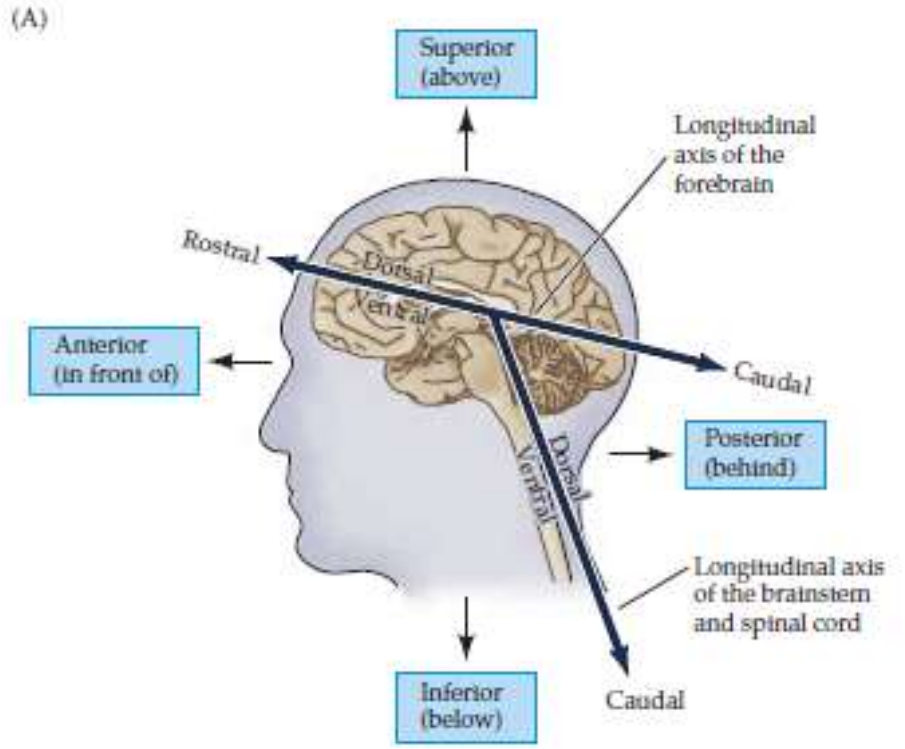
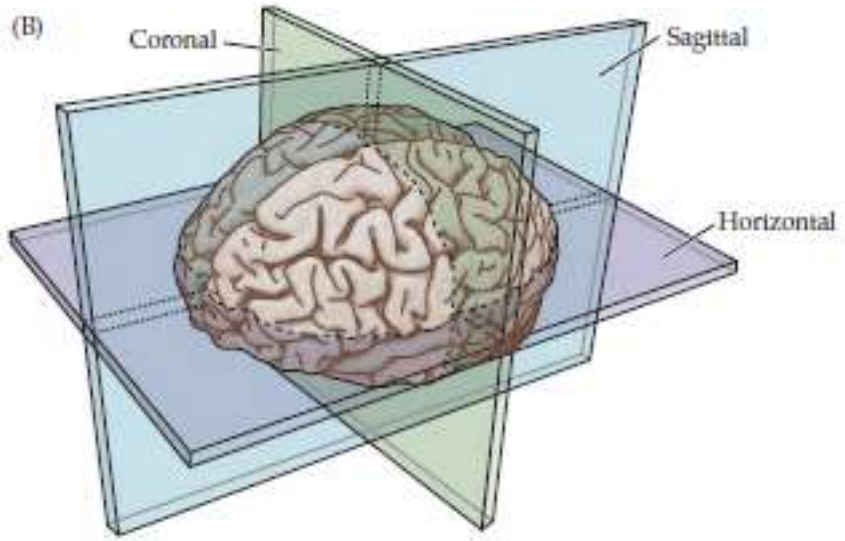
Introduction to Brain and Neuroscience (BM 1060)

Cognitive Neuroscience, Neurology, Systems Neuroscience

Directions in the brain





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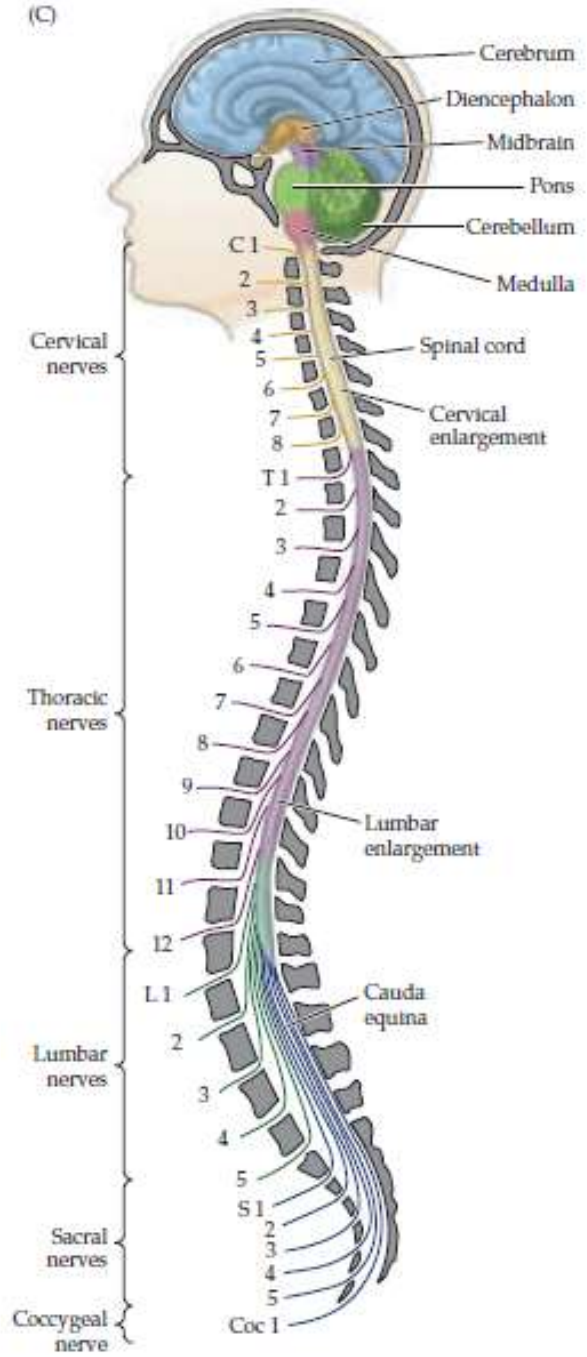
Brain and Spinal cord



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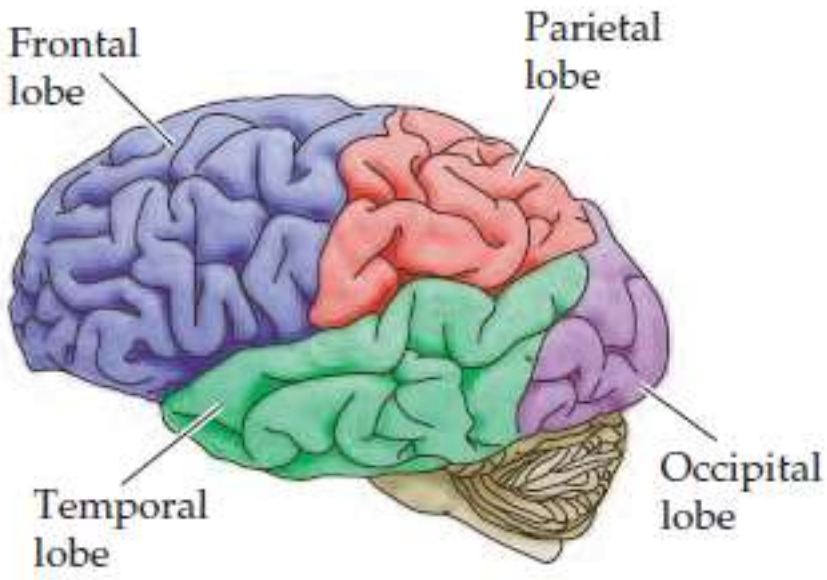
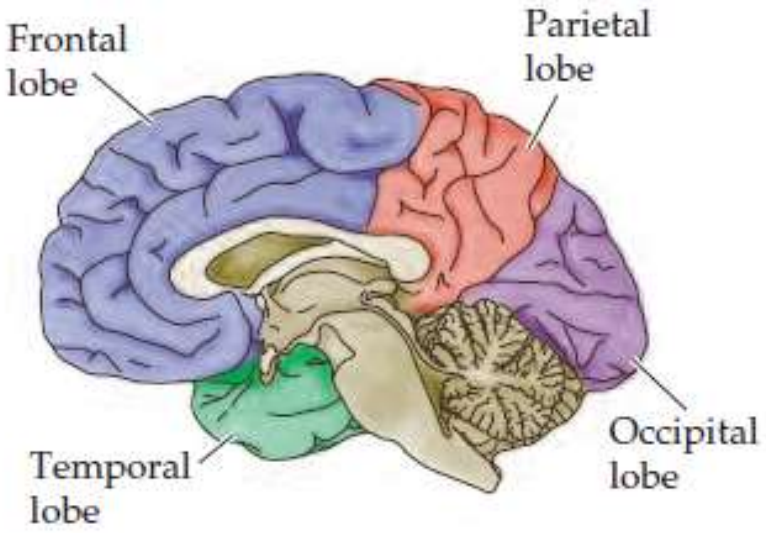
The 4 main lobes

Cerebral surface : Lateral view



Mid Sagittal Plane



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Sulcus and Gyrus

Sulcus : valleys e.g central sulcus

Gyrus : plateaus, hills, e.g. precentral , postcentral gyrii

Fissure : e.g. Longitudinal , sylvian

Dorsal and Ventral views

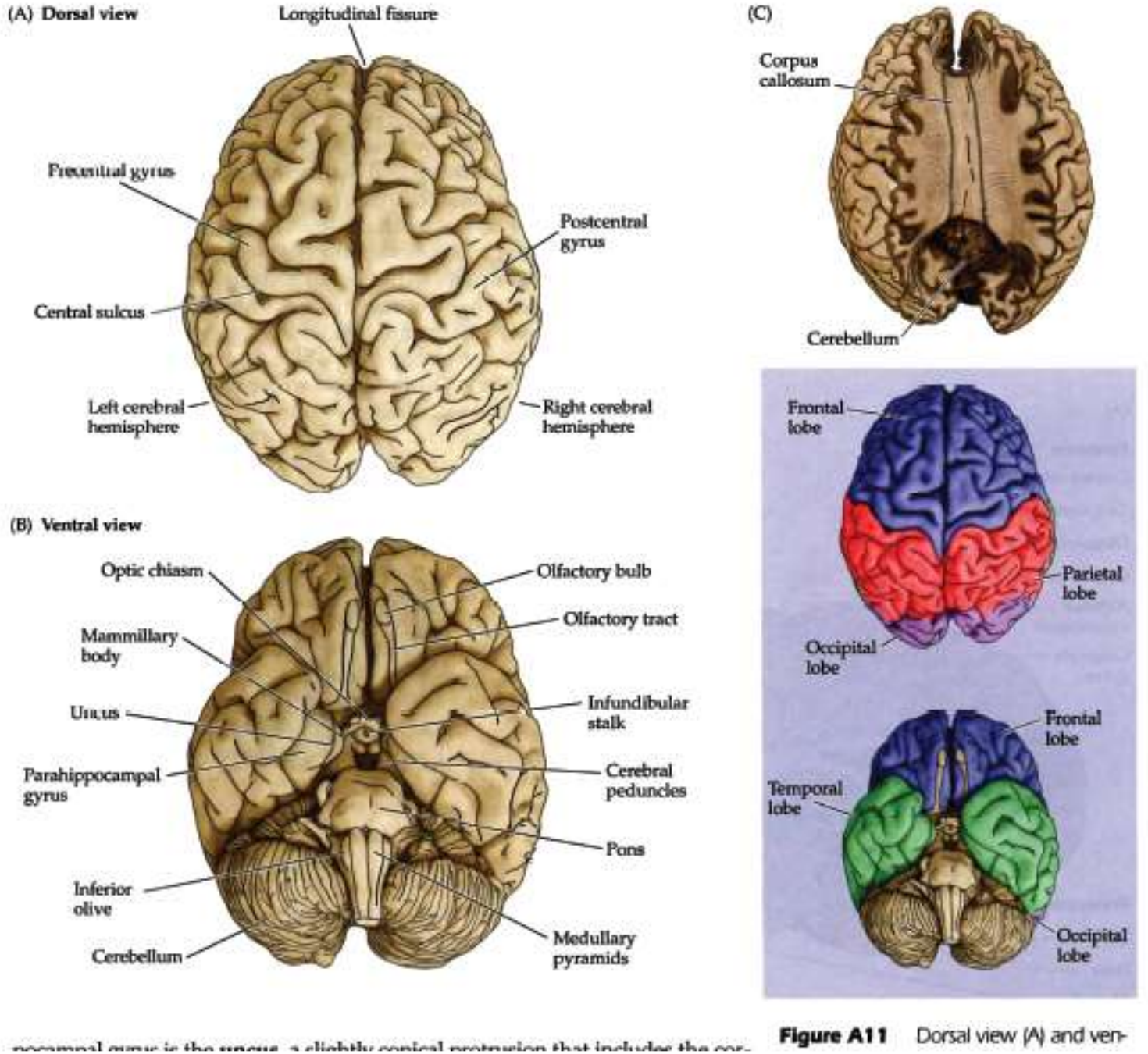

Figure A11 Dorsal view (A) and ven-

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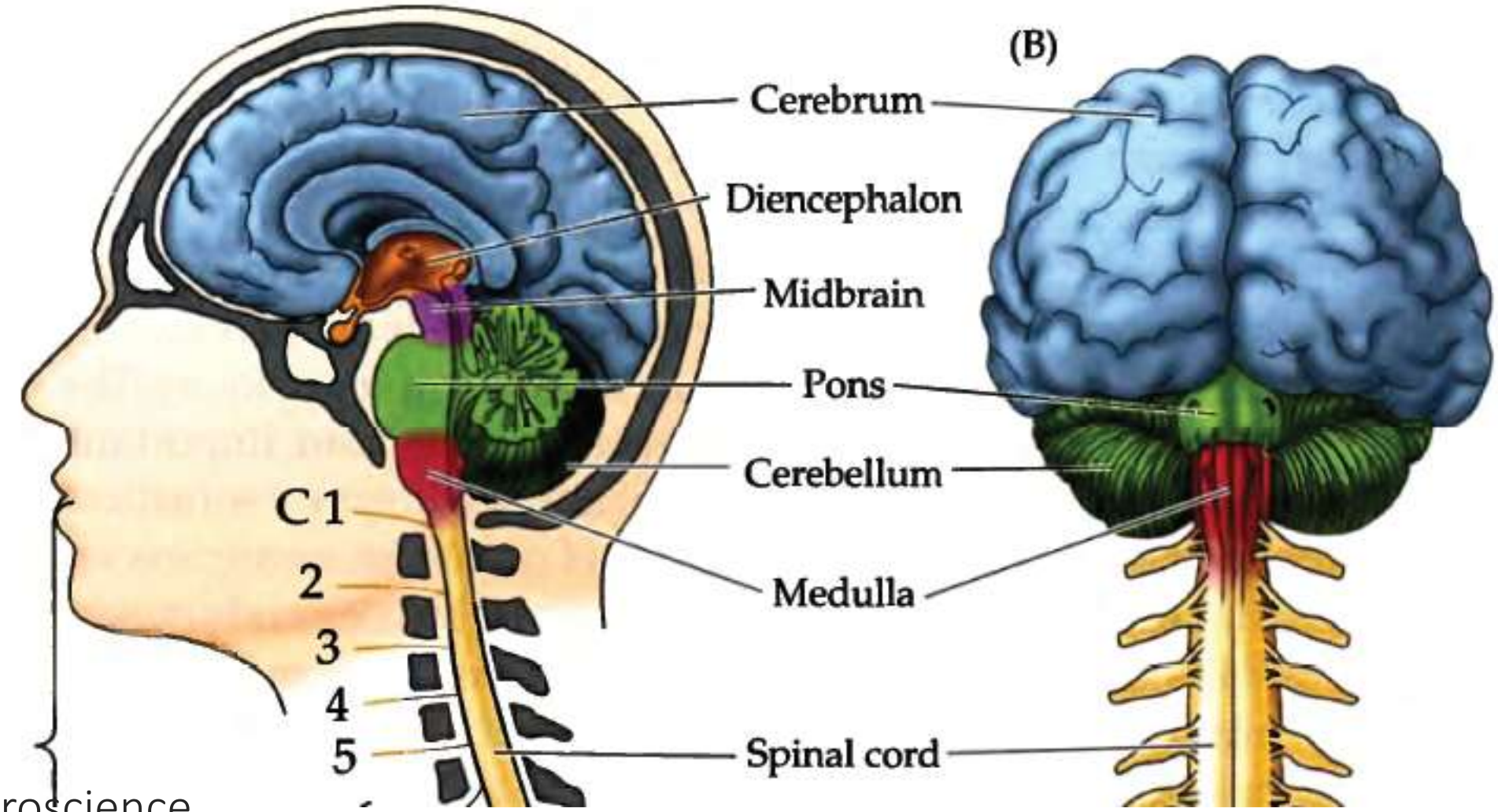

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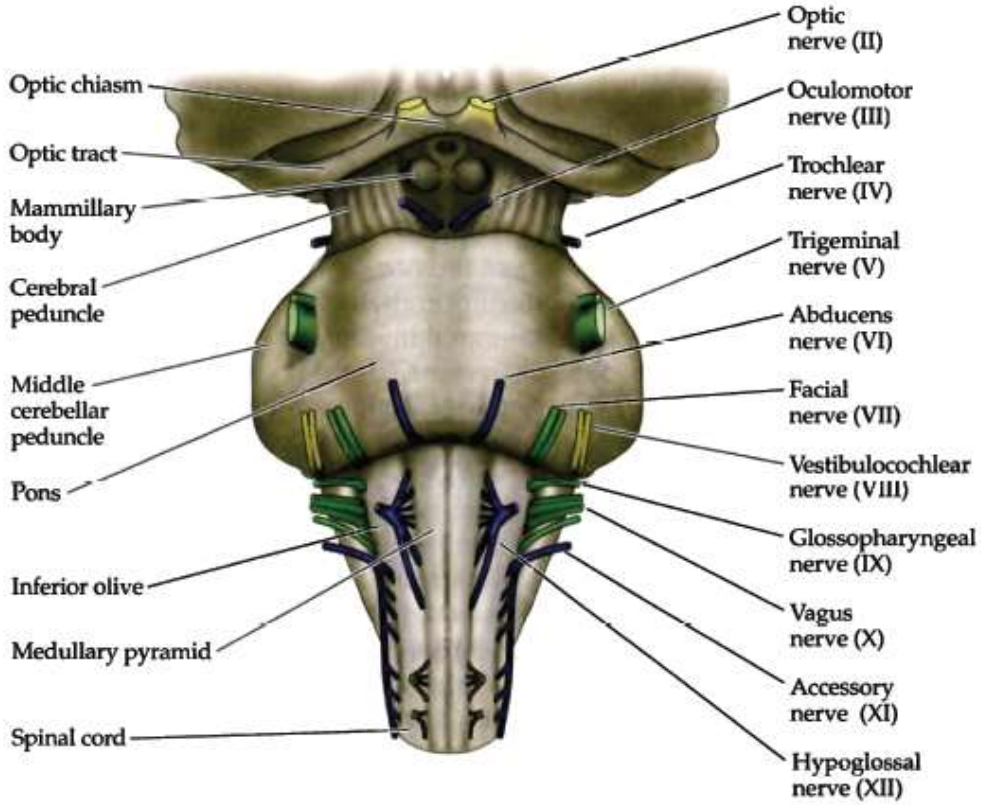
Brainstem & Cranial nerves



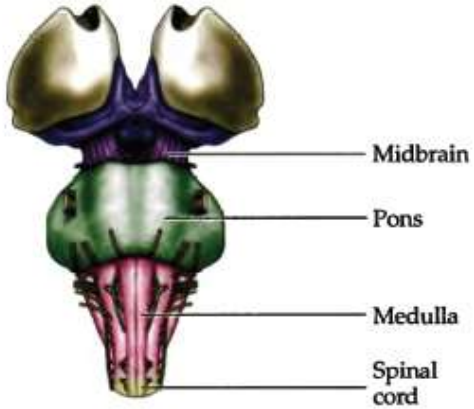


Figure A7 At left is a ventral view of the brainstem showing the locations of the cranial nerves as they enter or exit the midbrain, pons, and medulla. Nerves that are exclusively sensory are indicated in yellow, motor nerves are in blue, and mixed sensory/motor nerves are in green. At right, the territories included in each of the brainstem subdivisions (midbrain, pons, and medulla) are indicated.

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TABLE A2 The Cranial Nerves and Their Primary Functions

Cranial nerve	Name	Sensory and/or motor	Major function
I	Olfactory nerve	Sensory	Sense of smell
II	Optic nerve	Sensory	Vision
III	Oculomotor nerve	Motor	Eye movements; papillary constriction and accommodation; muscles of eyelid
IV	Trochlear nerve	Motor	Eye movements
V	Trigeminal nerve	Sensory and motor	Somatic sensation from face, mouth, cornea; muscles of mastication
VI	Abducens nerve	Motor	Eye movements
VII	Facial nerve	Sensory and motor	Controls the muscles of facial expression; taste from anterior tongue; lacrimal and salivary glands
VIII	Vestibulocochlear (auditory) nerve	Sensory	Hearing; sense of balance
IX	Glossopharyngeal nerve	Sensory and motor	Sensation from pharynx; taste from posterior tongue; carotid baroreceptors
X	Vagus nerve	Sensory and motor	Autonomic functions of gut; sensation from pharynx; muscles of vocal cords; swallowing
XI	Spinal accessory nerve	Motor	Shoulder and neck muscles
XII	Hypoglossal nerve	Motor	Movements of tongue

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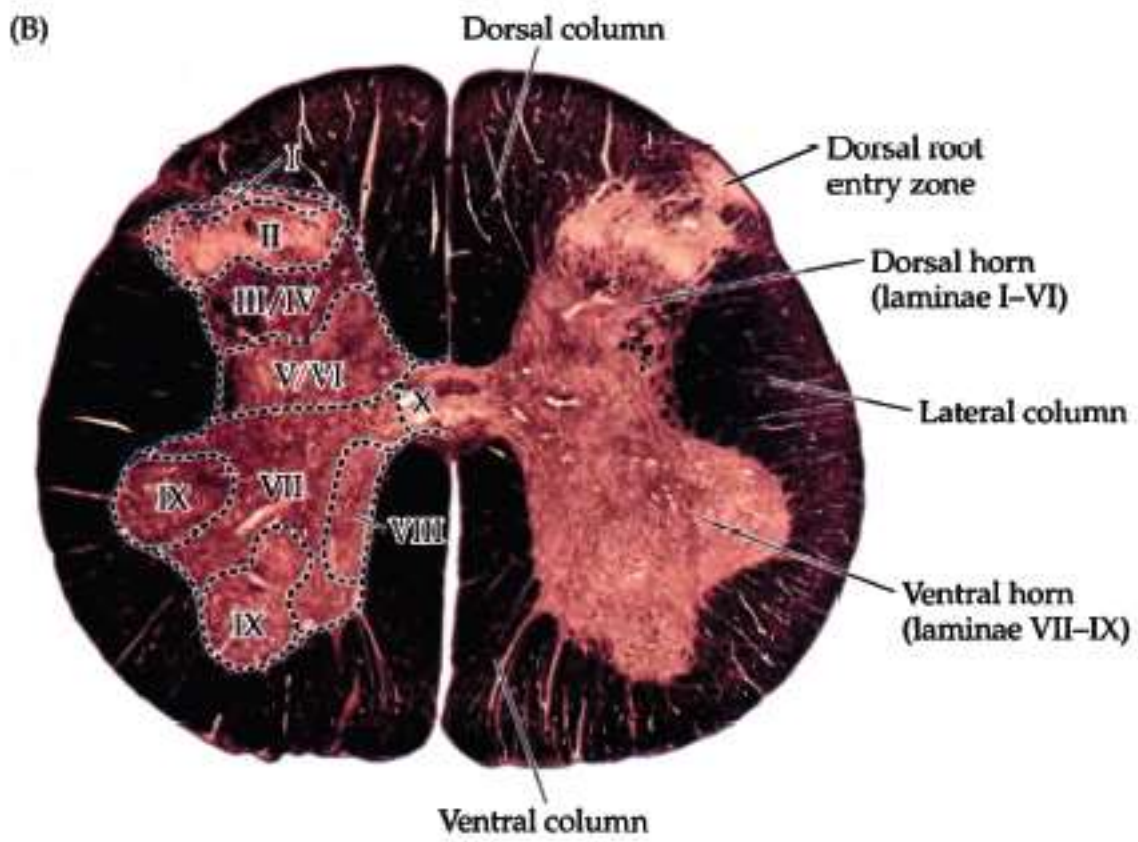
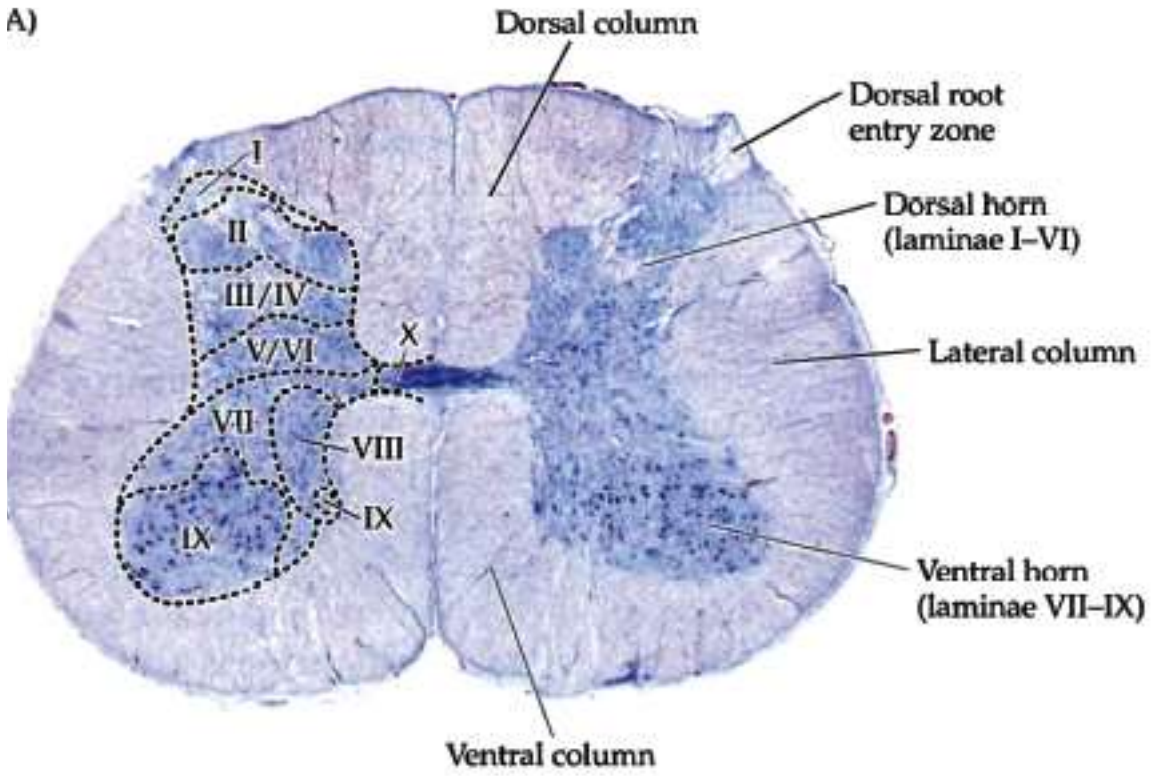
Spinal cord : cross section





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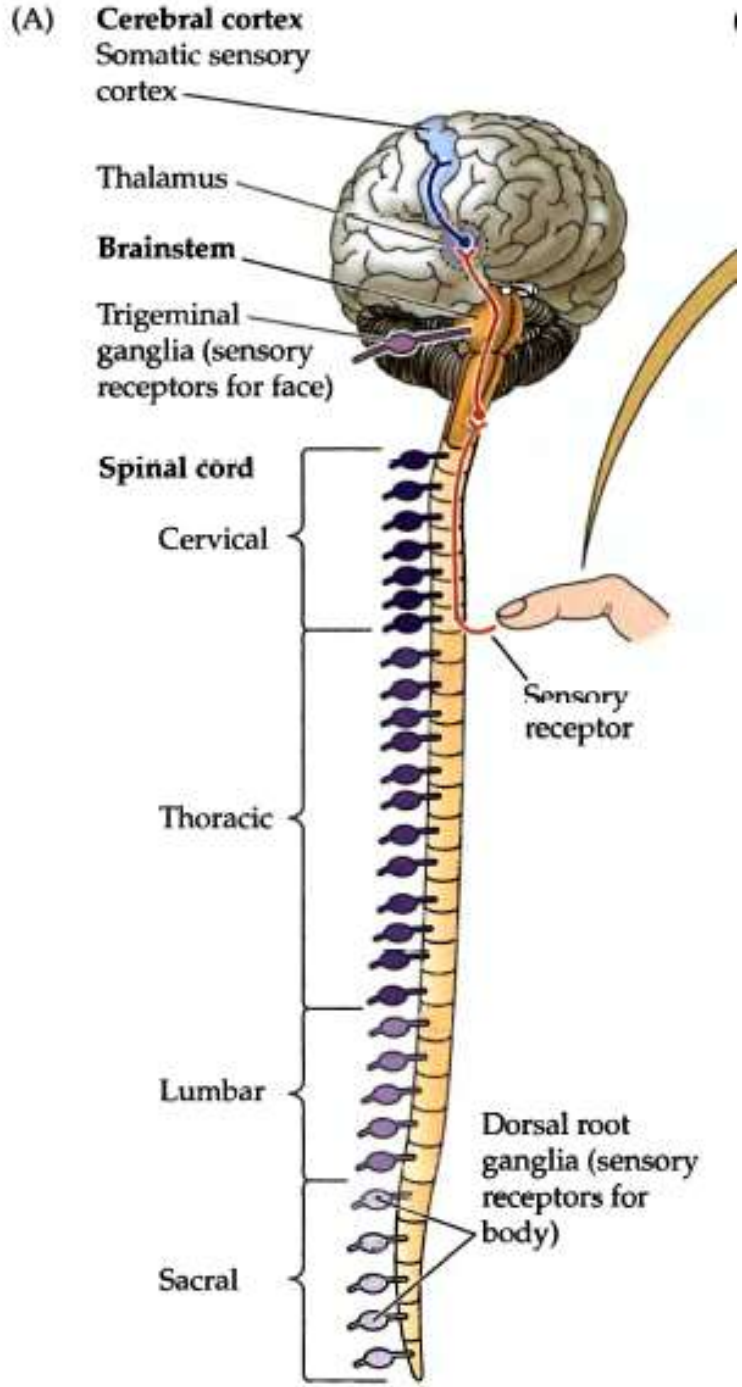
Action / perception divide

In brain (Frontal = action, parietal/occipital/temporal = perception)

In spinal cord (Ventral = Action, Dorsal = Perception)

Somatosensory system



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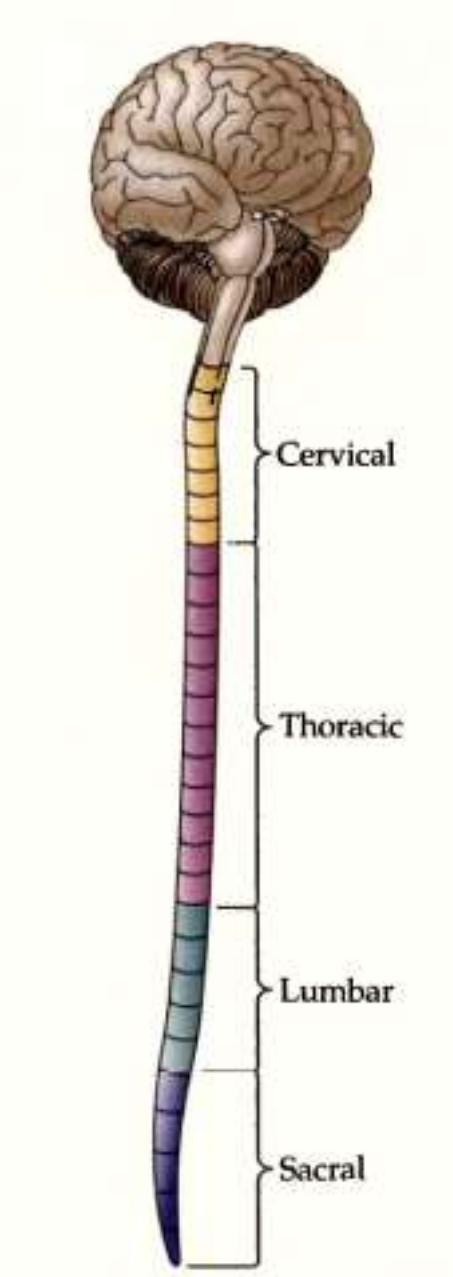
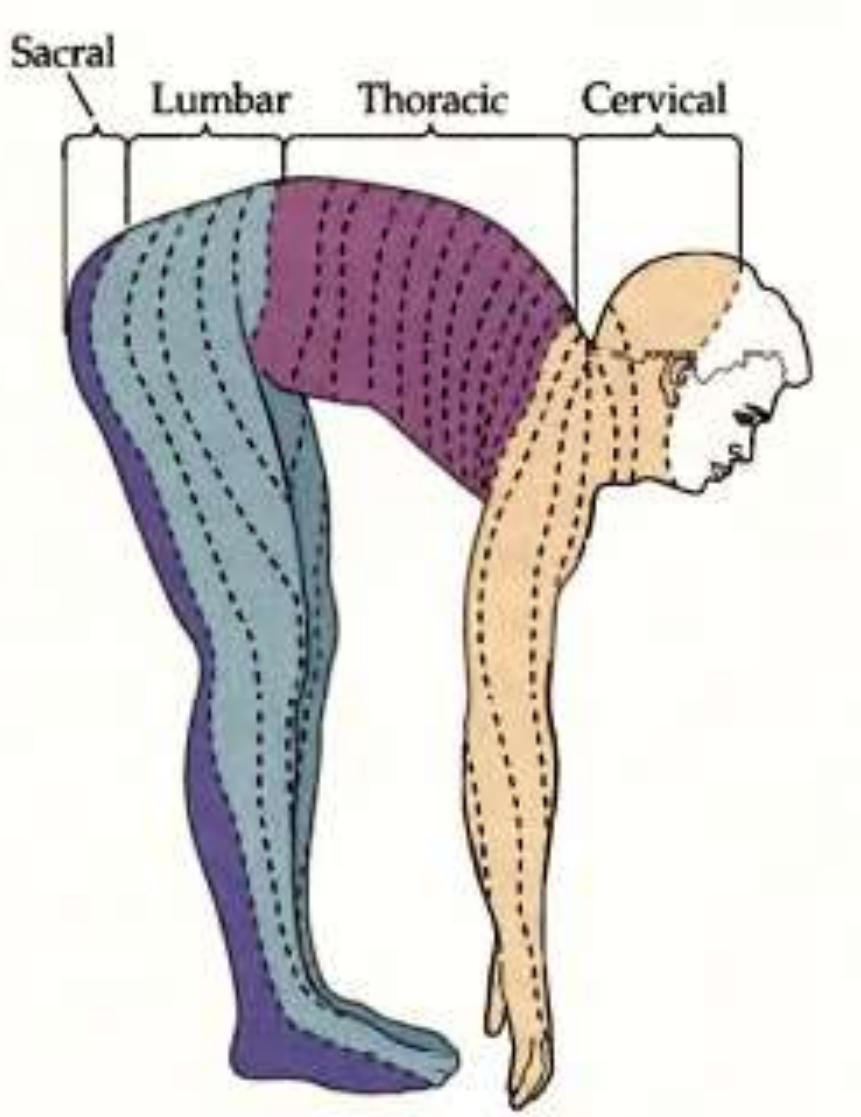
Spinal nerves and dermatomes





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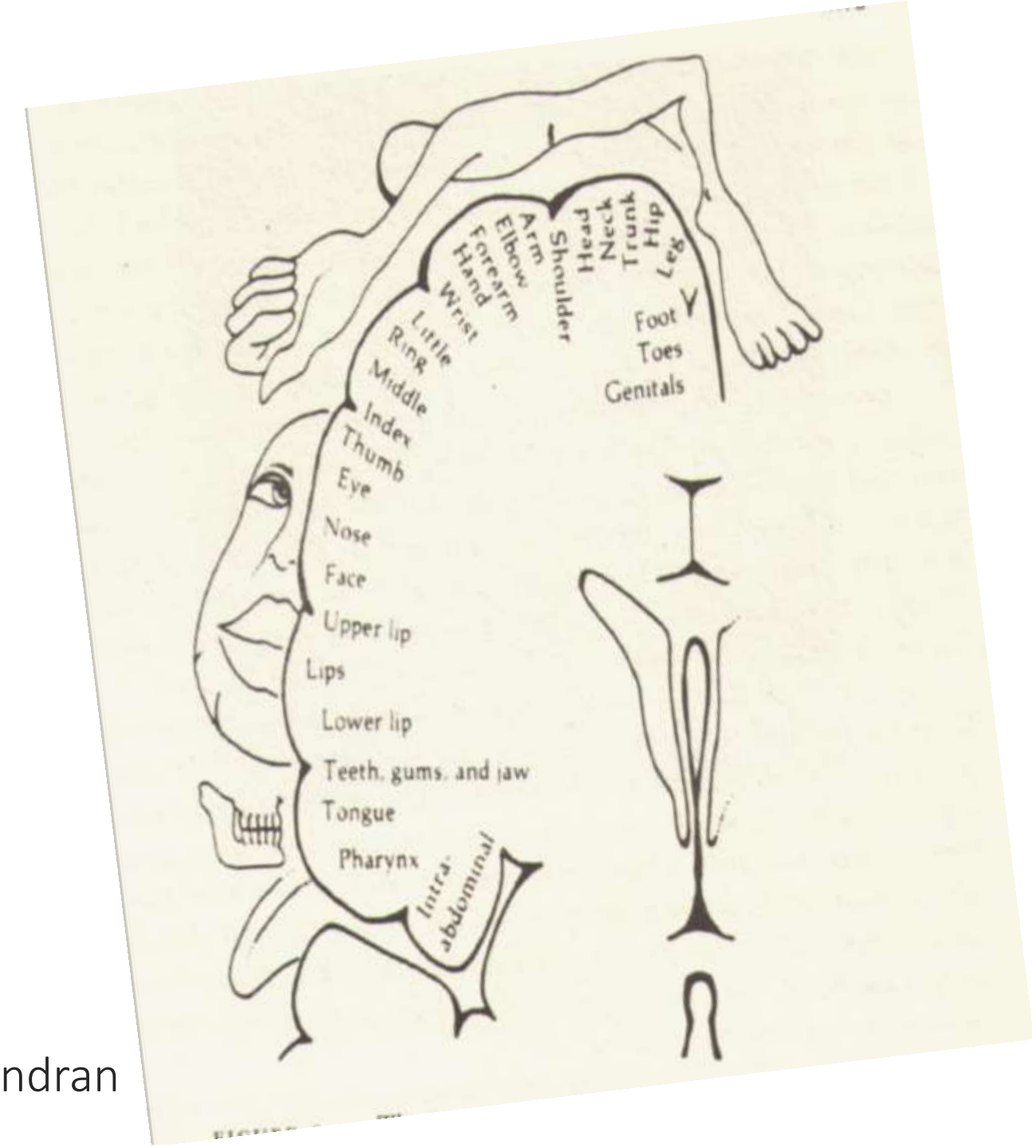
Penfield maps



Tell Tale brain : VS Ramachandran

Phantom limb phenomenon

War veterans with amputed limbs feel sensation in the amputed (absent) limbs !

Touching the face or some other body part gives a feeling of touching the phantom limb! (only when blindfolded)

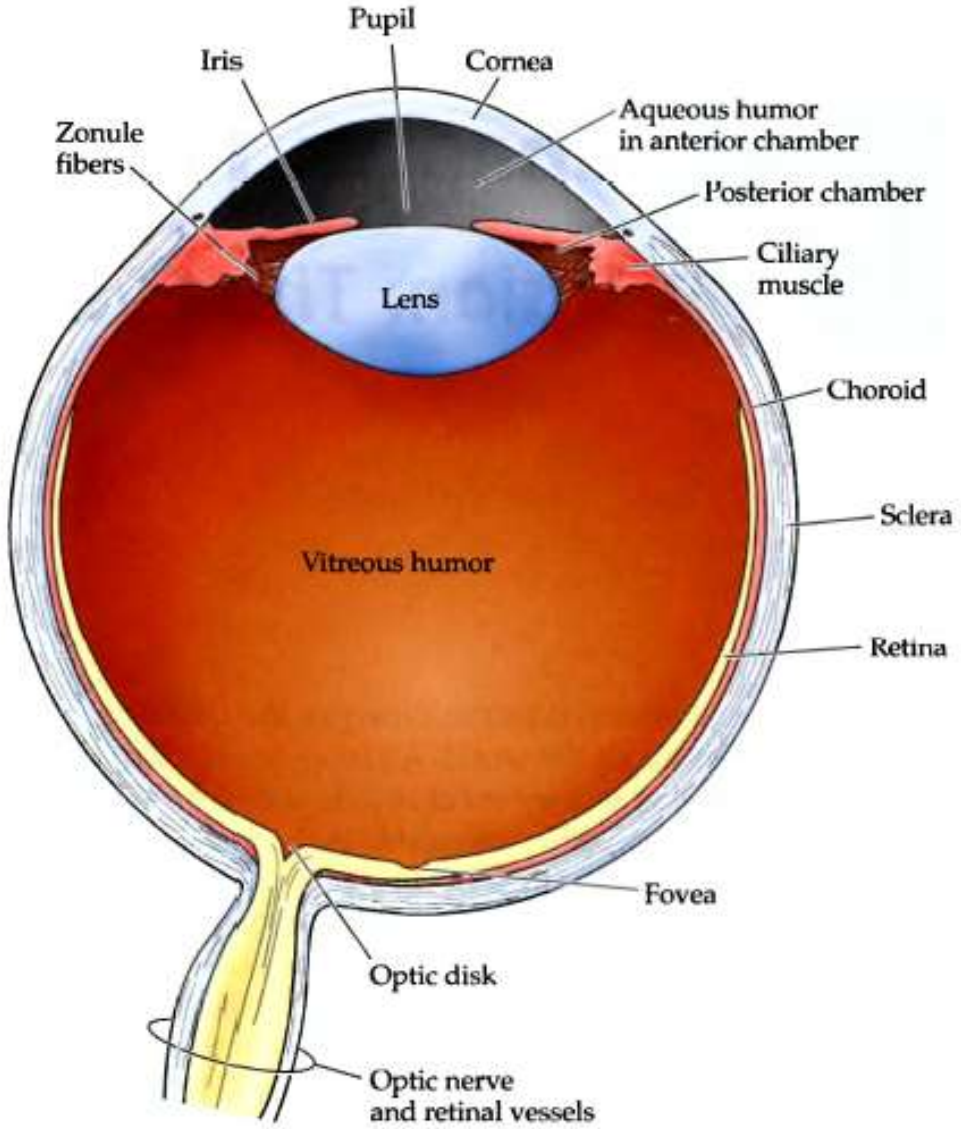
Phantom limb literature

- Series of papers on reorganization of somatosensory maps by Florence, Neeraj Jain and Kaas around 1995
- Popular Neuroscience : VS Ramachandran ties the phenomenon of phantom limb with remapping of somatosensory cortex

Visual system

Eye and retina

- Light falls on retina
- 3 neuron chain in retina : rods/cones , bipolar cells (graded potentials), retinal ganglion cells (RGC) (action potentials)



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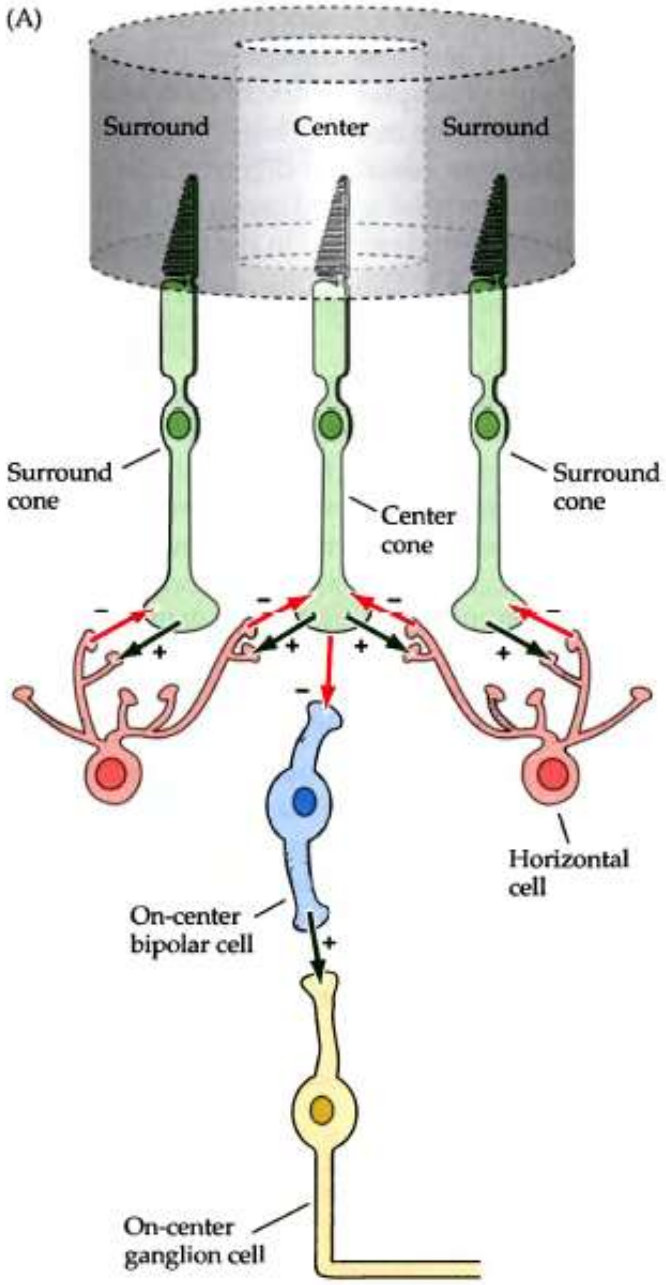
Centre-surround receptive fields

- RGC do not carry info on illumination, but difference in illumination of receptive field and surroundings
- centre surround field due to lateral inhibition from horizontal cells
- RGCs are of 2 types : on-centre or off-centre due to difference in receptor type



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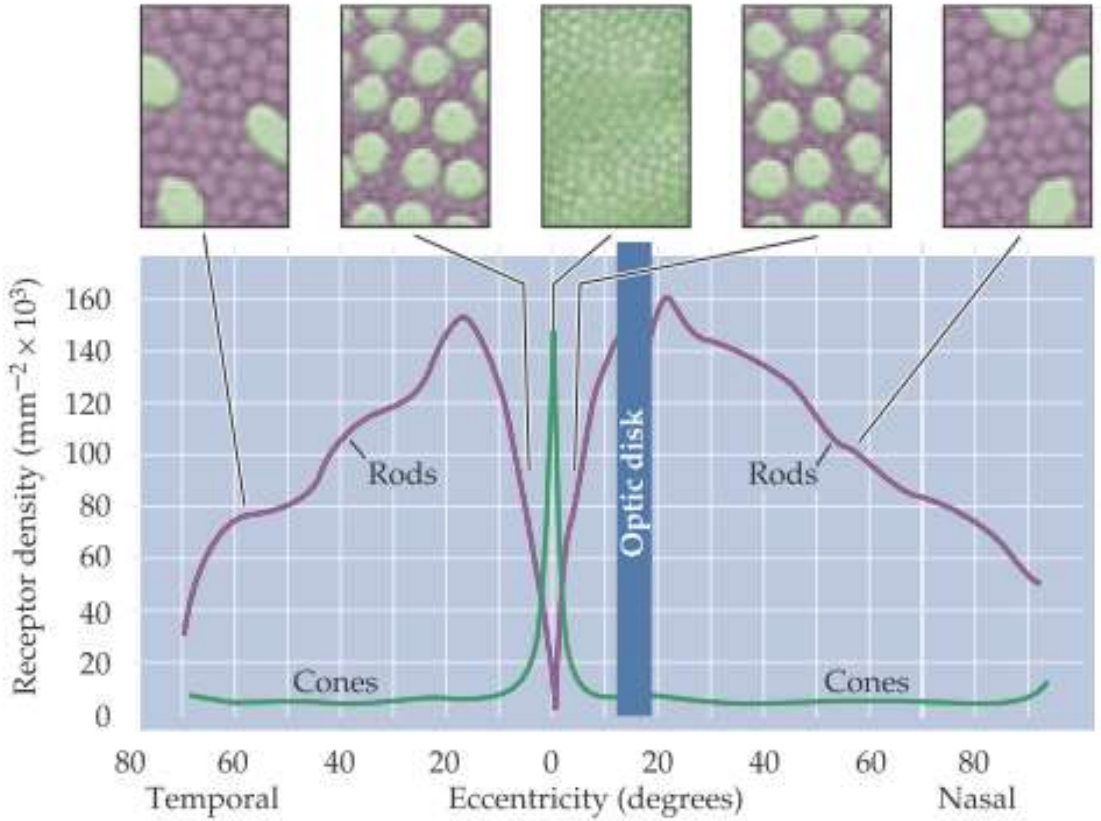
Distribution of rods and cones

Figure 10.10 Distribution of rods and cones in the human retina. Graph illustrates that cones are present at a low density throughout the retina, with a sharp peak in the center of the fovea. Conversely, rods are present at high density throughout most of the retina, with a sharp decline in the fovea. Boxes at top illustrate the appearance of face on sections through the outer segments of the photoreceptors at different eccentricities. The increased density of cones in the fovea is accompanied by a striking reduction in the diameter of their outer segments.



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Color vision

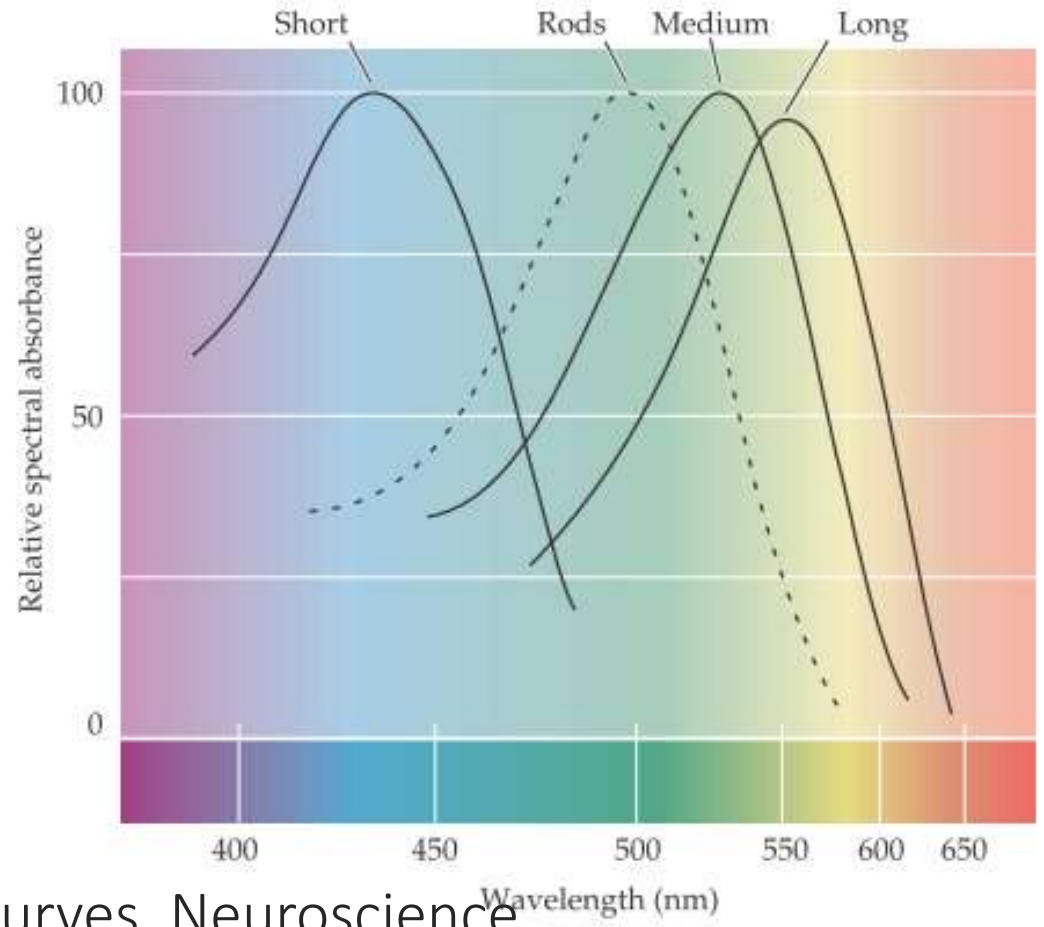

Figure 10.12 Color vision. The light absorption spectra of the four photopigments in the normal human retina. (Recall that light is defined as electromagnetic radiation having wavelengths between ~400 and 700 nm.) The solid curves indicate the three kinds of cone opsins; the dashed curve shows rod rhodopsin for comparison. Absorbance is defined as the log value of the intensity of incident light divided by intensity of transmitted light.

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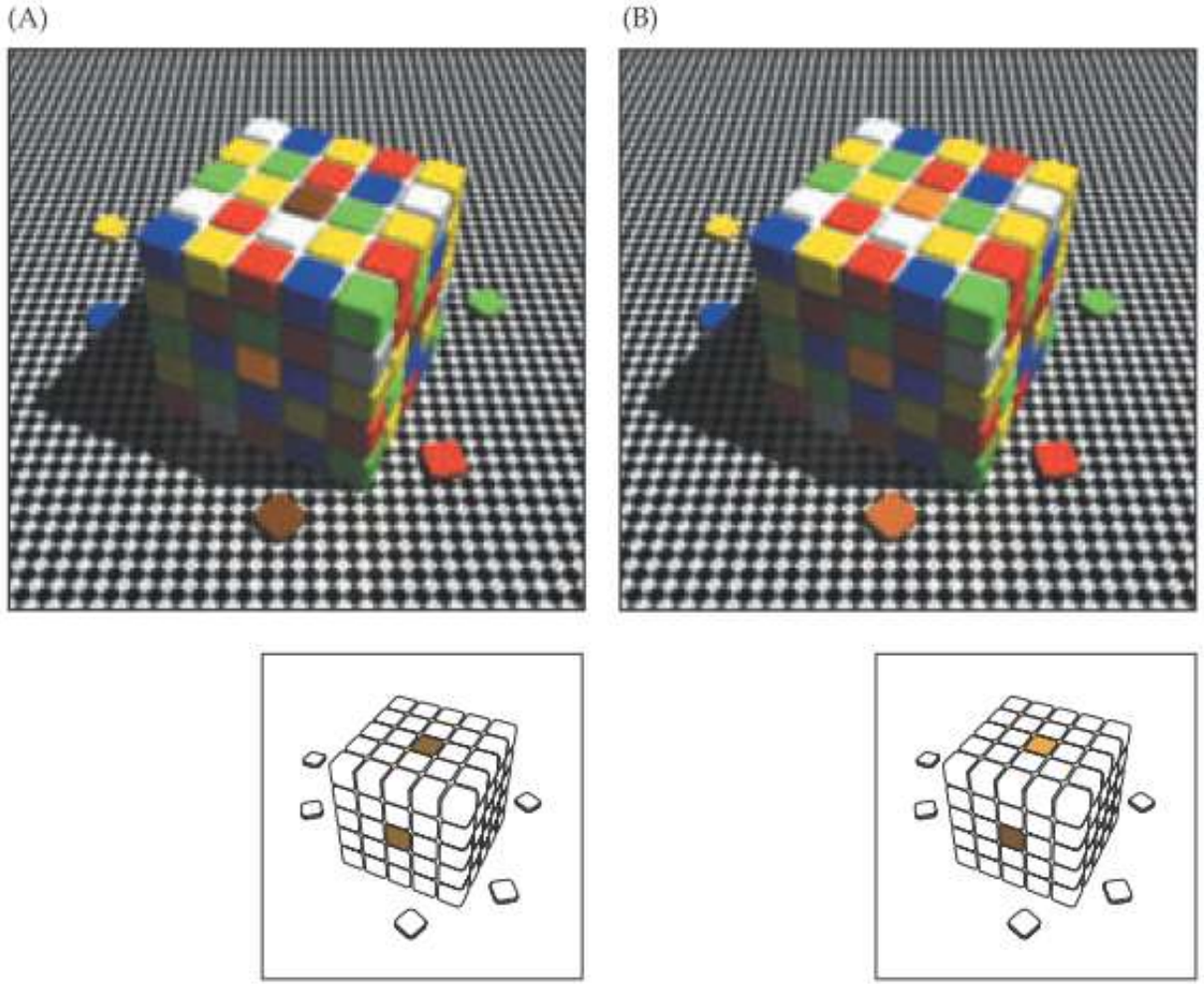
Context and color vision



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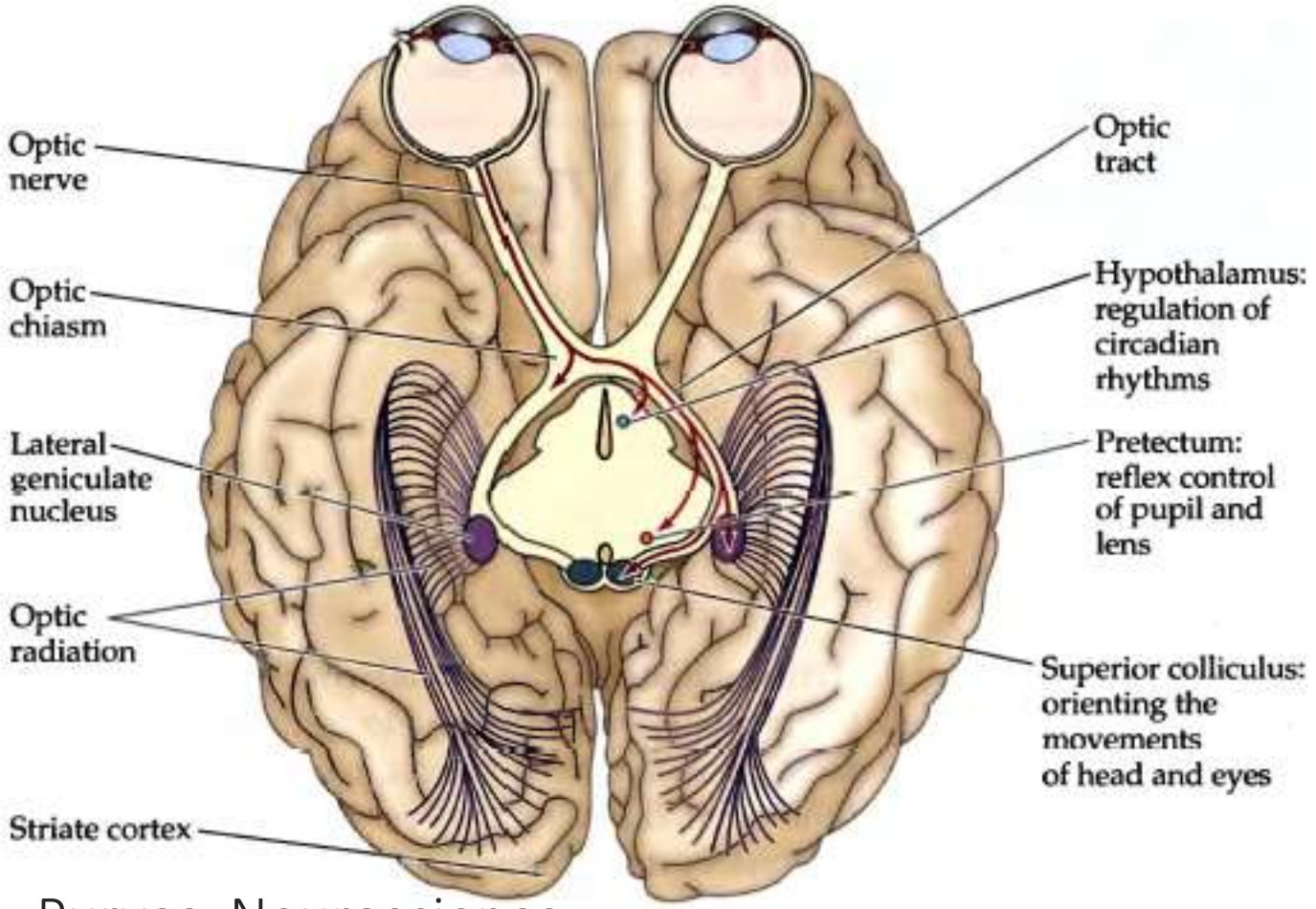
From retina to the visual cortex

- Pathways from two eyes converge at LGN at different layers
- Pathways actually mix at V1 , on the banks of the calcarine sulcus



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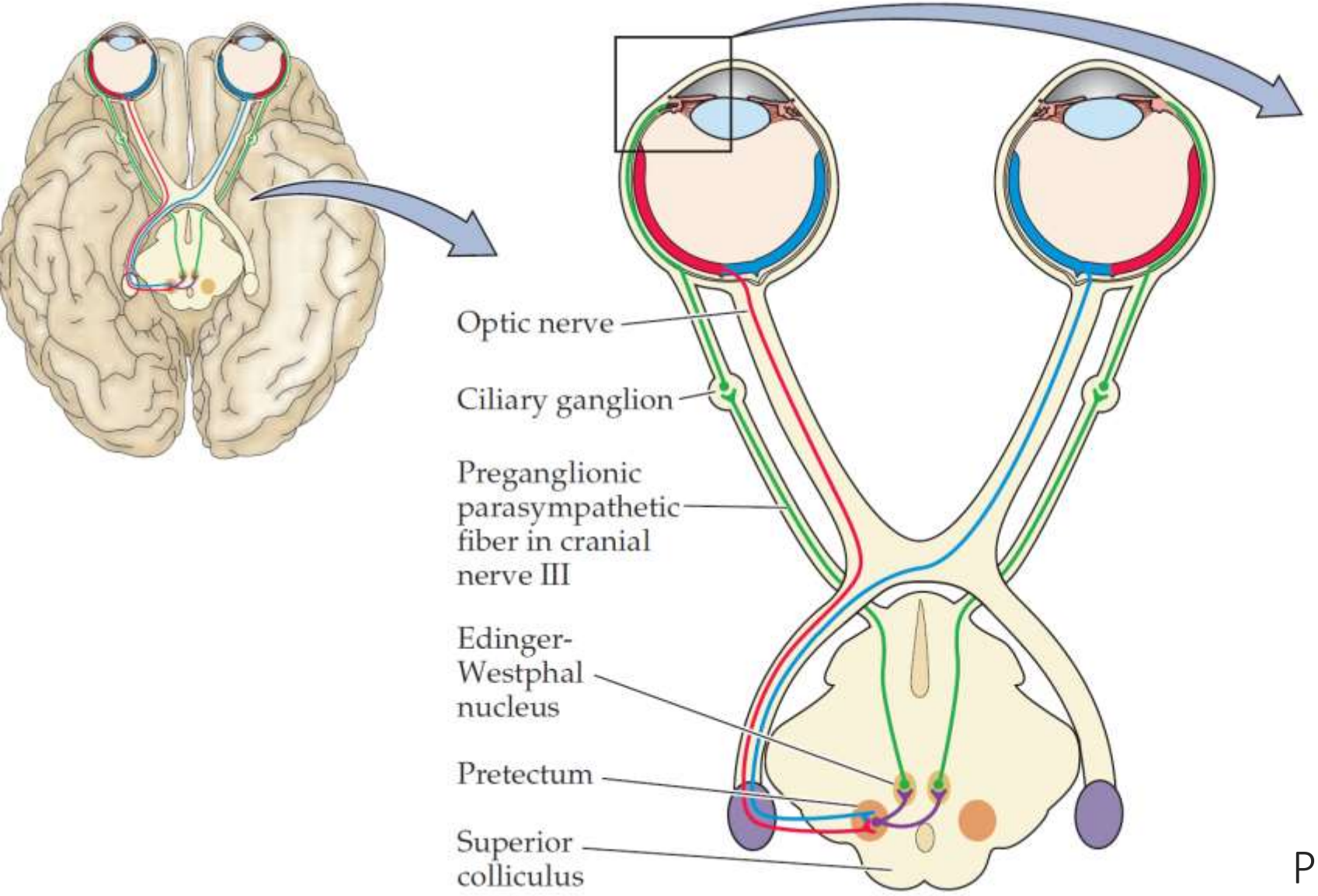
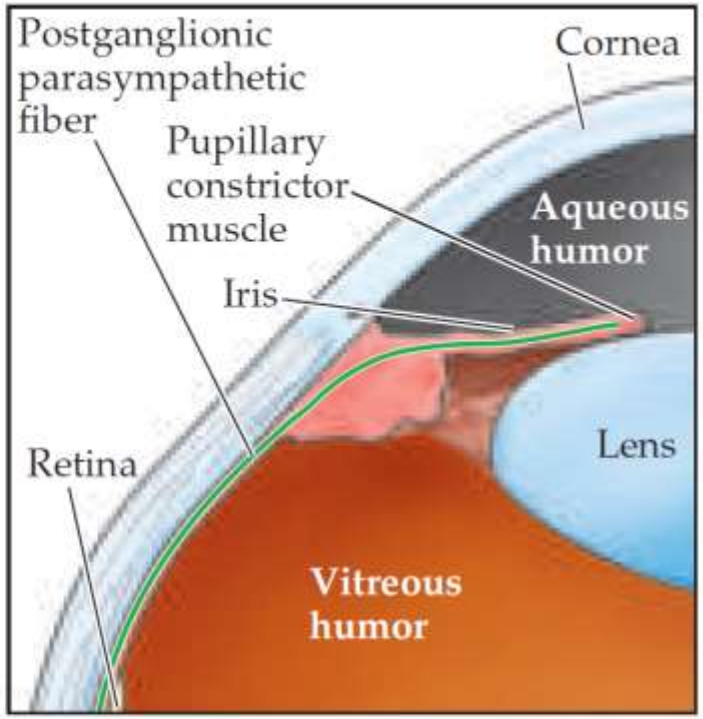
Pupillary reflex





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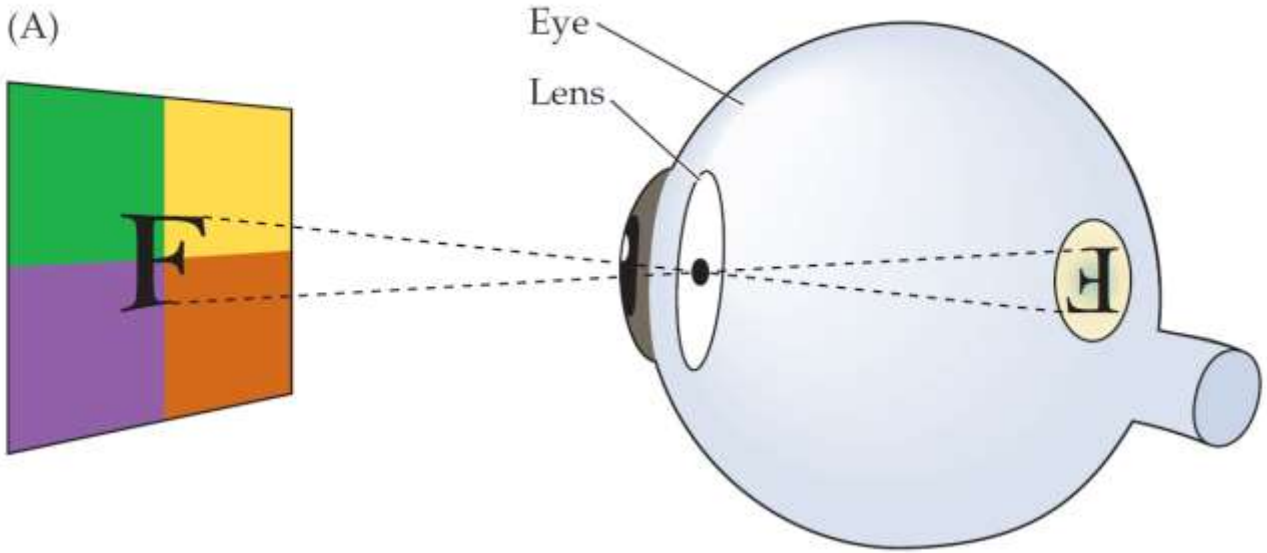
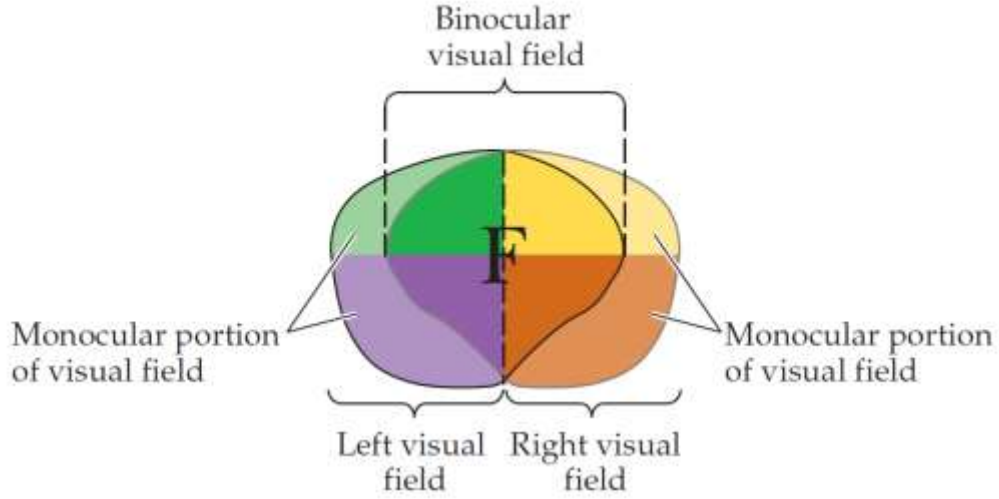
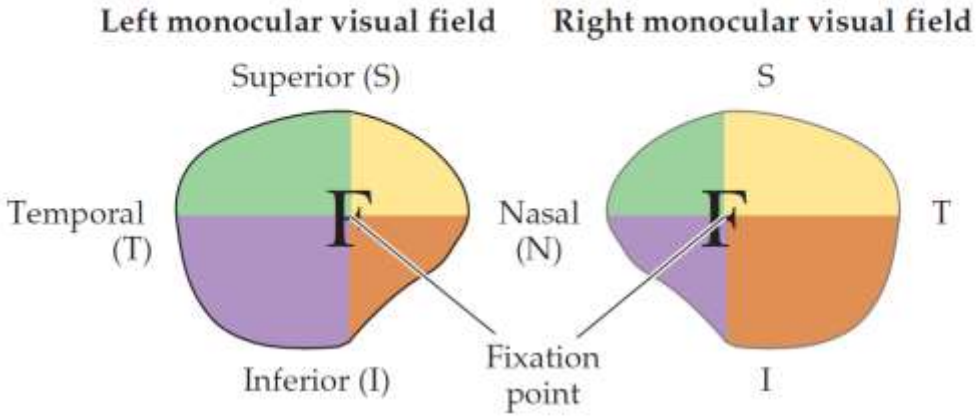
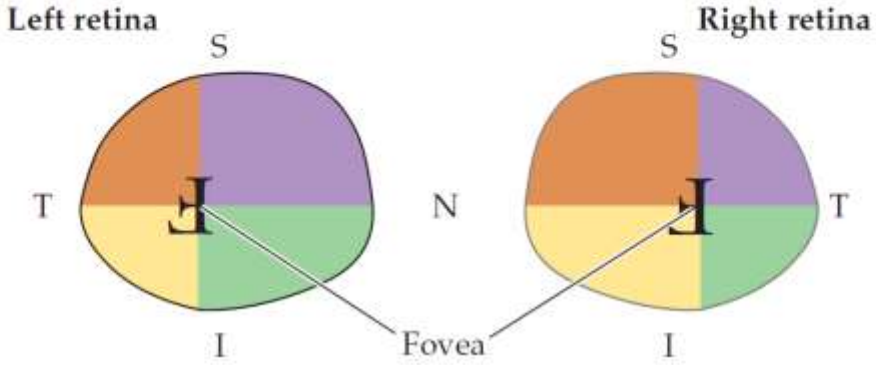
Visual field mapping on retina

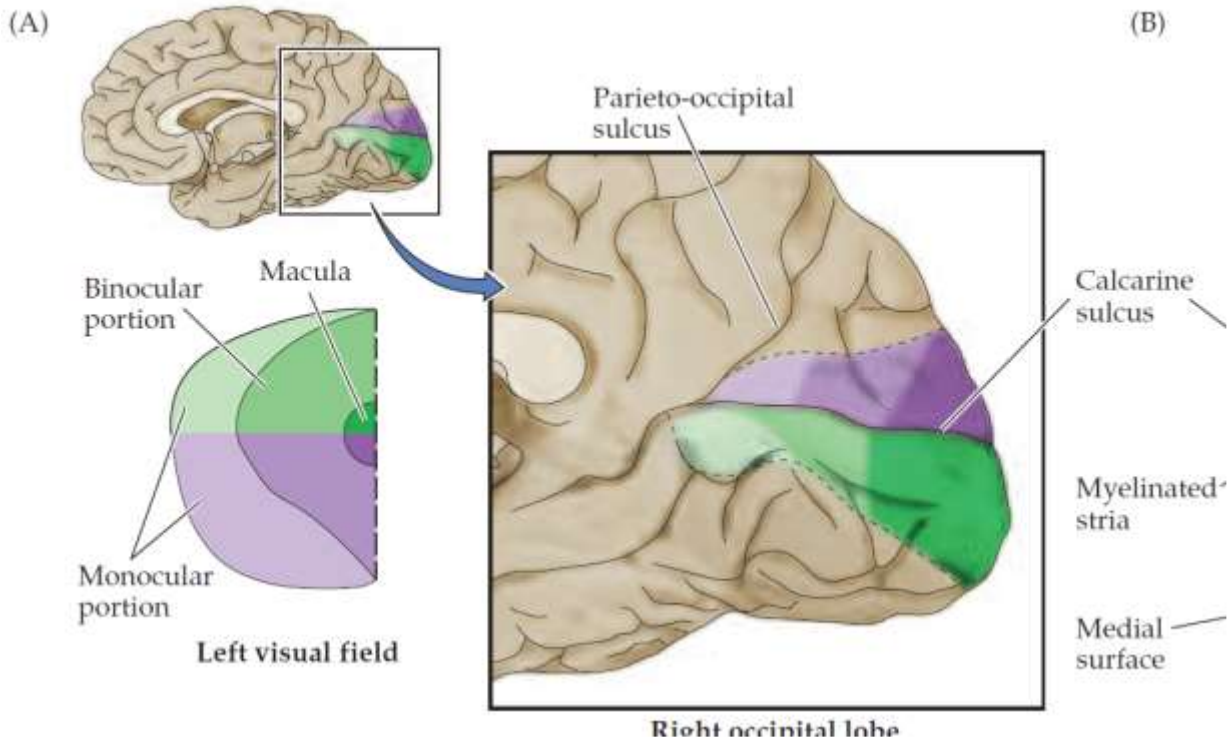


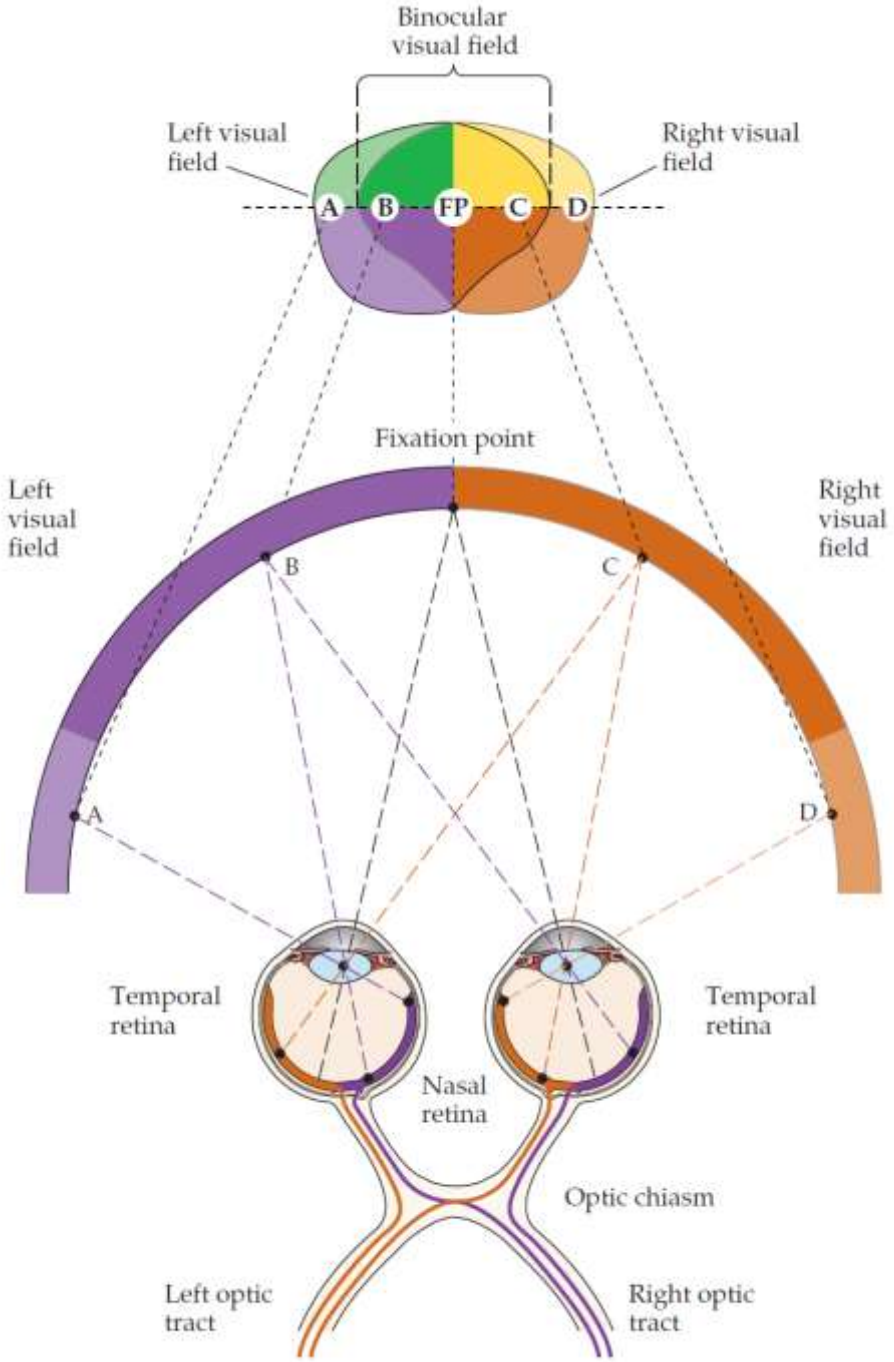






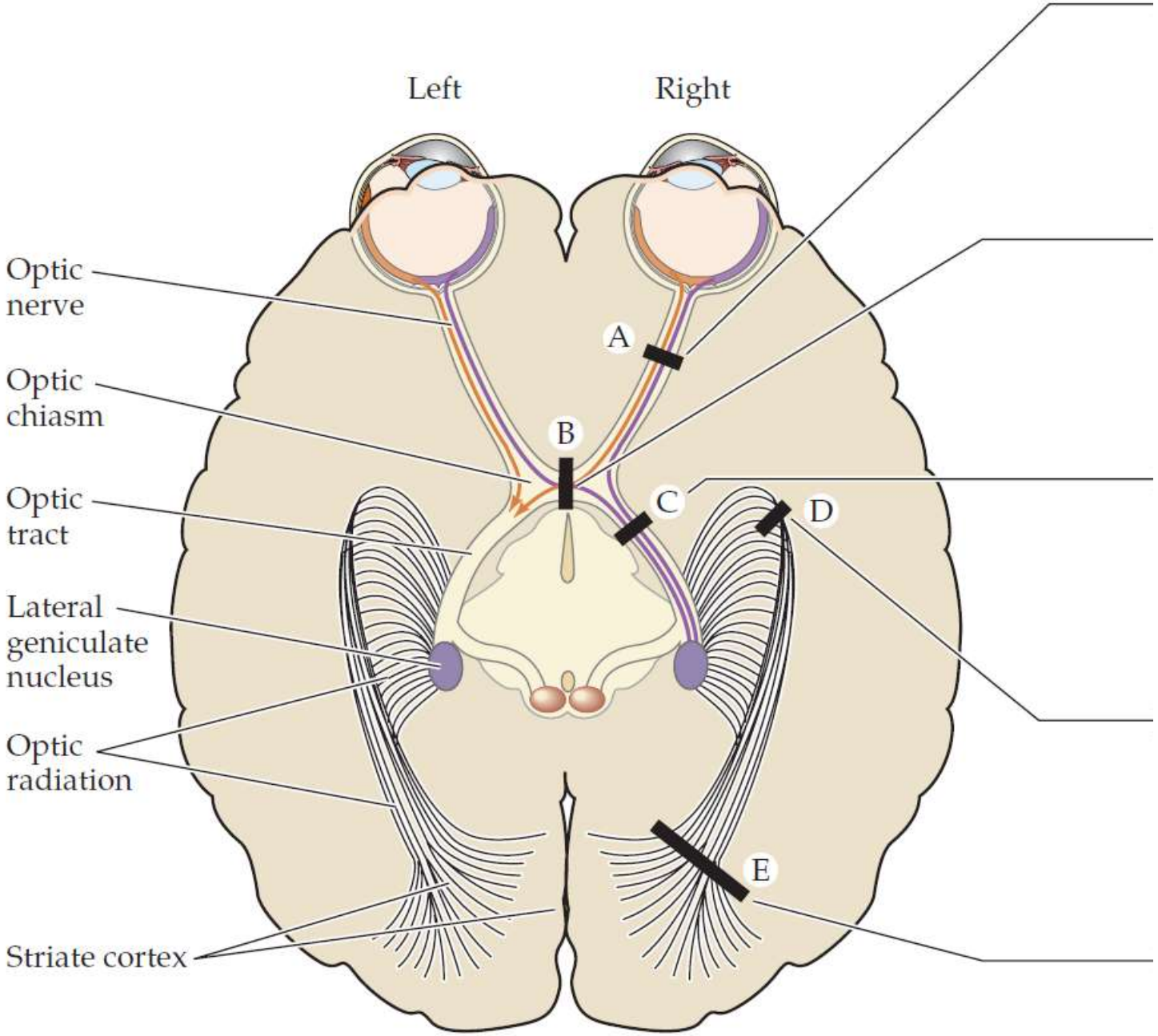
Visual field mapping to visual cortex





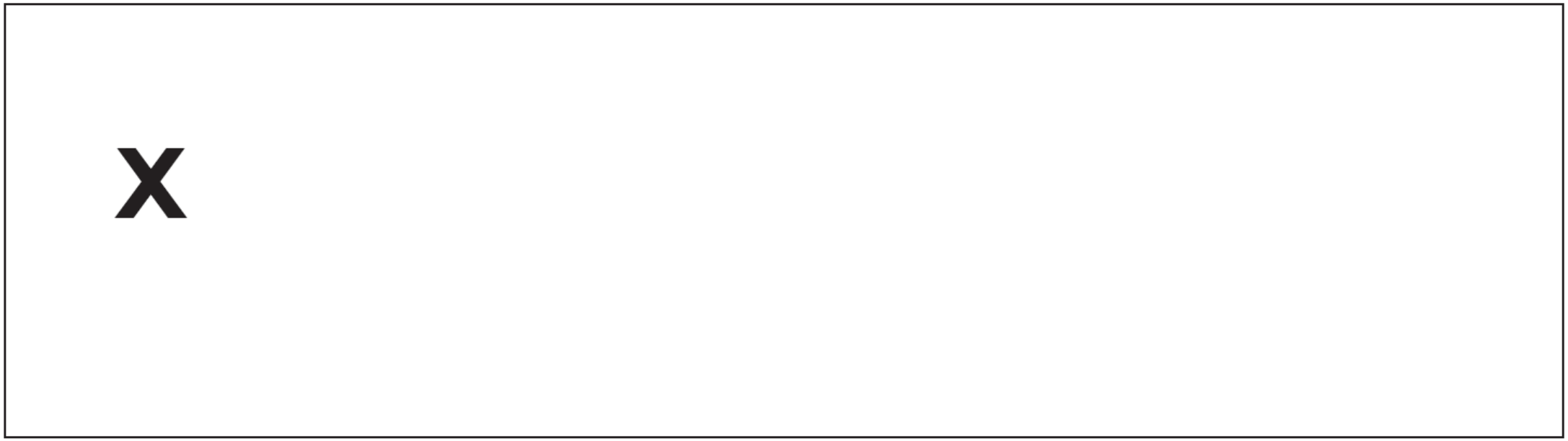
Visual Deficits

What kind of visual deficits are caused by damage in locations A-E ?



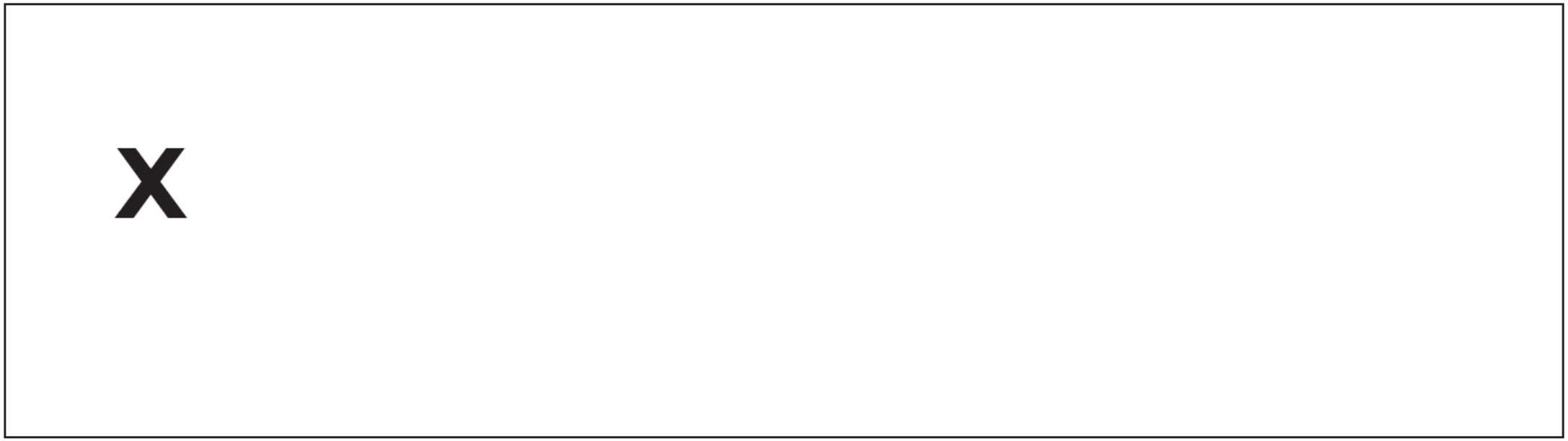
Blind spot !

- Move a vertical pencil from right to left, with left eye closed



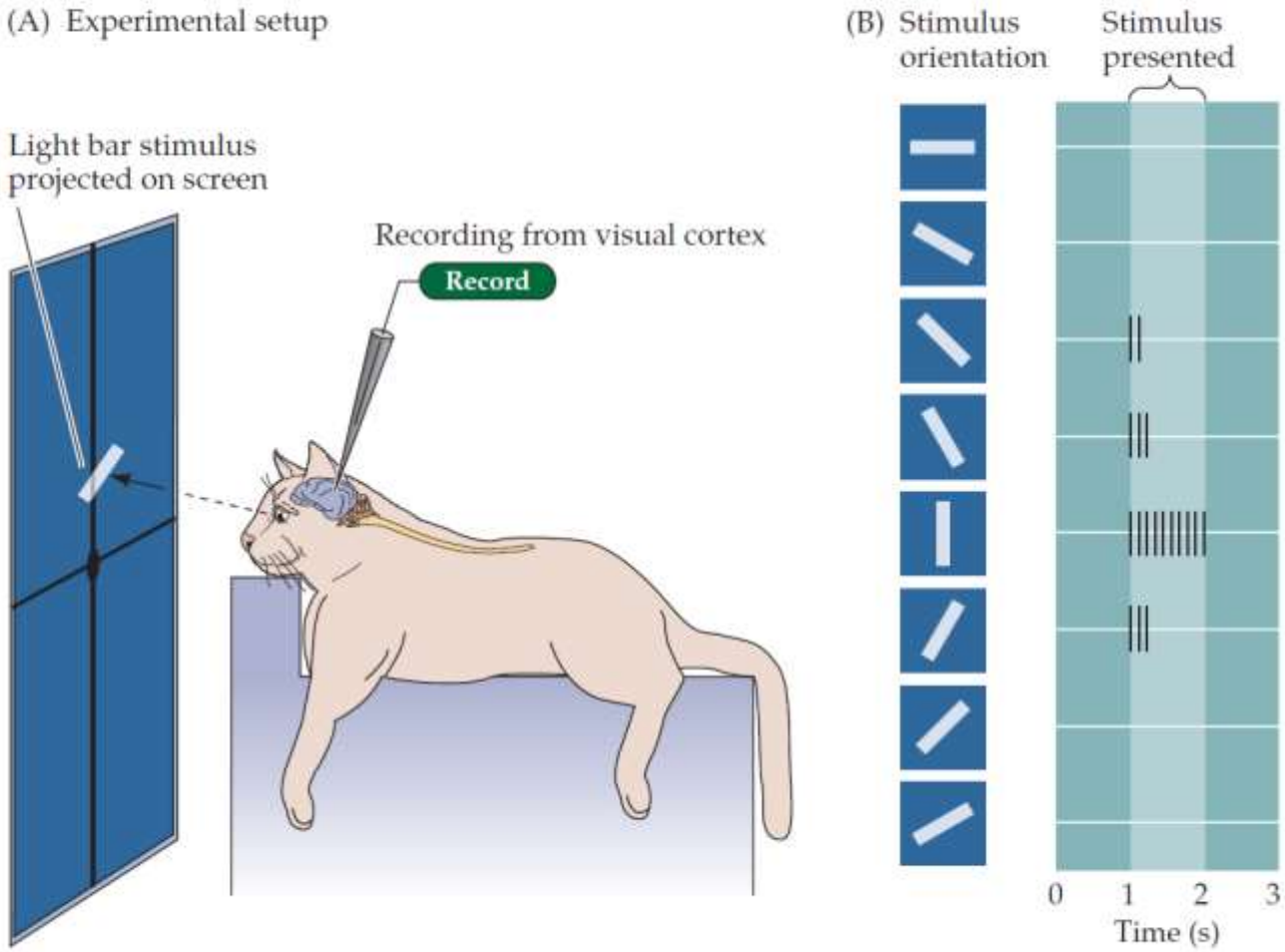
Blind spot !

- Do the same with pencil horizontal



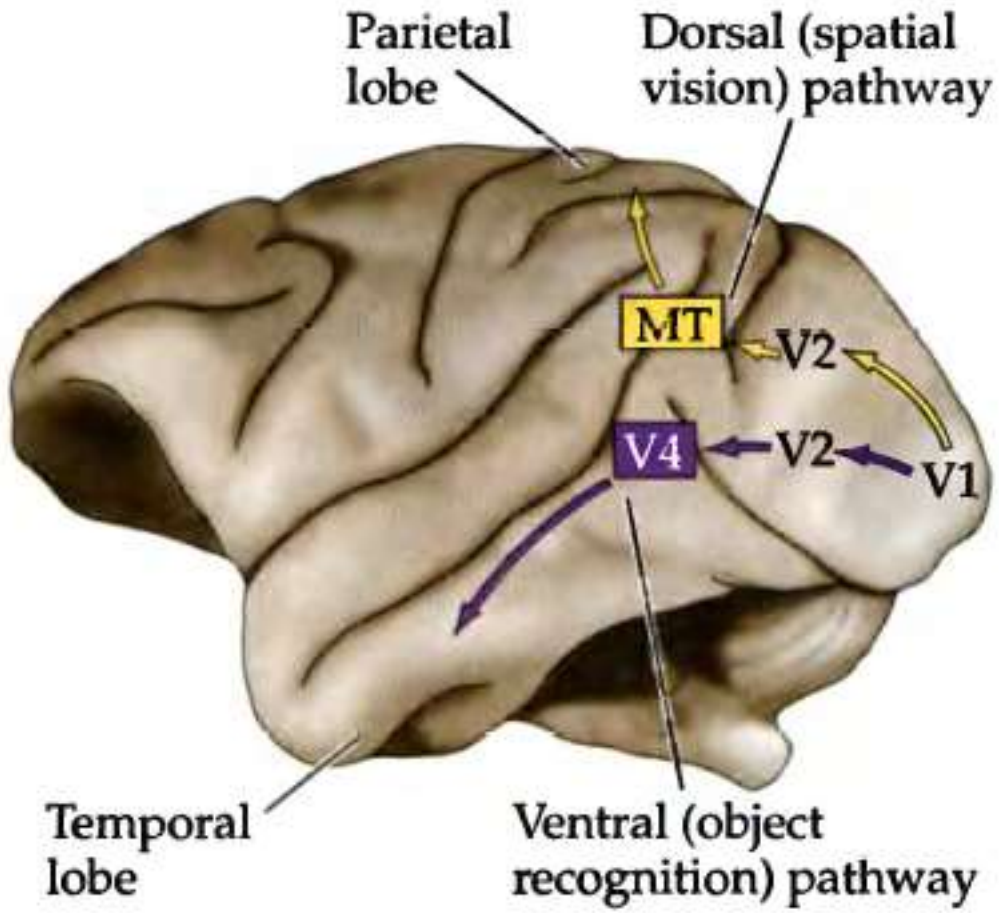
V1 : primary visual cortex

- Orientation selectivity
- Experiments of Hubel and Wiesel
- *Trying with spots of light got firing in LGN*
- *Same strategy failed in V1…. Accidentally a malfunction caused a bar of line to go across and neuron fired !*
- *https://www.youtube.com/watch?v=8VdFf3egwfg*
- *From centre-surround fields to orientations in V1*



“How” and “What” pathways

- From there V1 -> V2 -> MT : Dorsal “How” pathway… spatial information
- V1 -> V2 -> V4 -> IT : Ventral “what” pathway



Some interesting areas and case studies

- MT – motion
  - *Patient with injured MT… can see, recognize objects but great difficulty seeing motion.. Cant cross street or pour water into a glass..everything blurred out due to motion*
  - *Record from monkeys in MT : fires to motion direction and nothing else*
  - *TMS zapping of MT in humans causes motion blindness*
  - *Stimulation of monkeys in MT causes eye tracking of imaginary objects*
- V4 – colour, rudimentary shapes
- *Case study : Damage causes loss of colour vision*
- IT – object identification
- From IT -> Amygdala .. Emotional content of object

Blindsight !

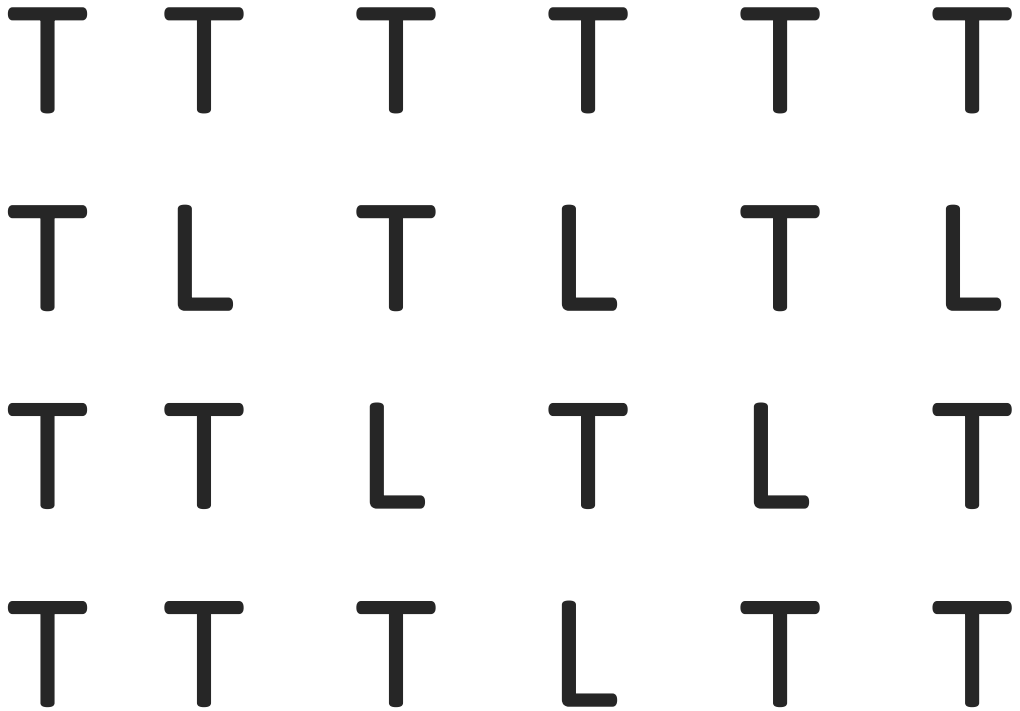
- Patient says he cannot see, but ask him to touch the spot of light he does it correctly !
- This is due to an old pathway from the superior colliculus to the parietal lobes… this usually helps us to orient ourselves and respond to objects in our surroundings

New insights into Blindsight

Massimo Scanziani, Science 2019

Superior Colliculus -> Post rhinal cortex pathway for encoding movement

Could this be the key to blindsight ?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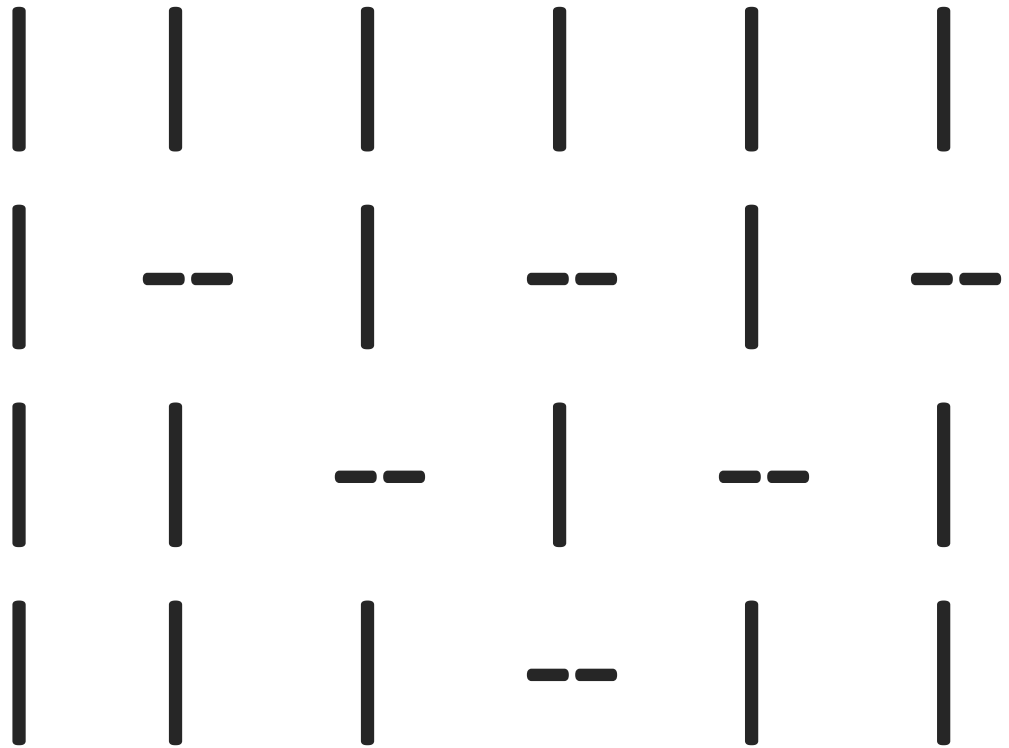

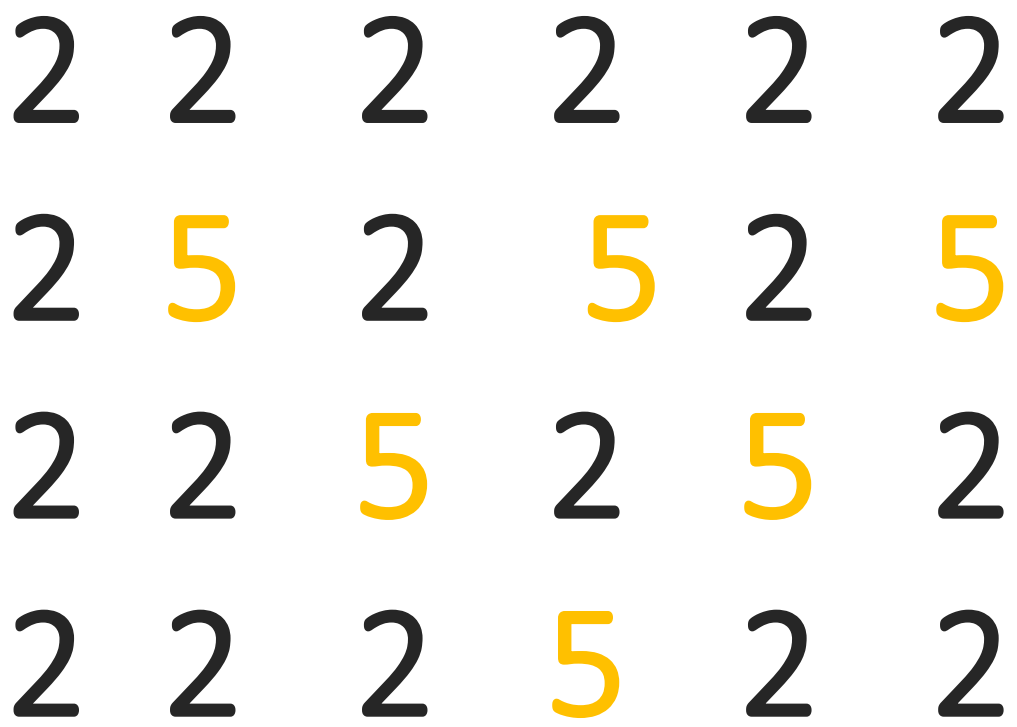
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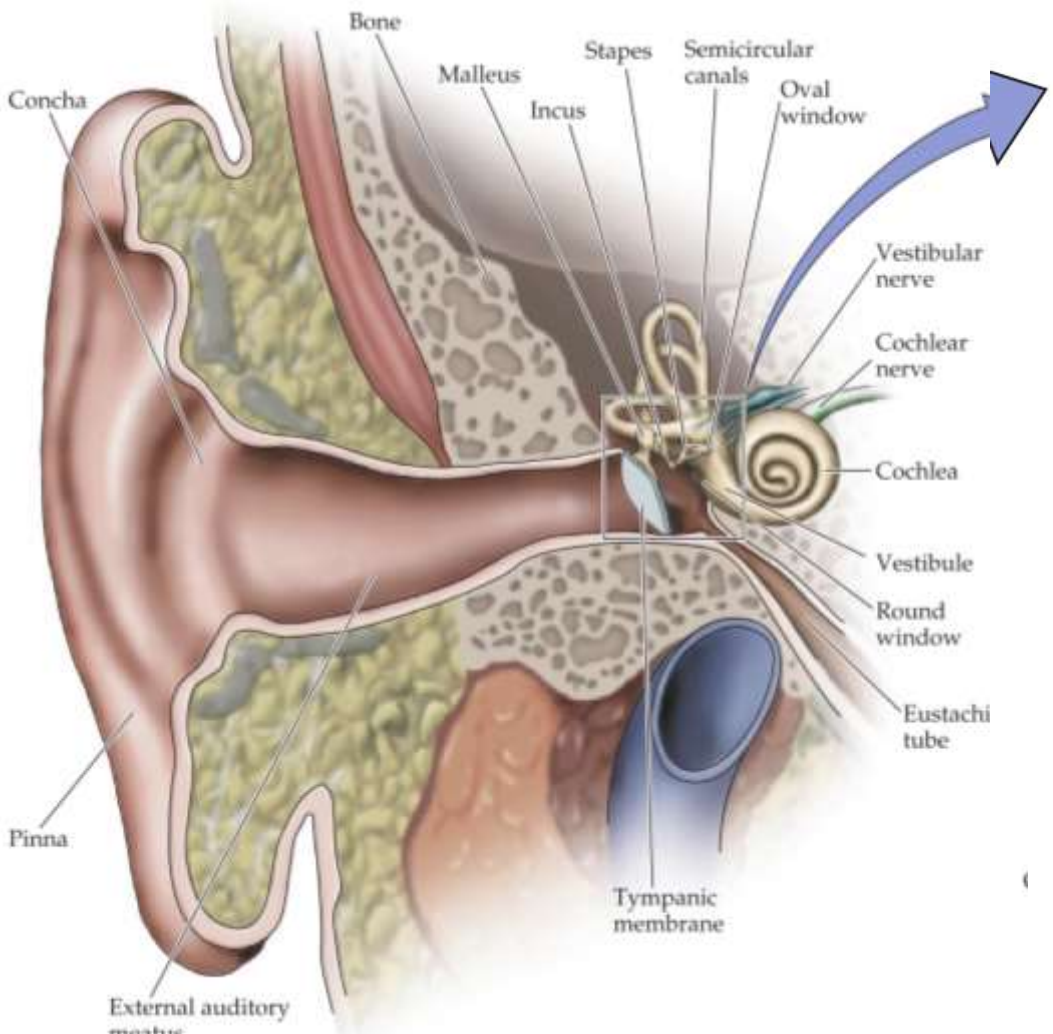
2 2 2 5 2 2

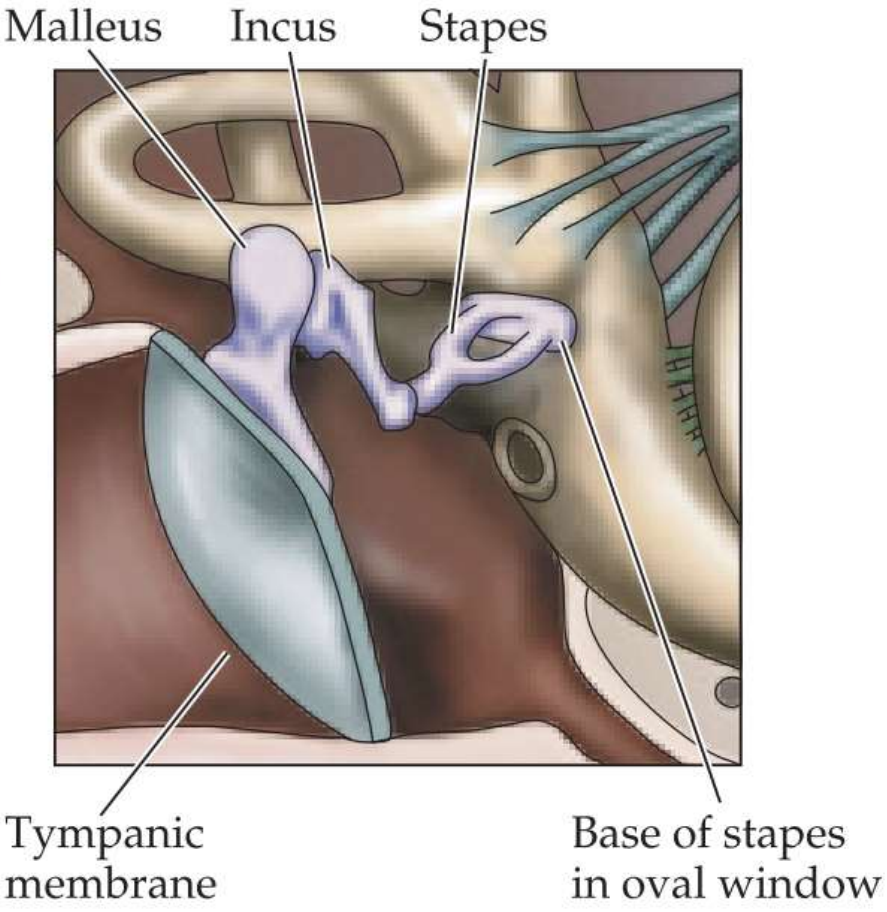
T/L vertical/horizontal detection

- Response times tell a story ?
- Pop out diff => Early processing stages ?
- T vs L and 2 vs 5 Linguistic or semantic meaning
- Colour, orientation are relatively more elementary features sorted out by the visual system

Audition

Structure of human ear





Working of the inner ear

Pinna and Concha along with meatus focus the sound onto the tympanic membrane

Activity: Cup your hands to extend the concha outwards in a silent room…

What do you hear ?

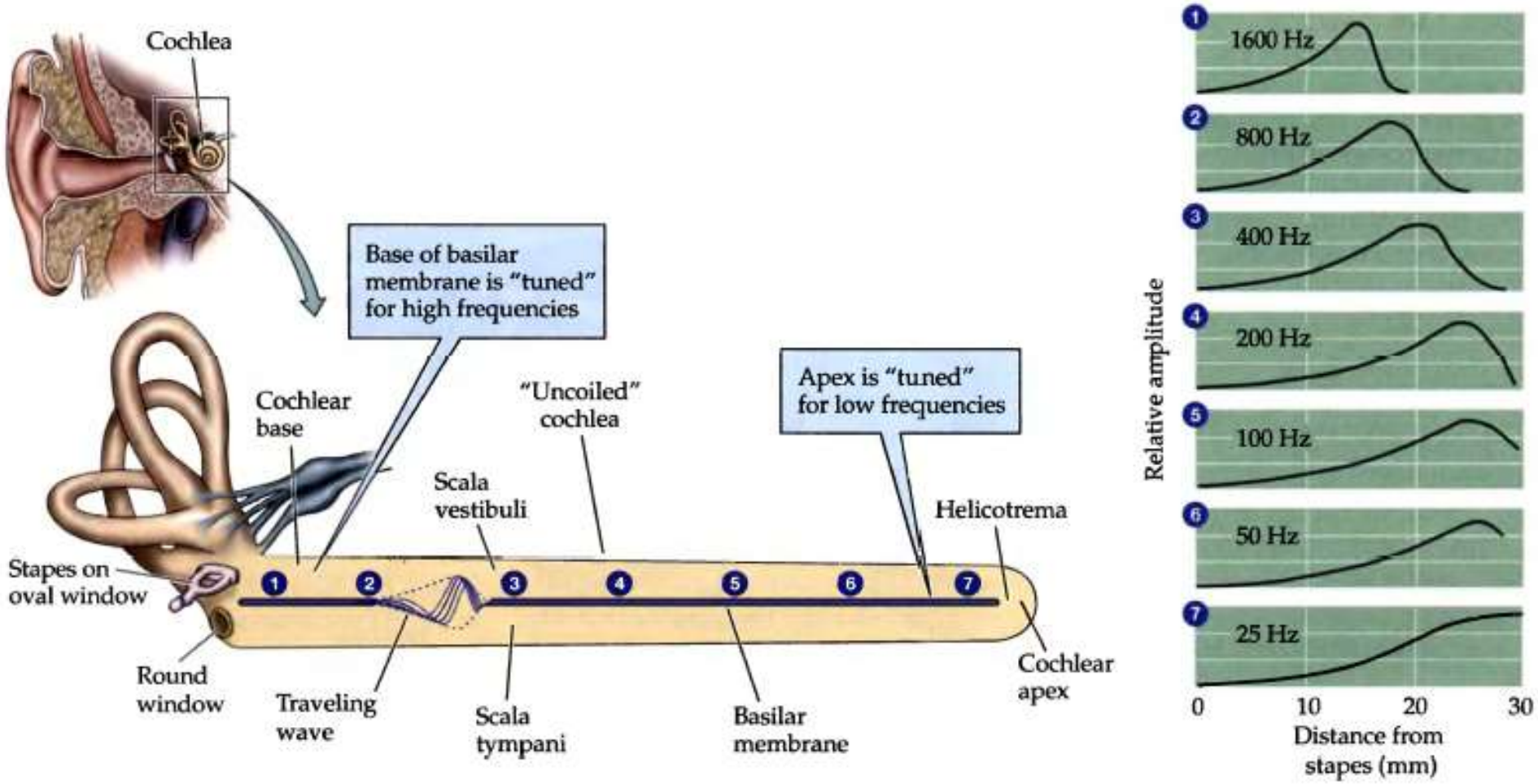
When do you adopt this pose ?

Instead of cupping, flatten your palm. Now what do you observe ?

Working of the inner ear

- Pinna, concha and meatus configured to boost audio frequencies ~ 3K Hz upto 100x
- Plosives (stops) that distinguish the essential phonemes have energy in this band

Cochlea and auditory sensing



Interaural differences

Superior Olive @ Mid Pons region

Medial Superior Olive : Interaural time difference

Lateral Superior Olive : Interaural intensity difference

< 3KHz – The neural signaling uses time codes or stimulus followers

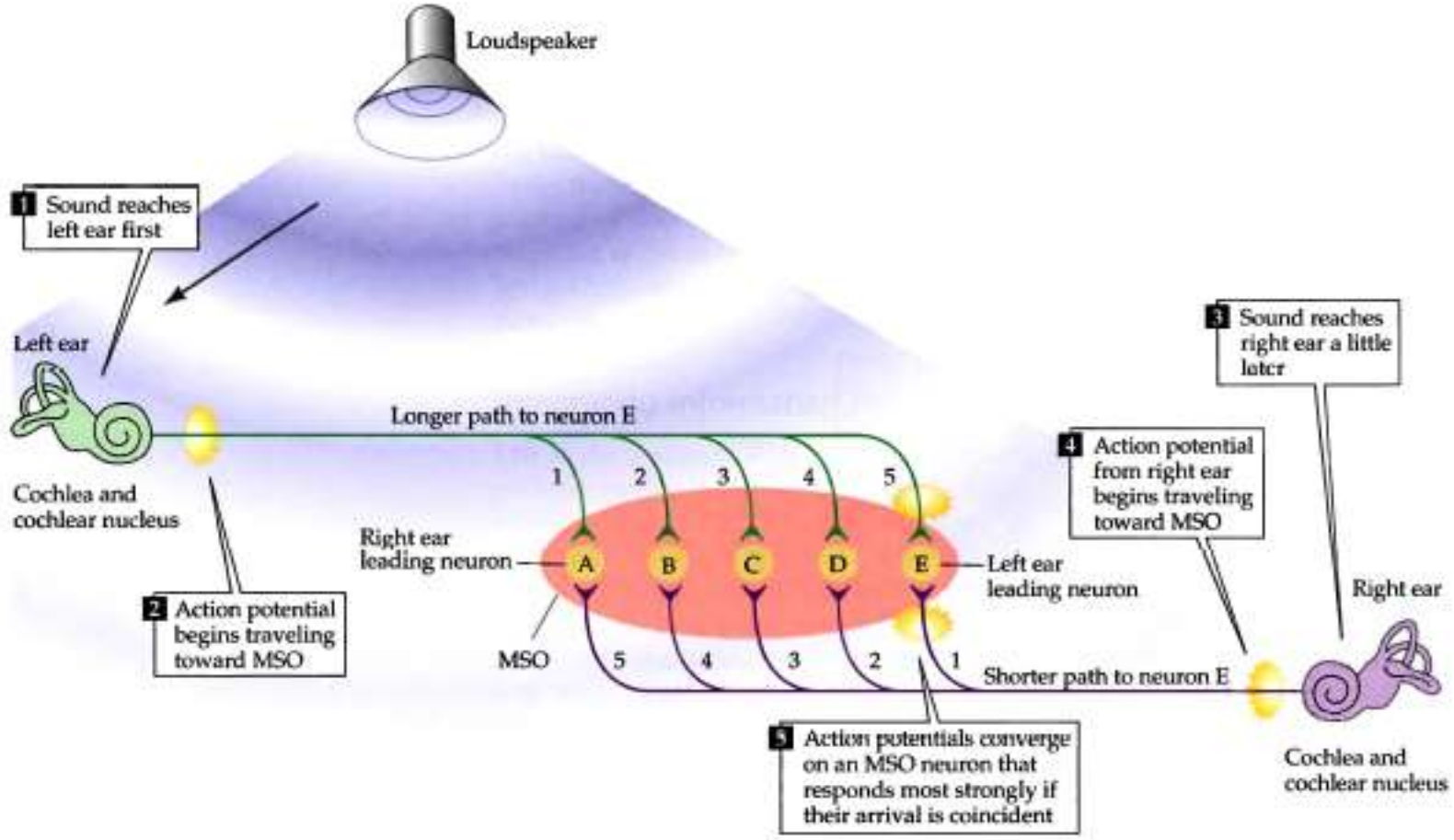
Localization by interaural time difference

> 3KHz – Labelled line coding, i.e. location of responding basilar membrane

Localization by interaural intensity difference

Medial Superior Olive: Time difference

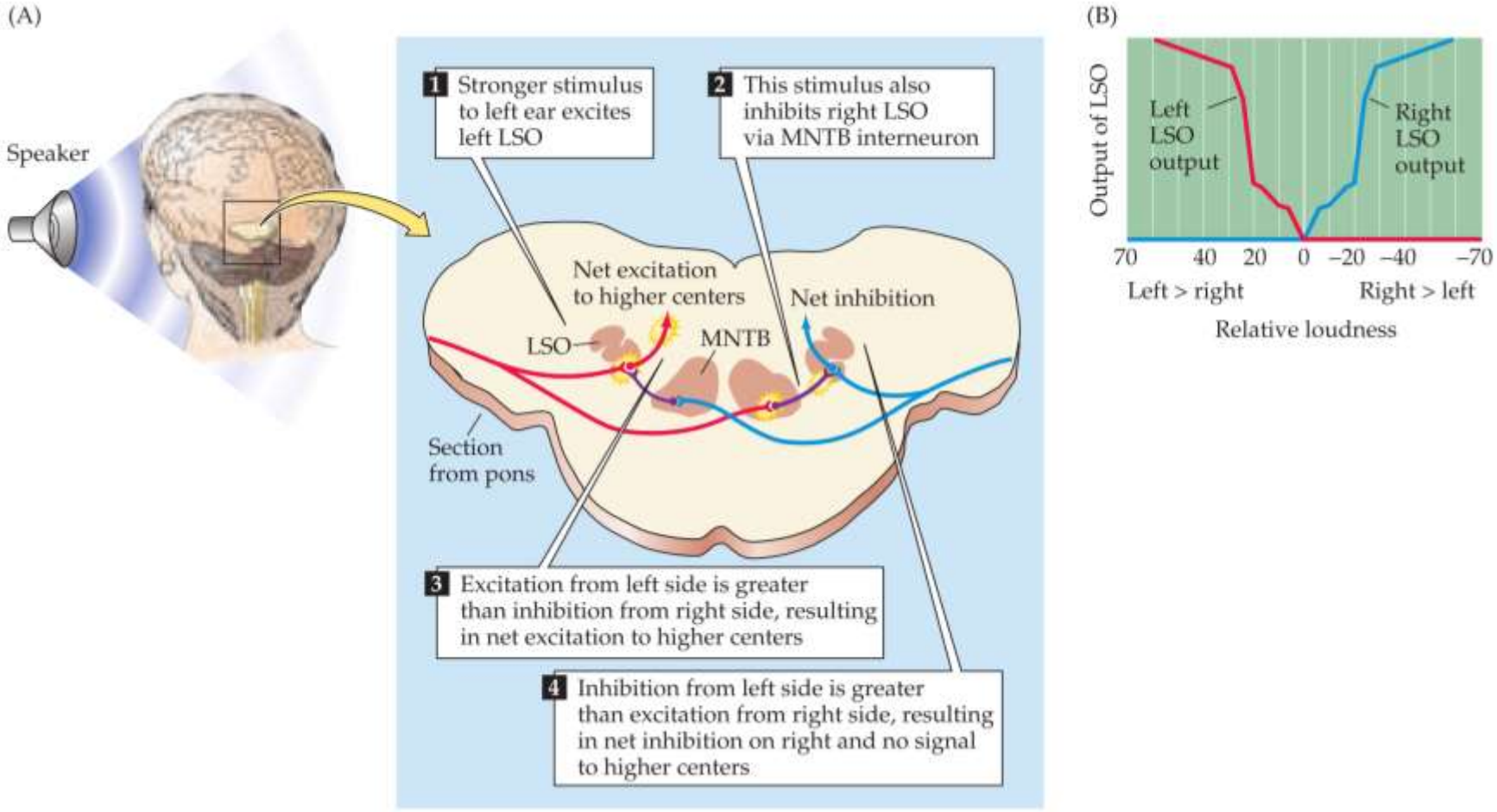
Interaural time difference of ~10 μs-700 μs detected



Lateral Superior Olive: Intensity difference

Inter aural intensity =>

net excitation/inhibition



Inferior colliculus

Spatial Maps of auditory space…

Specific neurons respond to sounds in particular location in auditory space

Complex sounds

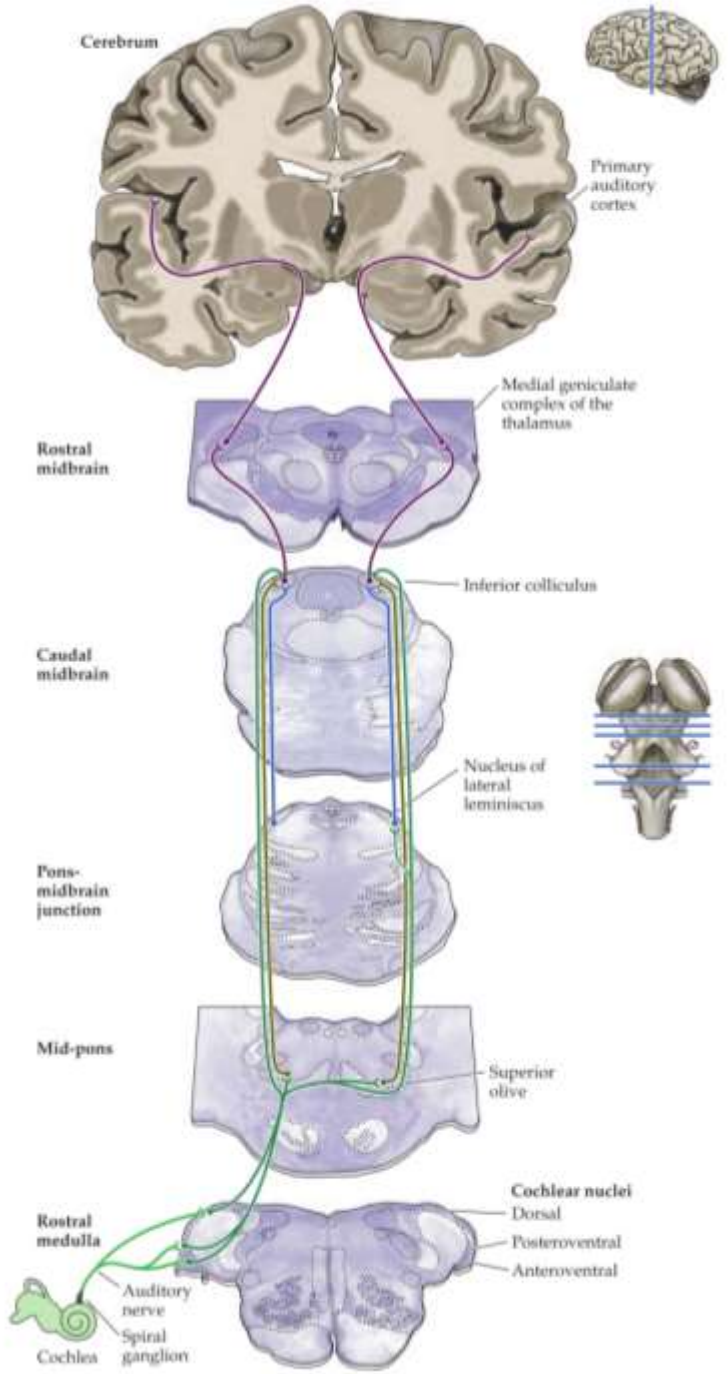
Specific neurons responding to frequency modulated sounds

Some respond to sounds of fixed durations

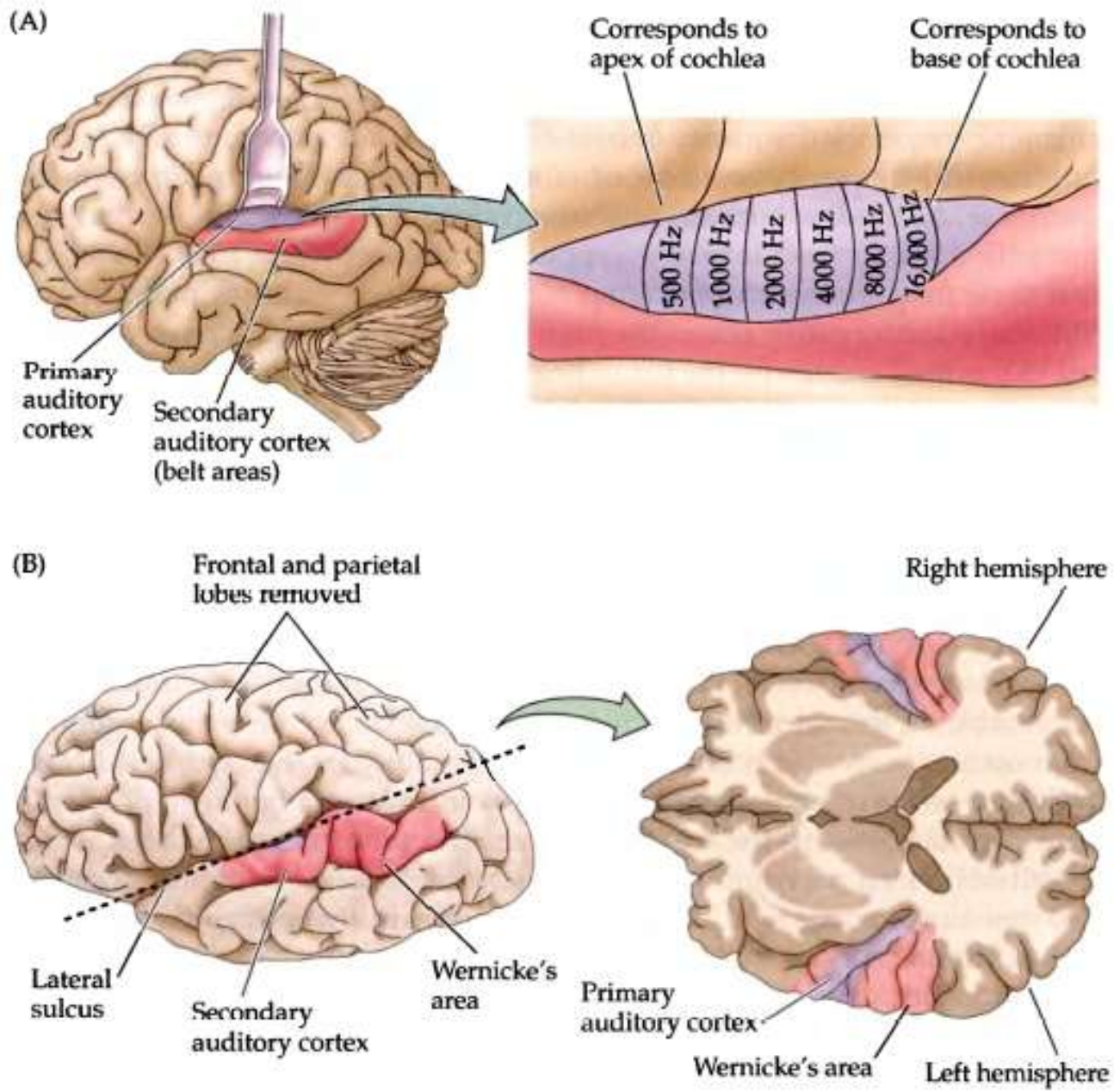
Auditory pathways

Function

Location



Auditory cortex and the language areas



Converging senses

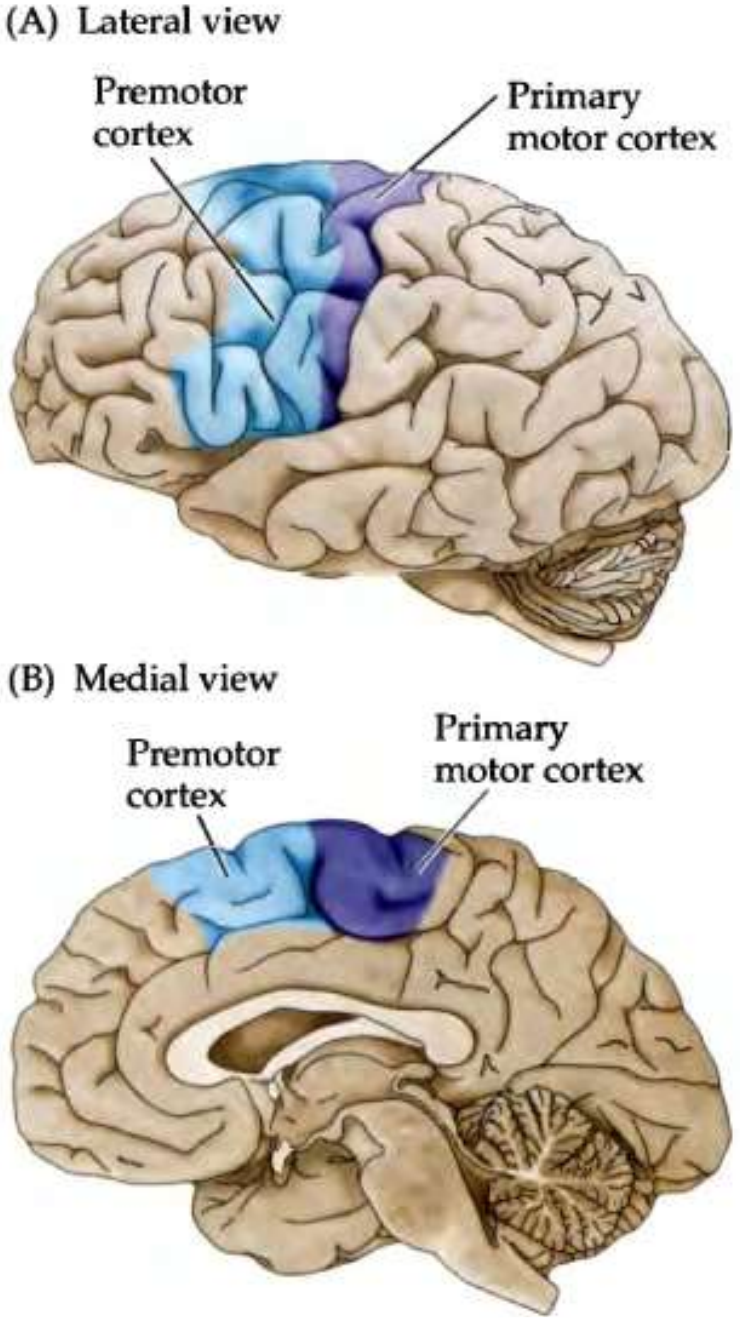
Parietal lobe

Image of our own body

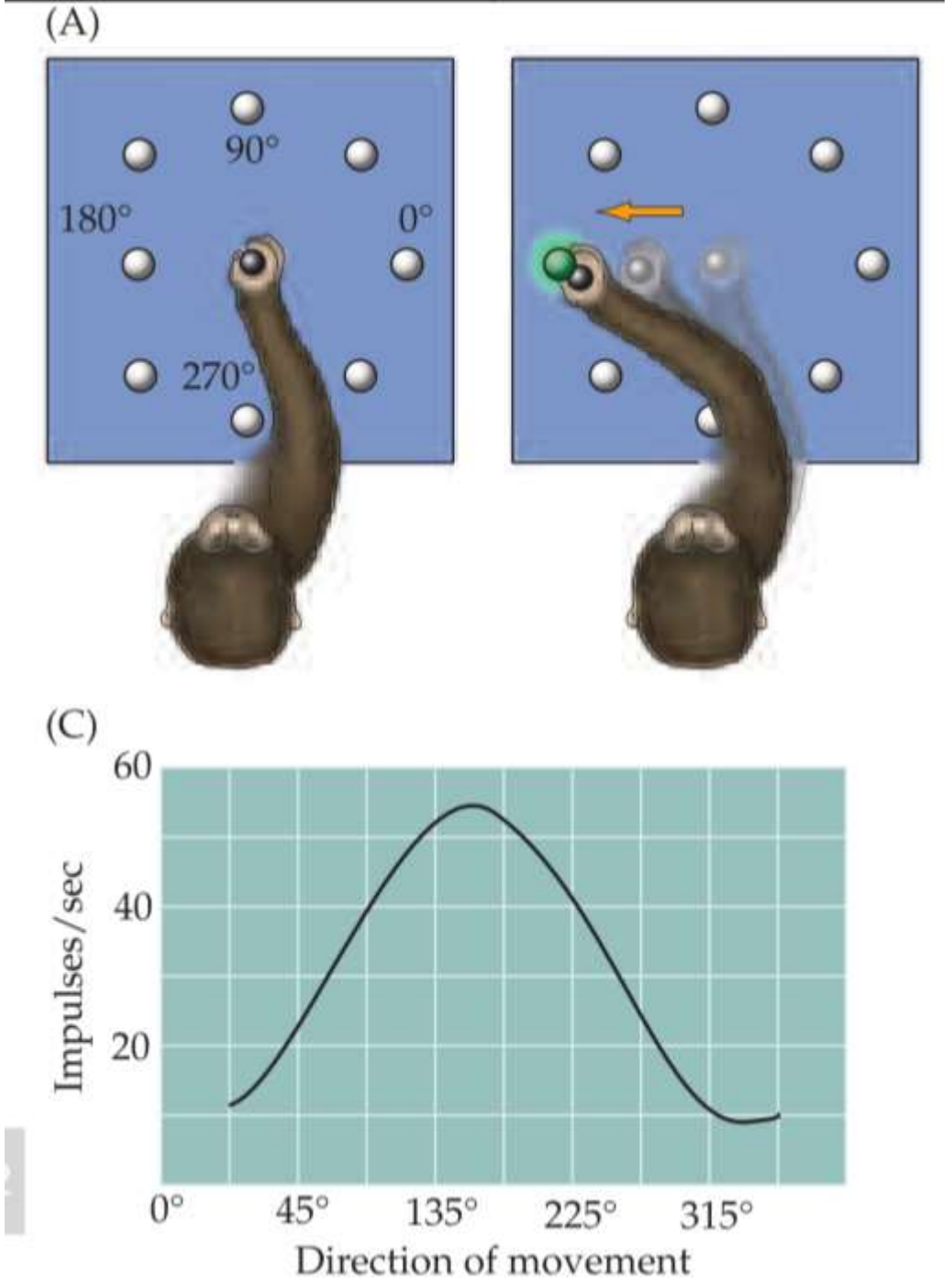
Motor system

Motor cortex

- Primary motor cortex : No clear somatotopy
- Codes movement , not muscles !
- *E.g. move hand to mouth*
- Premotor area : mosaic of different areas
- *Lateral : sensory guided movements e.g FEF*
- *Medial : volitional movements*



Directional tuning



Speech

Speech is a motor activity born of imitation

Brocha’s area : a part of pre motor area

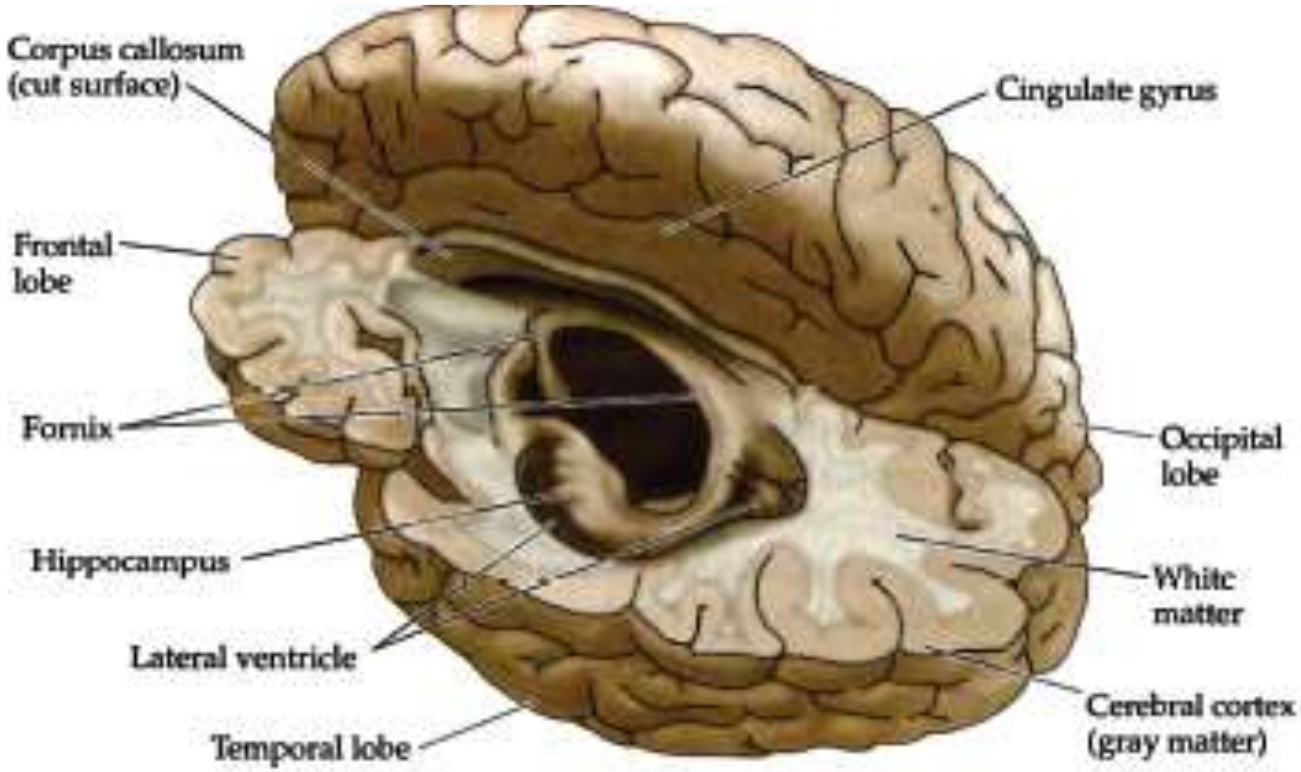
Modulation of movement

- Basal Ganglia : Initiation and suppression of movements
- Cerebellum : Error correction

Memory

Note : Hippocampus

Figure A13 Major internal structures of the brain, shown after the upper half of the left hemisphere has been cut away.



Hippocampus and patient “HM”

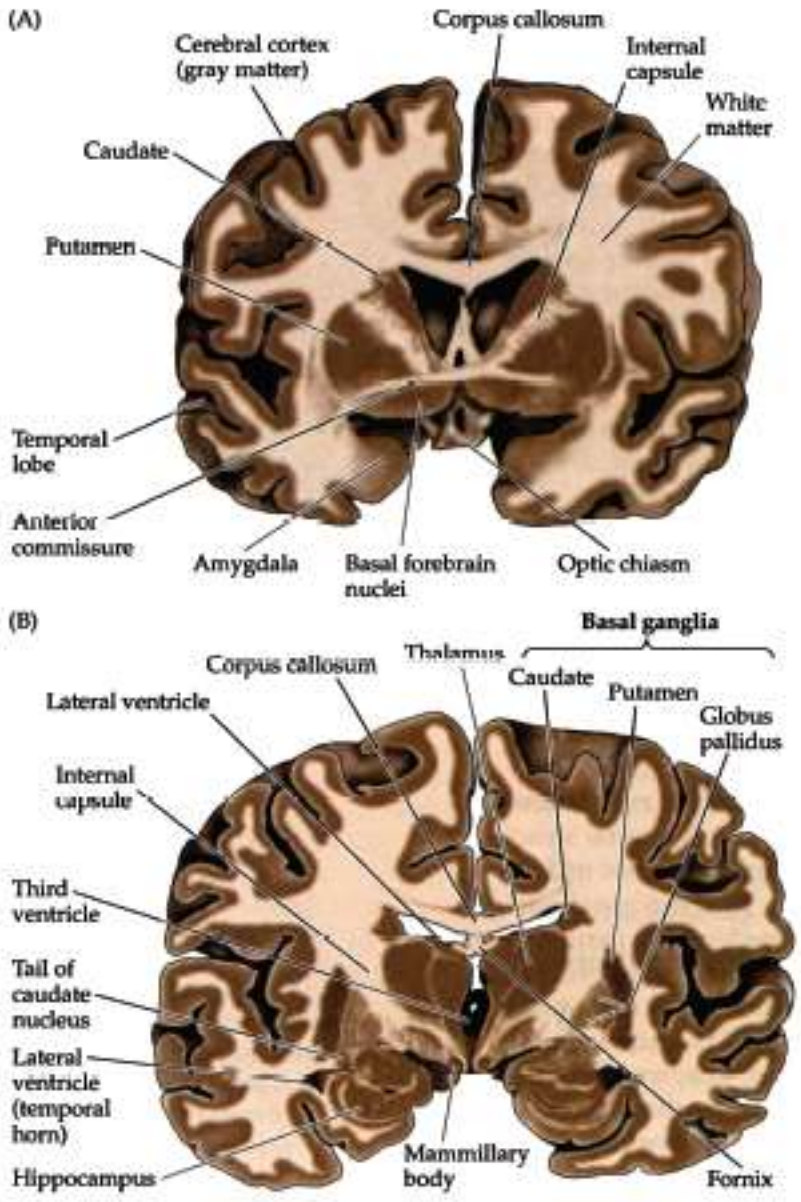
- https://www.youtube.com/watch?v=SQASyR0w8Qo
- Henry Molaison, had hippocampus removed surgically to control his epileptic seizures
- Could not remember anything beyond that point
- He was stuck in a time warp.
- But could remember memories of much before his operation
- Hippocampus : Essential for memory formation and consolidation. May not be crucial for retrieving memories formed and consolidated long ago !

Emotion

Amygdala

- Patient SM : No amygdala (congenital condition)
- Knows no fear. Knows there is danger but feels no fear !

Note : Amygdala & basal ganglia



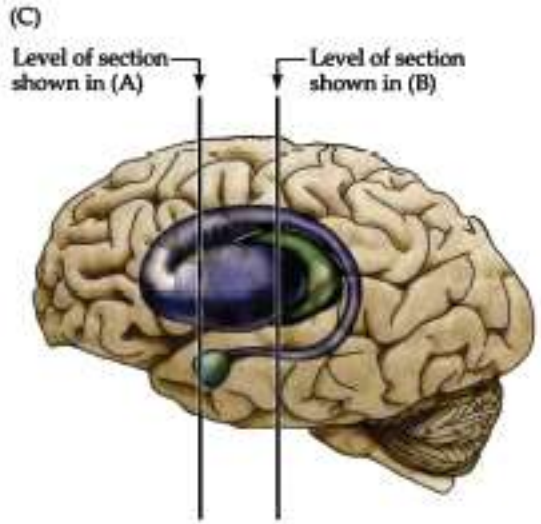
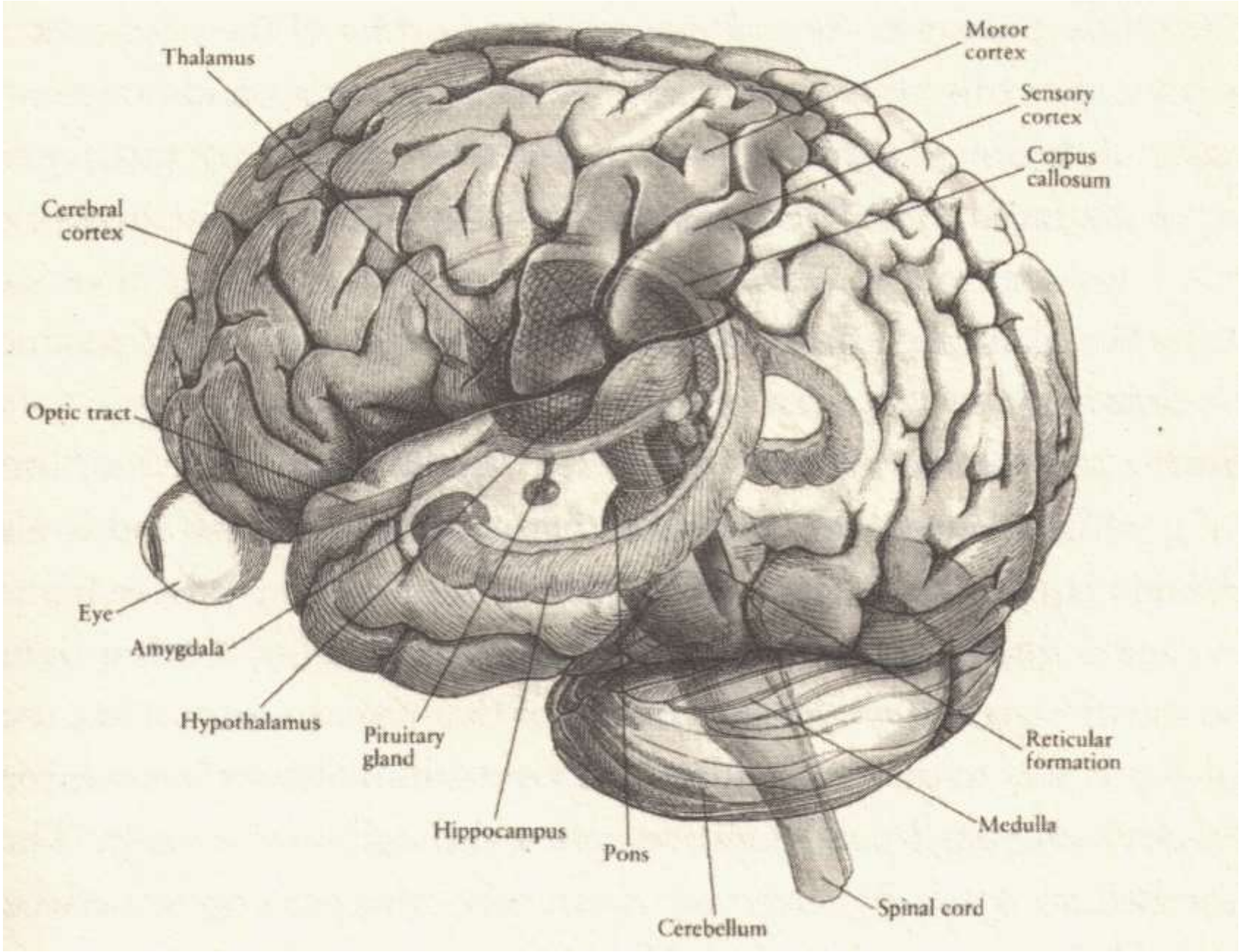


Figure A14 Internal structures of the brain seen in coronal section. (A) This sections passes through the basal ganglia. (B) A more posterior section that also includes the thalamus. (C) A transparent view of the cerebral hemisphere showing the approximate locations of the sections in (A) and (B) relative to deep gray matter (the basal ganglia, thalamus and amygdala are represented). Notice that because the caudate nucleus has a "tail" that arcs into the temporal lobe, it appears twice in section (B); the same is true of other brain structures, including the lateral ventricle.

Summary

Q :

Which areas are missed out in this fig ? ☺



Tell Tale brain : VS Ramachandran

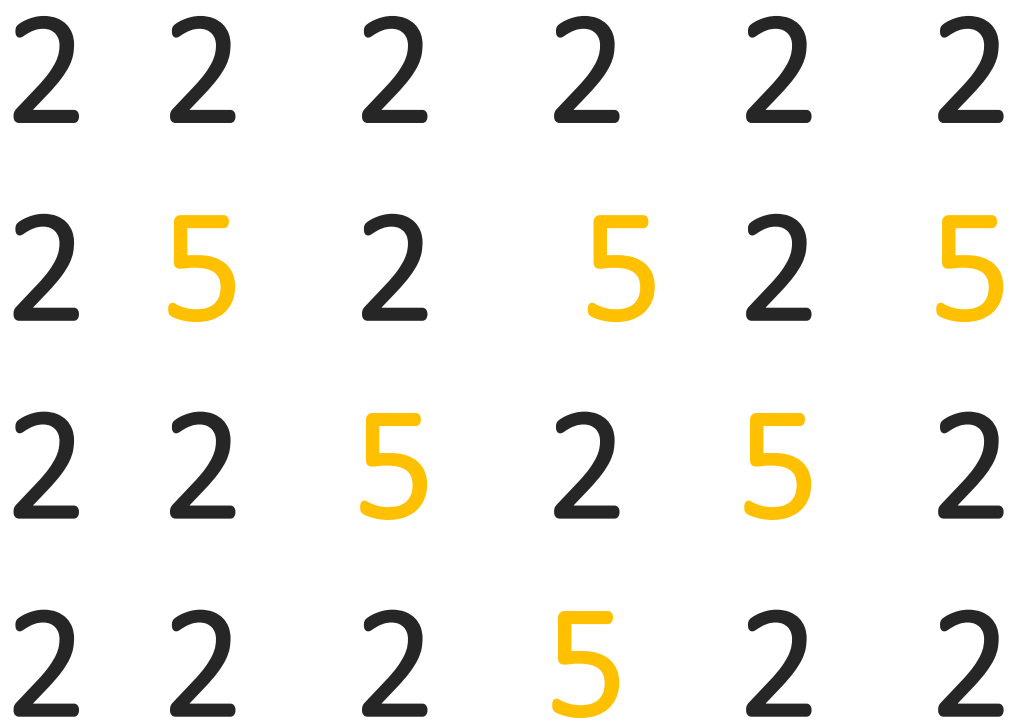
Backup

2 2 2 2 2 2

2 5 2 5 2 5

2 2 5 2 5 2

2 2 2 5 2 2


2 2 2 2 2 2
2 5 2 5 2 5
2 2 5 2 5 2
2 2 2 5 2 2

Psychophysics to understand the brain

Some people see numbers in colours… was this a fake? Or memory etc ?

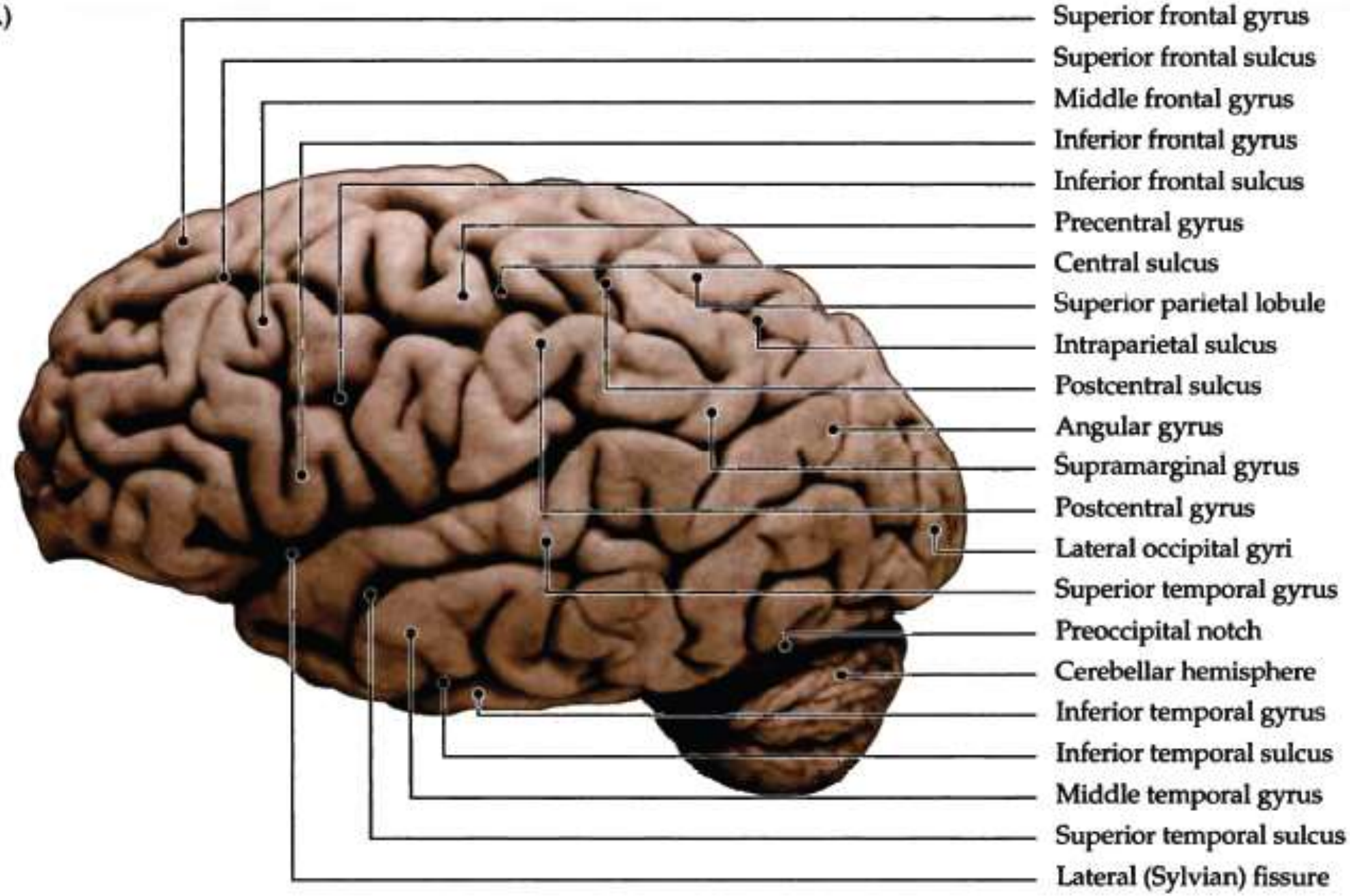
Colored 2s amongst 5s : normal ppl can see the pop out

2 amongst 5s form a global shape :

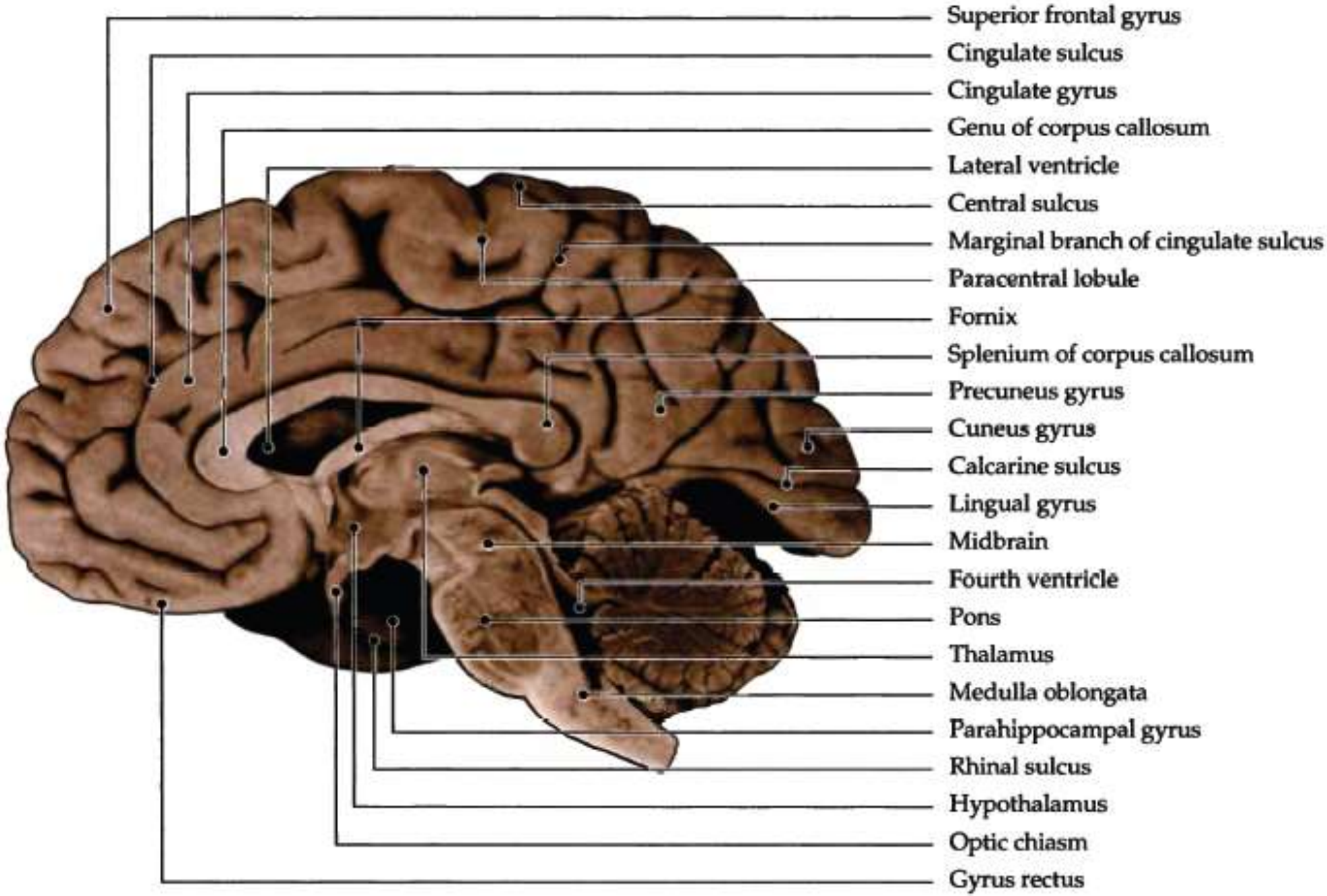
normal people cant see the global shape popout

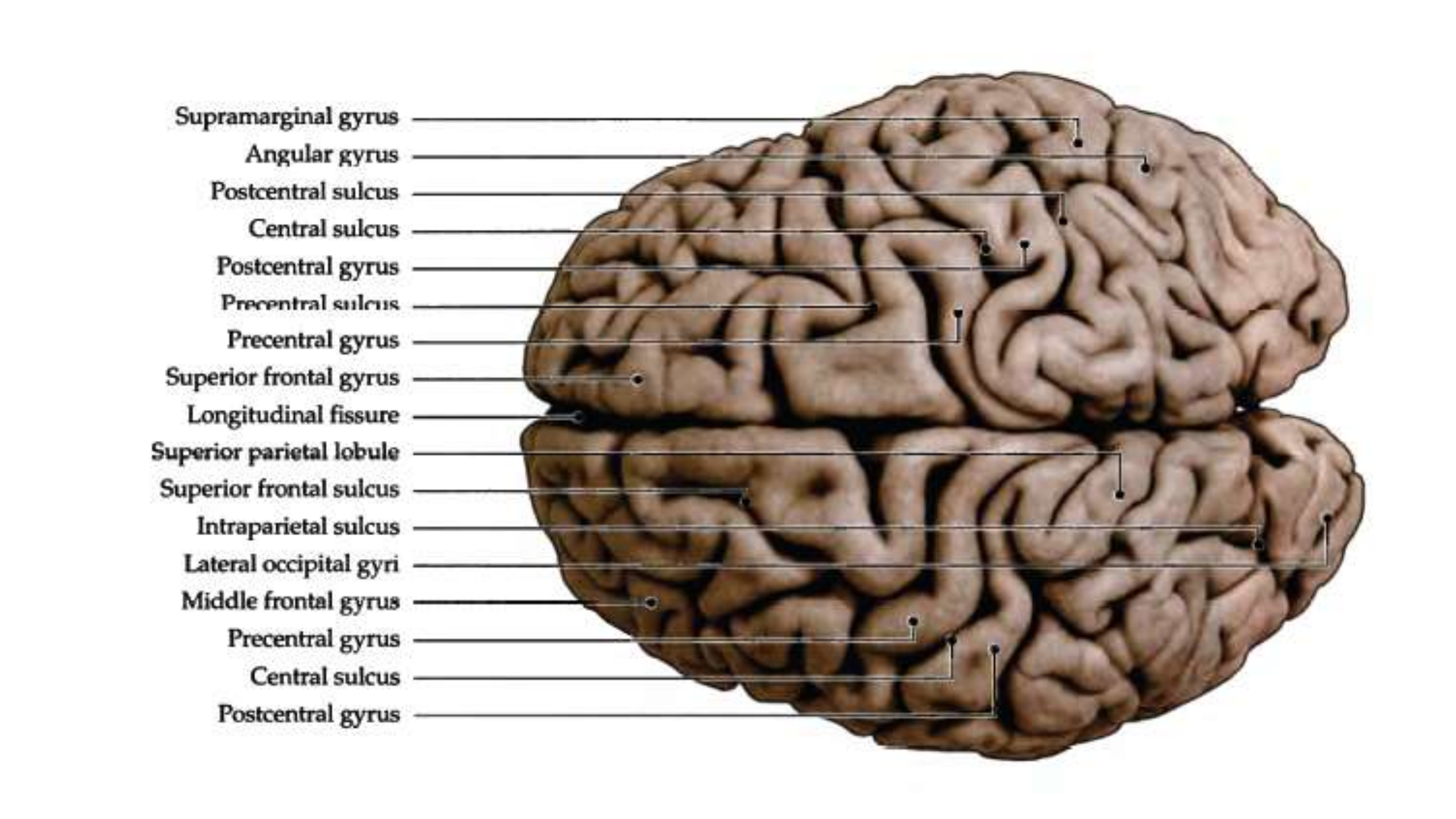
but synesthetes can

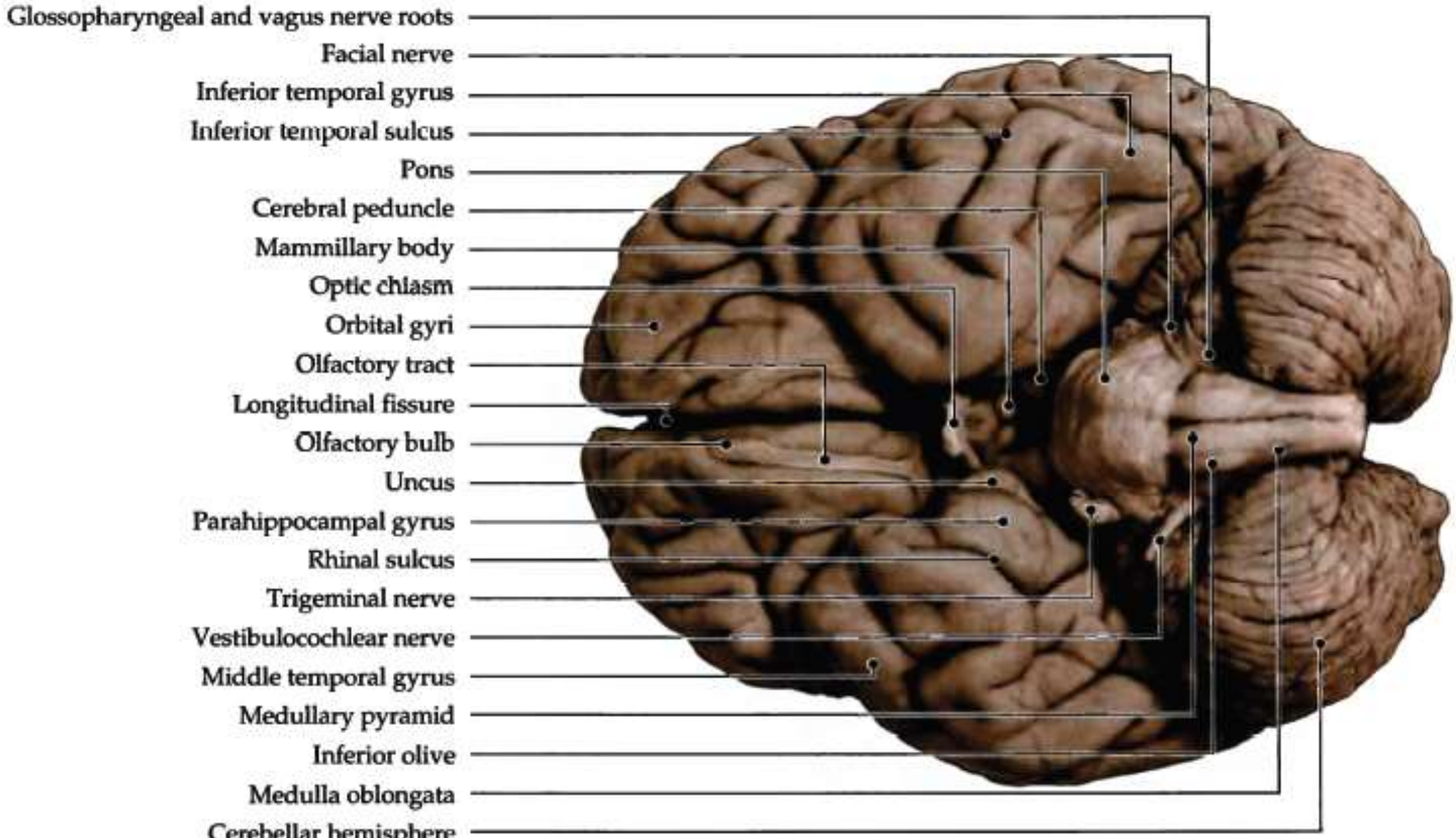
(A)


Superior frontal gyrus
Superior frontal sulcus
Middle frontal gyrus
Inferior frontal gyrus
Inferior frontal sulcus
Precentral gyrus
Central sulcus
Superior parietal lobule
Intraparietal sulcus
Postcentral sulcus
Angular gyrus
Supramarginal gyrus
Postcentral gyrus
Lateral occipital gyri
Superior temporal gyrus
Preoccipital notch
Cerebellar hemisphere
Inferior temporal gyrus
Inferior temporal sulcus
Middle temporal gyrus
Superior temporal sulcus
Lateral (Sylvian) fissure

(B)


Superior frontal gyrus
Cingulate sulcus
Cingulate gyrus
Genu of corpus callosum
Lateral ventricle
Central sulcus
Marginal branch of cingulate sulcus
Paracentral lobule
Fornix
Splenium of corpus callosum
Precuneus gyrus
Cuneus gyrus
Calcarine sulcus
Lingual gyrus
Midbrain
Fourth ventricle
Pons
Thalamus
Medulla oblongata
Parahippocampal gyrus
Rhinal sulcus
Hypothalamus
Optic chiasm
Gyrus rectus


Supramarginal gyrus
Angular gyrus
Postcentral sulcus
Central sulcus
Postcentral gyrus
Precentral sulcus
Precentral gyrus
Superior frontal gyrus
Longitudinal fissure
Superior parietal lobule
Superior frontal sulcus
Intraparietal sulcus
Lateral occipital gyri
Middle frontal gyrus
Precentral gyrus
Central sulcus
Postcentral gyrus


Glossopharyngeal and vagus nerve roots
Facial nerve
Inferior temporal gyrus
Inferior temporal sulcus
Pons
Cerebral peduncle
Mammillary body
Optic chiasm
Orbital gyri
Olfactory tract
Longitudinal fissure
Olfactory bulb
Uncus
Parahippocampal gyrus
Rhinal sulcus
Trigeminal nerve
Vestibulocochlear nerve
Middle temporal gyrus
Medullary pyramid
Inferior olive
Medulla oblongata
Cerebellar hemisphere