Cerebral Hemisphere and Cortex

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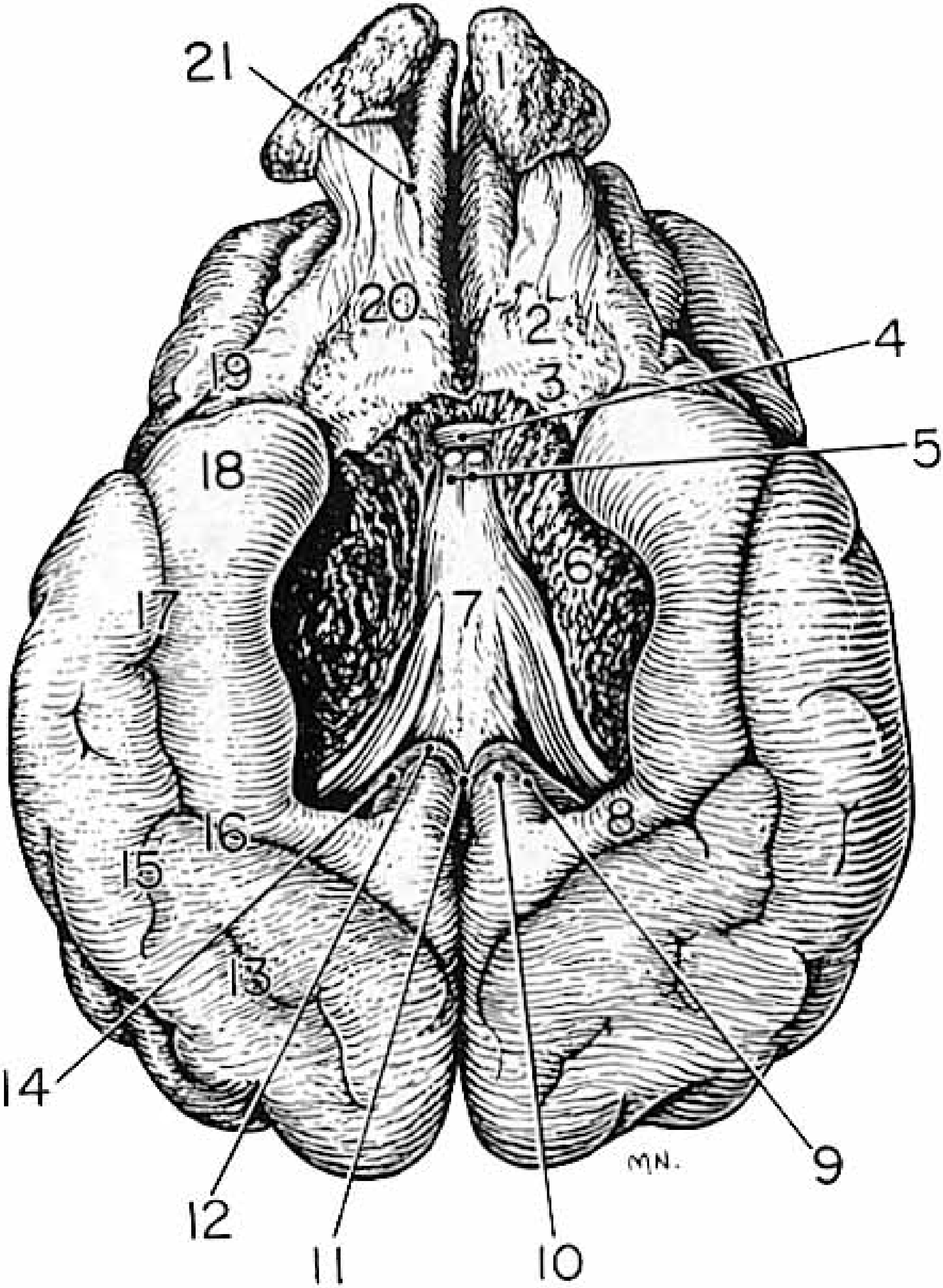
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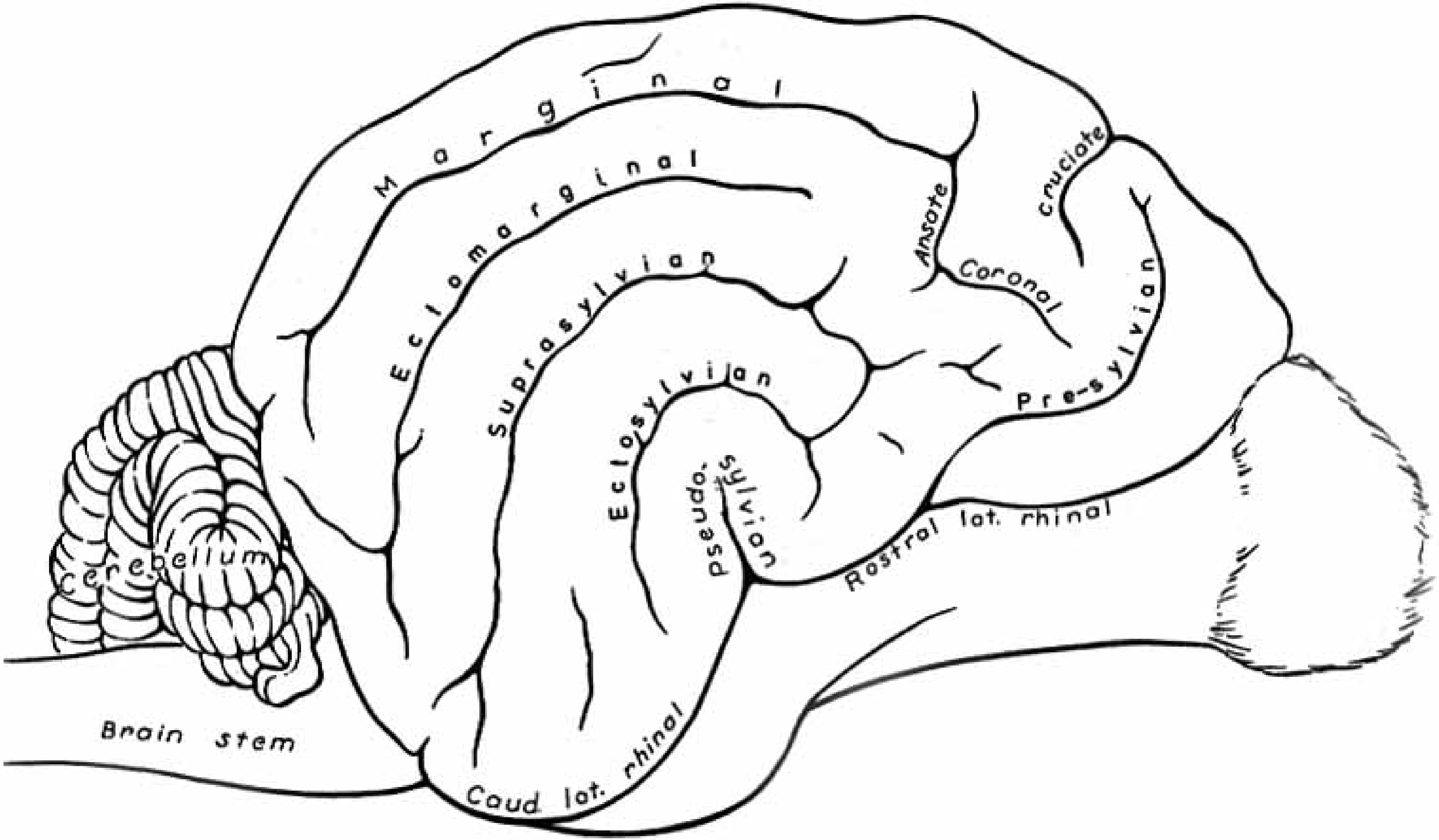

Marginal
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Ectosylvian
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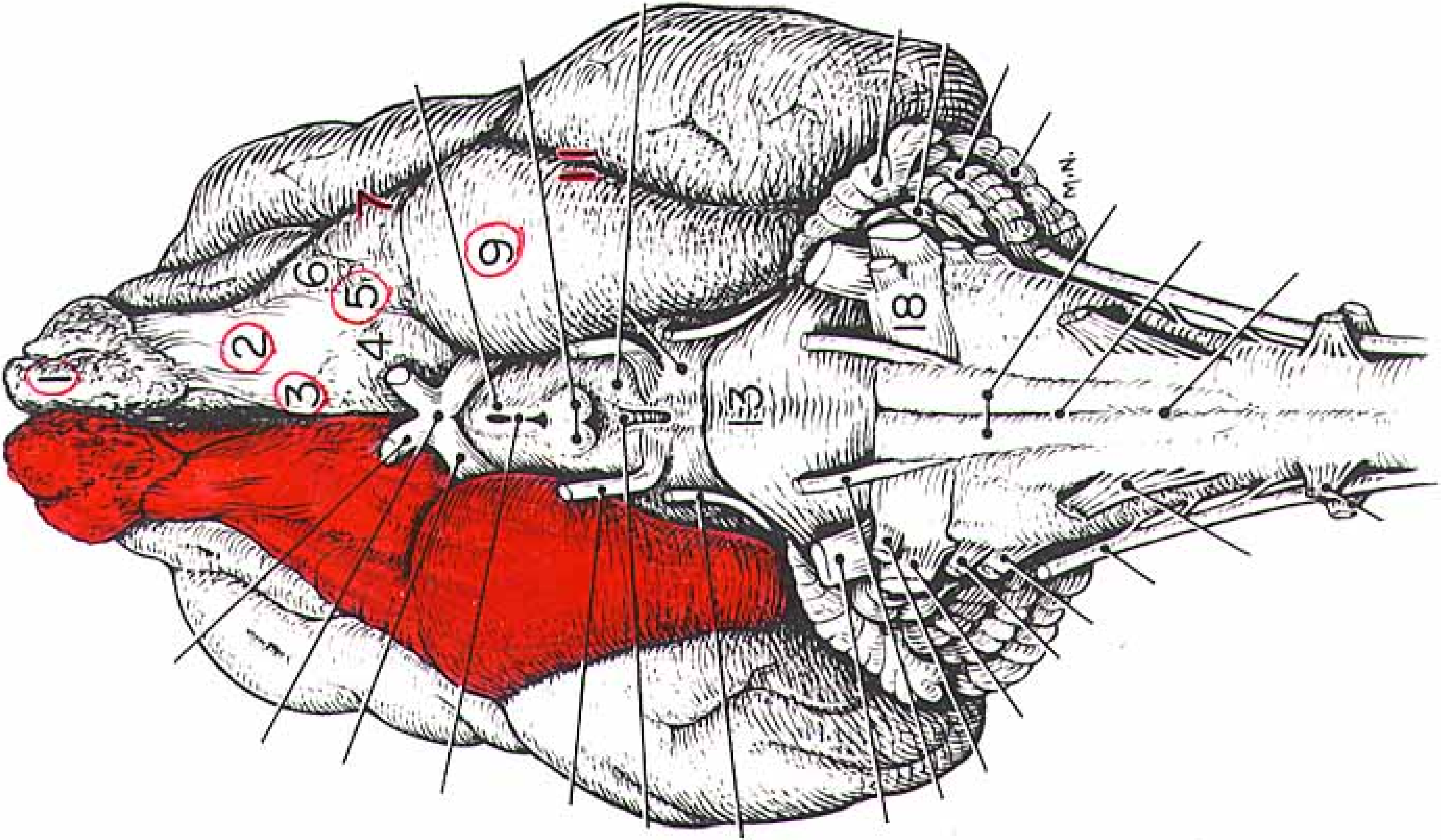
Ansate
Cruciate
Coronal
Presylvian
Rostral lat. rhinal
Caud. lat. rhinal
Cerebellum
Brain stem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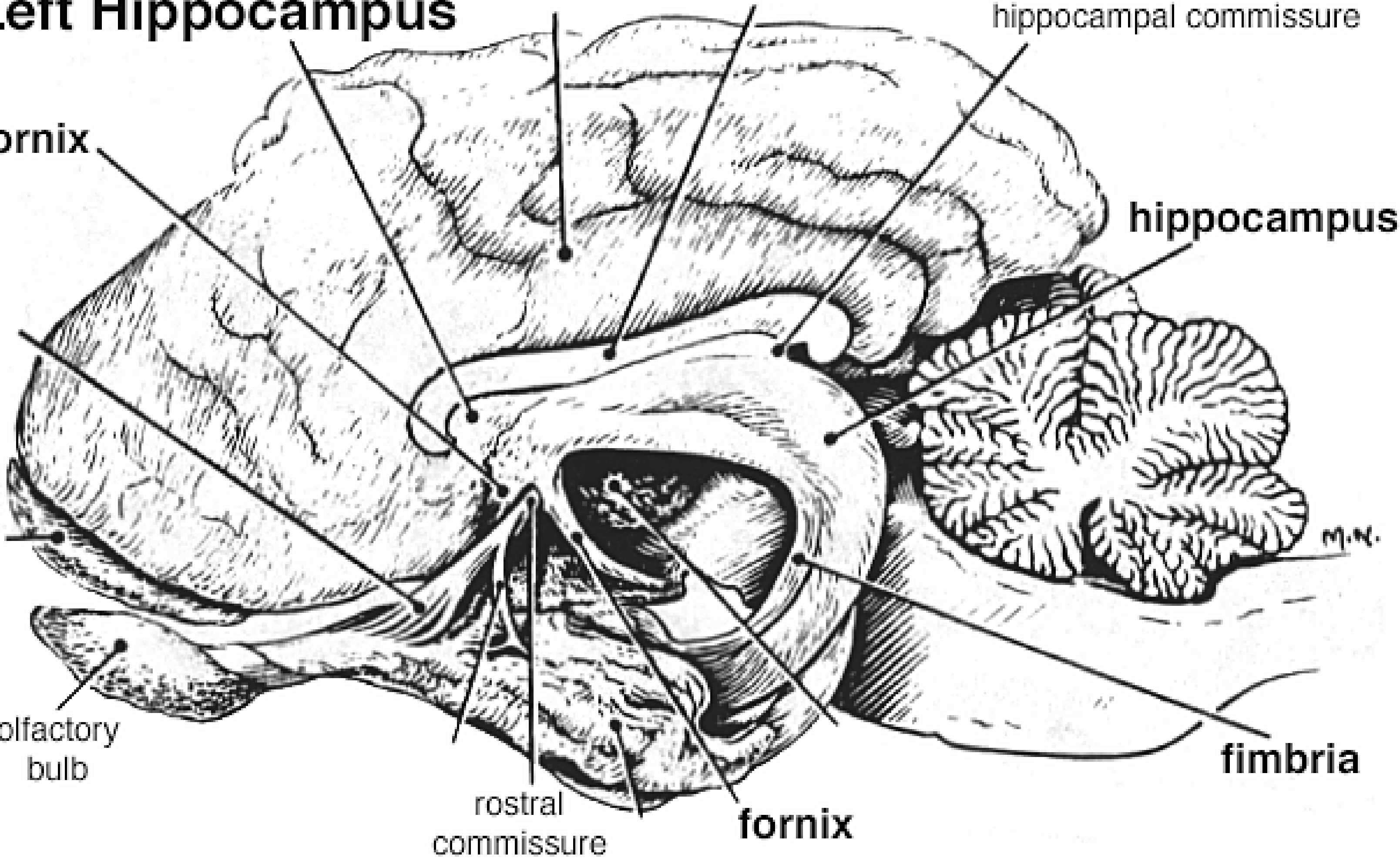
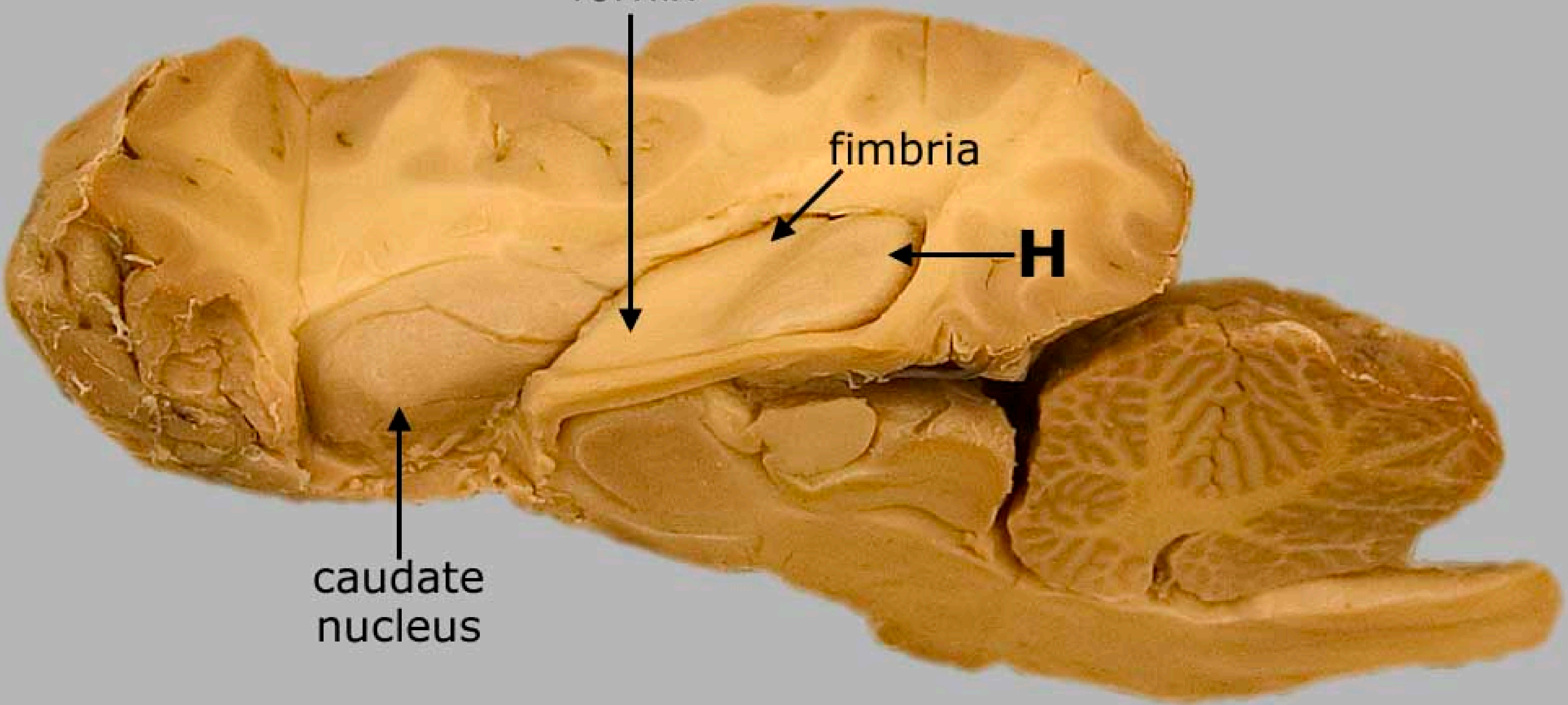
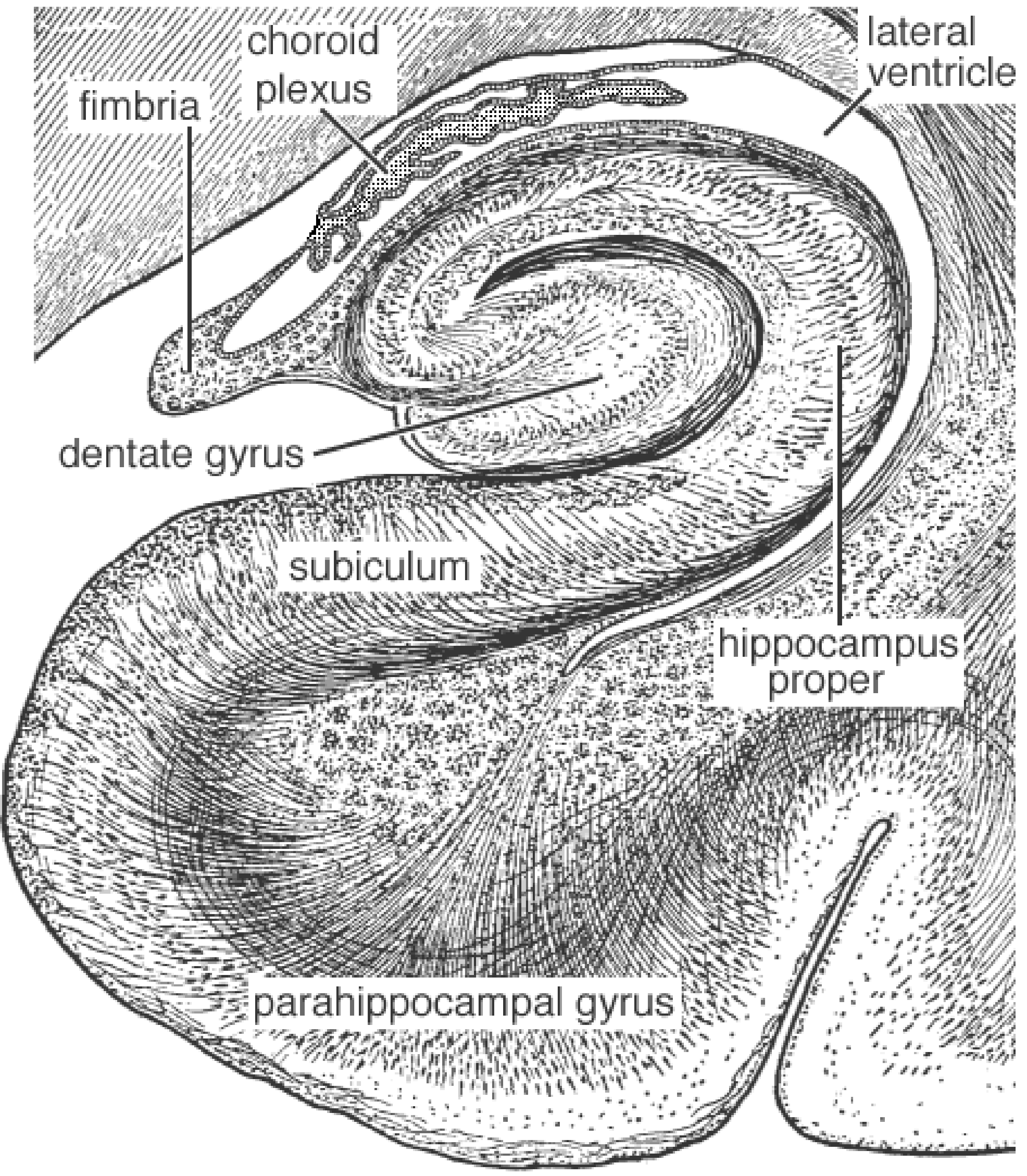
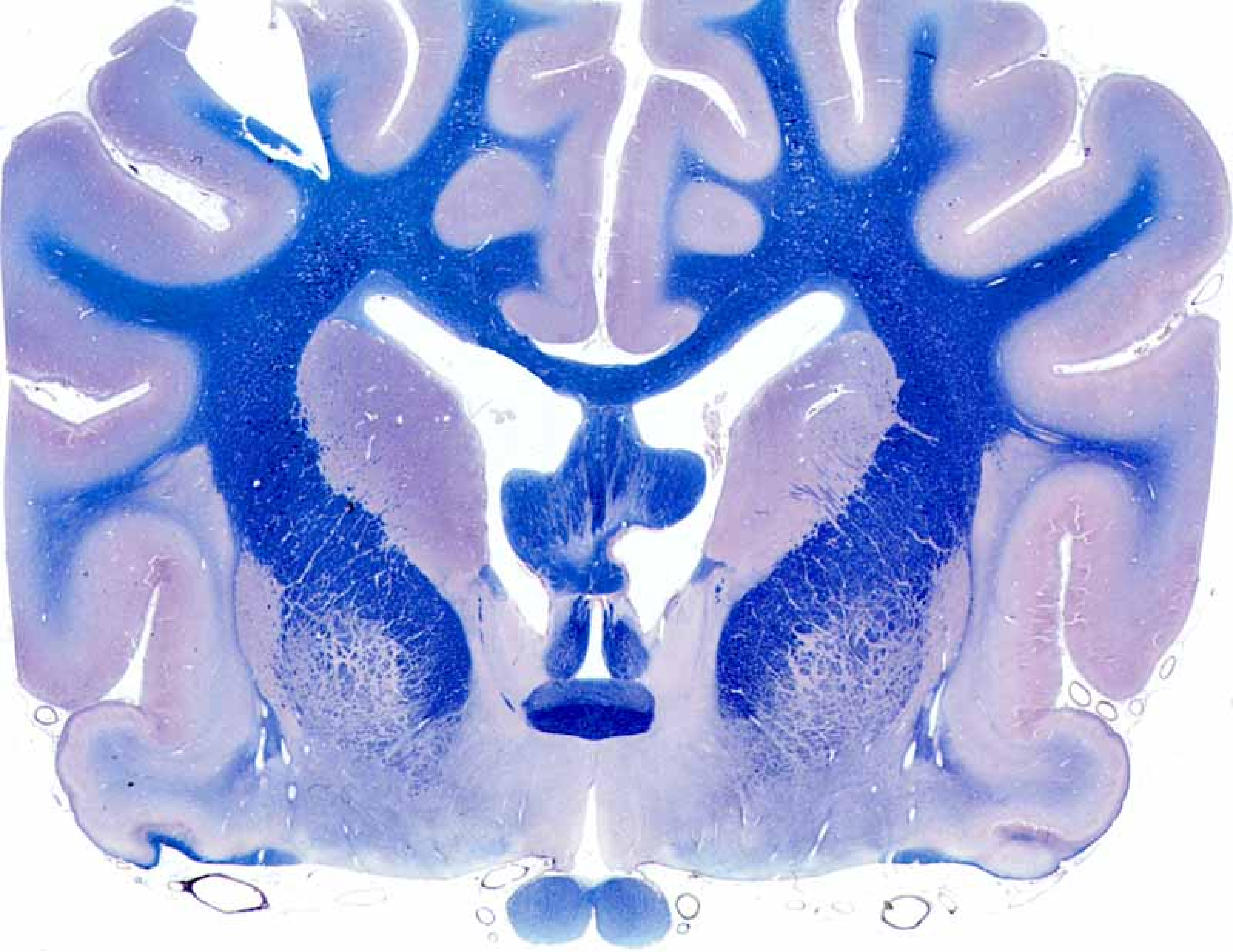
Left Hippocampus

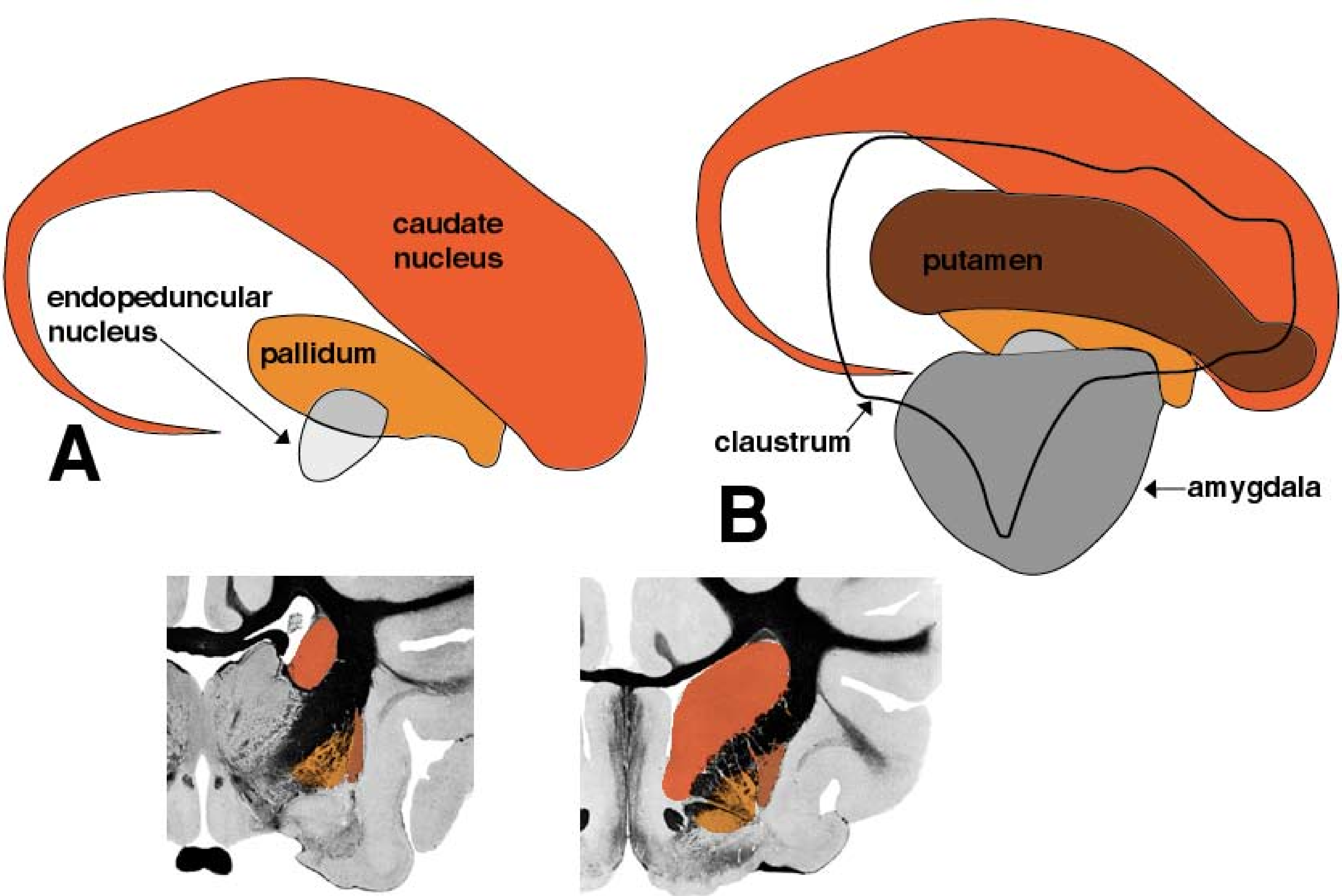



fornix
fimbria
H
caudate
nucleus



choroid plexus
lateral ventricle
fimbria
dentate gyrus
subiculum
hippocampus proper
parahippocampal gyrus




caudate
nucleus
endopeduncular
nucleus
pallidum
A
putamen
claustrum
amygdala
B

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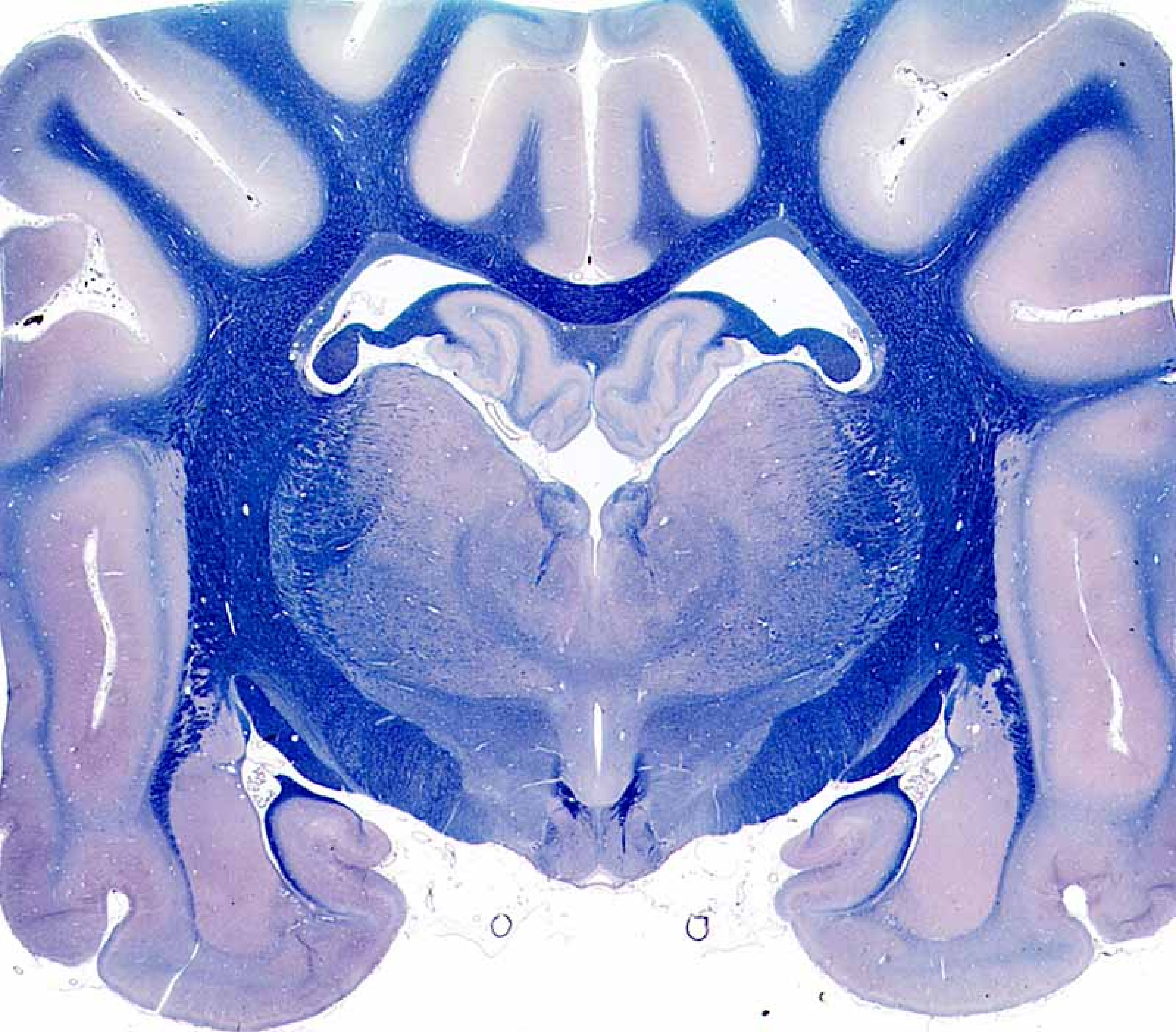

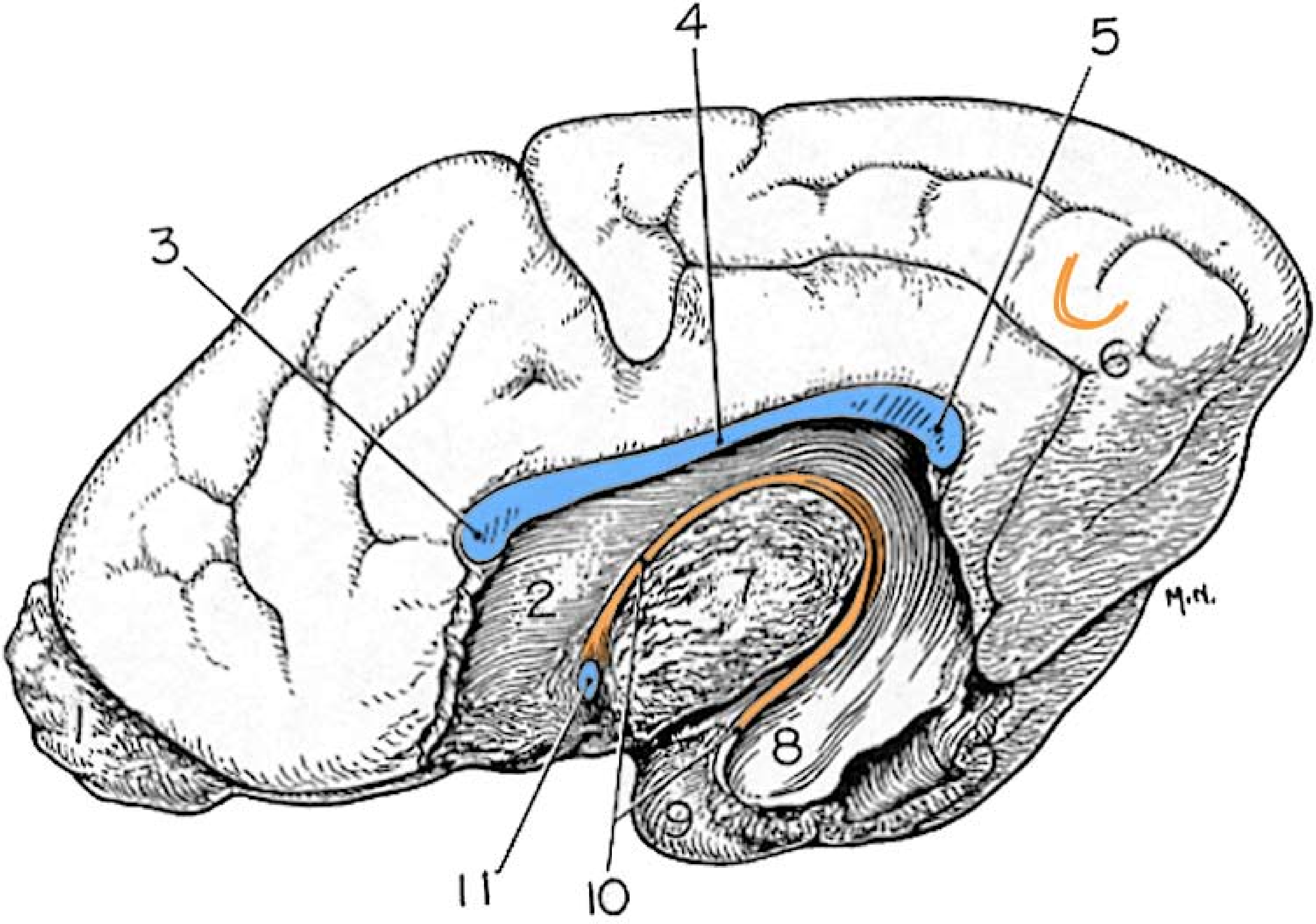
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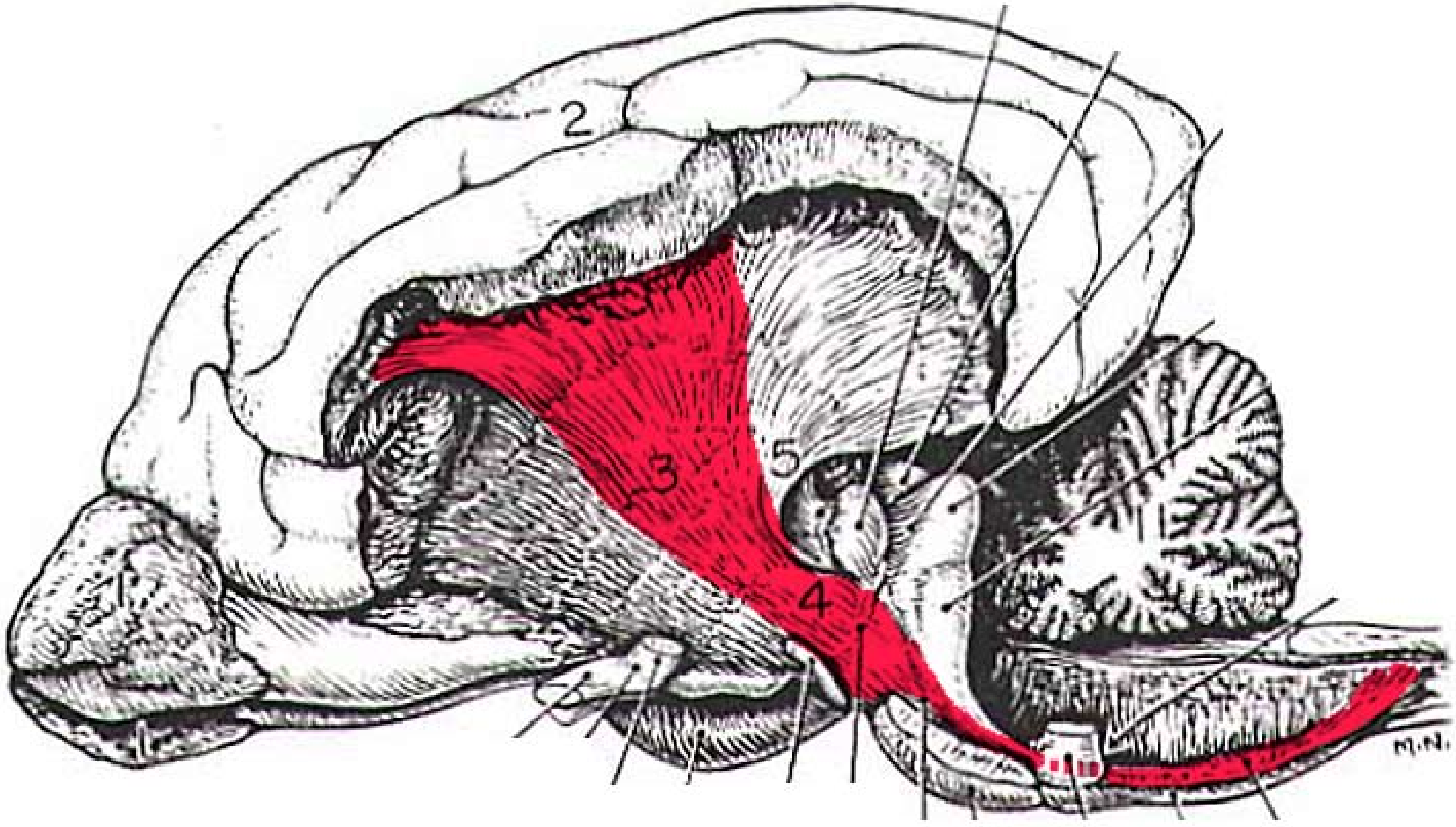
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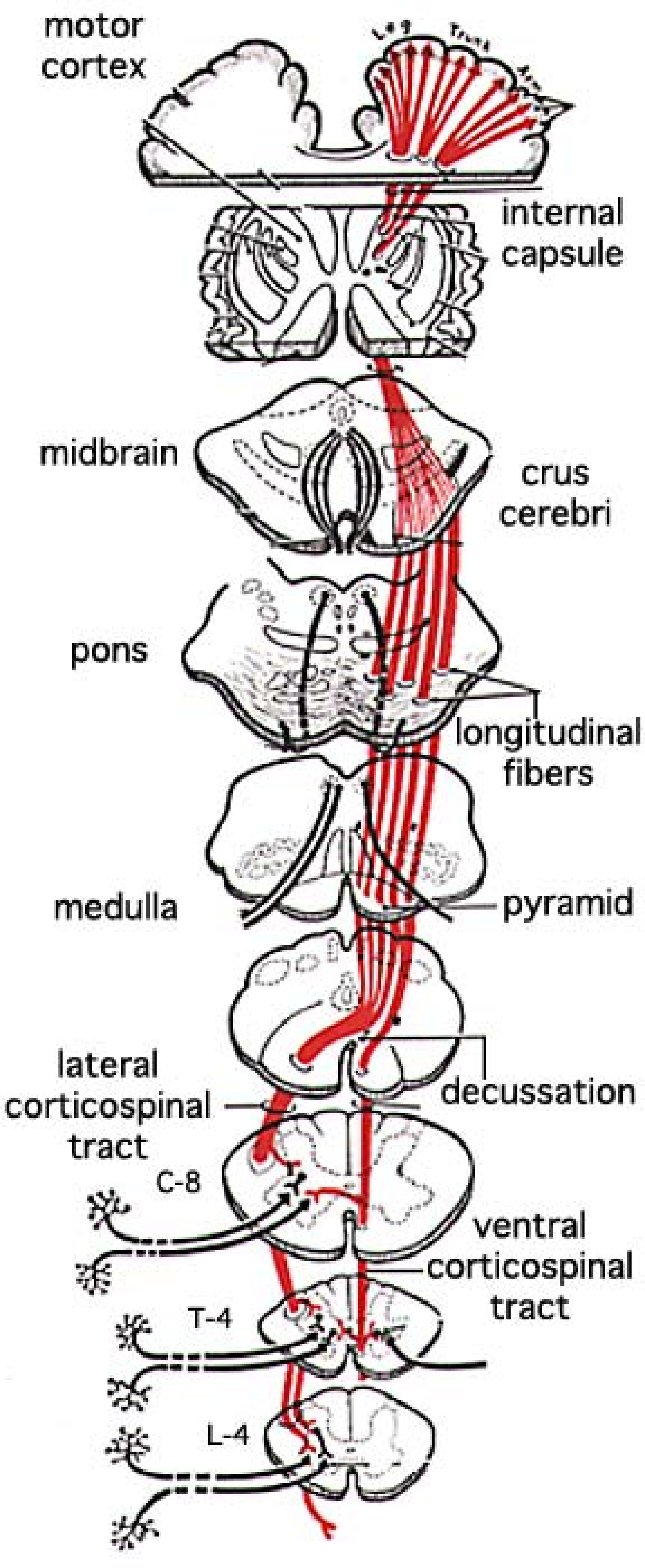
motor
cortex
internal
capsule
midbrain
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pons
longitudinal
fibers
medulla
pyramid
lateral
corticospinal
tract
decussation
C-8
ventral
corticospinal
tract
T-4
L-4

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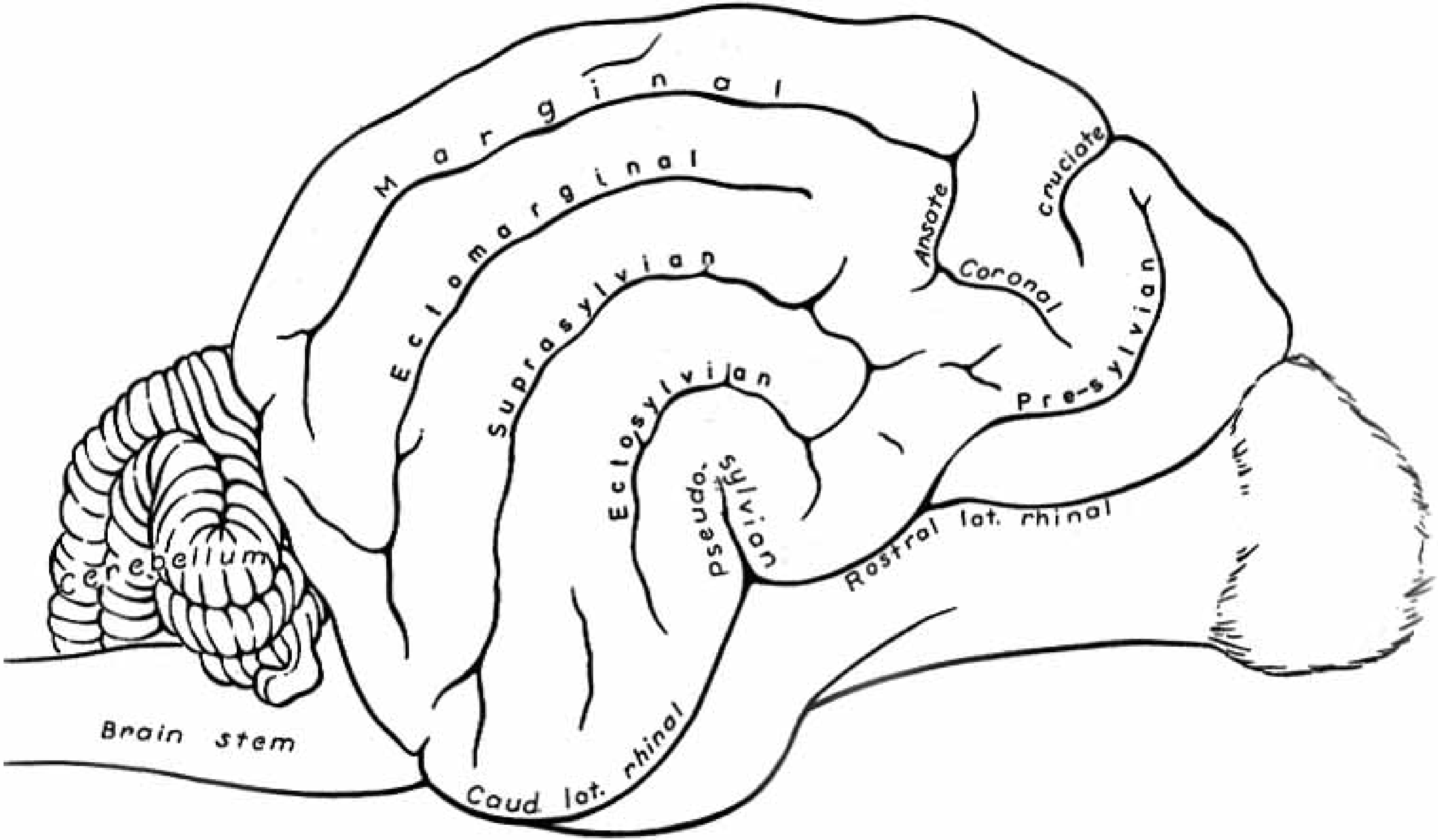
Marginal
Ectomarginal
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Pseudo-sylvian
Ansate
Cruciate
Coronal
Presylvian
Pre-sylvian
Rostral lat. rhinal
Caud. lat. rhinal
Cerebellum
Brain stem

Two neuron types predominate in the neocortex:

pyramidal cell — conical cell body (>30 μm in diameter) with apical and basal dendrites and an axon that leaves the base of the cell to enter white matter. Pyramidal cells vary in size. They are the output cells of the cerebral cortex.

granule cell — small, round cell body (<10 μm in diameter). Granule cells serve as interneurons, receiving input from cortical afferent fibers and synapsing on output neurons (pyramidal cells) of the cortex.

Two types of afferent projection fibers from the thalamus enter the neocortex:

specific afferents — modality specific input; terminate in inner granule cell layer

non-specific afferents — background excitation; terminate in molecular layer.

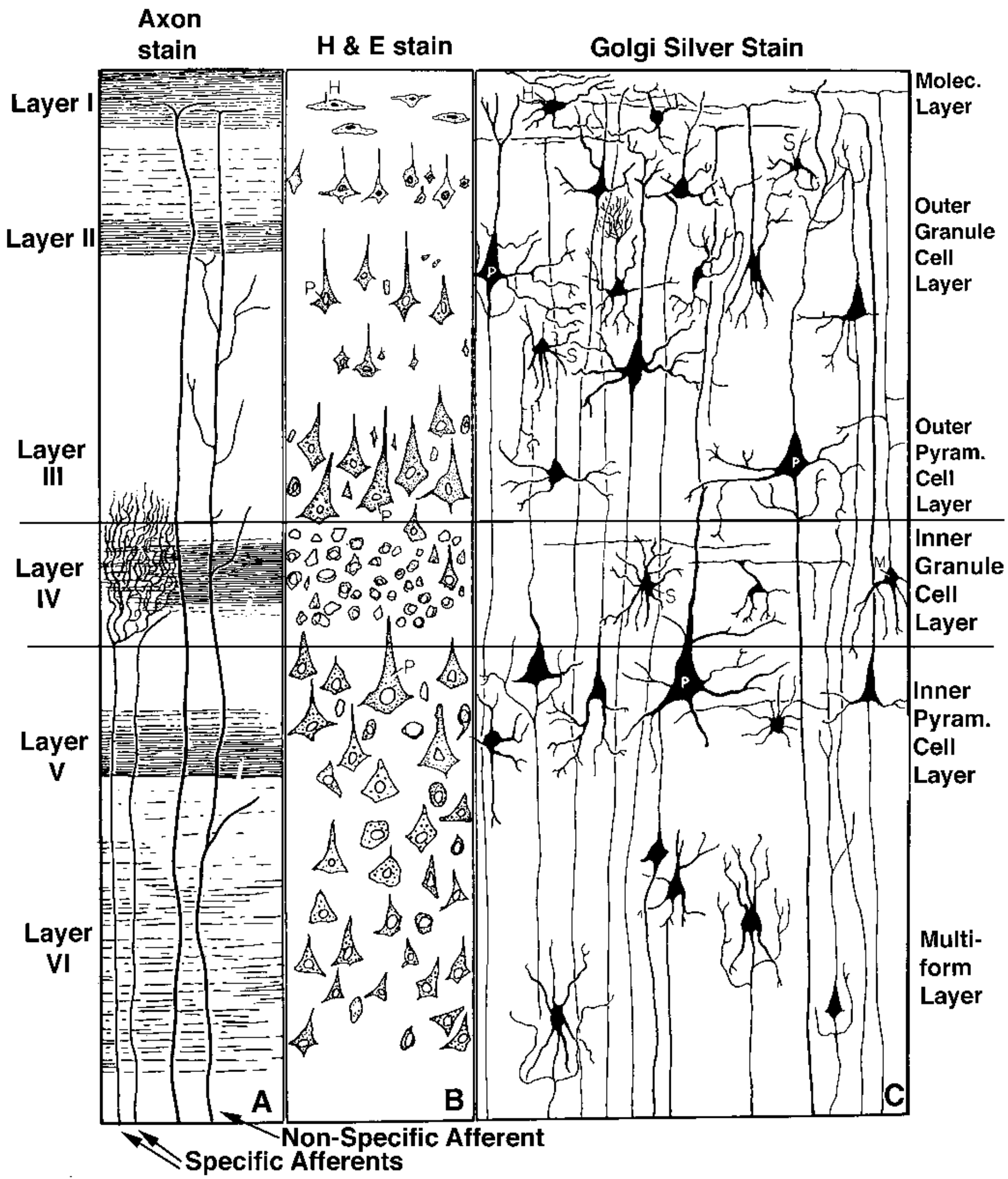
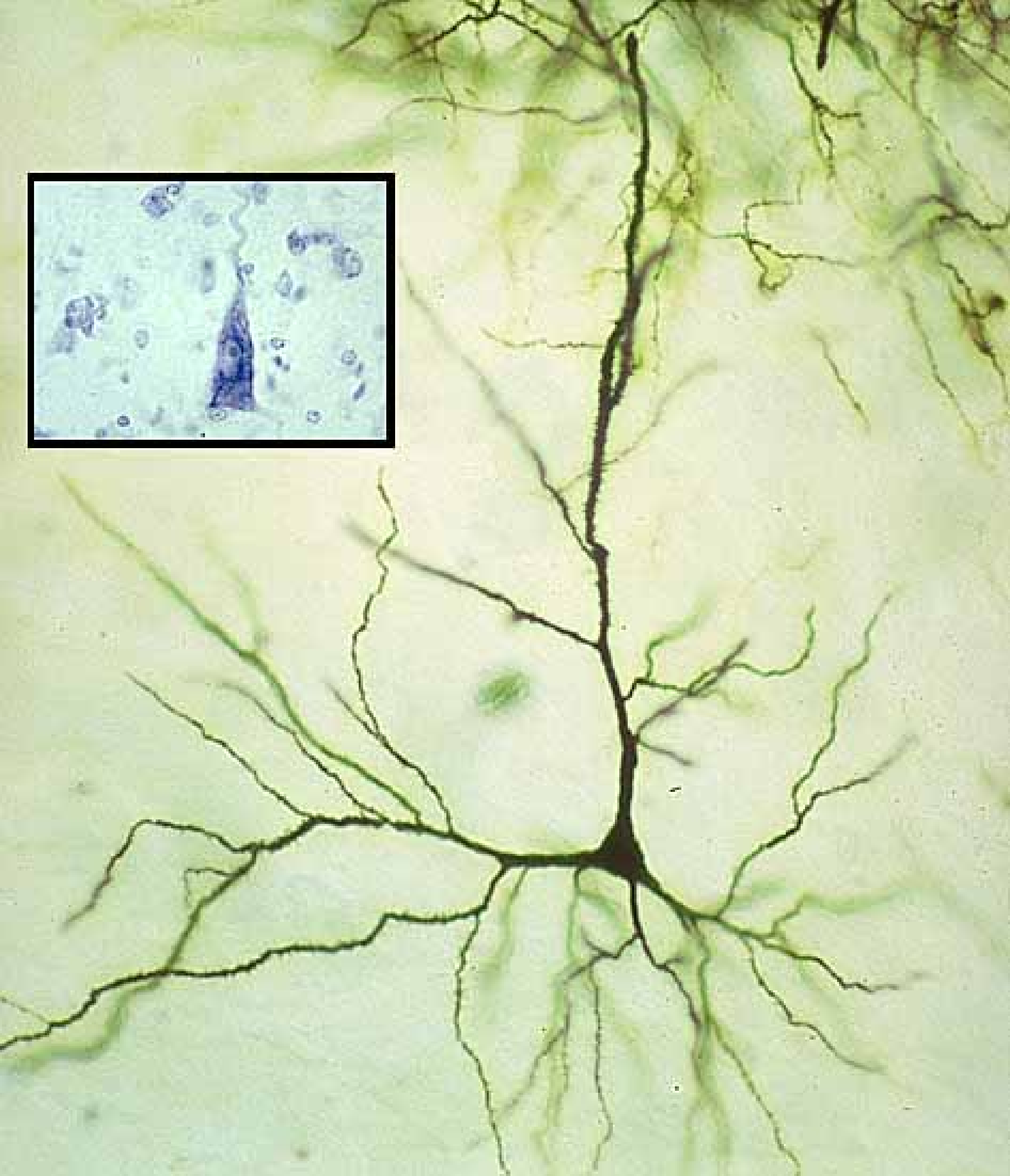


Fig. 1. Six layers of cerebral cortex as seen with three stains used to show different histologic features (axons; cell bodies; & whole neurons). The six layers are numbered at the left and named at the right. P = pyramidal cell; S = granule (stellate) cell.



Horizontal Layers of Cerebral Cortical

The cerebral cortex is organized into six horizontal layers (although layer boundaries are not very obvious in routine sections). The individual layers have different roles and vary in relative thickness among cortical regions (e.g., a sensory region has a thick internal granule layer; a motor area has a thick internal pyramidal cell layer).

From superficial to deep, the six layers are:

1] Molecular layer — fiber layer; apical dendrites & non-specific afferents;
2] Outer granule cell layer — interneurons for non-specific afferent input;
3] Outer pyramidal cell layer — small and medium cells; short association output
4] Inner granule cell layer — interneurons for specific afferent input
5] Inner pyramidal layer — large cells; projection & long association output
6] Multiform layer — variably shaped cells; projection & long association output

Cell Column (Vertical) Organization of Cerebral Cortical

The entire cerebral cortex is organized into functional units, each unit being a column (about 0.4 mm diameter) extending the entire thickness of the cortex (including all six layers). Each vertical column is a functional unit because all cells within an individual column are activated by the same particular feature of a stimulus. The vertical organization is the result of neuronal connections within a cortical column:

— non-specific input to the column terminates in the molecular layer on distal dendrites of pyramidal cells, to provide background excitation to the column;

— specific thalamic input terminates in the internal granule cell layer, exciting interneurons which excite other neurons of the column;

— small pyramidal cells send their axons into the white matter to excite nearby cell columns;

— large pyramidal cells (and multiform cells) send their axons into the white matter to excite distant sites via long association fibers, commissural fibers, and corticofugal projection fibers.

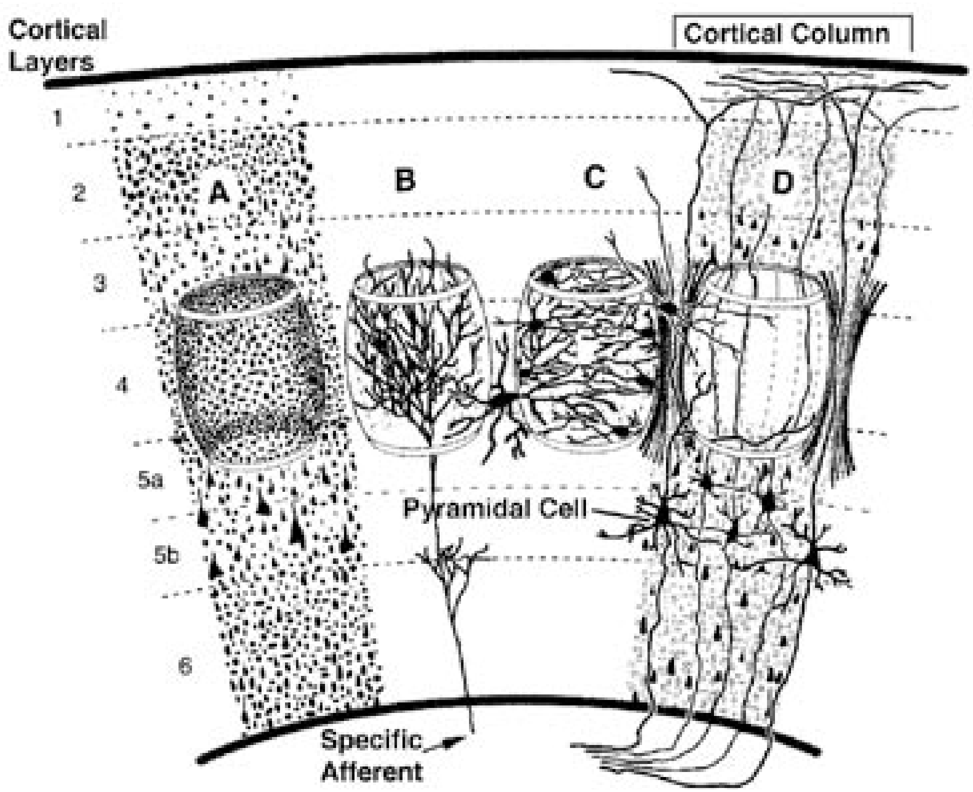
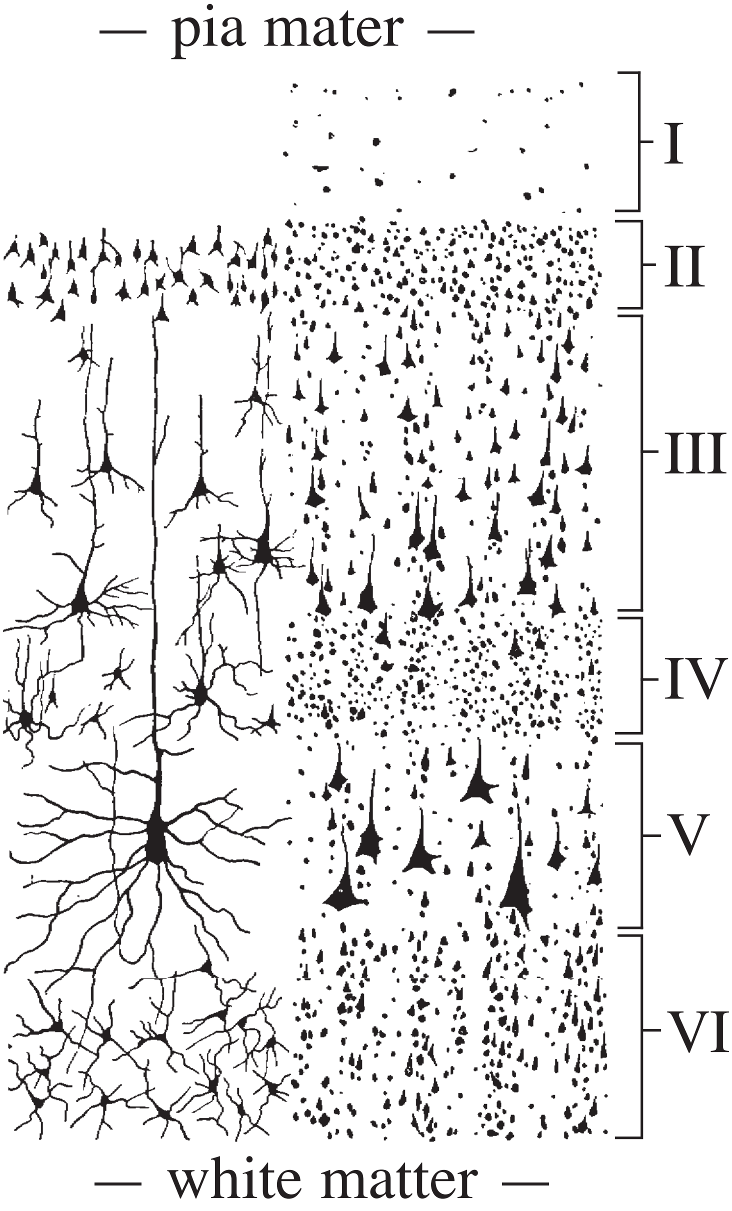
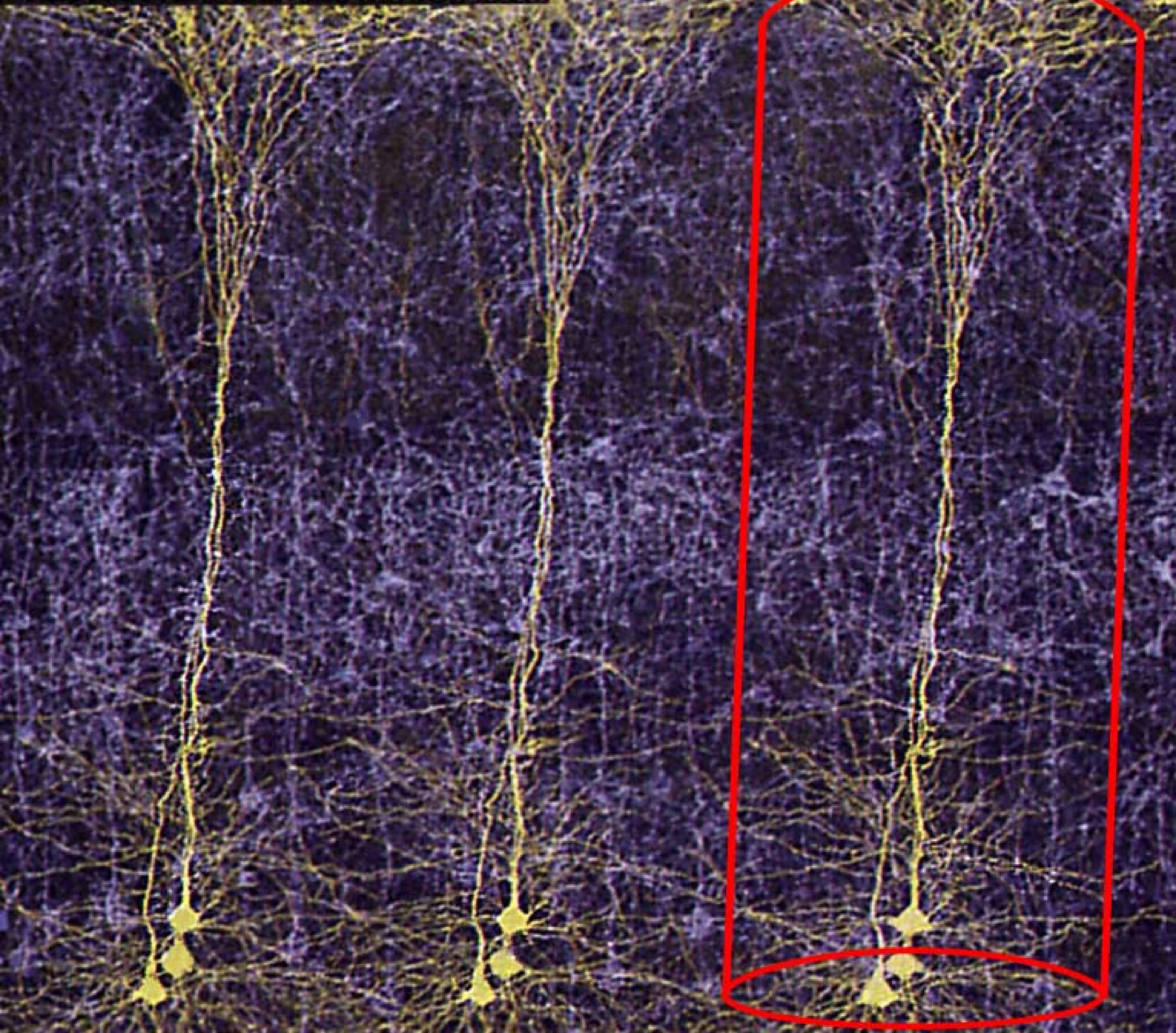


Fig. 2. Vertical cells columns constitute the functional units of cerebral cortex. Usually the functional columns are not anatomically distinct, but in the case of the massive sensory input from rat vibrissae, the cell columns per vibrissae are morphologically evident and give the impression of a "barrel".



Note: The cerebral neocortex features six layers, that are illustrated above by two different staining methods. Golgi silver impregnation (left) stains selective individual neurons entirely. Nissl stain (right) stains only the cell bodies of all neurons.

NEURONS from the neocortex.



Functional areas (regions) of cerebral neocortex:

Motor area: somatotopically organized around the *cruciate sulcus*. The motor area drives voluntary movement and it is the primary source of pyramidal tract fibers to cranial nerve nuclei and spinal cord (corticospinal tracts).

> *Somatotopic* organization = organization based on regional organization of the body (e.g., neck is near the head; hindlimb is near the tail; etc.). The organization can be represented by an *animunculus*, which appears distorted because amount of cortex is proportional to density of innervation, not area of body surface.

Primary sensory areas: receive specific afferents of a given modality from the thalamus or geniculate bodies:

- somesthetic (somatosensory) area — receives specific tactile input as well as information related to pain, temperature and pressure sensation. The area is somatotopically organized around the coronal sulcus.
- visual area — receives visual input. The area is retinotopically organized in the occipital lobe around the marginal sulcus.
- auditory area — receives auditory input. The area is cochleotopically organized around the apex of the pseudosylvian fissure.
- vestibular area — receives vestibular apparatus input. It is rostral to the auditory area.

Note: Taste is represented in the somesthetic area near the tongue region.
Olfaction is conscious detected at the piriform lobe (paleocortex).

Association areas:

These are cortical areas that receive their specific input from other cortical areas, and so they are not involved directly with processing sensory and motor information. Rather these areas are involved integrating and interpreting information derived from primary sensory areas.

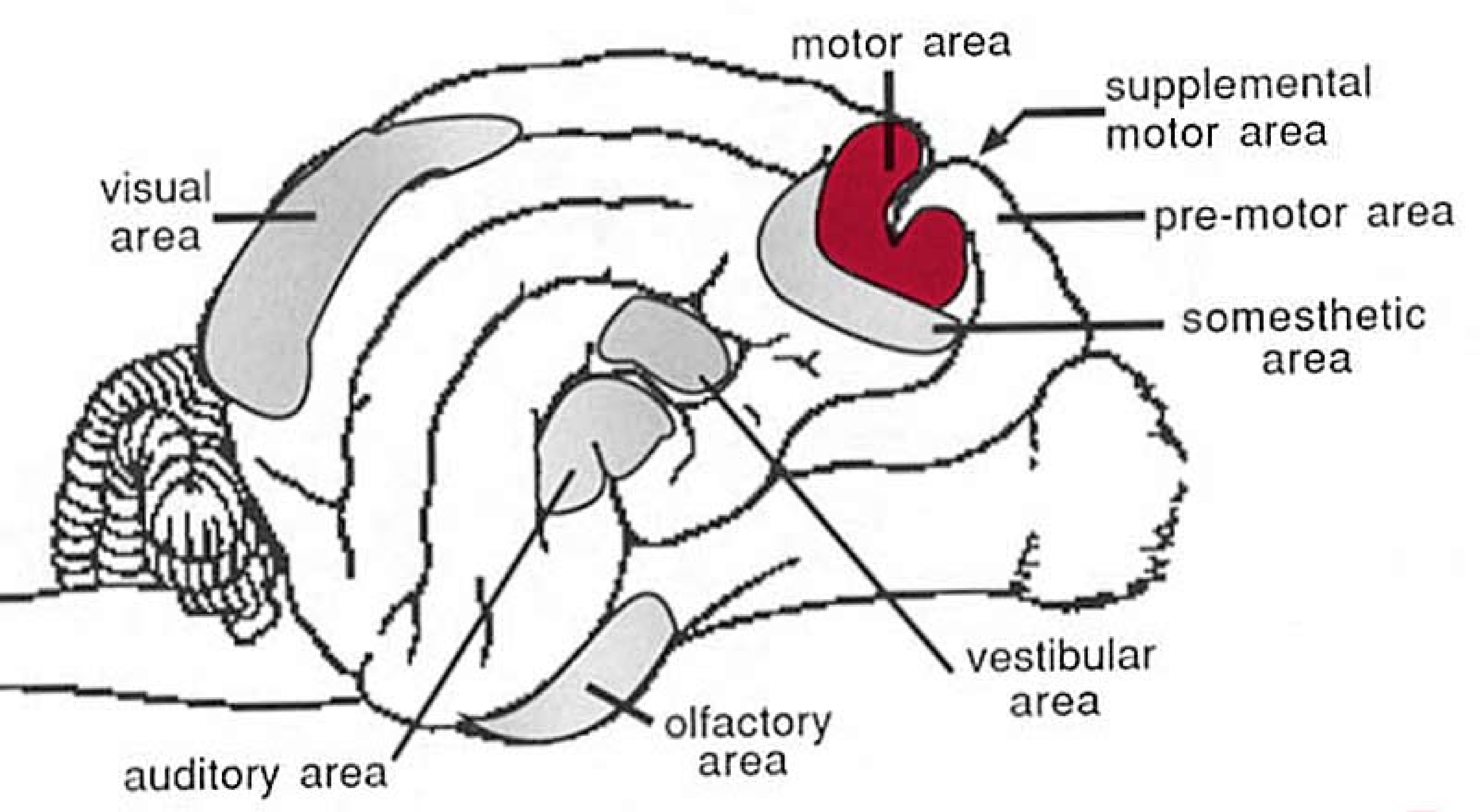
There are different hierarchies of association areas: the lowest association areas (adjacent to primary sensory areas) extract significance from components of a stimulus, the highest areas are involved with thought, planning, memory, speech, creativity, etc. Association areas comprise 20% of the canine brain and 85% of the human brain.

> *Note:* In humans, language processing (written, vocal, signing) occurs in one cerebral hemisphere (left hemisphere in 95% of right handed and 70% of left handed persons) and visual-spatial processing (shapes, symbols, patterns, configuration analysis) is dominant in the other hemisphere. Handedness is also a representation of hemispheric dominance.

Methods of Determining Cortical Function:

Destructive Lesions — information obtained by producing experimental lesions and by observing patients whose lesions can be confirmed at necropsy. Findings include:

Somesthetic area — loss of the fine aspects of discrimination (e.g., cats loose the ability to discriminate various degrees of texture roughness)


motor area
supplemental
motor area
visual
area
pre-motor area
somesthetic
area
vestibular
area
olfactory
area
auditory area

Auditory Area — bilateral lesions cause difficulty in localizing sounds and the meaning (temporal & pitch pattern) of sound is lost.

Electrical Stimulation — stimulate with electrodes and observe the resulting response.

Motor area — stimulation of the area surrounding the cruciate sulcus causes contraction of contralateral muscles in a somatotopic pattern.

Electrical Recording — following a stimulus the corresponding primary sensory areas become excited first. Next sensory information is relayed to association areas of cortex.

Primary auditory area — high frequency tones; activate neurons in the caudal sylvian gyrus; low frequency tones activate neurons in the rostral sylvian gyrus (tonotopic organization).

Primary Visual Area—cell columns respond to edges, flashes, colors, and intensities the elements that comprise an image.

Metabolic Mapping — mapping studies utilize a radiolabeled glucose analogue, 2-deoxyglucose, which competes with glucose for neuronal uptake. During a particular brain function, neurons which are active utilize more glucose and thus take up more of the 2-deoxyglucose. These neurons become highly radioactive and can be localized with autoradiographic techniques.

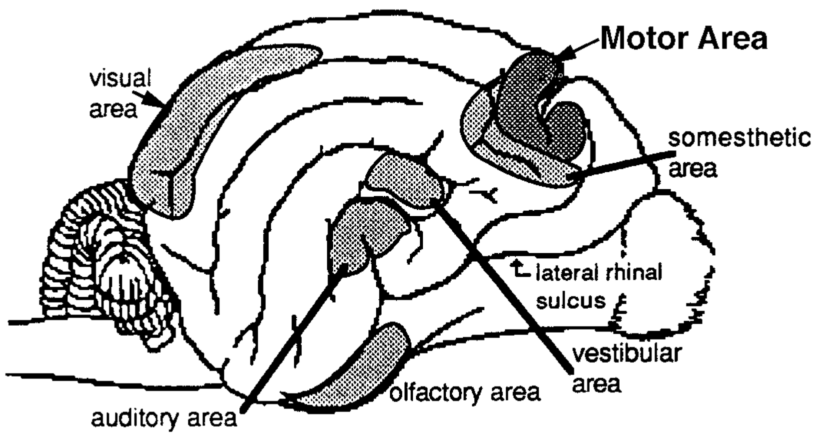


Figure 3: Diagram of a right cerebral hemisphere illustrating locations of the primary motor area and various primary sensory areas.

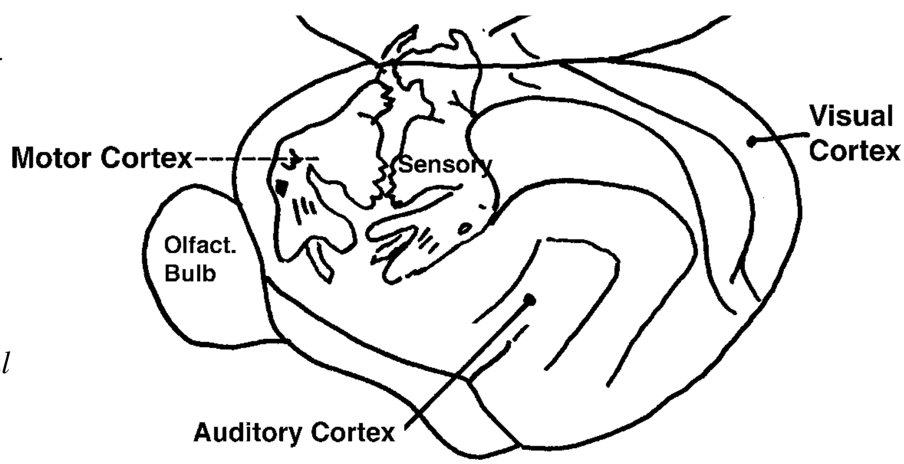
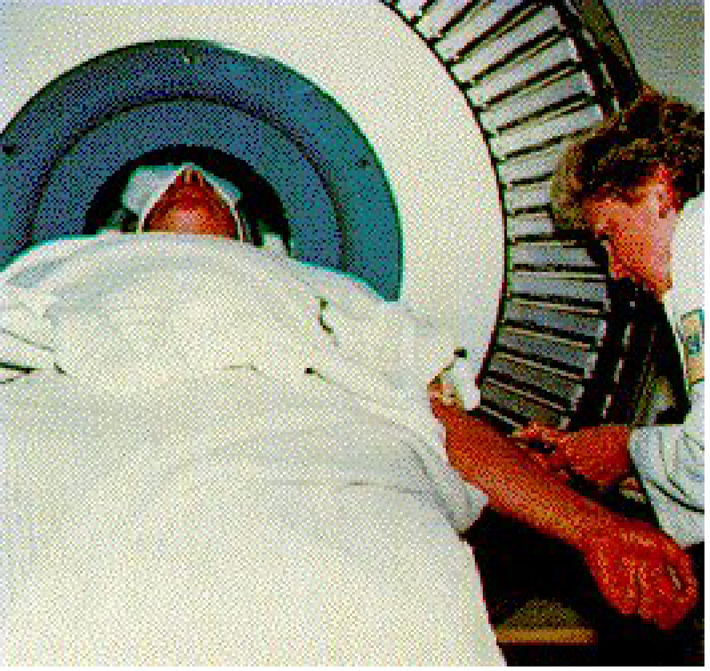
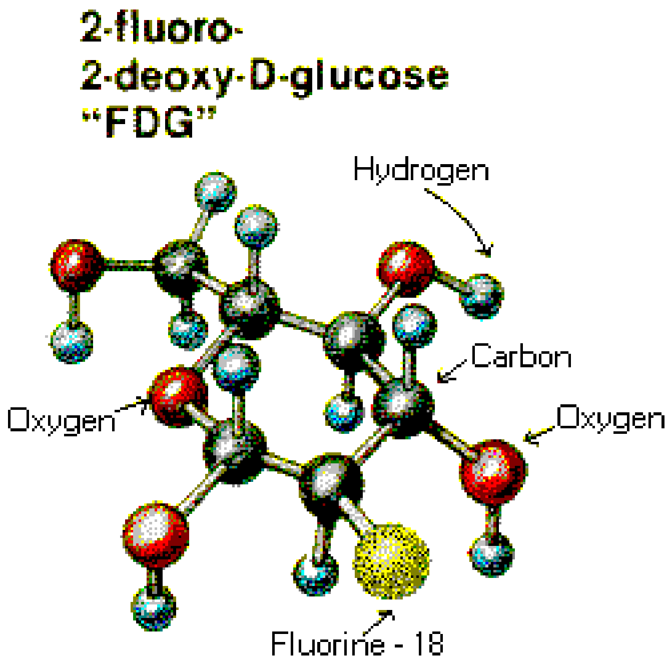


Figure 4: A schematic diagram illustrating a left cerebral hemisphere of a cat. Representation of the motor area and somethetic are is shown by an animunculus in each case. The anumunculus displays the the amount of cortical surface devoted to each region of the body. Notice that the hindlimbs and tail extends onto the medial surface of the hemisphere.

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"FDG"
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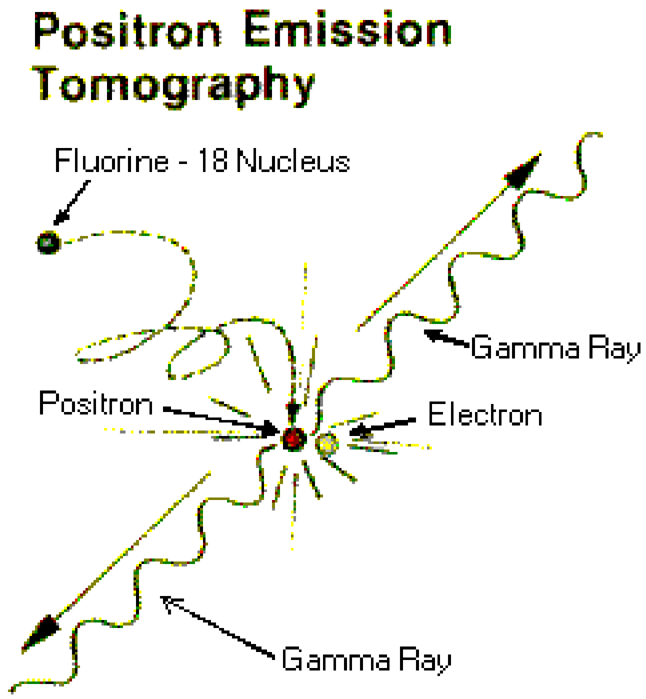
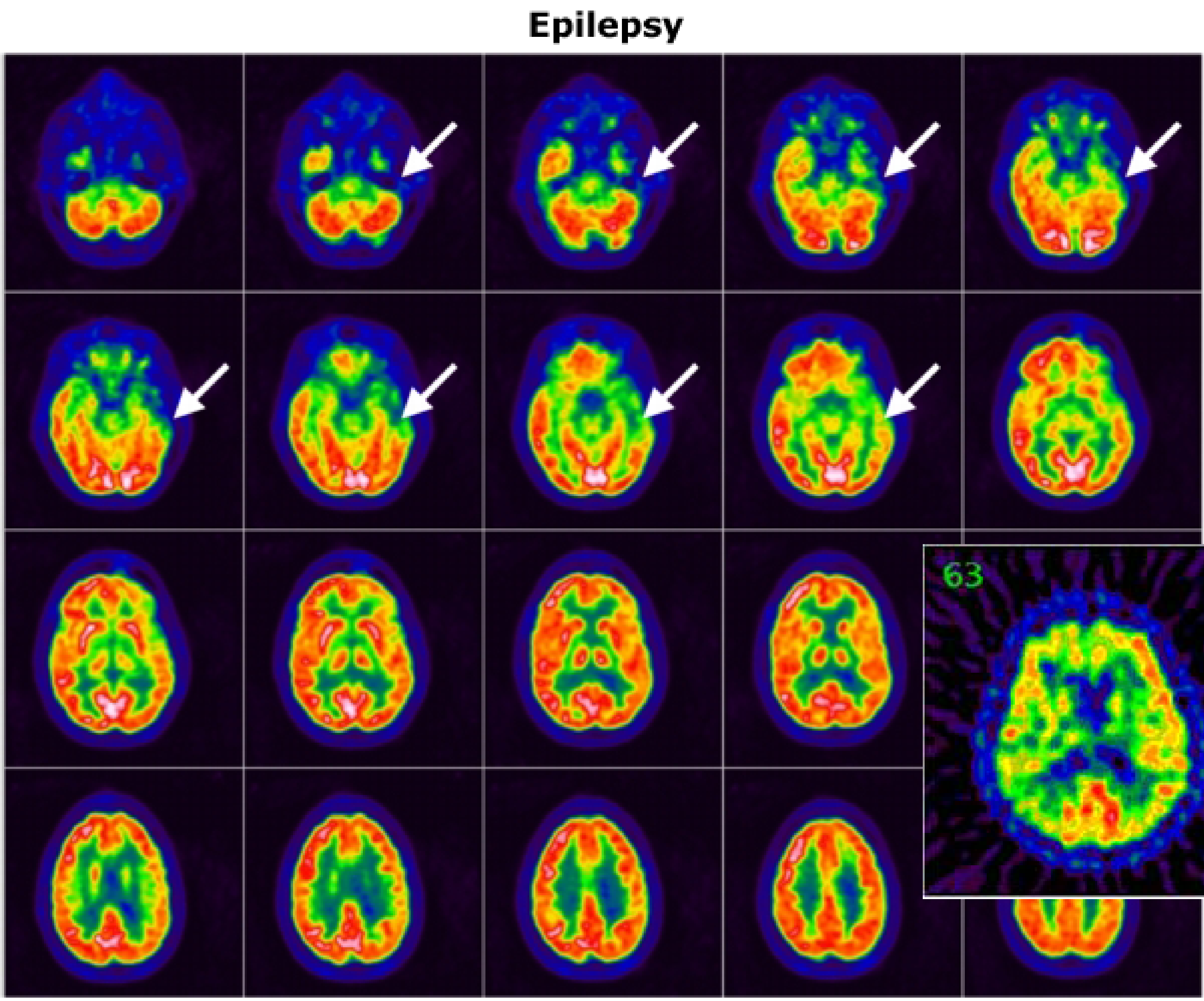
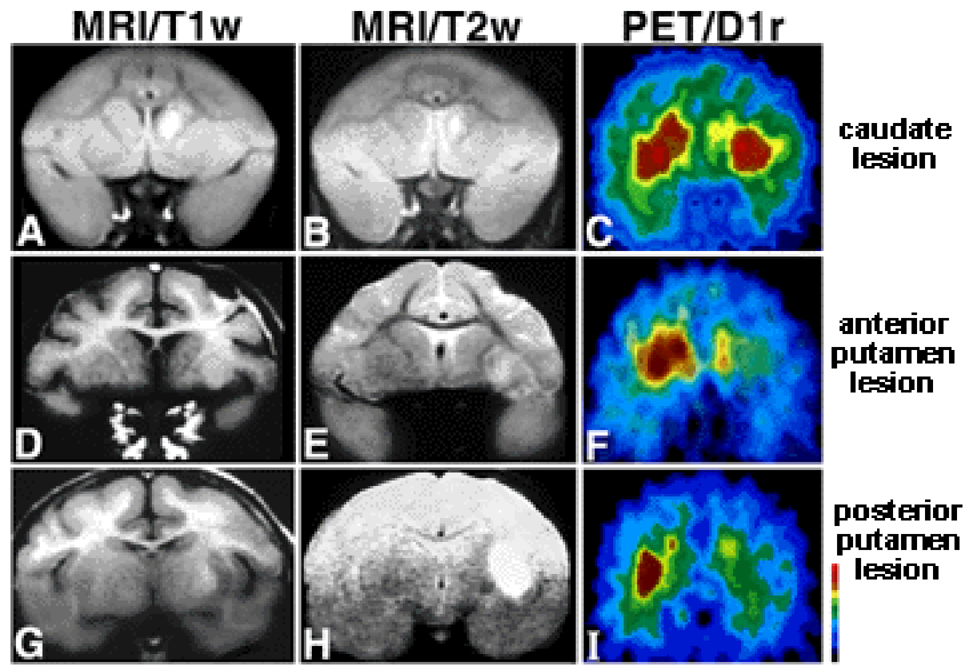
Oxygen
Oxygen
Fluorine - 18


Positron Emission
Tomography
Fluorine - 18 Nucleus
Gamma Ray
Positron
Electron
Gamma Ray


Epilepsy


MRI/T1w
MRI/T2w
PET/D1r
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caudate lesion
D
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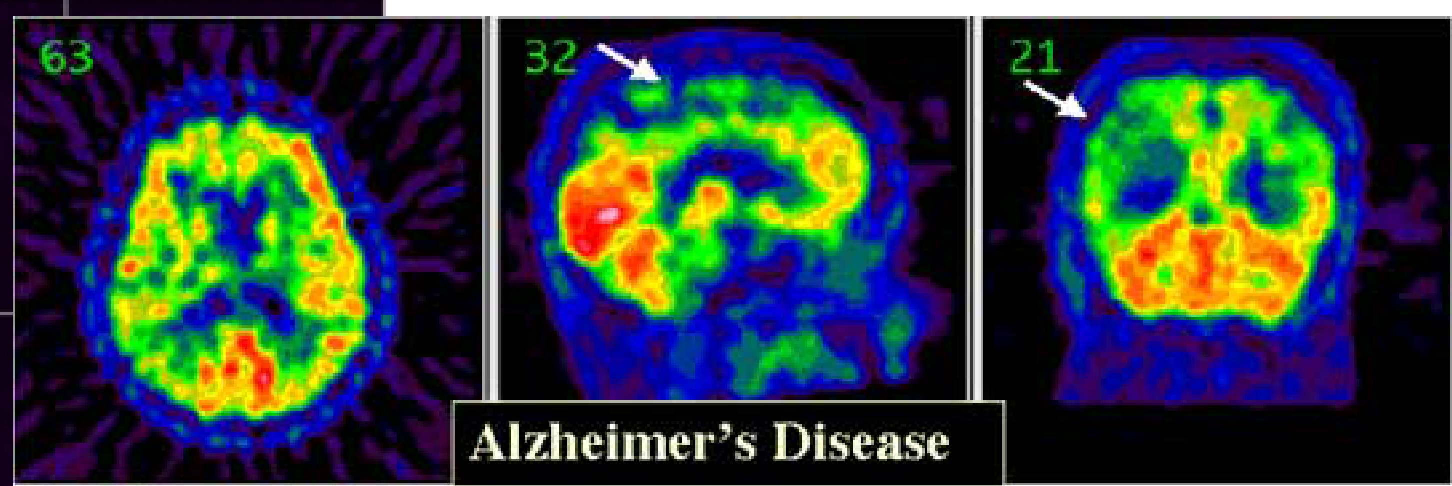
F
anterior putamen lesion
G
H
I
posterior putamen lesion


63
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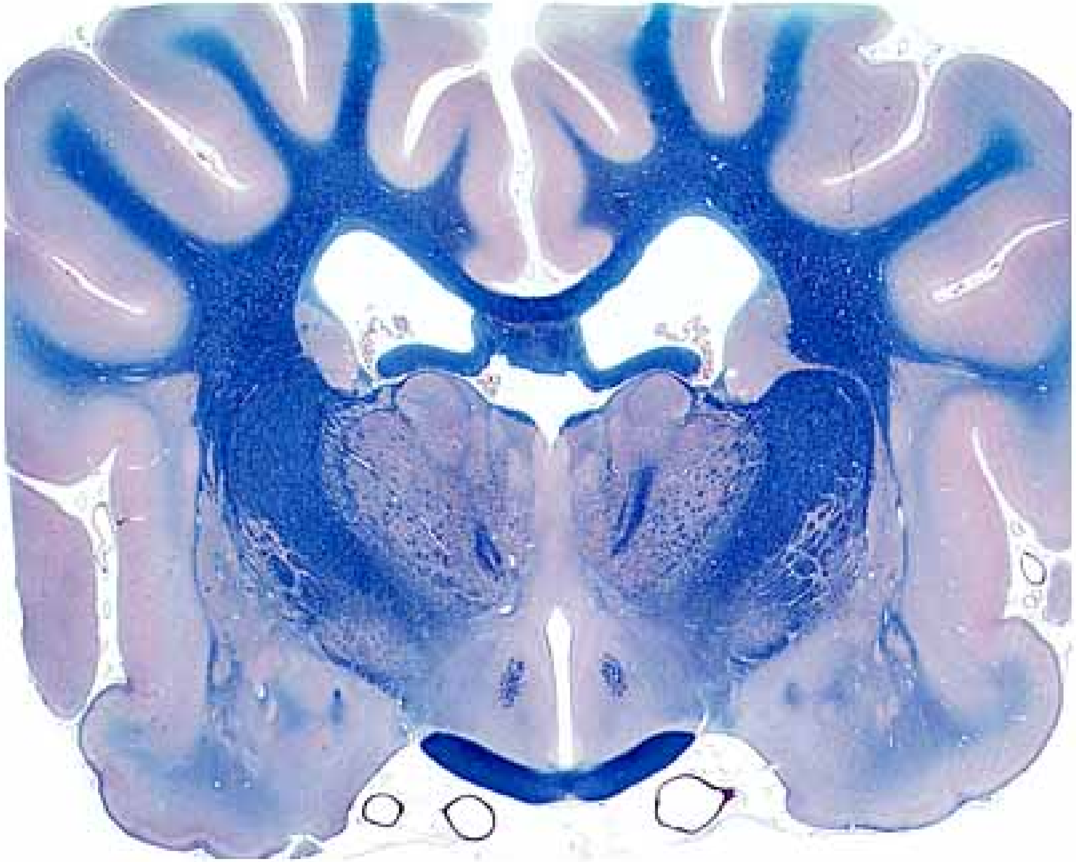
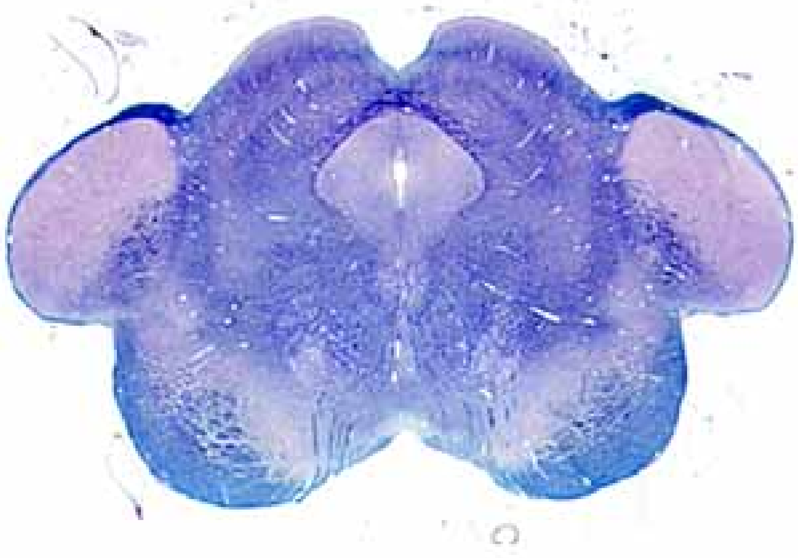
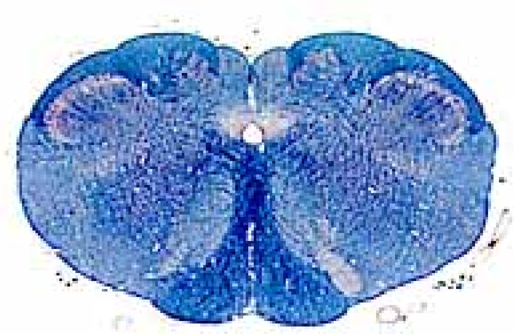
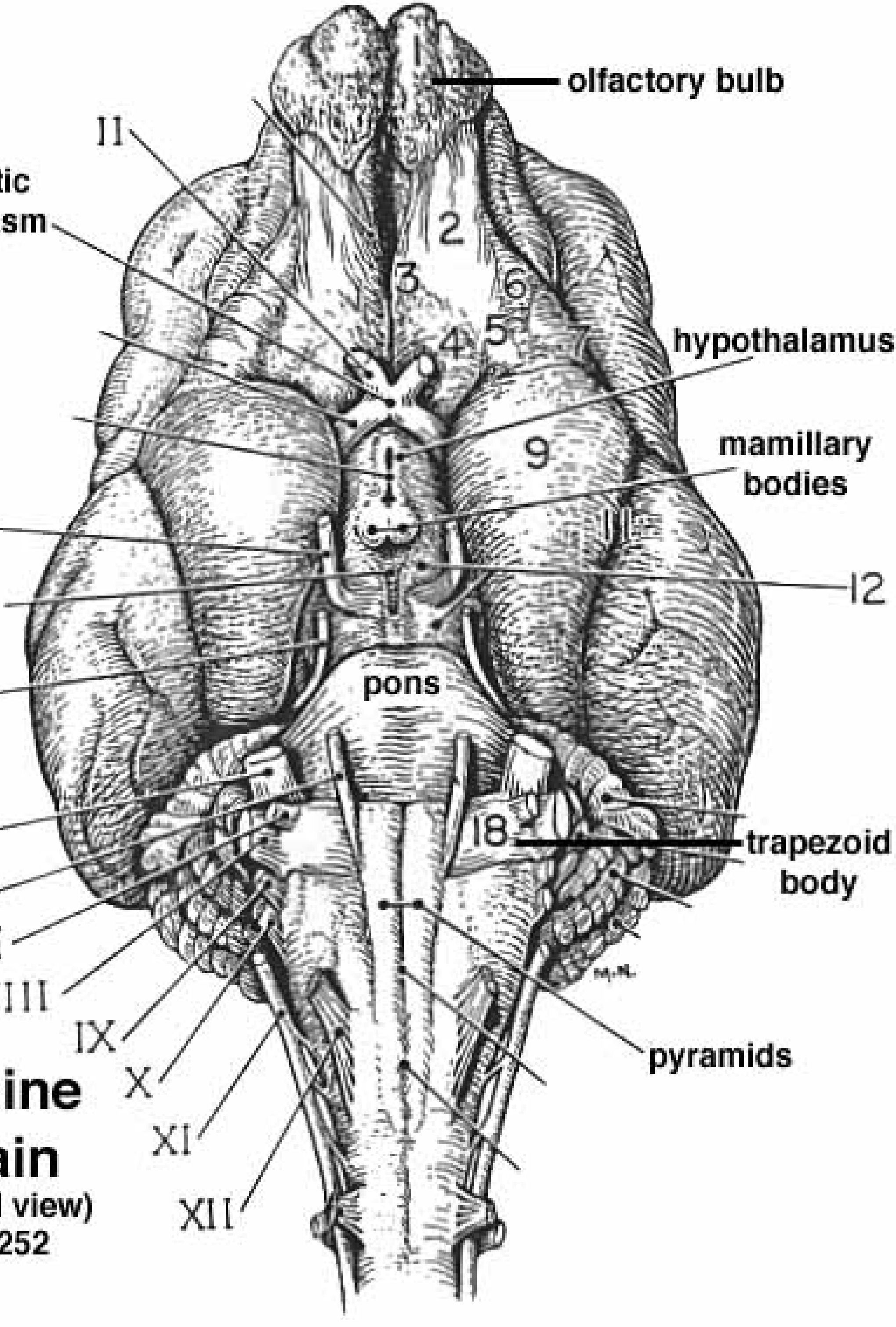
Alzheimer's Disease

PET Imaging

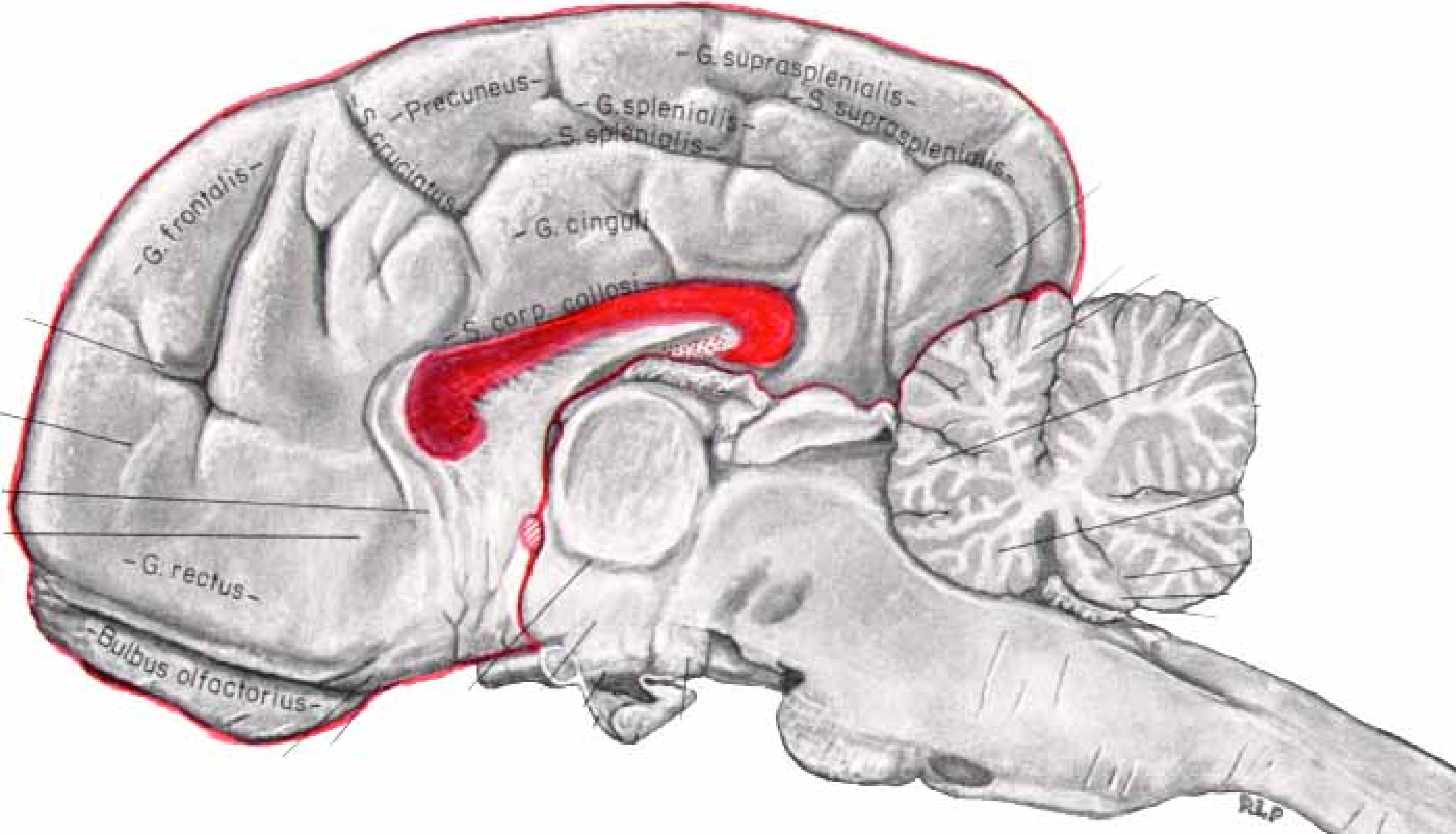








Canine Brain
(ventral view)
Fig. 252


G. suprasplenialis
Precuneus
G. splenialis
S. suprasplenialis
S. splenialis
S. cruciatus
G. frontalis
G. cinguli
S. corp. callosi
G. rectus
Bulbus olfactorius