

## Chapter 3 : Nervous System Organization

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## Case Report : RS - Ischemic Stroke

- History:
  - male, age unspecified (mid 30s?) movie theater manager
  - left hand numb, collapsed
  - taken to hospital
  - CT revealed ischemic stroke damaged RH
  - no treatment given
  - sent to rehabilitation ward for physical therapy

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## Case Report : RS

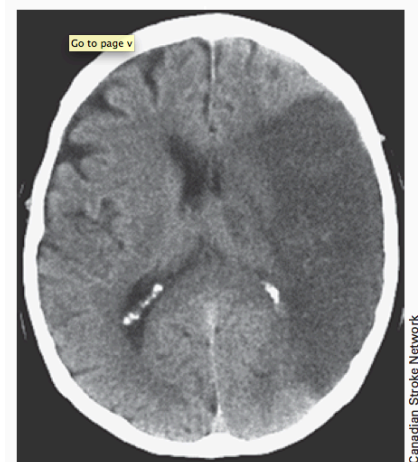
- Sequelae:
  - recovery
    - left leg stiff, but able to walk
    - left arm rigid, no use
  - To family, appeared mostly recovered, but apathetic
    - no interest in business
    - once talkative, now quiet, speaks w/low prosody
- Recovery:
  - after initial physical recovery, no changes for 10 years
- Issues:
  - Ischemic stroke : Tx with TPA within 3 hours
  - Not given TPA in hospital (MD unsure if TBI due to fall)

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## CT scan of RS

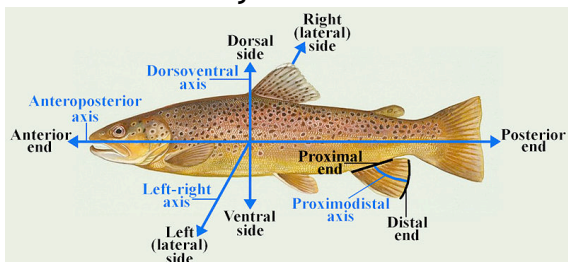


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## Neuroanatomy - Orientation - Fish



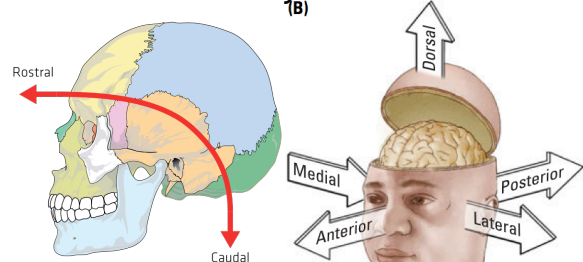
Axis	More	Less
up/down	dorsal / superior back / above	ventral / inferior belly / below
front/rear	rostral / anterior beak/nose	caudal / posterior tail
left/right	medial middle	lateral to the side

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## Neuroanatomy - Orientation - Human



Axis	More	Less
up/down	dorsal / superior back / above	ventral / inferior belly / below
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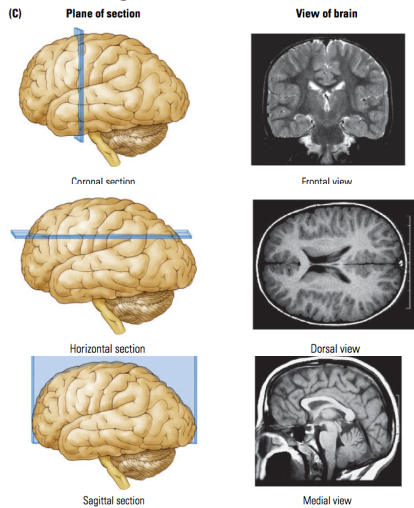
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## Orientation - Other Terms

Section	Description
coronal <i>crown</i>	looking from the front
horizontal	looking from the top down
sagittal <i>arrow</i>	separates the hemispheres



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## Orientation - Other Terms

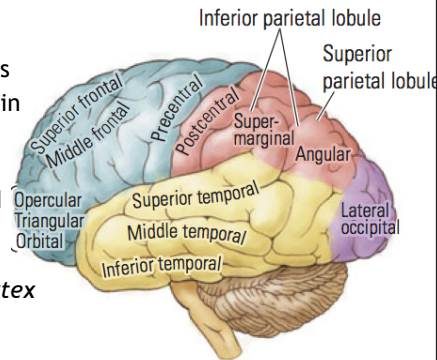
Topic	Description
symmetry	ipsilateral - same side contralateral - opposite sides bilateral - both sides
direction	afferent - toward efferent - away
front-rear relationship	pre- : in front of post- : behind
up-down relationship	superior - above medial - middle inferior - below

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## Nomenclature - confusion

- RS had damage to his **precentral gyrus**, affecting motor abilities
- gyrus precentralis** - Latin
- The motor strip - colloquial
- Jackson's Strip - named after John Hughlings-Jackson
- M1 - *primary motor cortex*
- somatomotor strip
- motor homunculus
- area pyramidalis - based on type of neurons

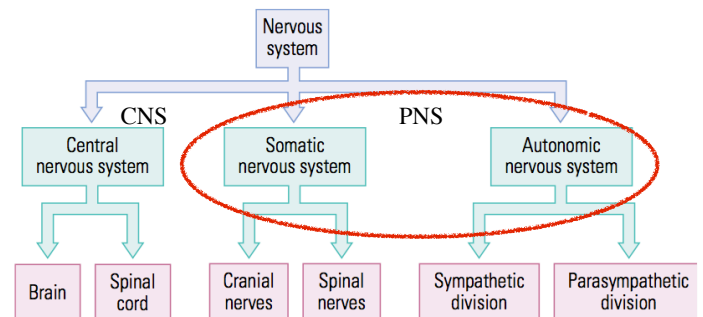


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## Nervous System



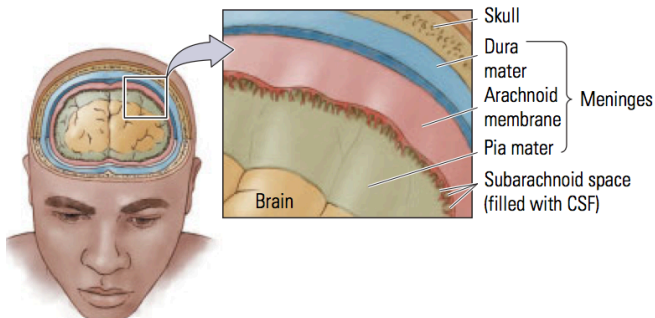
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## Physical protection of Brain

- Skull
  - Meninges (dura, arachnoid, pia mater)
    - Subarachnoid space (CSF)
  - Brain



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## Chemical Protection of brain

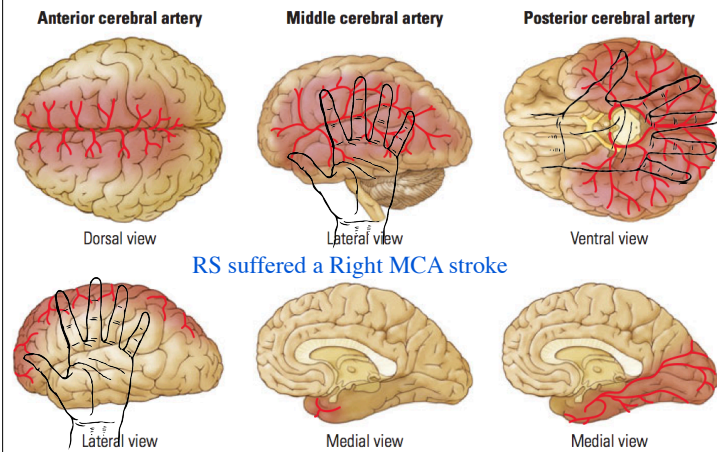
- Brain has separate biological compartment
- Blood Brain Barrier (BBB)
  - prevents many chemicals from entering brain

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## Blood Supply



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## Neurons & Glia

- Glial Cells
  - supportive cells
    - nutrition
    - defense
    - insulation
- Neural cells
  - sensory input (afferent)
  - interneurons (computation)
  - motor output (efferent)
- Human brain :
  - roughly 10 billion neurons
  - 1000 or more connections each
  - 10,000,000,000,000 (ten trillion) connections

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## Brain as computer

- Human brain :
  - roughly 10 billion neurons
  - 1000 or more connections each
  - 10,000,000,000,000 connections
    - ten thousand billion or ten trillion
- Comparison:
  - Milky Way Galaxy : 300 billion stars

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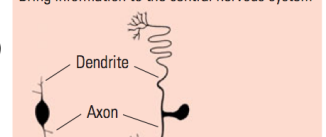
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## Types of Neurons

- Neural cells
  - sensory input (afferent)
  - interneurons (computation)
  - motor output (efferent)

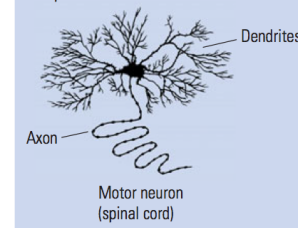
### (A) Sensory neurons

Bring information to the central nervous system



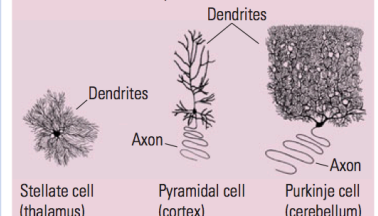
### (C) Motor neurons

Send signals from the brain and spinal cord to muscles



### (B) Interneurons

Associate sensory and motor activity in the central nervous system



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## Grey, White & Reticular Matter

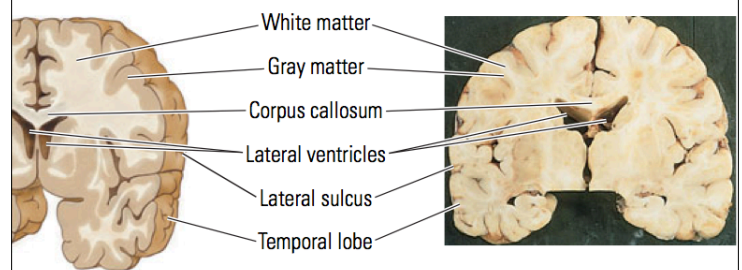
Type	Composition	City Analogy
Gray	cell bodies blood capillaries	City
White	myelinated axons	Roads
Reticular	mixture <i>Latin, "net"</i>	Suburbs

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## Grey, White & Reticular Matter



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## Layers, Nuclei, Nerves and Tracts

- Cell bodies
  - Layer - flat sheet of cell bodies
  - Nucleus - round group of cell bodies
- Axons
  - Tract - group of axons
    - aka “fiber” or “fiber pathway”
  - Nerves - a fiber that leaves the CNS
    - major nerves:
      - spinal cord
        - 30 segments
      - cranial nerves
        - 12
- Ganglia - nerve bundles that function outside CNS

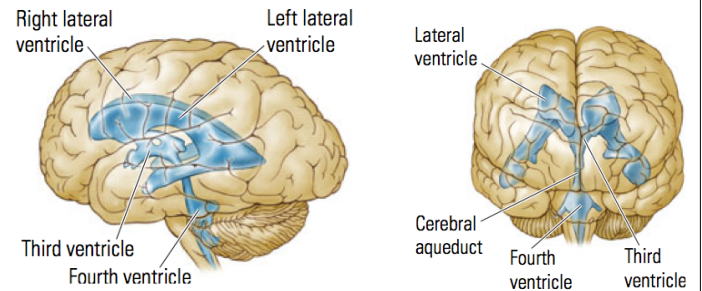
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## Brain Development, Ventricles and CSF

- Human brain has hollow spaces during development
- Ventricles (*bladders*) - hold Cerebrospinal fluid (CSF)
- CSF circulates from brain to spinal cord



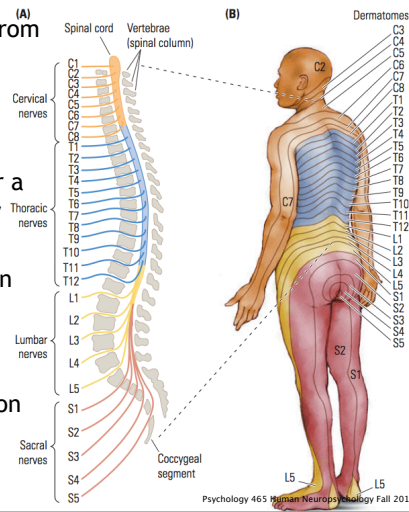
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## Spinal Cord and Dermatomes

- Spinal cord nerves exit from spine between spinal segments
- Each nerve supports sensation and motion for a specific part of the body
- “Dermatomes” are odd in humans due to upright posture
- Imagine person walking on all fours

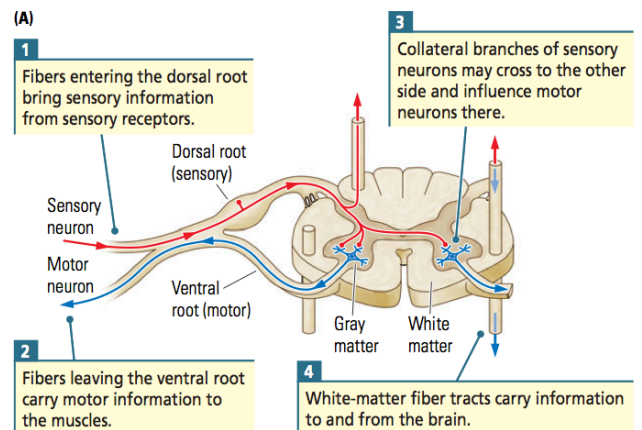


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## Dorsal and Ventral Roots



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## Spinal Cord Damage

- Minor damage:
  - sensory
    - numbness, tingling, parathesia
  - motor
    - weakness, paralysis, spasticity
  - reflexes imapired
- Major Damage:
  - Paraplegic - spinal cord cut above legs but below level of arms
  - Quadriplegic - spinal cord cut above level of arms

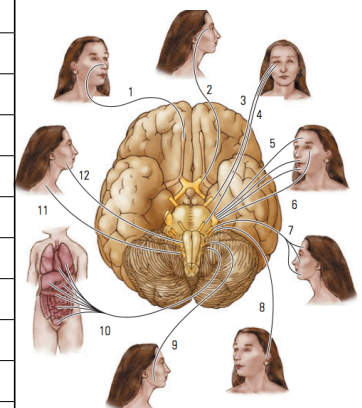
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#	Name	Function
1	olfactory	smell
2	optic	vision
3	oculomotor	eye movement in/out, eyelid
4	trochlear	eye movement up/down
5	trigeminal	chewing and sensory
6	abducens	facial movement
7	facial	facial movement and sensation
8	auditory vestibular	hearing, balance
9	glossopharyngeal	tongue & pharynx (S + M)
10	vagus	heart, blood vessels, viscera
11	spinal accessory	neck muscles
12	hypoglossal	tongue muscles

## Cranial Nerves

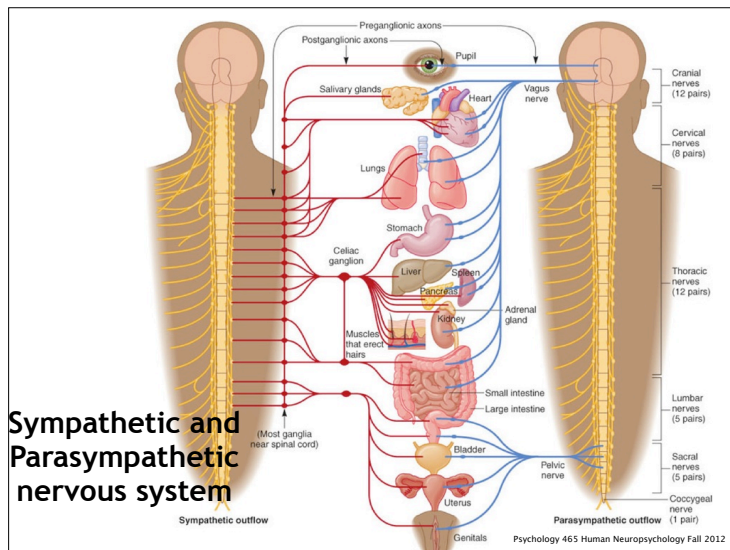


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## Brain

### • Forebrain

- Cerebral Cortex
- Limbic System
  - Hippocampus
  - Cingulate Gyrus
  - Septum
  - Amygdala
- Basal Ganglia
  - Globus Pallidus
  - Caudate
  - Putamen

### • Brain Stem

- Diencephalon
  - Thalamus
  - Hypothalamus
- Midbrain
  - RAS
- Hindbrain
  - Pons
  - Cerebellum
  - Medulla

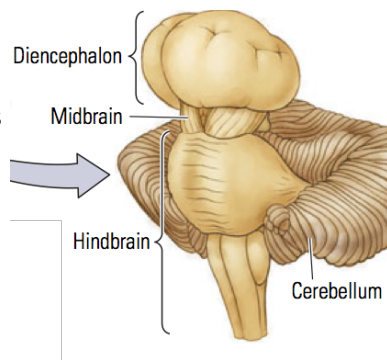
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## Brain Stem Overview

- Diencephalon
- Midbrain
- Hindbrain
- Functions:
  - basic biological processes
  - coordinated movement and balance
  - cranial nerve Nuclei



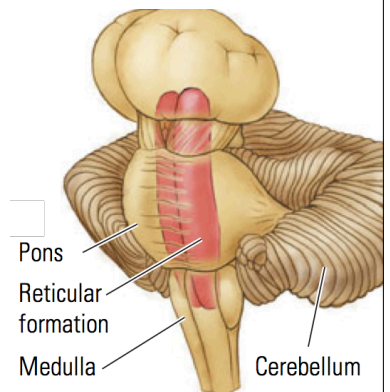
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## Hindbrain

- Pons
  - sleep, breathing, bladder control, hearing, balance, taste, eye & facial movement, posture...
- Reticular Formation
  - aka Reticular Activating Systems (RAS)
  - Arousal and consciousness
- Cerebellum
  - coordinated movement & balance
- Medulla
  - breathing, vomiting, heart rate, blood pressure...



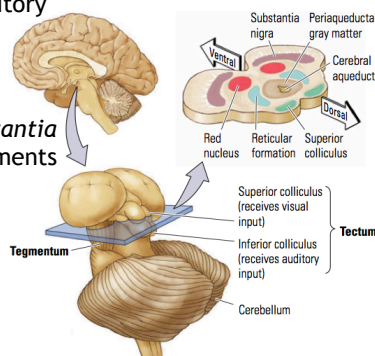
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## Midbrain

- Nuclei related to motion
- superior & inferior colliculi coordinates visual/auditory motor responses
- red nucleus - limb movements
- black substance - *substantia nigra* - initiating movements & rewards



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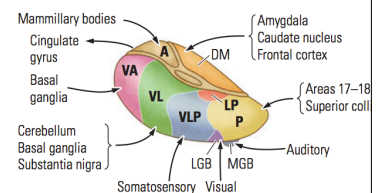
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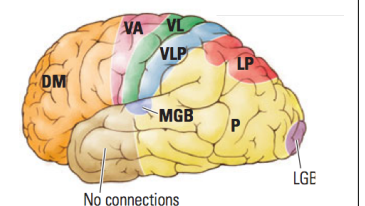
## Diencephalon

- Border between old & new brain - thus *sometimes considered part of forebrain*
- Thalamus (*inner room*)
  - relay center
    - sensory to brain
    - brain to brain
    - forebrain to brainstem
- Hypothalamus (*lower room*)
  - small but important
  - 22 nuclei
  - aspects in many behaviors
  - neuroendocrine

### (A) Thalamus



### (B) Cortex



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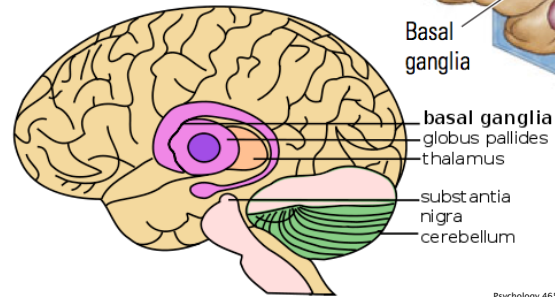
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## Basal Ganglia

### • “lower knots”

### Basal Ganglia and Related Structures of the Brain



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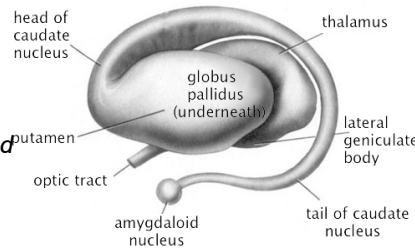
## Basal Ganglia

### • Structure

- Putamen “shell”
- Globus Pallidus “pale globe”
- Caudate Nucleus “tailed nucleus”

### • Function

- smooth sequencing of motor functions
- learning of stimulus-response habits



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## Basal Ganglia Disorders

### • Huntington’s

- basal ganglia die
- writhing snake-like dance

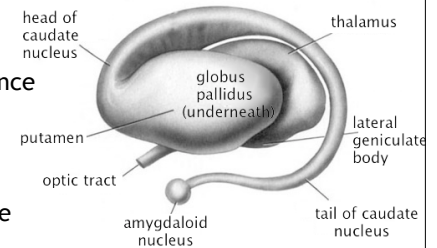
### • Parkinson’s

- connections from substantia nigra die
- rigid, unable to initiate action

### • Tourette’s

- motor tics, unable to stop action

- Disorders of controlling movement



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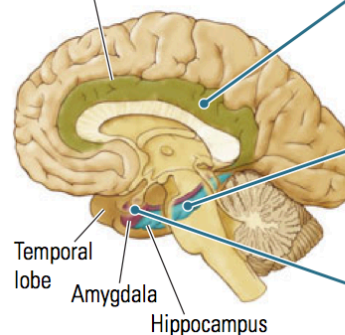
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## Limbic System

### (A) The limbic lobe, medial view

Cingulate cortex (limbic cortex)



**1**  
The limbic-lobe structures are in the midline,...

**2**  
...the hippocampus curves away into the temporal lobe,...

**3**  
...and the limbic lobe terminates in the amygdala.

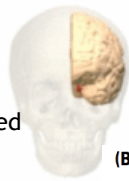
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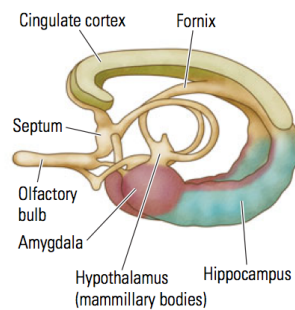
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## Limbic System

- “border”
- History
  - functions unknown, thought to be associated with smell
  - then emotion
  - then memory
  - ? is it a unified system?
- Functions:
  - emotion, behavior, motivation, memory (LTM), olfaction



(B) The limbic lobe (dissected out)



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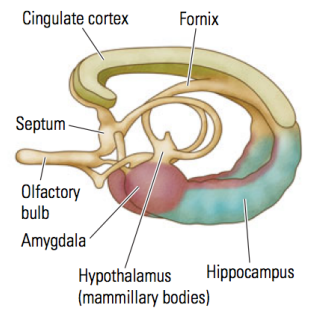
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## Limbic System

- Hippocampus - “sea horse”
  - long term memory
- Amygdala - “almond”
  - emotional behavior
- Septum - “partition”
  - emotional behavior
- Cingulate Cortex - “girdle”
  - emotion, reward, memory, executive function

(B) The limbic lobe (dissected out)



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## Neocortex

- 80% of human brain volume
- 2.5m<sup>2</sup> in area
- only 2mm thick
- six layers
- wrinkled - gyri and sulci
  - gyrus - raised area
  - sulcus - cleft
    - fissure: a deep sulcus

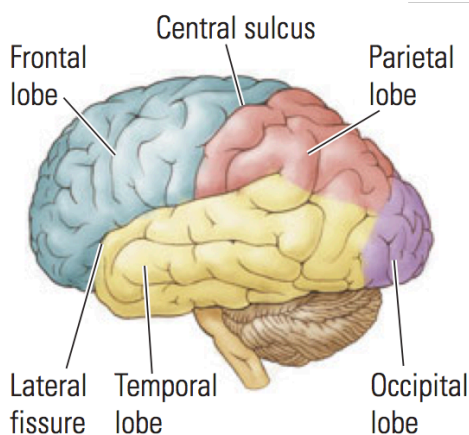
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## Brain Anatomy : lobes, sulci, fissures

### Lateral view



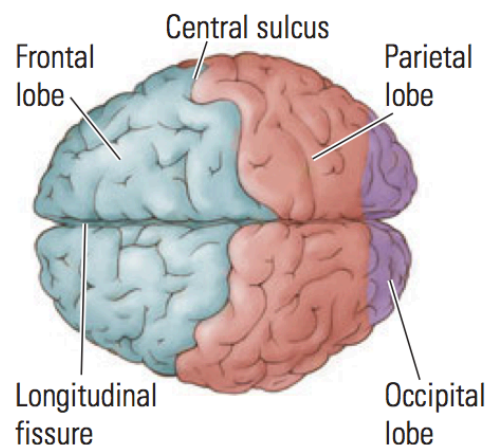
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## Brain Anatomy : lobes, sulci, fissures

### Dorsal view



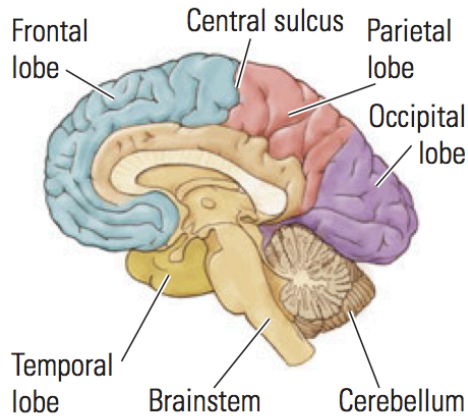
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## Brain Anatomy : lobes, sulci, fissures

### Medial view



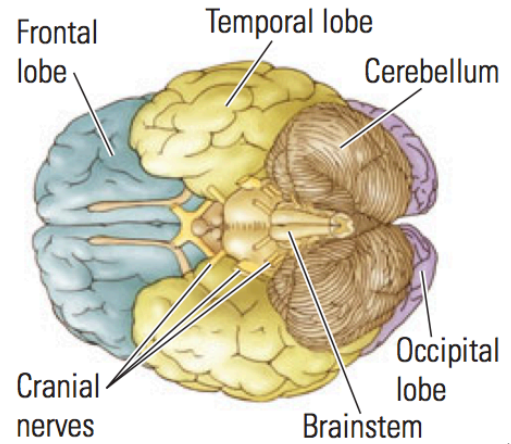
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## Brain Anatomy : lobes, sulci, fissures

### Ventral view



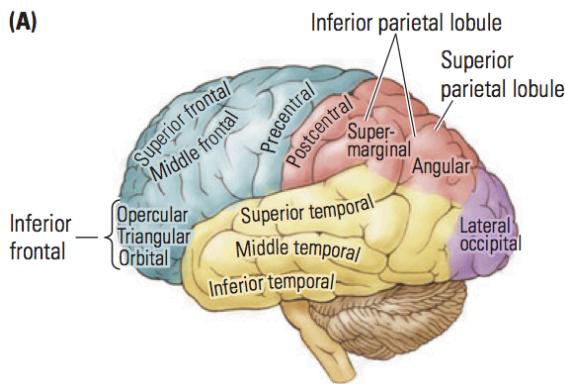
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## Brain Anatomy : Major Gyri

(A)



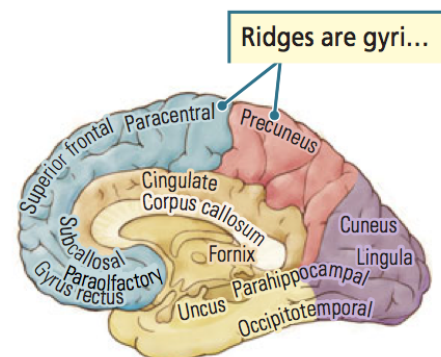
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## Brain Anatomy : Major Gyri

(B)



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## Neocortex Organization - Mapping

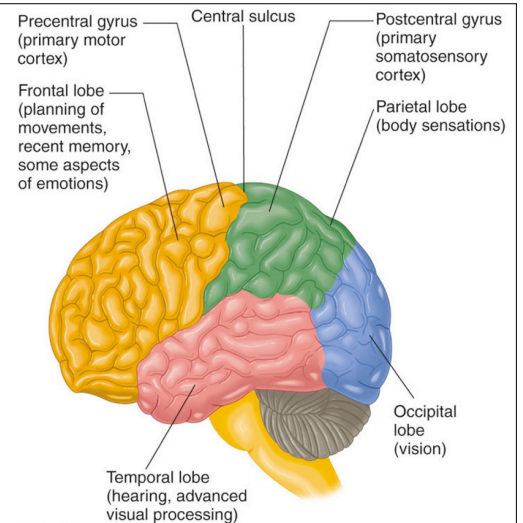
- Anatomically trace pathways of axons to and from sensory/motor systems
- Projection Areas - aka Projection Map
  - area of brain that serves particular sense and location
- Gross overview:
  - Frontal lobe : motor
  - Parietal : somatic
  - Temporal : auditory
  - Occipital : visual

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## Cerebral Cortex Projection Maps



© Wadsworth, Cengage Learning

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## Primary, Secondary, Association

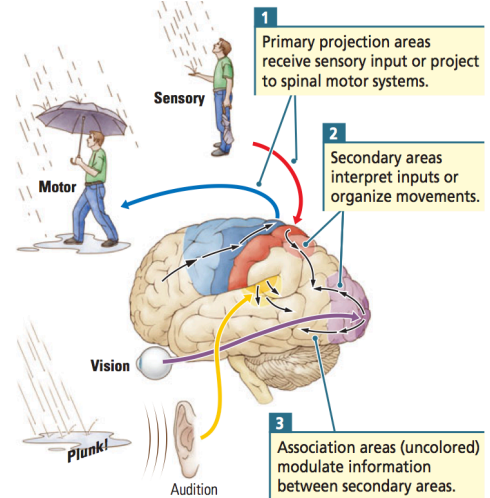
- Primary - first area to receive sensory input or final area to send motor commands
- Secondary - interpret sensory inputs or organize movement
- Tertiary - aka Association Cortex
  - everything else

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## Primary, Secondary, Association

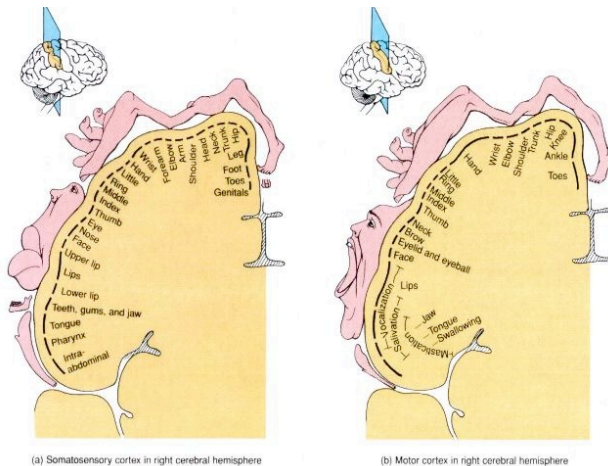


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## Brain Homunculi



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## Cellular organization

- Cortex has 6 layers
- Layers tend to have specialized functions
- Layers appear different in different areas of the brain

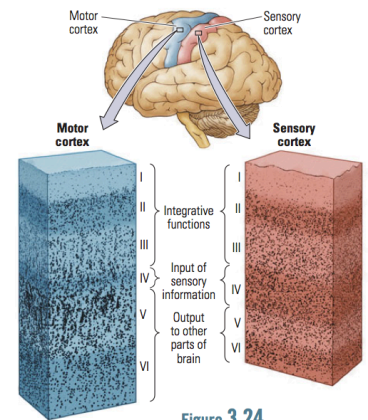


Figure 3.24

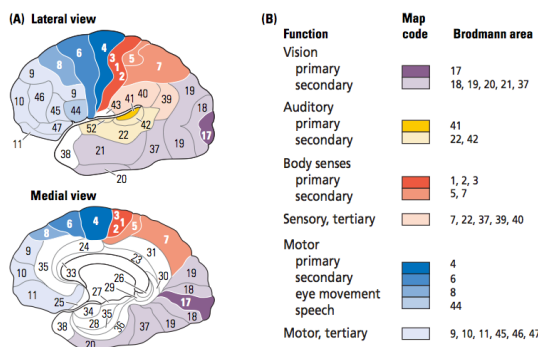
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## Broadmann's Map

- Based on neural architecture



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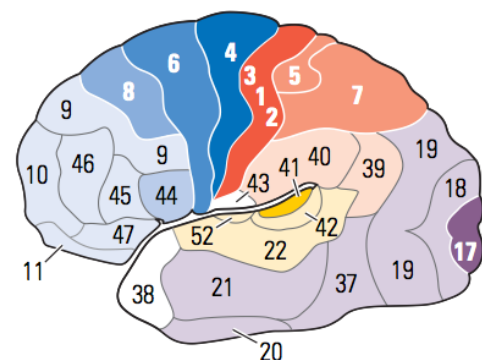
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## Broadmann's Map

- Area 17 - primary visual cortex
- Area 18 - secondary visual cortex

### (A) Lateral view



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## Connections within the Brain

- Areas are different, have unique functions
- But are also highly connected
- Difficult to damage one area without affecting another!
- Major connections:
  - inter-lobe
  - intra-lobe
  - inter-hemisphere
    - homotopic points
  - thalamus

(A) Lateral view

1

Axon fibers connect one lobe of the brain to another,...

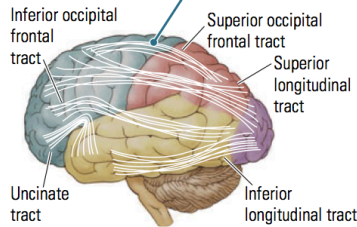


Figure 3.26

Connections Between Various Regions of the Cortex

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## Inter-Lobe Connections

- Connect one lobe to another

(A) Lateral view

1

Axon fibers connect one lobe of the brain to another,...

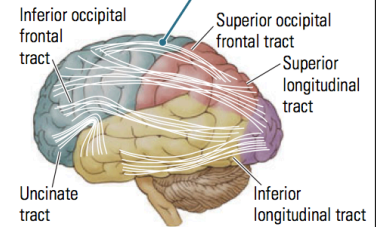


Figure 3.26

Connections Between Various Regions of the Cortex

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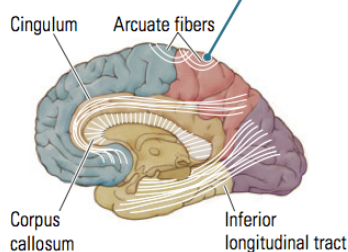
## Intra-Lobe Connections

- Connect areas within a single lobe

(B) Medial view

2

...one part of a lobe to another part,...



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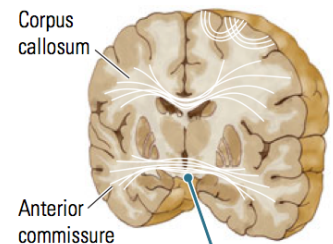
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## Inter-Hemisphere Connections

- Connect the two hemispheres
- Usually connect same area in each hemisphere
  - “homotopic”
- Corpus Callosum
- Anterior Commissure

(C) Frontal view



3

...and one hemisphere of the brain to the other.

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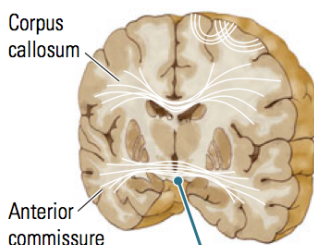
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## The Crossed Brain

- Most brain areas serve opposite side of body or sensory space
- Left arm controlled by right hemisphere
- “Contralateral”
- Perhaps 10% of fibers don’t cross - “ipsilateral”
- Neural crossings are called “decussations”

(C) Frontal view



3

...and one hemisphere of the brain to the other.

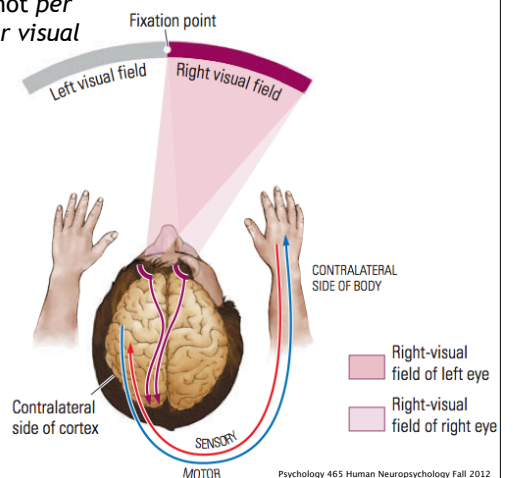
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## The Crossed Brain - Vision

- Vision is crossed not *per eye* but rather *per visual field*



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