
MIRECC
*Mental Illness Research, Education and Clinical Center*


***Post Deployment Mental Health***
***VISN 6***

# Windows to the Brain:
# Introduction to Neuroanatomy

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- Radiographic Perspective
- Major Divisions

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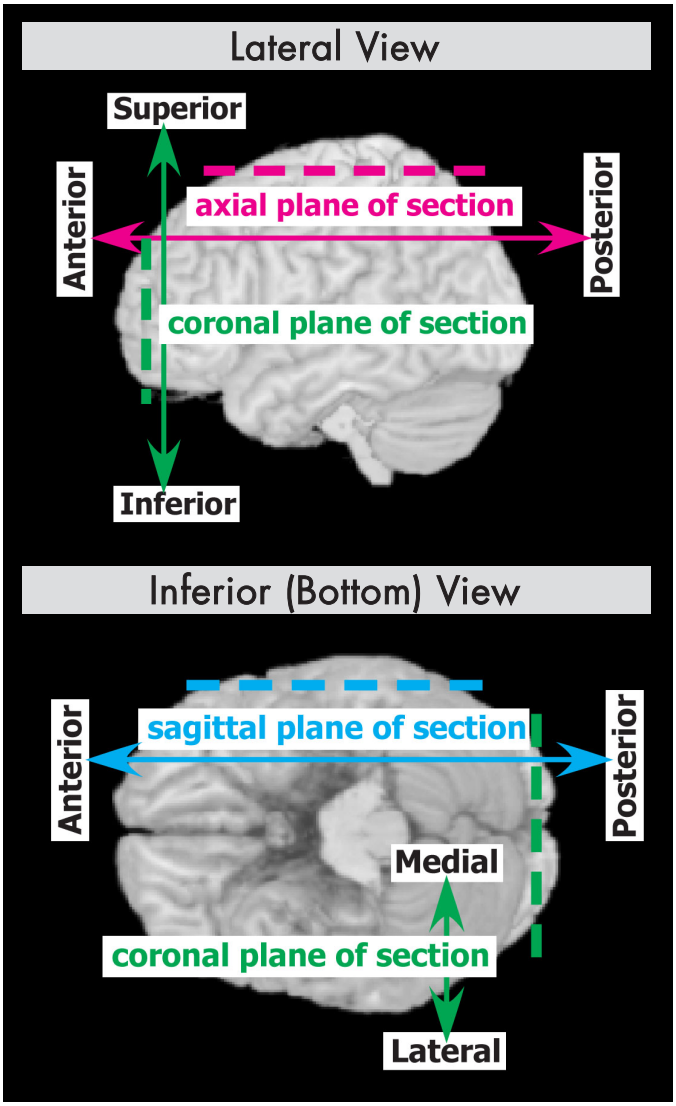
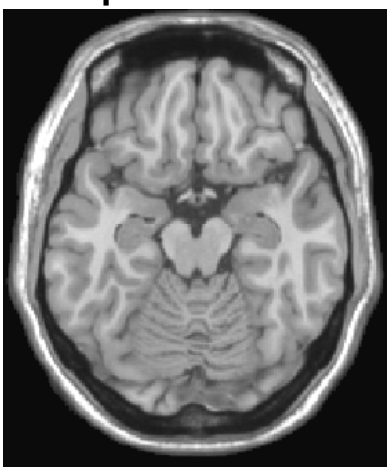
## Planes of Section

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).

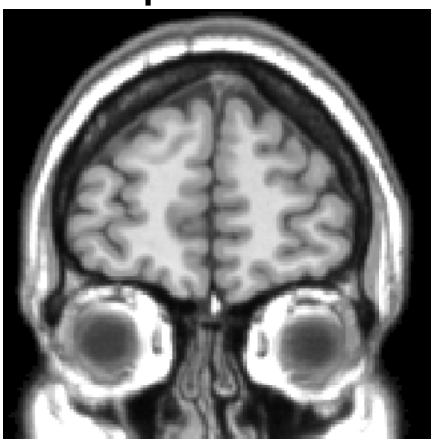



**axial plane of section**



**sagittal plane of section**

**coronal plane of section**



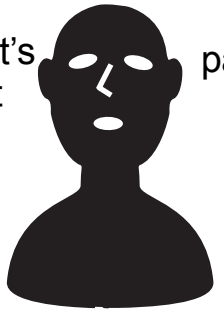
## Radiographic Perspective

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:

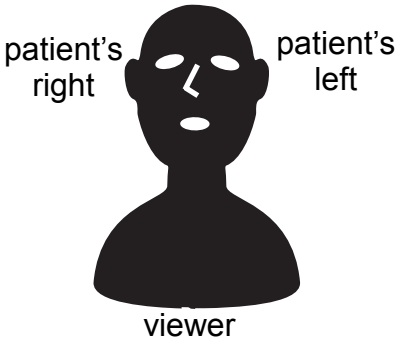
patient is lying on his/her back (supine)

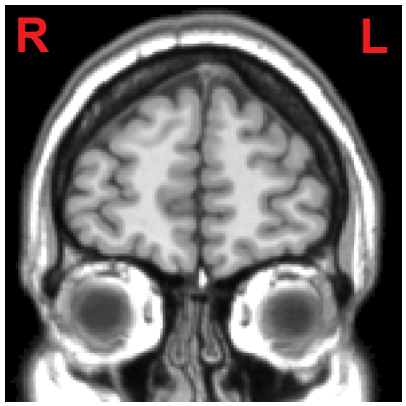
viewer is at patient's feet looking toward the patient's head




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

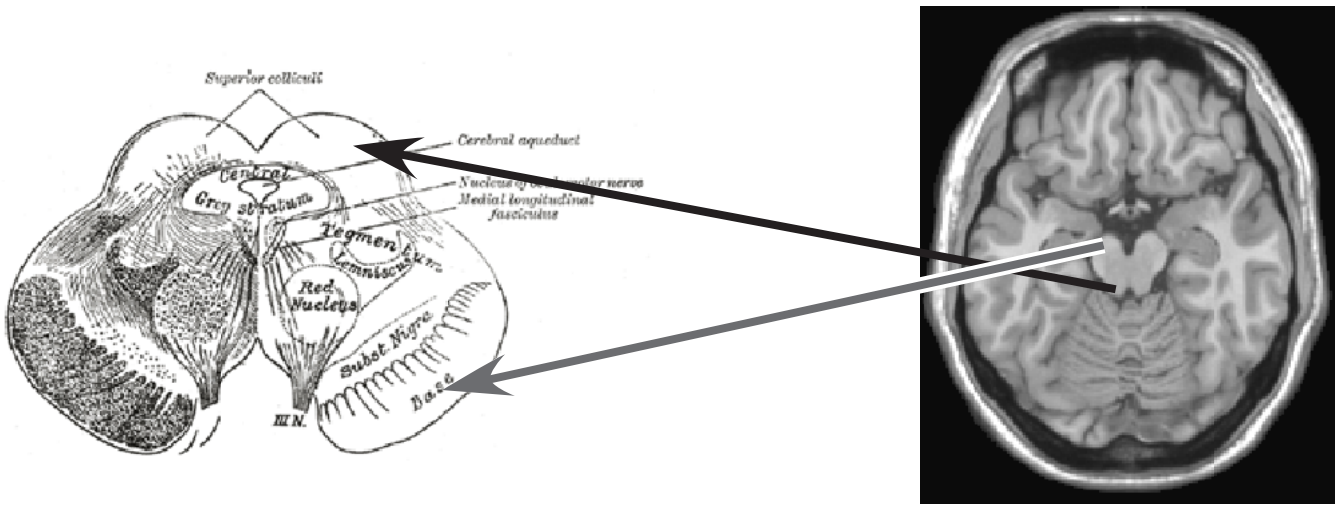
**[1]** The left side of an axial or coronal brain image is the right side of the brain:



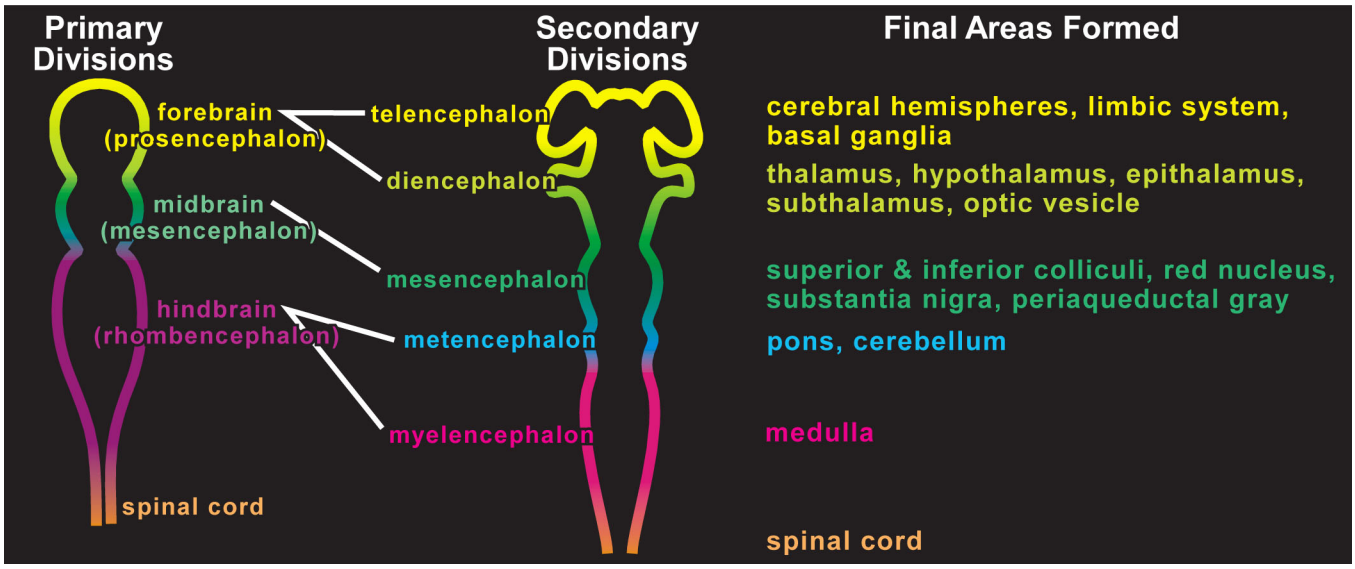


**[2]** On axial images brainstem and spinal cord will be inverted compared to how they are displayed in most teaching and reference materials:

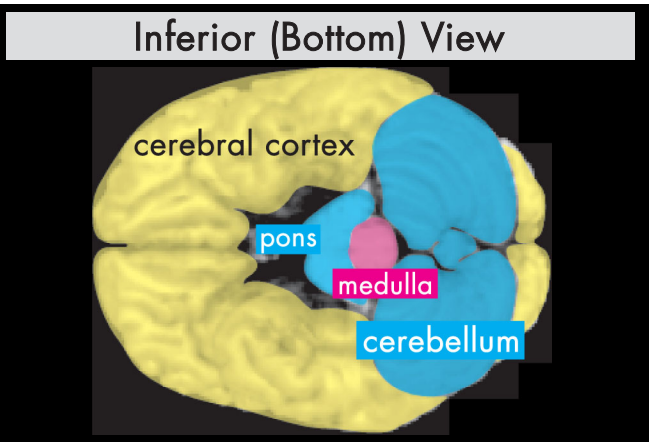


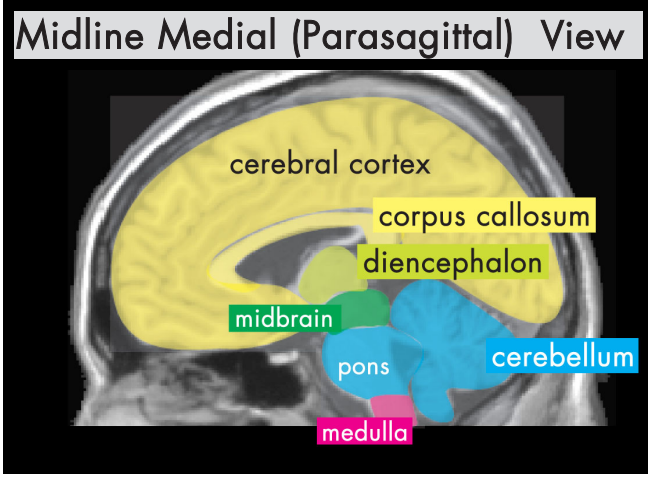
## Major Divisions

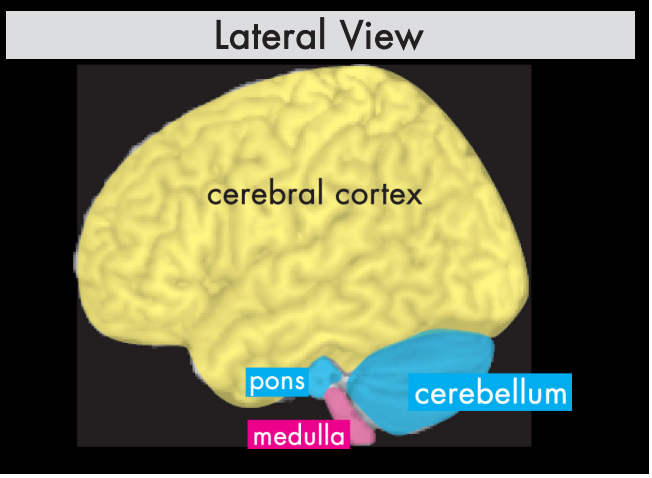
The neural tube (illustrated in schematic form) expands locally to form the 3 primary divisions or vesicles: forebrain (prosencephalon, yellow), midbrain (mesencephalon, green), and hindbrain (rhombencephalon, purple). These in turn form the 5 secondary divisions. The forebrain vesicle subdivides into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

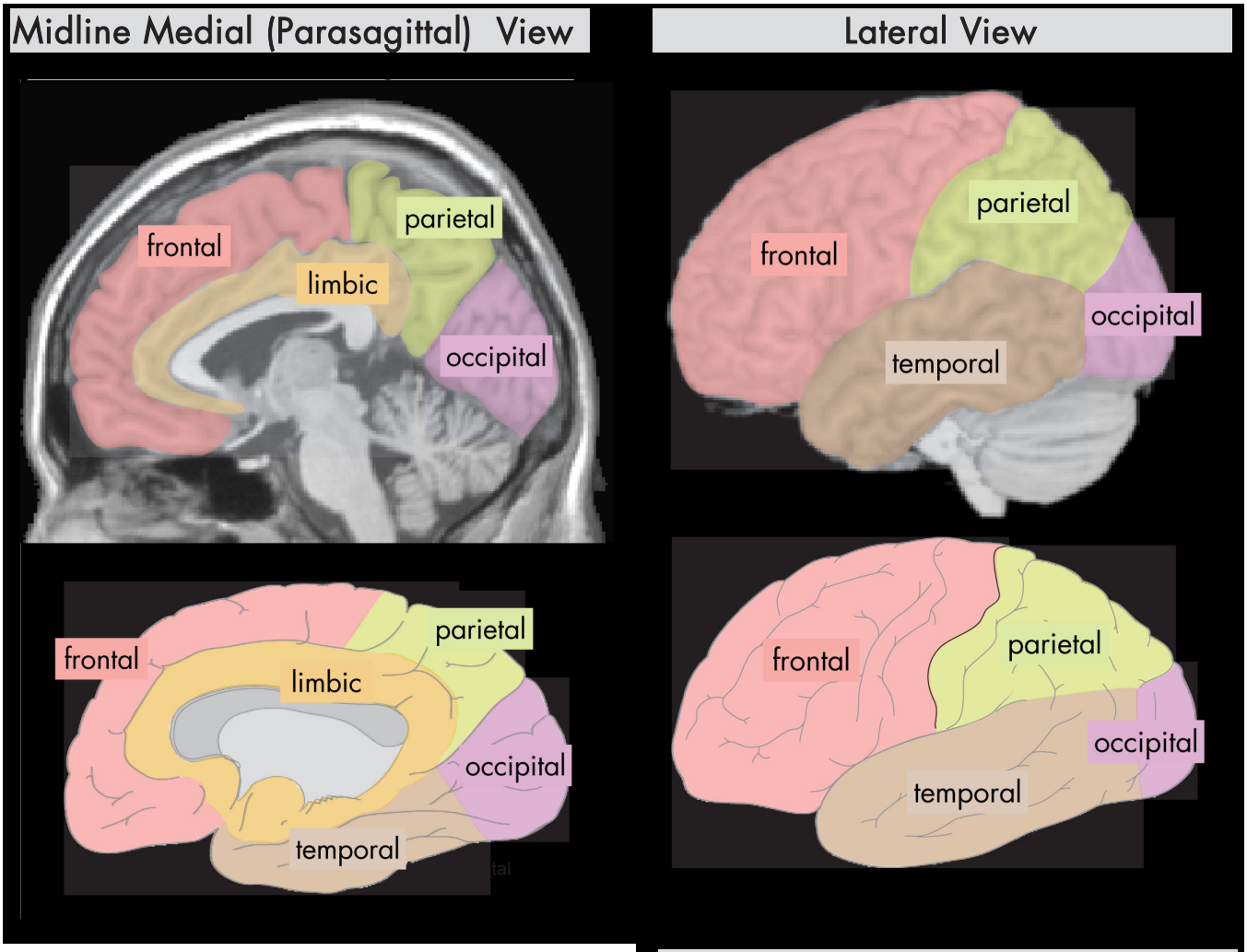


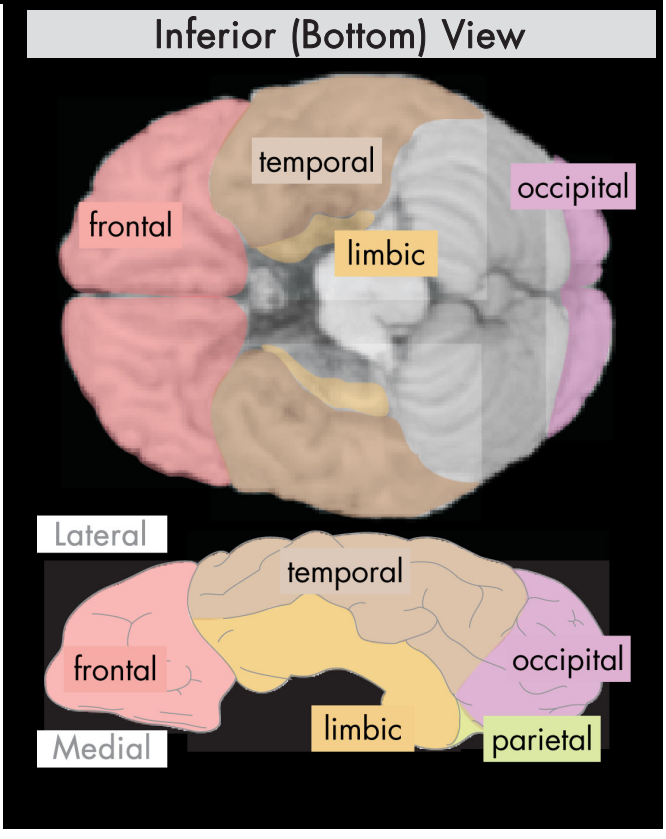




*Taber KH, Salpekar J, Wong AHC, Hurley RA. J Neuropsychiatry Clin Neurosci 2011;23(1): 1-5.

# Cerebral Cortex - Lobes

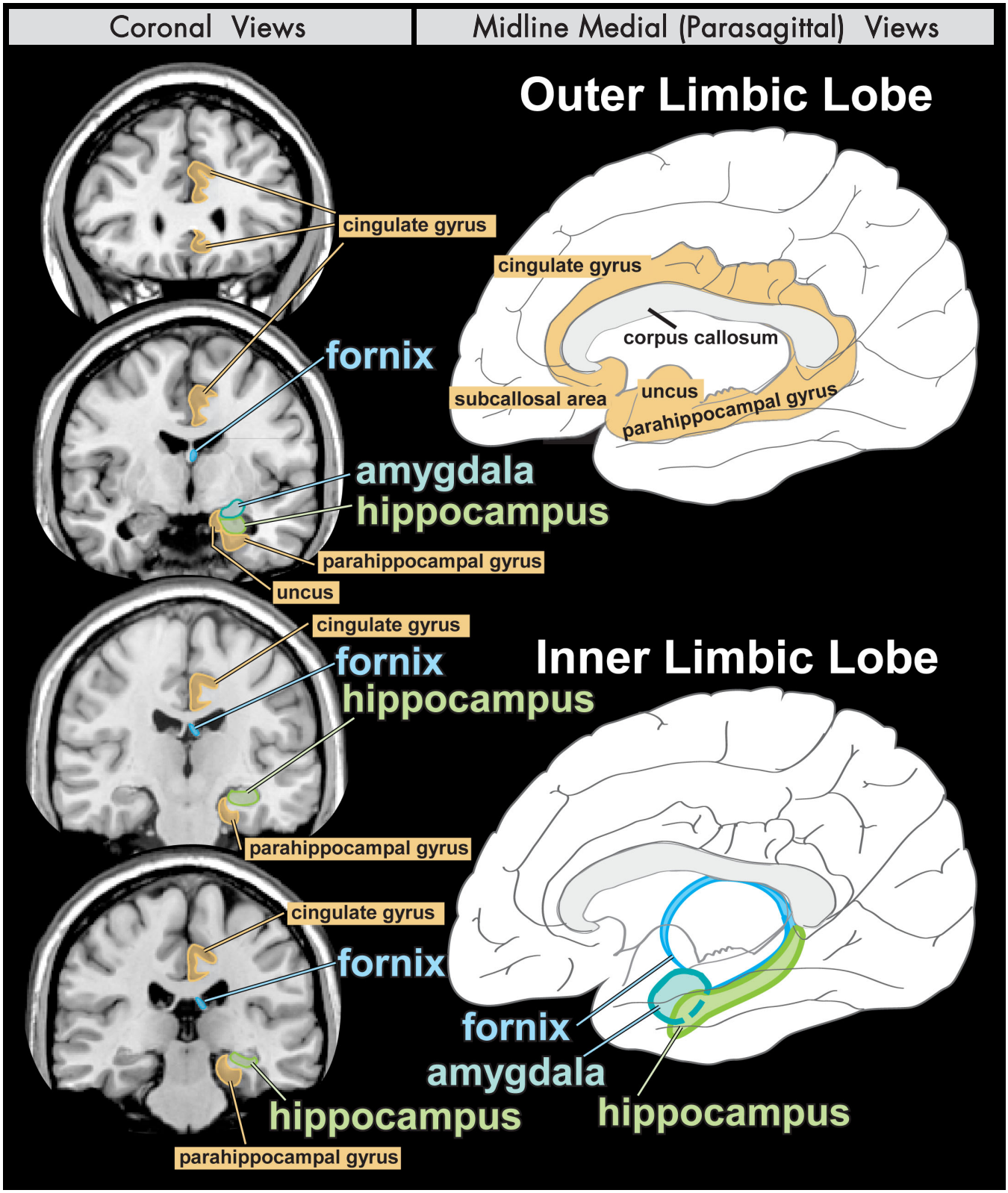


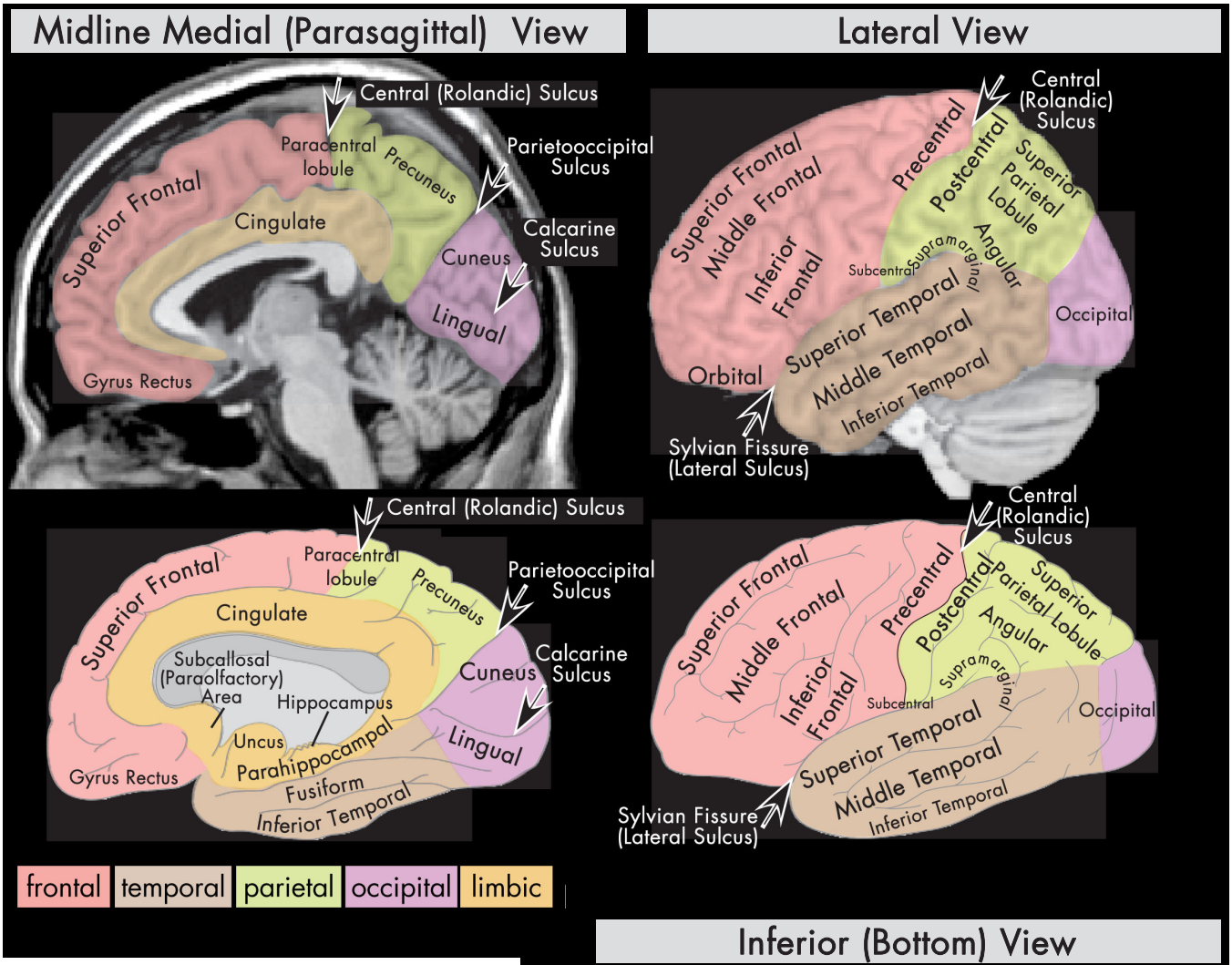

The highly infolded cerebral cortex is the largest single division of the human brain. Anatomists commonly divide it into four sections or lobes - the frontal, temporal, parietal and occipital lobes. Some consider the limbic areas of cortex to comprise a fifth lobe, whereas others include these areas 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.

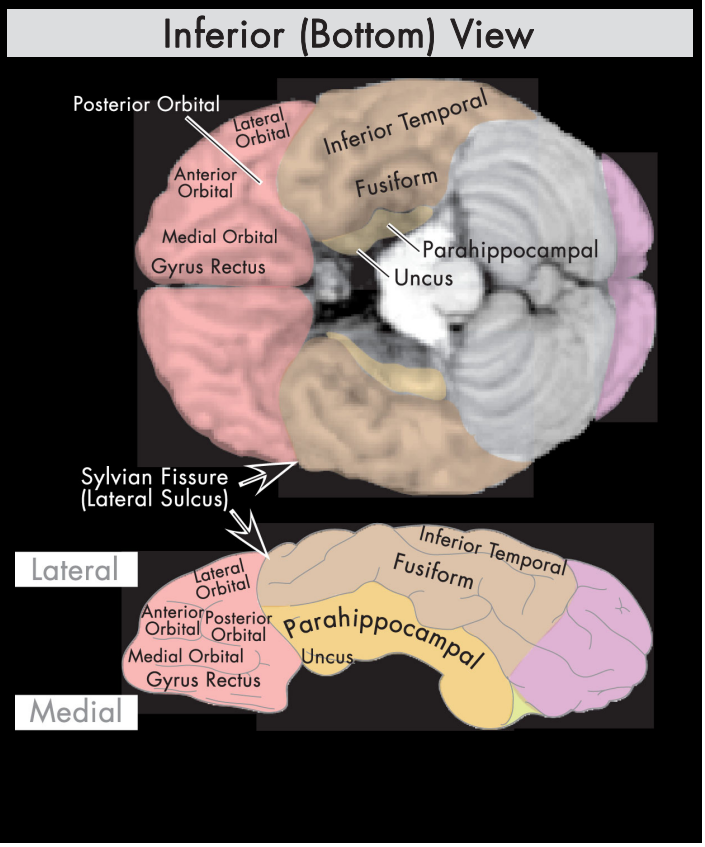
## Outer & Inner Limbic Lobes

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



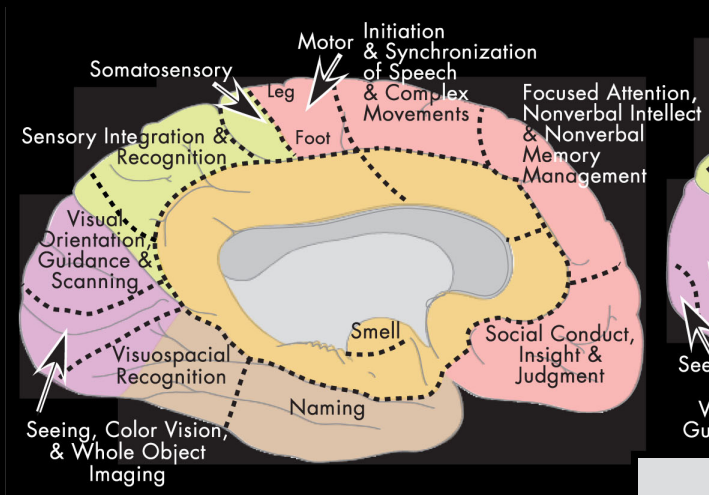




An outfolding of the cerebral cortex is called a gyrus (plural is gyri), an infolding is called a sulcus (plural is sulci). Some very large sulci are called fissures. Although major gyri and sulci are present in all normal brains, they can vary considerably in both extent and location. Many areas have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

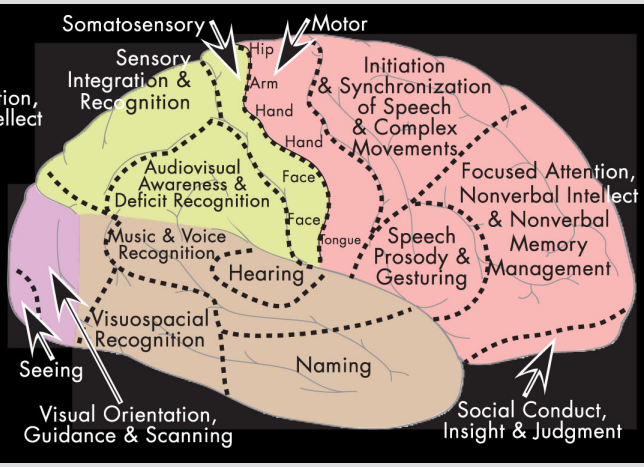
# Major Functions

## Right Hemisphere

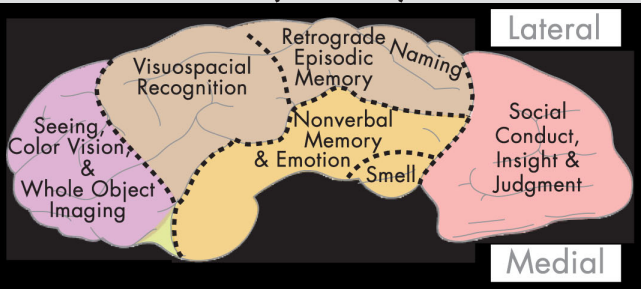
### Medial (Parasagittal) View




### Lateral View




### Inferior (Bottom) View

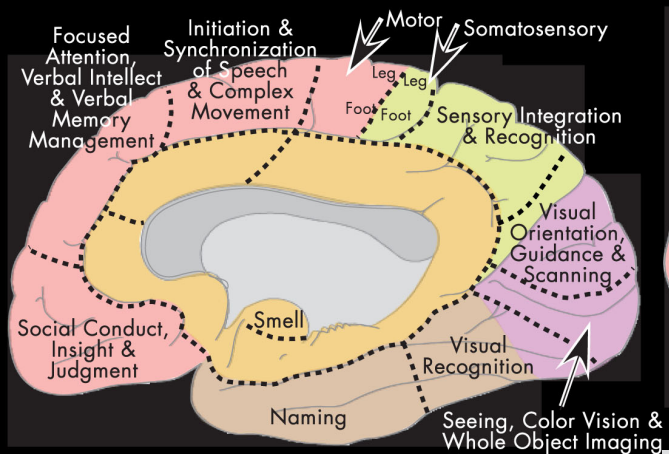



**Right Hemisphere -** In most individuals, the processing of nonverbal information, such as music or visuospatial information, occurs primarily in the right hemisphere.

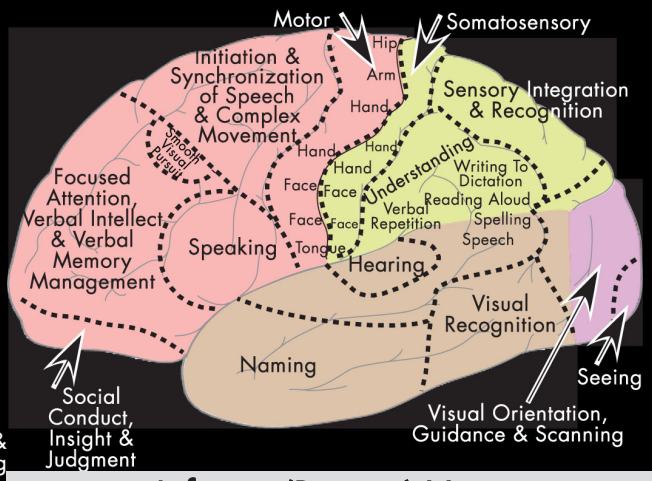
frontal | temporal | parietal | occipital | limbic

## Left Hemisphere

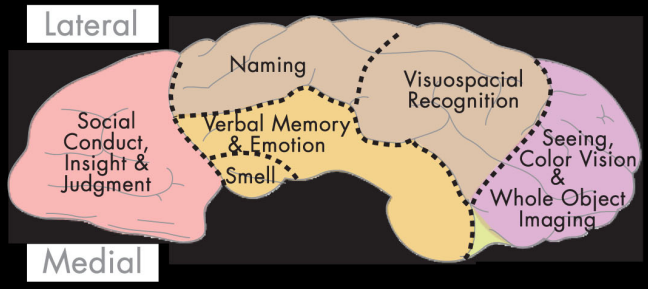
### Medial (Parasagittal) View




### Lateral View




### Inferior (Bottom) View

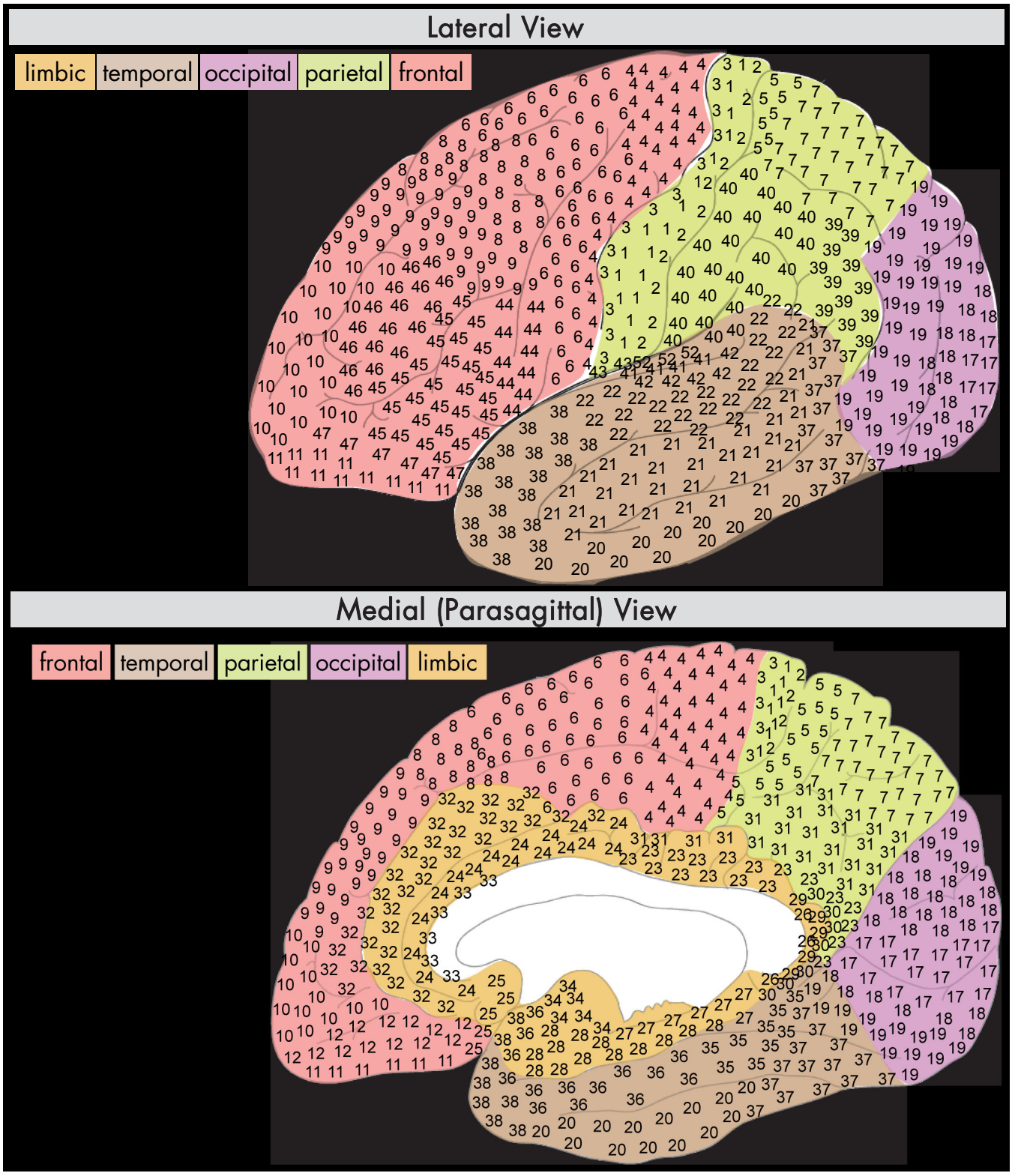



**Left Hemisphere -** In most individuals, the processing of verbal information, including language, occurs primarily in the left hemisphere.

frontal | temporal | parietal | occipital | limbic

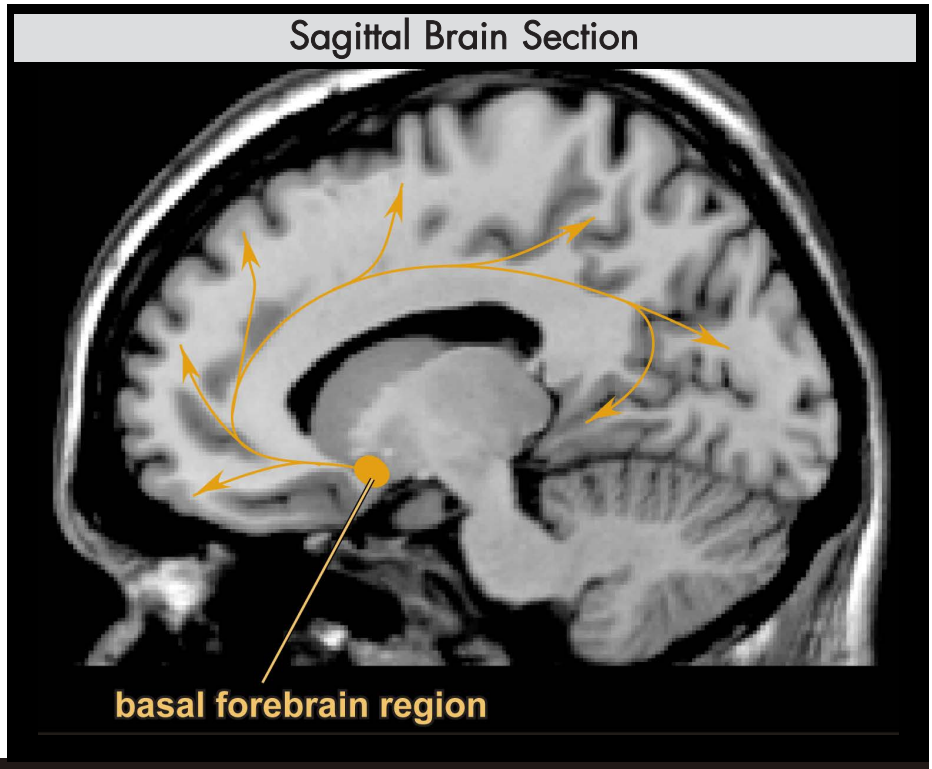
## Brodmann's Areas

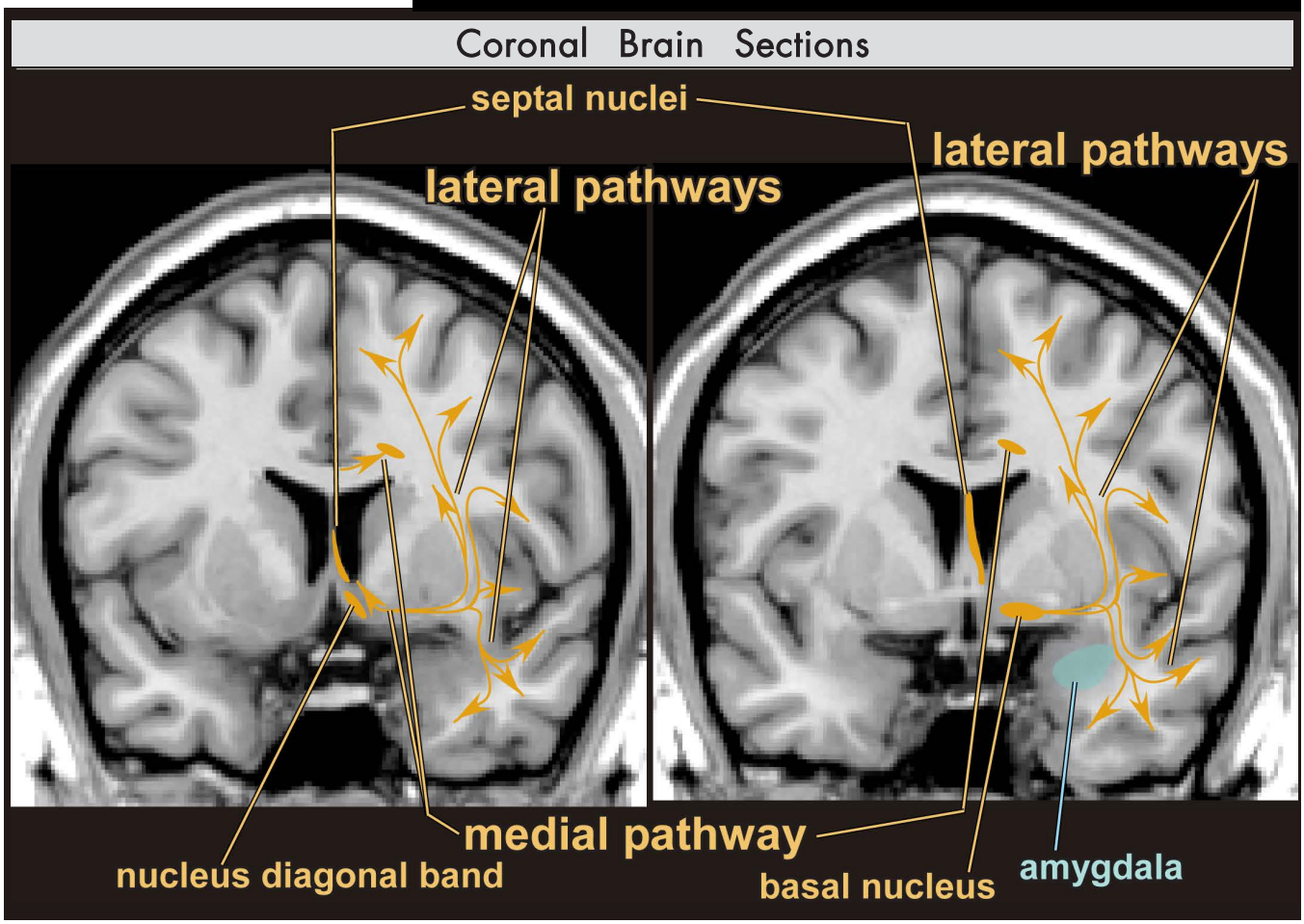
In the early part of the 20th century, Brodmann defined cortical areas based upon features such as the size, shape and distribution of neurons (cytoarchitecture). An approximation of these areas are provided in the illustrations below. Versions of this system are still widely used. While useful, it is 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

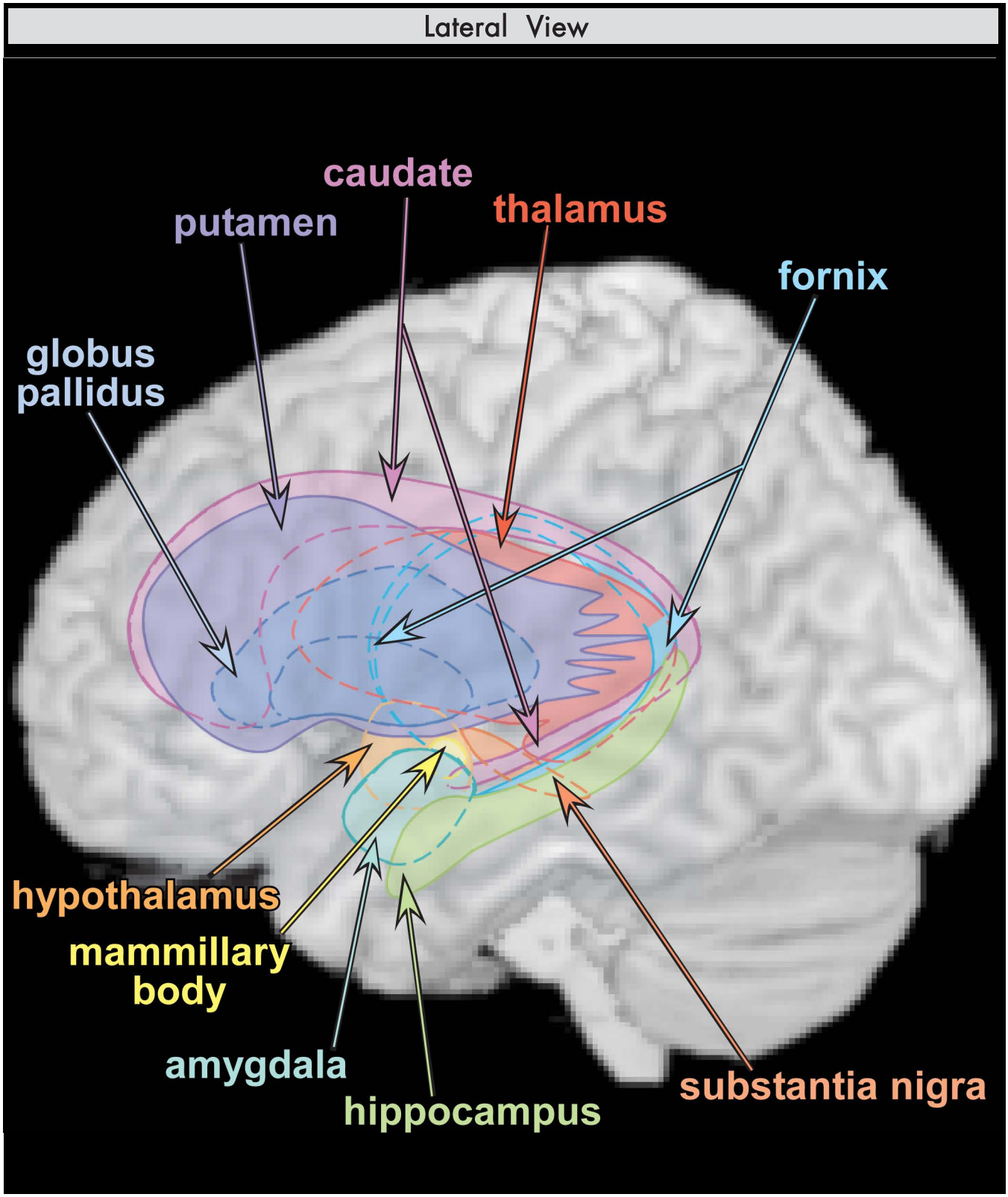
The basal forebrain area contains many cholinergic neurons in the basal nucleus of Meynert, nucleus of the diagonal band and septal nuclei. The general location of this important region and its projections to cortex are approximated on sagittal and coronal magnetic resonance images. The basal forebrain 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 amydala 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.