

## Chapter 3 : Nervous System Organization

Tuesday, September 4, 2012

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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

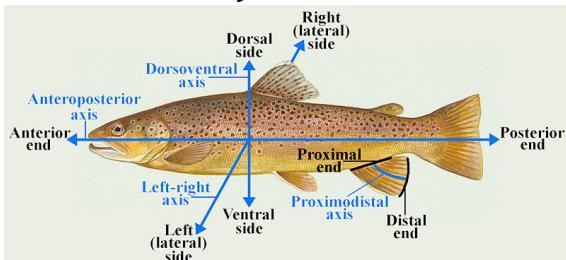


Canadian Stroke Network

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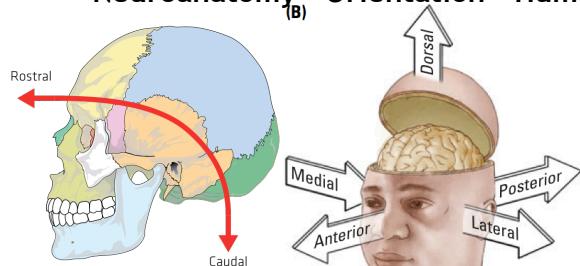
## Neuroanatomy - Orientation - Fish



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
front/rear	rostral / anterior beak/nose	caudal / posterior tail
left/right	medial middle	lateral to the side

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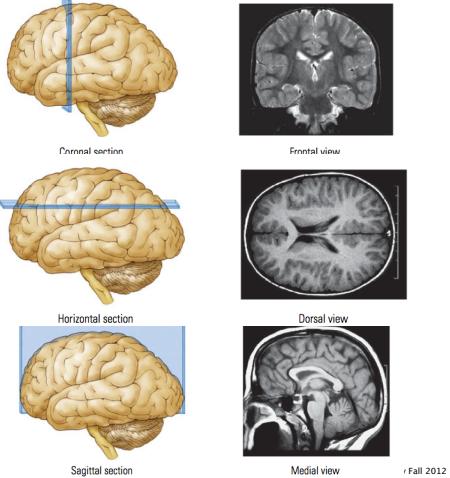
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## Orientation - Other Terms

Section	Description
coronal crown	looking from the front
horizontal	looking from the top down
sagittal arrow	separates the hemispheres

(C) Plane of section



View of brain

Coronal section

Horizontal section

Sagittal section

Medial view

Frontal view

Dorsal view

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## Orientation - Other Terms

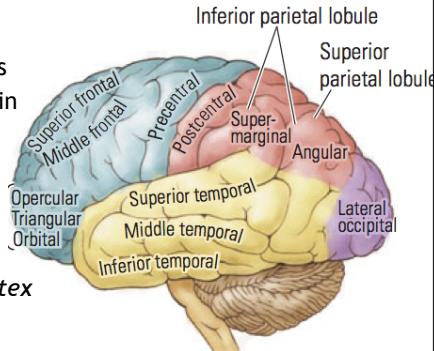
Topic	Description
symmetry	ipsilateral - same side contralateral - opposite sides bilateral - both sides
direction	afferent - toward efferent - away
front-rear relationship	pre- : in front of post- : behind
up-down relationship	superior - above medial - middle inferior - below

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## Nomenclature - confusion

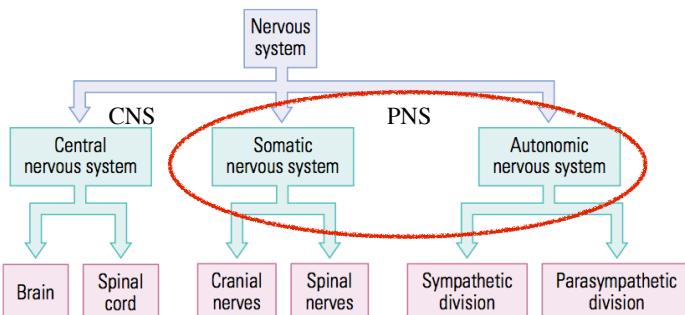
- RS had damage to his **precentral gyrus**, affecting motor abilities
- gyrus precentralis** - Latin
- The motor strip - colloquial
- Jackson's Strip - named after John Hughlings-Jackson
- M1 - **primary motor cortex**
- somatotmotor strip
- motor homunculus
- area pyramidalis - based on type of neurons



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## Nervous System

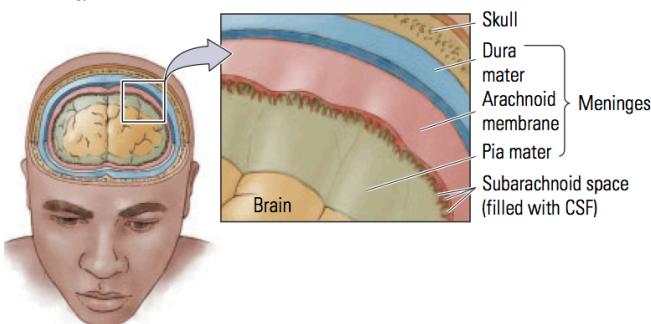


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## Physical protection of Brain

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



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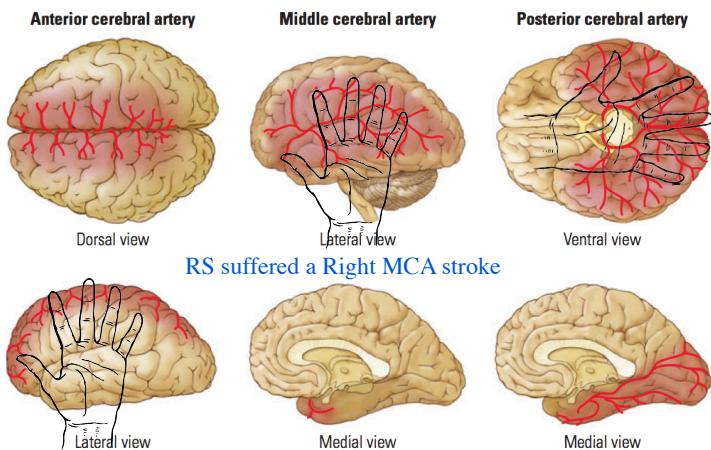
## Chemical Protection of brain

- 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 connections

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## Brain as computer

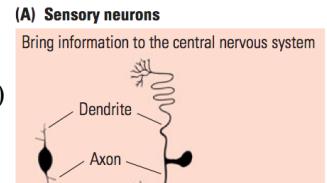
- Human brain :
  - roughly 10 billion neurons
  - 1000 or more connections each
  - 10,000,000,000,000 connections
    - ten thousand billion or ten trillion
- Comparison:
  - Milky Way Galaxy : 300 billion stars

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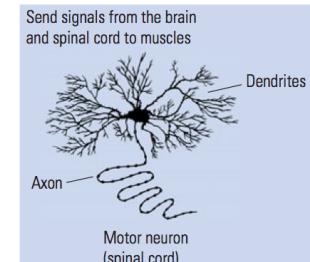
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## Types of Neurons

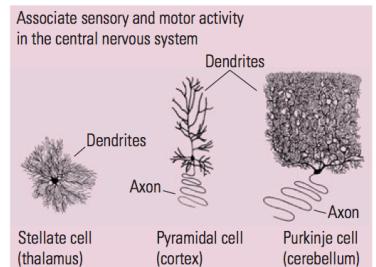
- Neural cells
  - sensory input (afferent)
  - interneurons (computation)
  - motor output (efferent)



### (C) Motor neurons



### (B) Interneurons



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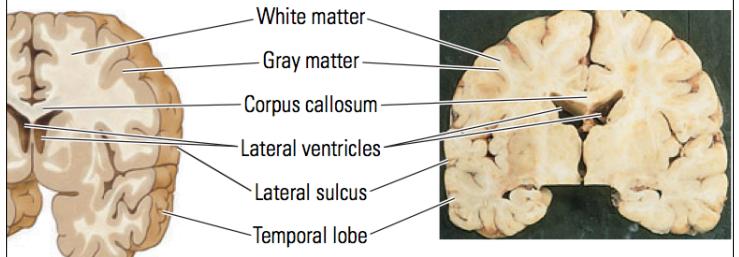
## Grey, White & Reticular Matter

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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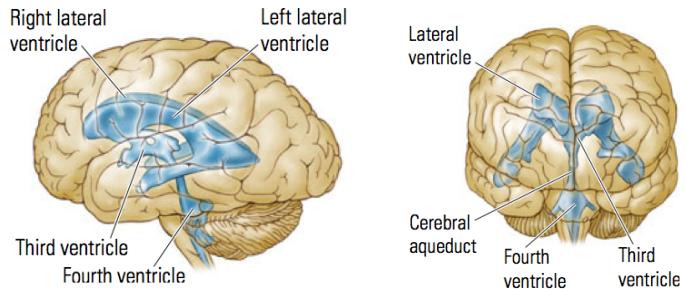
## Layers, Nuclei, Nerves and Tracts

- 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

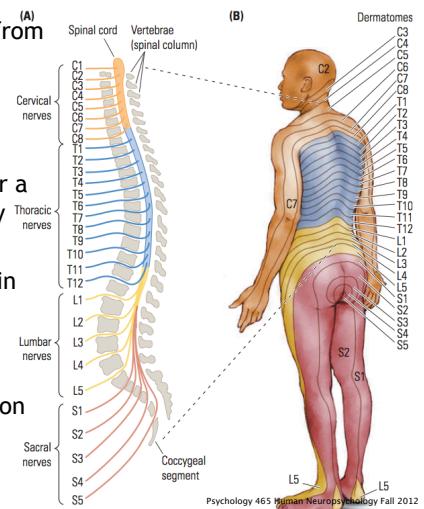


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## Spinal Cord and Dermatomes

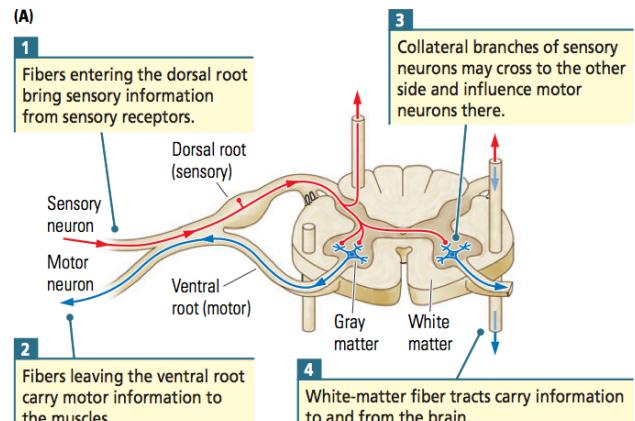
- Spinal cord nerves exit from spine between spinal segments
- Each nerve supports sensation and motion for a specific part of the body
- "Dermatomes" are odd in humans due to upright posture
- Imagine person walking on all fours



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## Dorsal and Ventral Roots



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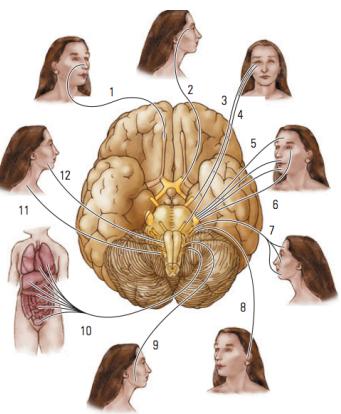
## Spinal Cord Damage

- Minor damage:
  - sensory
    - numbness, tingling, paresthesia
  - motor
    - weakness, paralysis, spasticity
  - reflexes impaired
- 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, elevatd
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



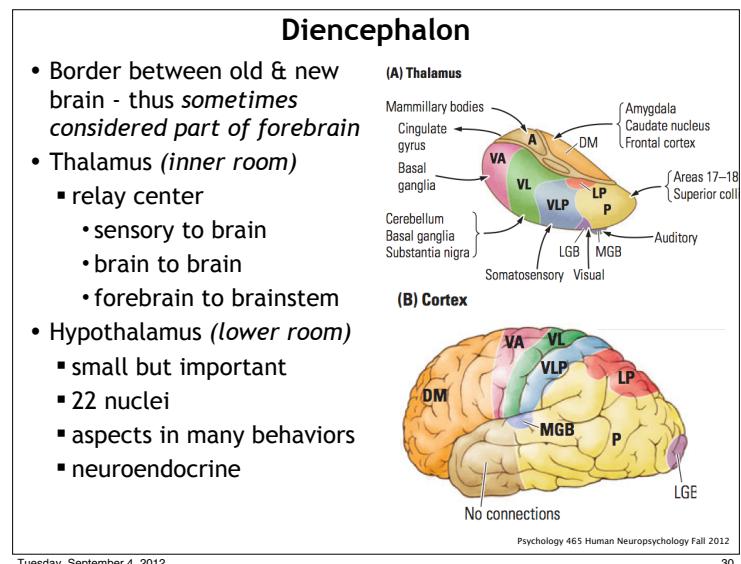
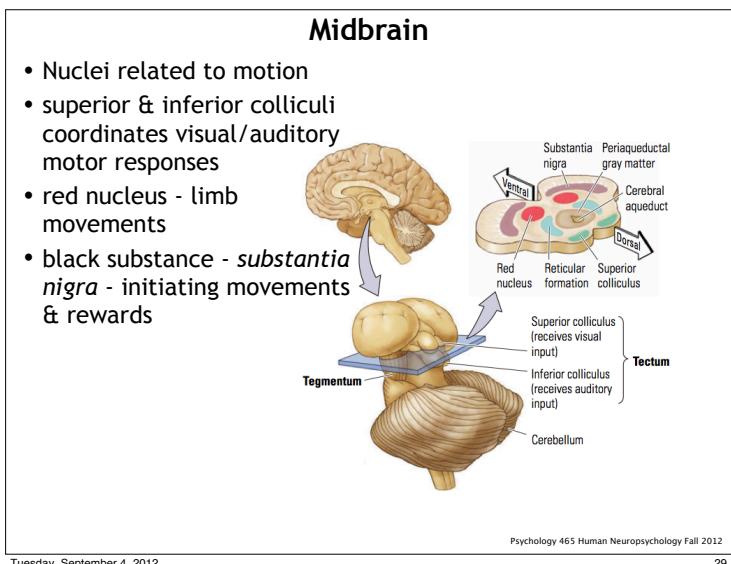
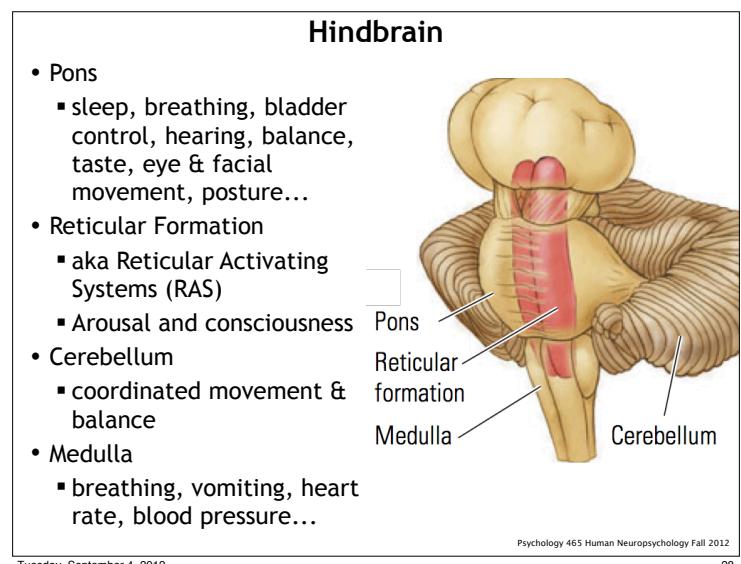
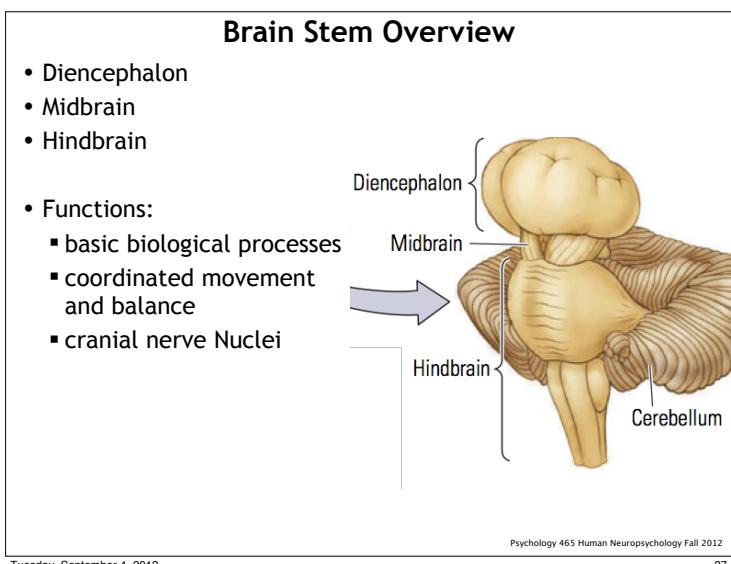
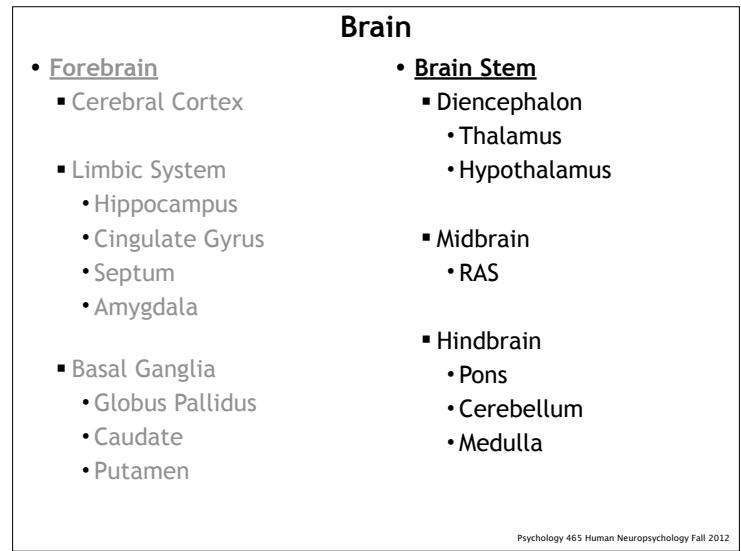
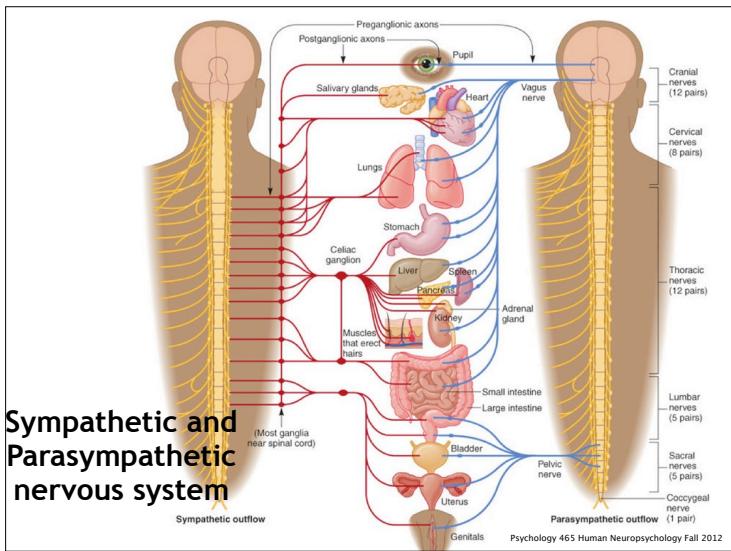
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## Brain

- **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

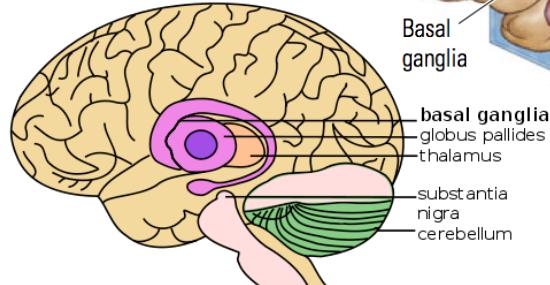
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## Basal Ganglia

- “lower knots”

### Basal Ganglia and Related Structures of the Brain

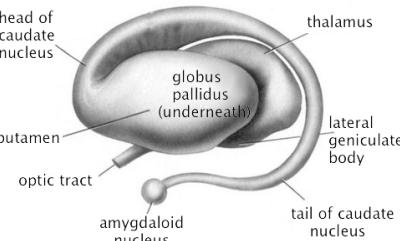


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## Basal Ganglia

- **Structure**
  - Putamen “shell”
  - Globus Pallidus “pale globe”
  - Caudate Nucleus “tailed nucleus”
- **Function**
  - smooth sequencing of motor functions
  - learning of stimulus-response habits

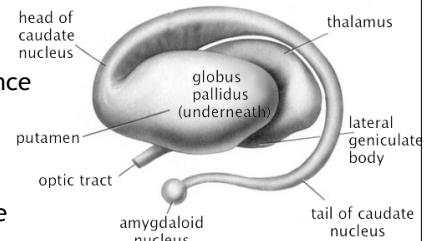


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## Basal Ganglia Disorders

- 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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## Brain

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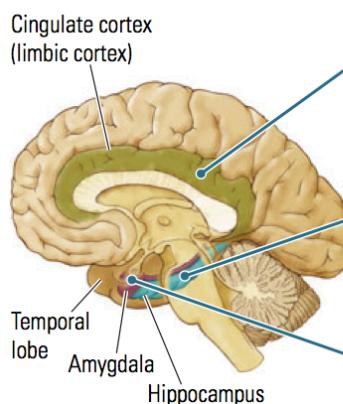
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## Limbic System

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



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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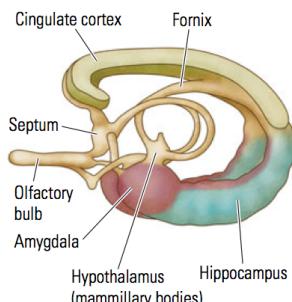
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## Limbic System

- “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)

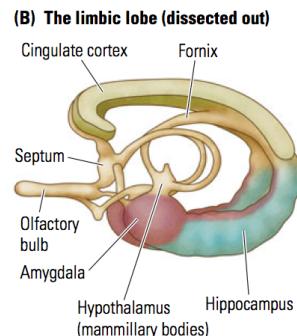


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## Limbic System

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



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## Brain

- Forebrain
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  - Limbic System
    - Hippocampus
    - Cingulate Gyrus
    - Septum
    - Amygdala
  - Basal Ganglia
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    - Caudate
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- Brain Stem
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    - Medulla

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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

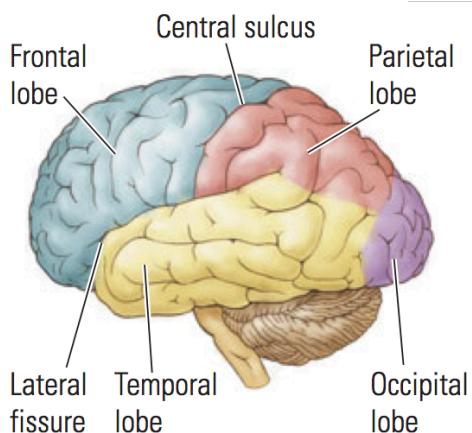
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## Brain Anatomy : lobes, sulci, fissures

### Lateral view

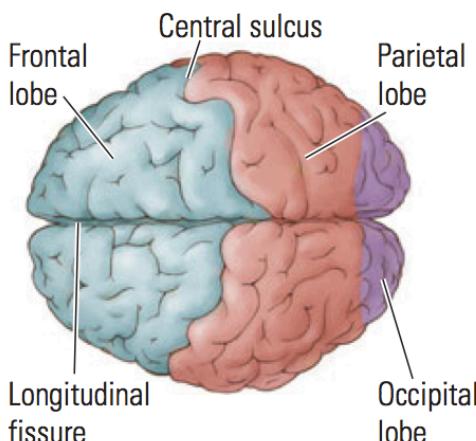


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## Brain Anatomy : lobes, sulci, fissures

### Dorsal view



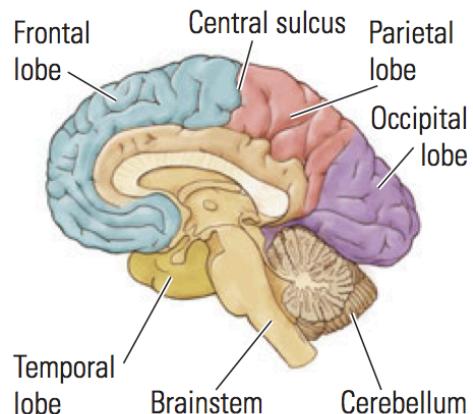
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## Brain Anatomy : lobes, sulci, fissures

### Medial view



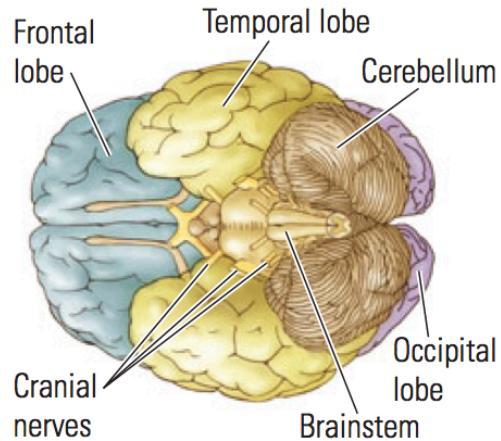
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## Brain Anatomy : lobes, sulci, fissures

### Ventral view

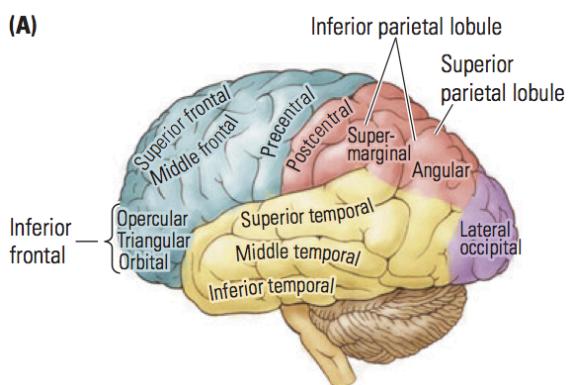


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## Brain Anatomy : Major Gyri

(A)



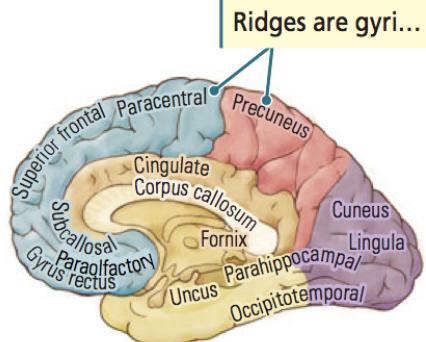
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## Brain Anatomy : Major Gyri

(B)



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## Neocortex Organization - Mapping

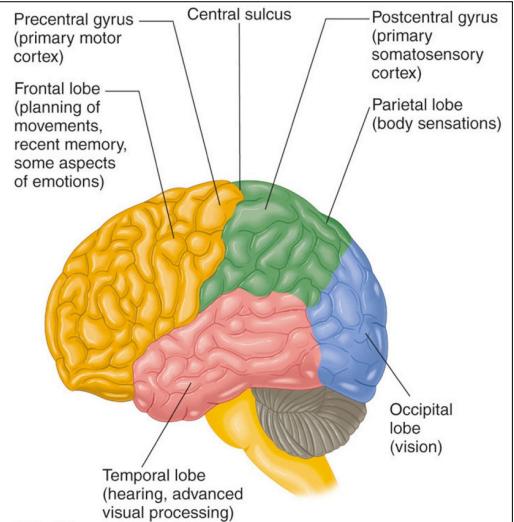
- Anatomically trace pathways of axons to and from sensory/motor systems
- Projection Areas - aka Projection Map
  - area of brain that serves particular sense and location
- Gross overview:
  - Frontal lobe : motor
  - Parietal : somatic
  - Temporal : auditory
  - Occipital : visual

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## Cerebral Cortex Projection Maps



© Wadsworth, Cengage Learning

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## Primary, Secondary, Association

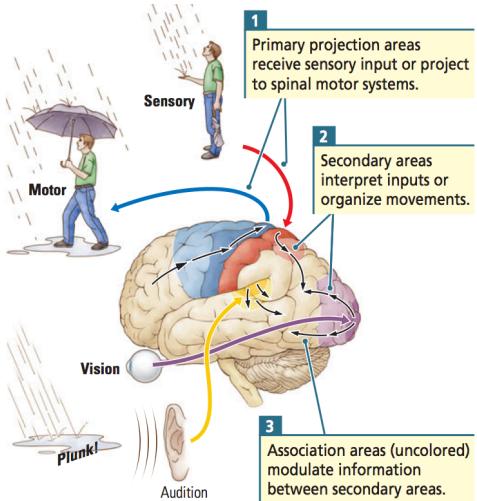
- Primary - first area to receive sensory input or final area to send motor commands
- Secondary - interpret sensory inputs or organize movement
- Tertiary - aka Association Cortex
  - everything else

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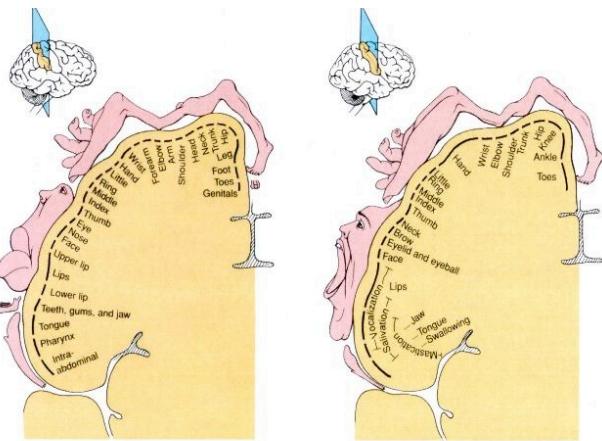
## Primary, Secondary, Association



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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
- Broadmann's Map

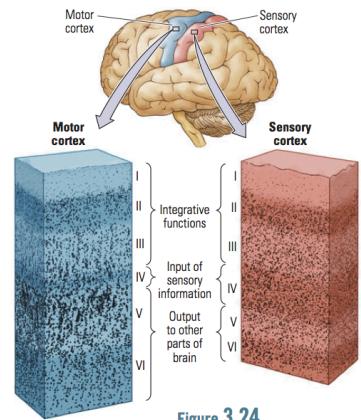


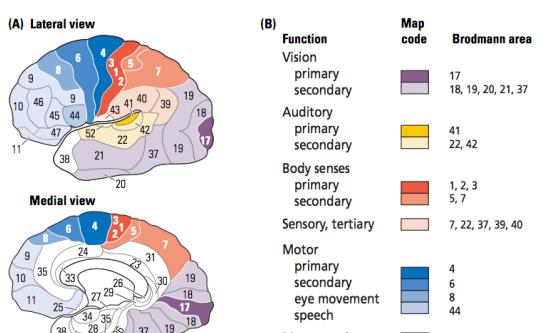
Figure 3.24

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## Broadmann's Map

- Based on neural architecture



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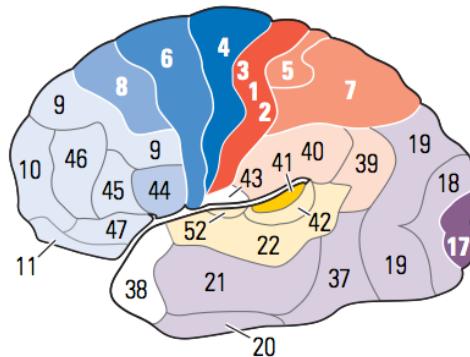
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## Broadmann's Map

- 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

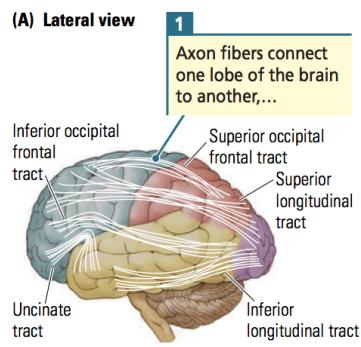


Figure 3.26

Connections Between Various Regions of the Cortex

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## Inter-Lobe Connections

- Connect one lobe to another

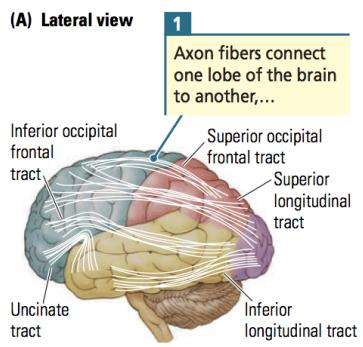


Figure 3.26

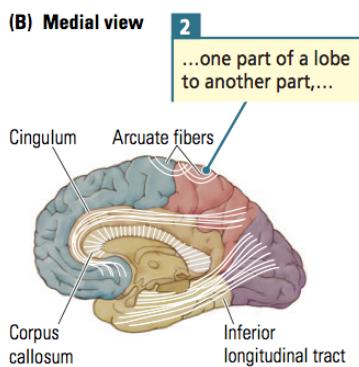
Connections Between Various Regions of the Cortex

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## Intra-Lobe Connections

- Connect areas within a single lobe



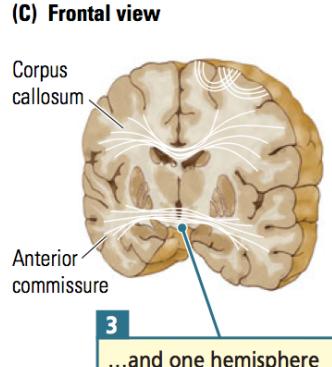
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## Inter-Hemisphere Connections

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



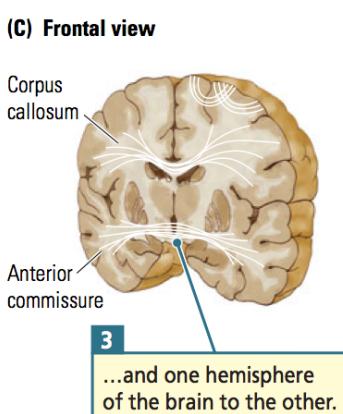
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## The Crossed Brain

- 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”



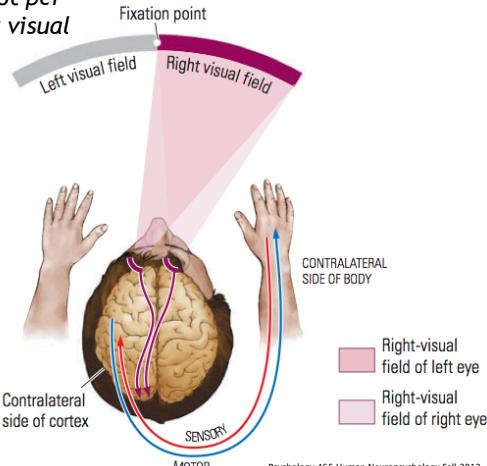
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## The Crossed Brain - Vision

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



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