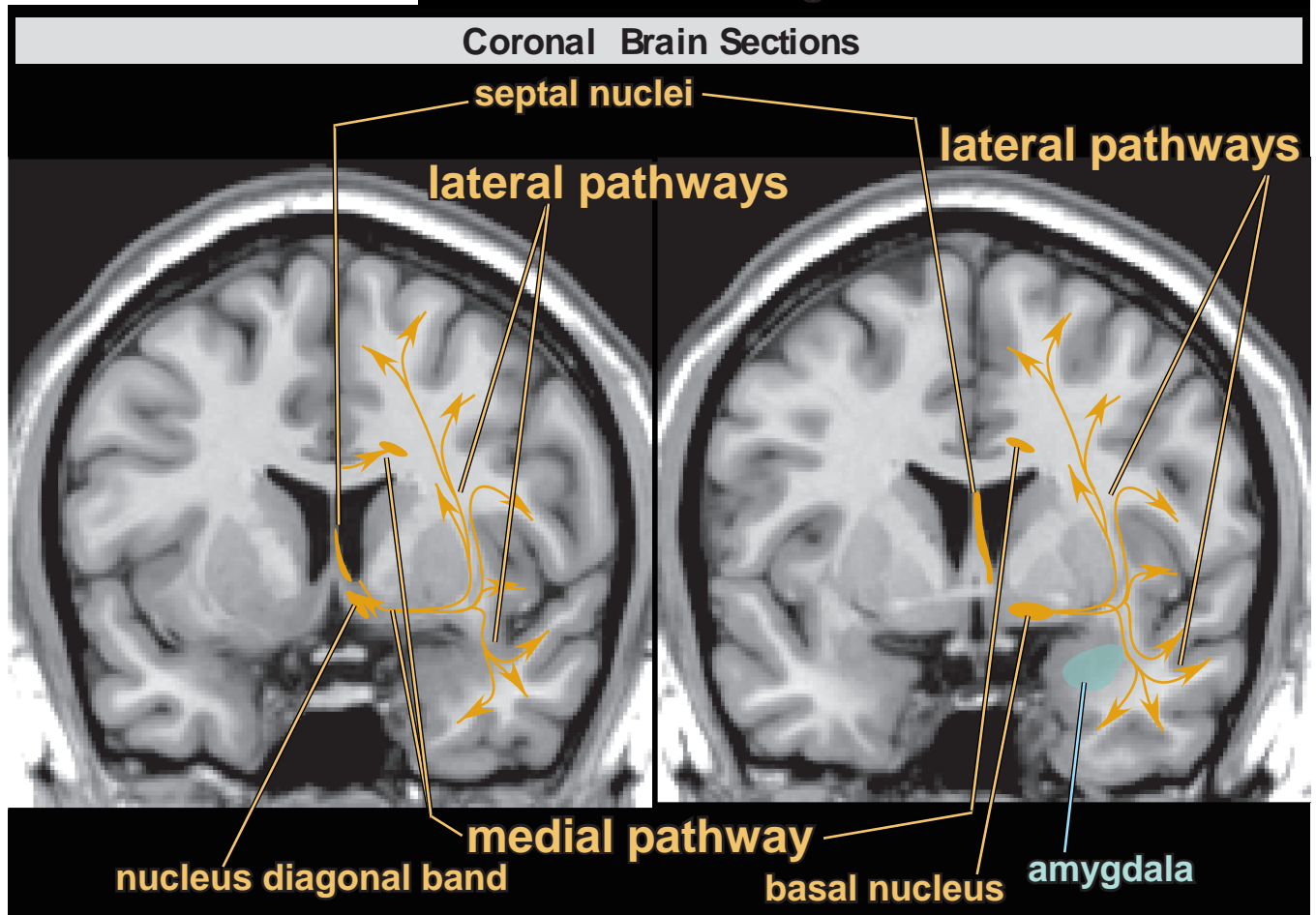
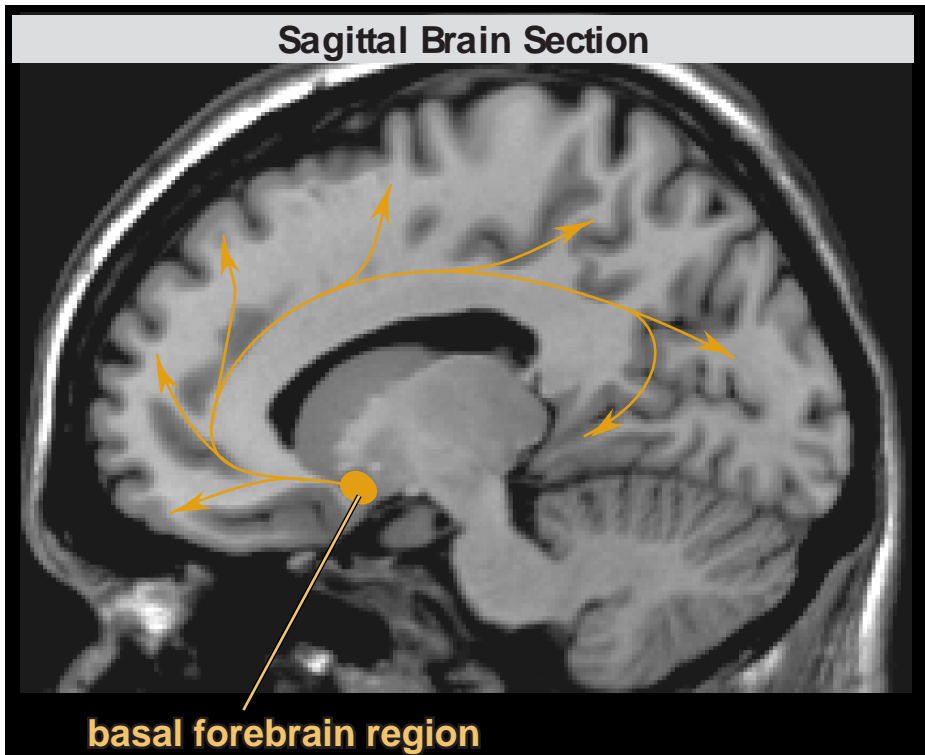
Brodmann's Areas

In the early part of the 20th century, Brodmann defined cortical areas based upon features such as the size, shape and distribution of neurons (cytoarchitecture). An approximation of these areas are provided in the illustrations below. Versions of this system are still widely used. While useful, it is important to always keep in mind that Brodmann's work was based upon analysis of a single brain. Brains vary greatly in size, shape, and infolding patterns. Research has shown that there is a wide range in the extent of a specific Brodmann area when compared across individuals. Thus, such maps should be used only as extremely general guides.



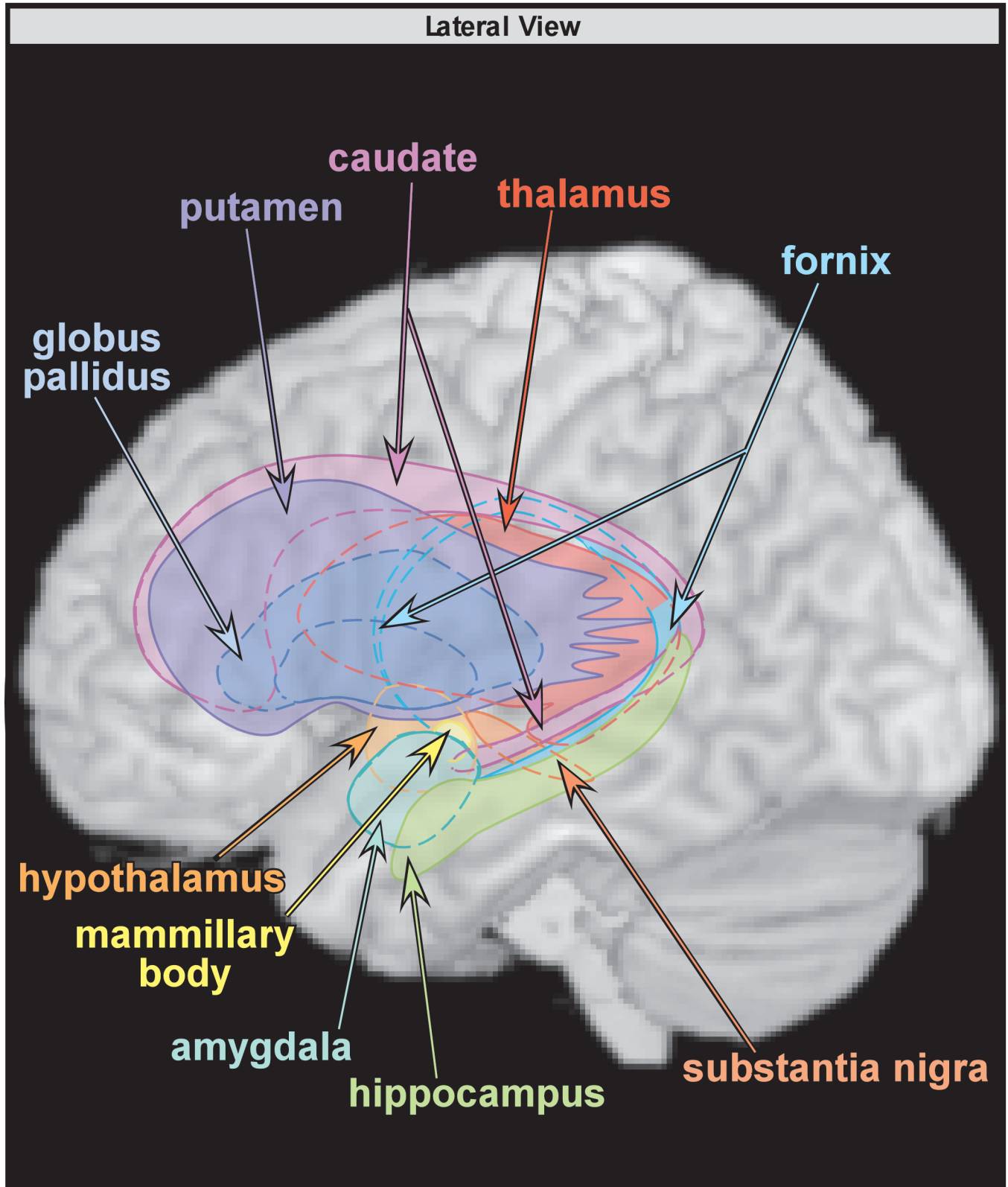
Basal Forebrain

The basal forebrain area contains many cholinergic neurons in the basal nucleus of Meynert, nucleus of the diagonal band and septal nuclei. The general location of this important region and its projections to cortex are approximated on sagittal and coronal magnetic resonance images. The basal forebrain cholinergic neurons project to cortex via both medial and lateral routes. Fibers travel to hippocampus via the fornix, olfactory cortex via the olfactory tract and amygdala via stria terminalis and the ventral amygdalofugal pathway.



Major Subcortical Structures

The major subcortical structures are color-coded to match the sectional atlases. The next page contains a brief guide to neuropsychiatric symptoms associated with injury to each structure.*



*Naumescu I, Hurley RA, Hayman LA, Taber KH. Int J Neuroradiol 1999; 5(1): 51-59.

Major Subcortical Structures

A brief guide to neuropsychiatric symptoms associated with injury to each of the major subcortical structures is color-coded to match the illustration on the previous page.

Thalamus - (left) deficits in language, verbal intellect, and verbal memory (right) deficits in visuospatial and nonverbal intellect and visual memory, (bilateral) severe memory impairment (“thalamic amnesia”) as well as dementia; damage to the anterior and medial thalamus can also result in disturbances of autonomic functions, mood, and the sleep/waking cycle.

Caudate - apathy, disinhibition, disorganization, executive dysfunction, depression, memory loss, atypical aphasia, psychosis, personality changes, and predisposition for delirium.

Putamen - most commonly language and behavioral deficits (i.e., atypical aphasia, obsessive - compulsive traits, executive dysfunction); hemineglect, depression, and memory loss have also been reported.

Globus pallidus - anxiety, depression, apathy, psychosis, and central pain; less often reported symptoms include amnesia and cognitive deficits.

Amygdala - passivity or aggression, hypersexuality, hyperorality, hyperphagia, decreased fear, anxiety or startle, and decreased link between emotion and memory.

Hippocampal formation - primarily memory deficits including anterograde and retrograde amnesia, inability to form new memories, and temporally graded amnesia.

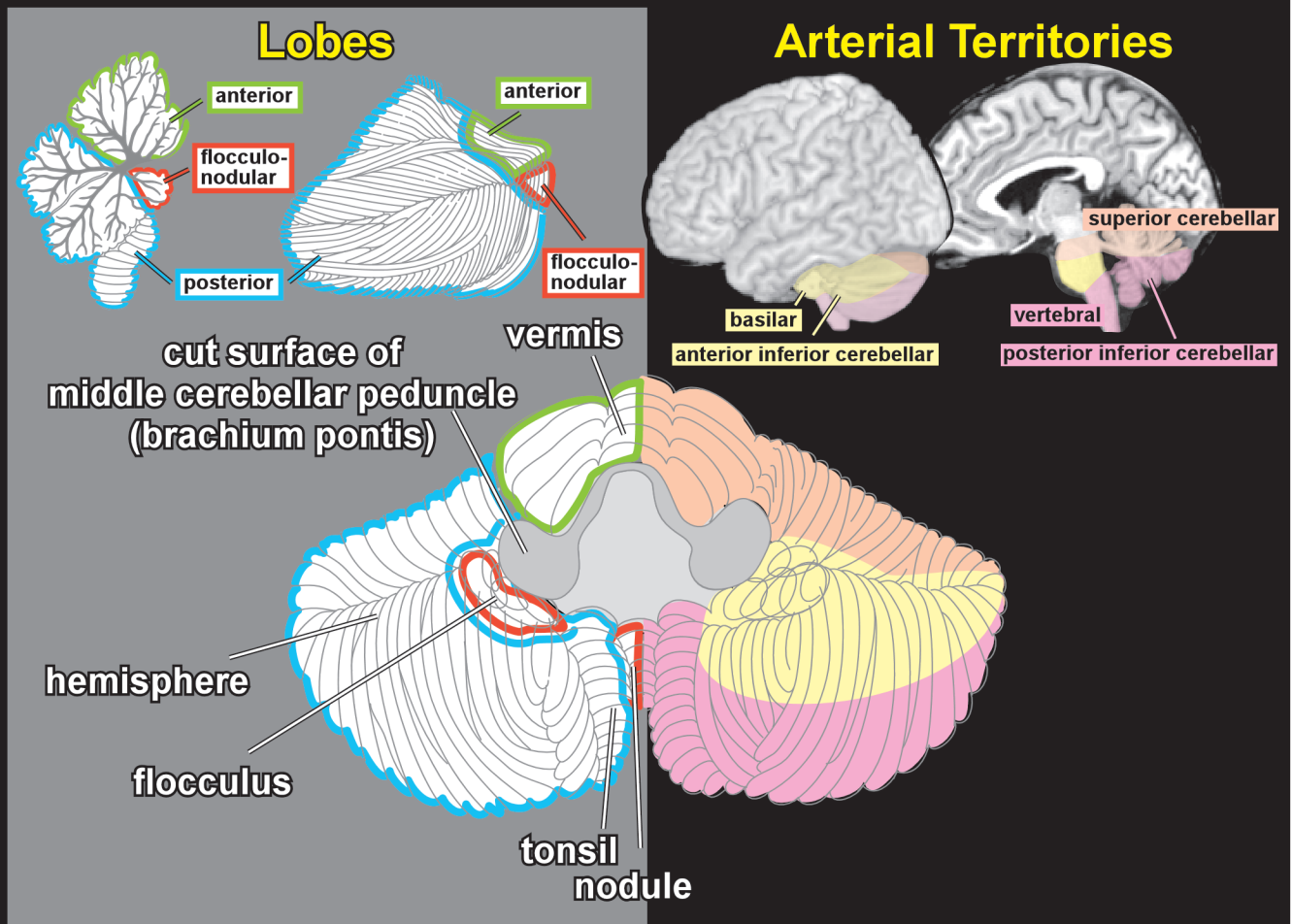
Fornix - memory deficits include impaired recent memory, syndrome of transitory amnesia, and long-term anterograde amnesia.

Hypothalamus - aggression, violence, anorexia, depression, impaired short-term memory, dementia, gelastic seizures, and altered sleep/wake cycle.

Mammillary body - memory deficits and psychosis.

Substantia nigra - primarily behavioral and emotional deficits (i.e., apraxia, ataxia, aggression, and depression), with less frequent reports of memory and cognitive deficits.

Cerebellum - Anterior View



Major Functions

Old View

anterior lobe syndrome - ataxia & broad-based staggering gait

gross head & body movement, muscle tone

voluntary muscle coordination

neocerebellum syndrome - changes in muscle tone, reflexes & coordination of voluntary movements

truncal equilibrium

balance & spatial orientation
vestibulocerebellum - vertigo, nystagmus

New View

motor control - movement execution
cerebellar motor syndrome - ataxia, dysmetria, dysarthria

nonmotor control (executive, visuospatial, language, affective)

cerebellar cognitive affective syndrome - language, visuospatial & executive deficits, affective dysregulation (dysmetria of thought)

motor control - movement planning