Week 3 : Nervous System Organization

- KW Chapter 3

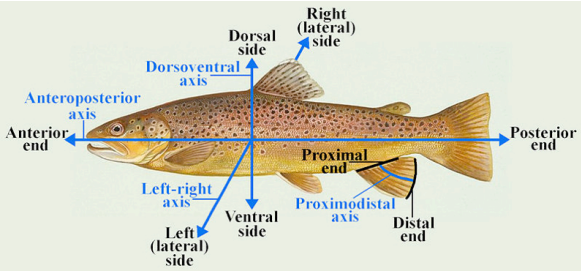
Case Report : RS - Ischemic Stroke

- 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

Case Report : RS

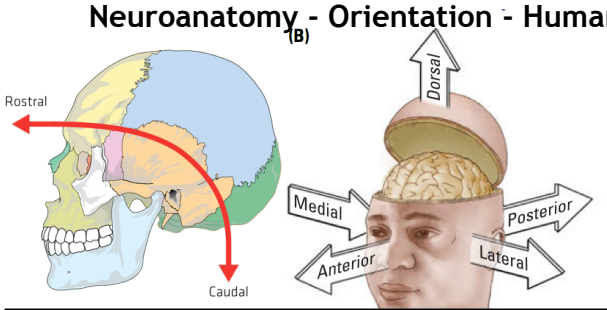
- Sequelae:
  - recovery
    - left leg stiff, but able to walk
    - left arm rigid, no use
  - To family, appeared mostly recovered, but apathetic
    - no interest in business
    - once talkative, now quiet, speaks w/low prosody
- Recovery:
  - after initial physical recovery, no changes for 10 years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

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*

Neuroanatomy - Orientation - Human



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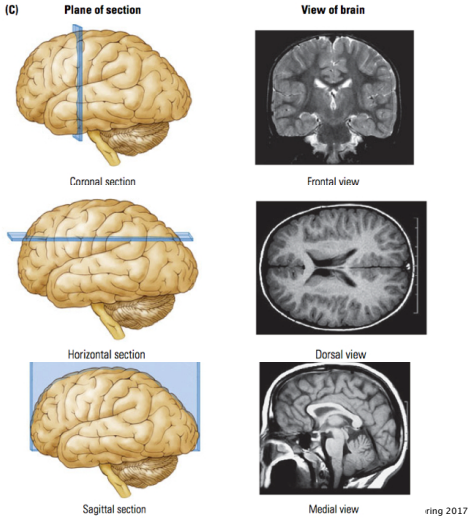
Orientation - Other Terms

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

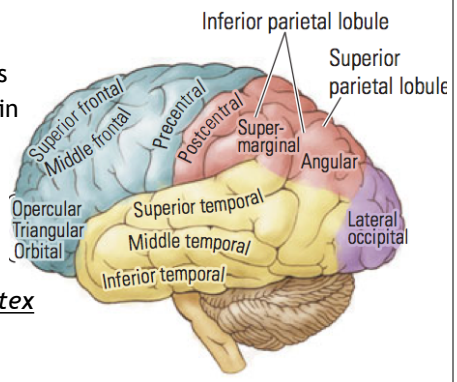


Orientation - Other Terms

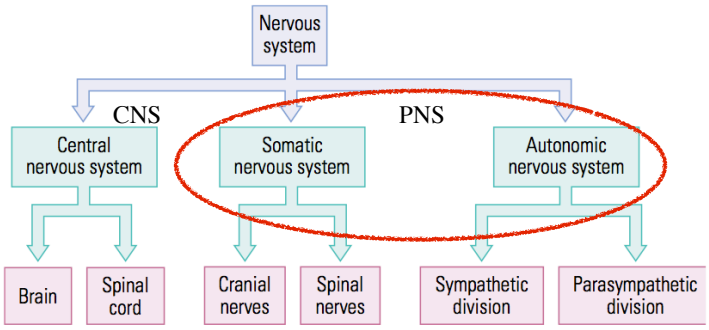
Topic	Description
symmetry	ipsilateral - same side contralateral - opposite sides bilateral - both sides
direction	afferent - toward efferent - away
front-rear relationship	pre- : in front of post- : behind
up-down relationship	superior - above medial - middle inferior - below

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

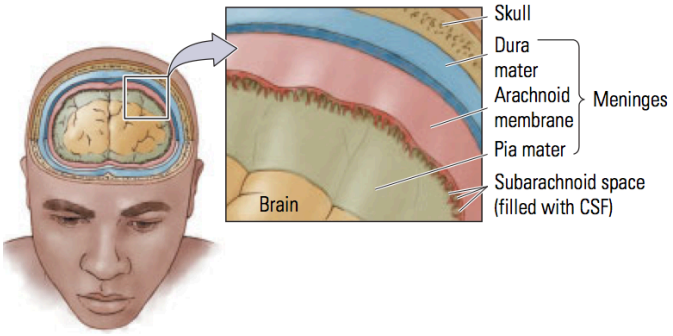


Nervous System



Physical protection of Brain

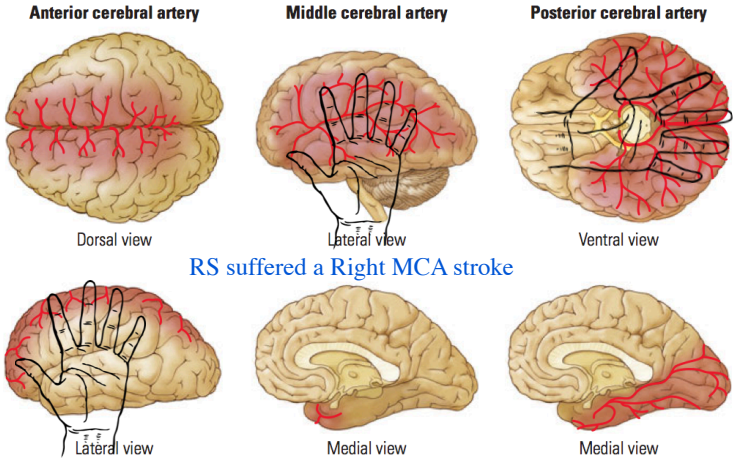
- Skull
  - Meninges (dura, arachnoid, pia mater)
    - Subarachnoid space (CSF)
      - Brain



Chemical Protection of brain

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

Blood Supply



Neurons & Glia

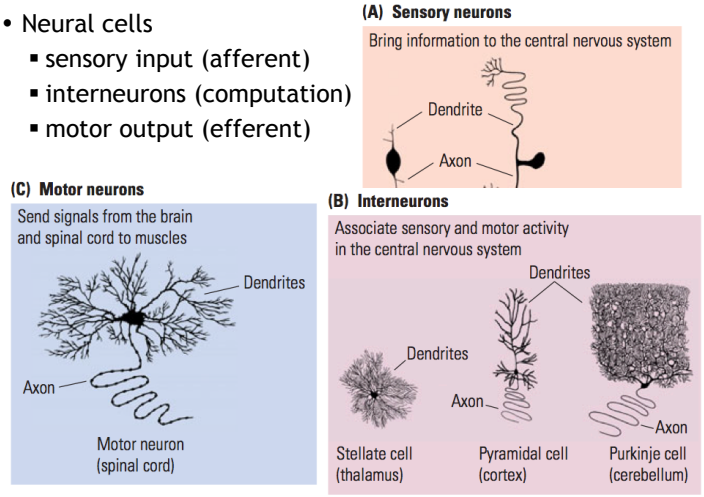
- Glial Cells
  - supportive cells
    - nutrition
    - defense
    - insulation
- Neural cells
  - sensory input (afferent)
  - interneurons (computation)
  - motor output (efferent)
- Human brain :
  - roughly 10 billion neurons
  - 1000 or more connections each
  - 10,000,000,000,000 (ten trillion)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

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

Types of Neurons

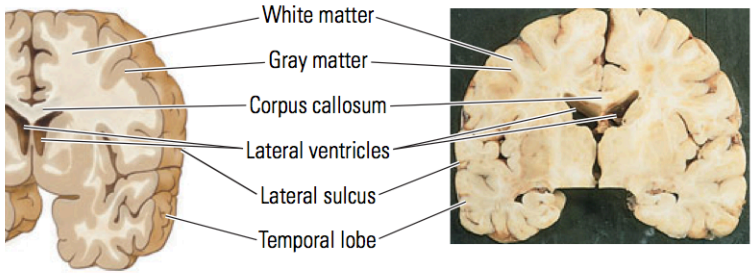
- Neural cells
  - sensory input (afferent)
  - interneurons (computation)
  - motor output (efferent)



Grey, White & Reticular Matter

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

Grey, White & Reticular Matter

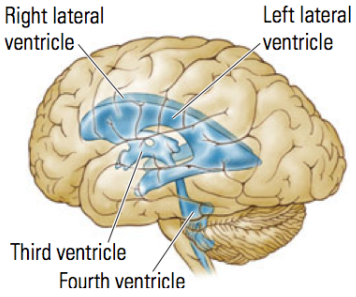


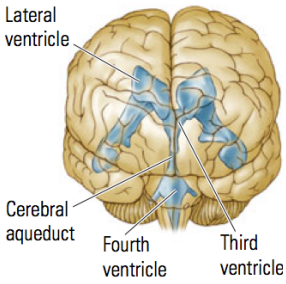
Layers, Nuclei, Nerves and Tracts

- 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

Brain Development, Ventricles and CSF

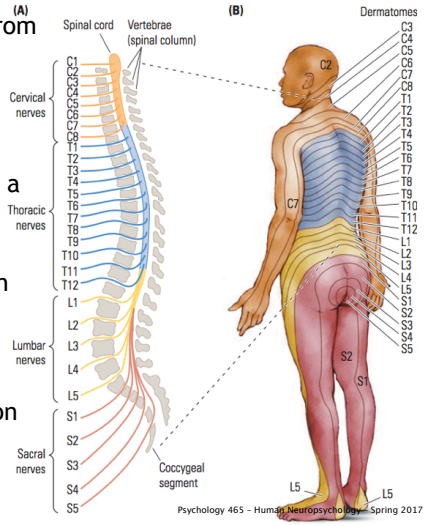
- Human brain has hollow spaces during development
- Ventricles (*bladders)* - hold Cerebrospinal fluid (CSF)
- CSF circulates from brain to spinal cord



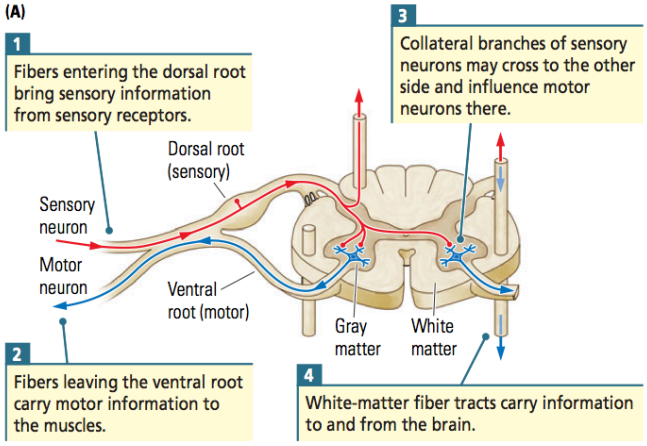


Spinal Cord and Dermatomes

- 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



Dorsal and Ventral Roots

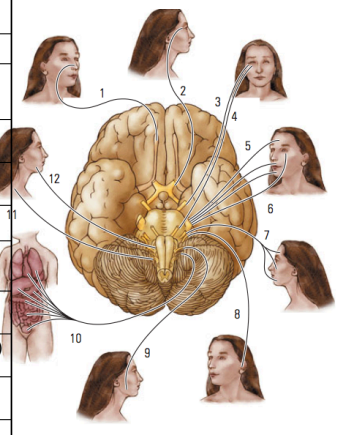


Spinal Cord Damage

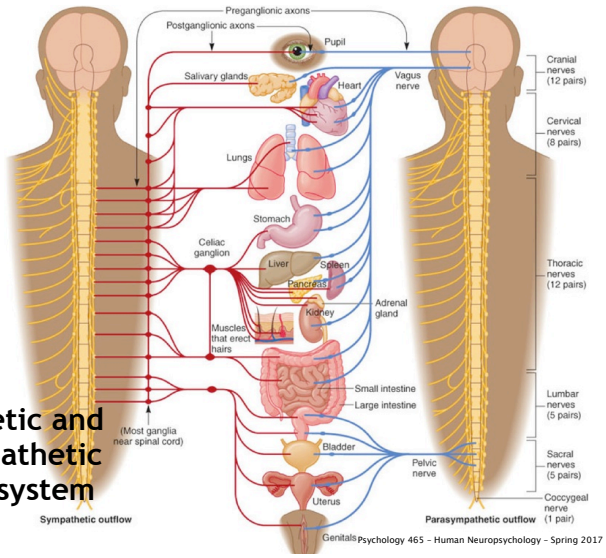
- Minor damage:
  - sensory
    - numbness, tingling, parathesia
  - motor
    - weakness, paralysis, spasticity
  - reflexes impaired
- Major Damage:
  - Paraplegic - spinal cord cut above legs but below level of arms
  - Quadriplegic - spinal cord cut above level of arms

Cranial Nerves

#	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



Sympathetic and Parasympathetic nervous system

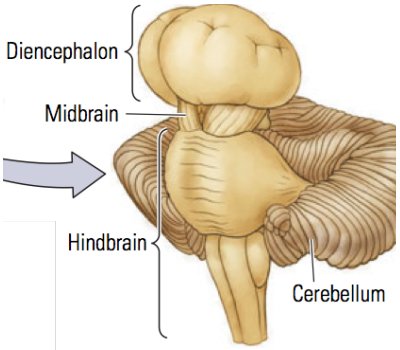


Brain

- 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

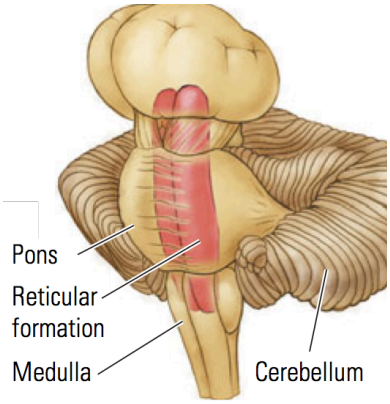
Brain Stem Overview

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



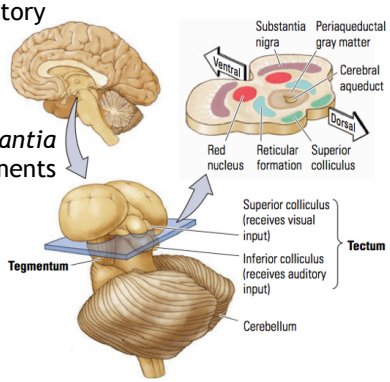
Hindbrain

- 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...



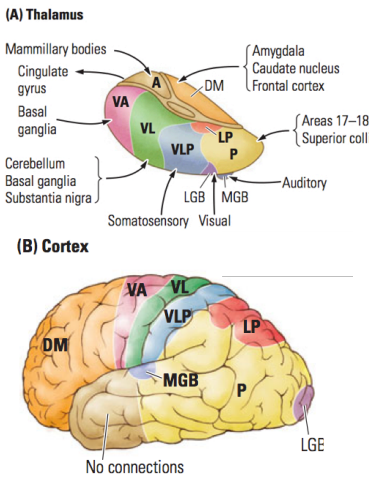
Midbrain

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



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



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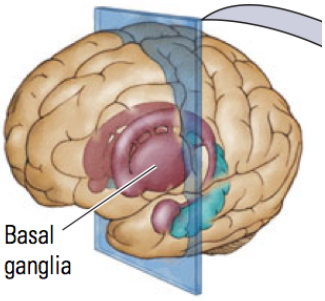
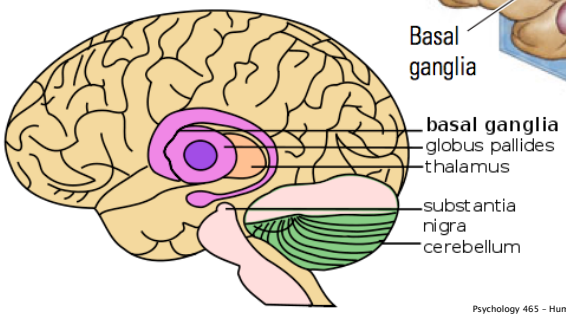
Basal Ganglia

- *"lower knots"*

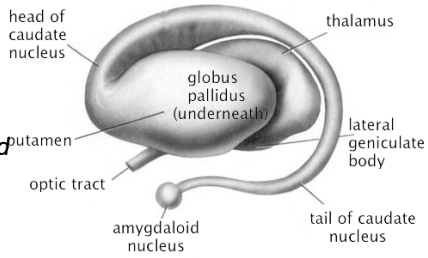


Basal Ganglia and Related Structures of the Brain



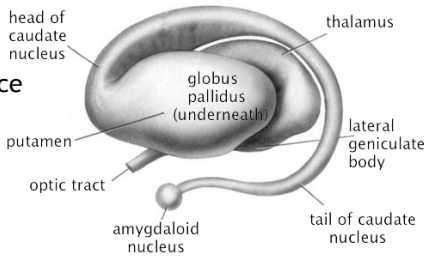
Basal Ganglia

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



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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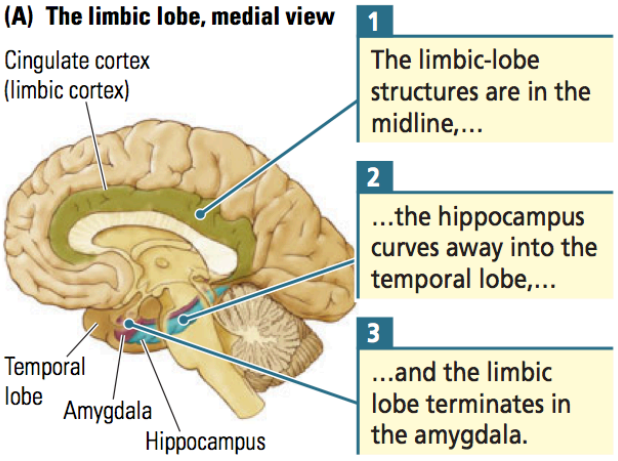
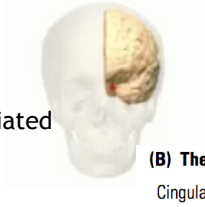
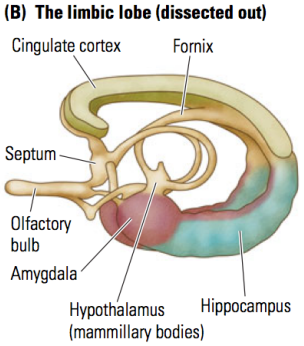
Limbic System



Limbic System

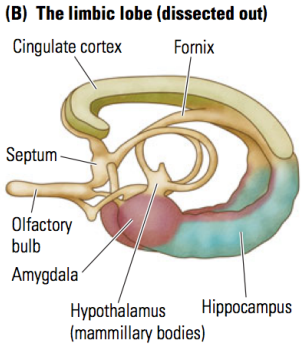
- *"border"*
- History
  - functions unknown, thought to be associated with smell
  - then emotion
  - then memory
  - ? is it a unified system?
- Functions:
  - emotion, behavior, motivation, memory (LTM), olfaction





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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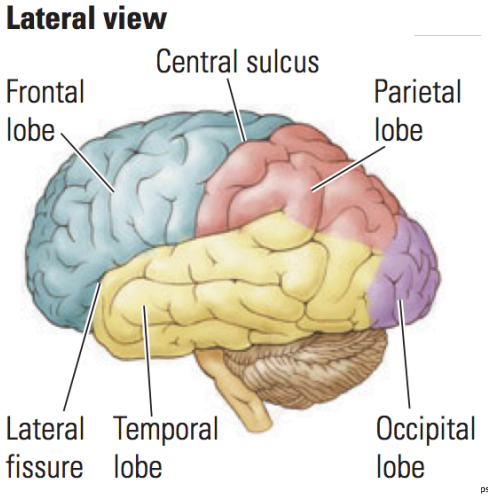
Neocortex

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

Brain Anatomy : lobes, sulci, fissures



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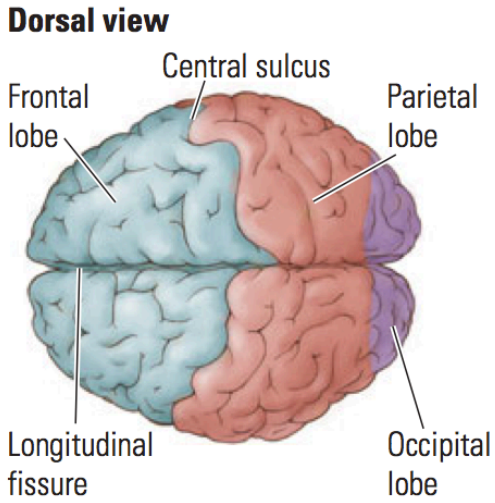

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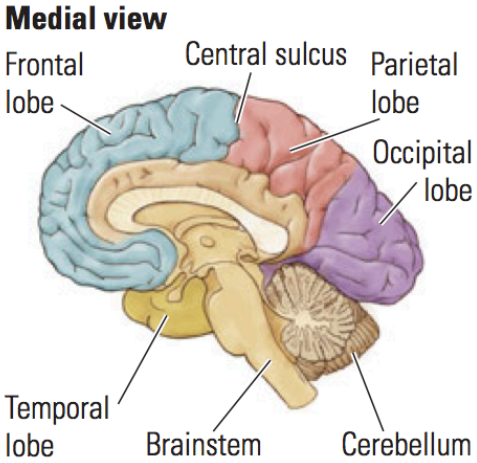

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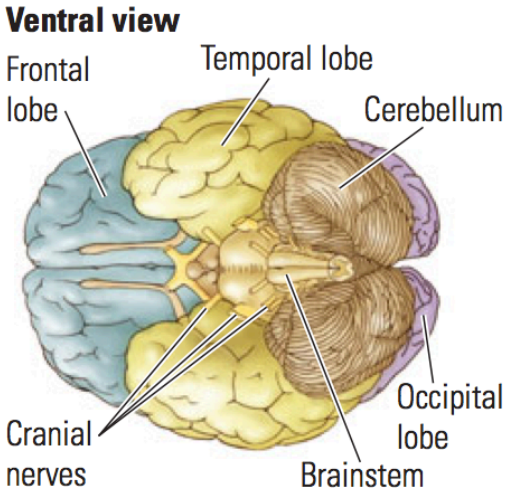
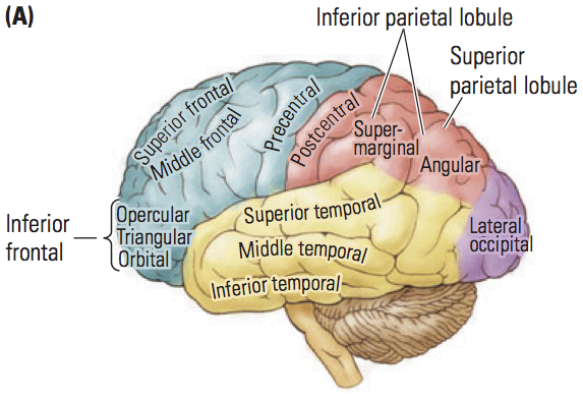
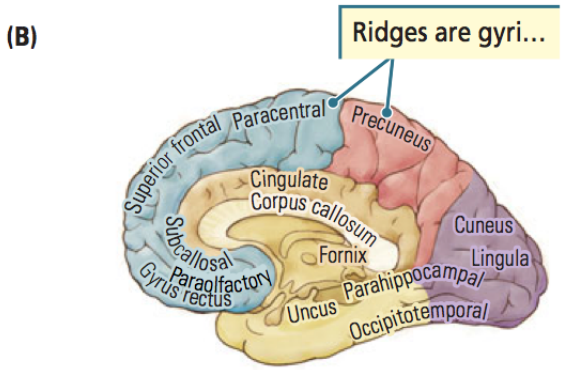


Brain Anatomy : Major Gyri



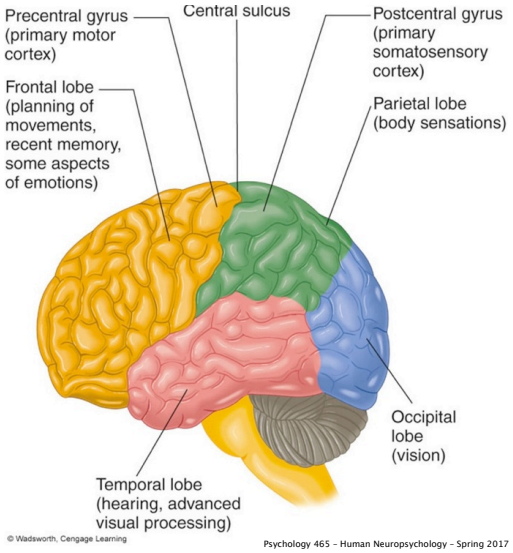
Brain Anatomy : Major Gyri



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

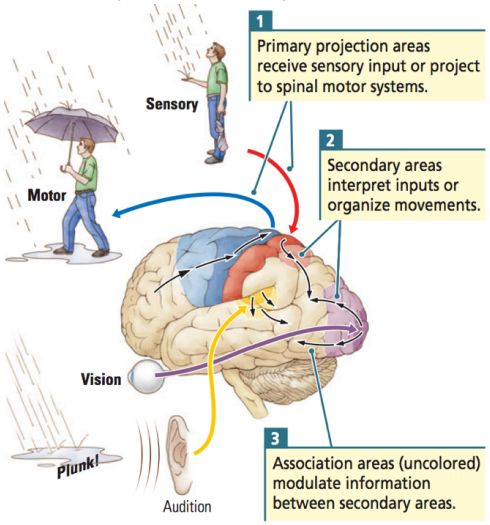
Cerebral Cortex Projection Maps



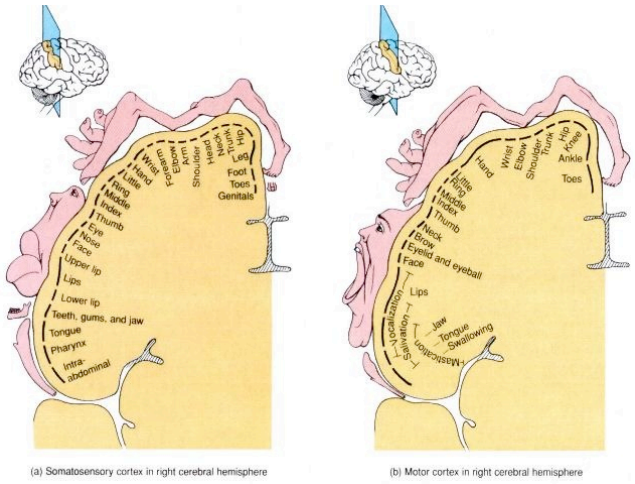
Primary, Secondary, Association

- 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

Primary, Secondary, Association



Brain Homunculi



(a) Somatosensory cortex in right cerebral hemisphere (b) Motor cortex in right cerebral hemisphere

Cellular organization

- Cortex has 6 layers
- Layers tend to have specialized functions
  - Layer IV : sensory input
  - Layers I, II, III : integration
  - Layers V, VI : output
- Layers appear different in different areas of the brain
- Brodmann's Map

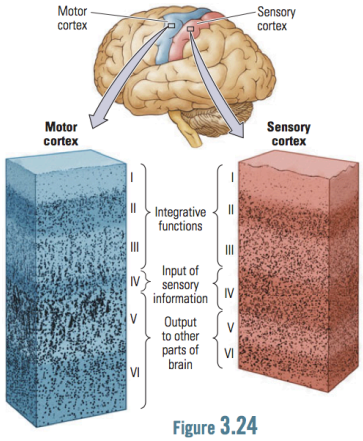
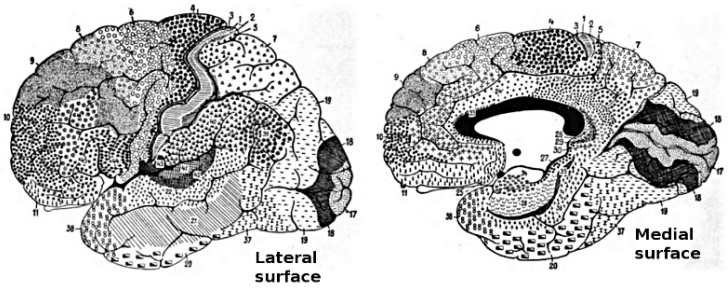


Figure 3.24

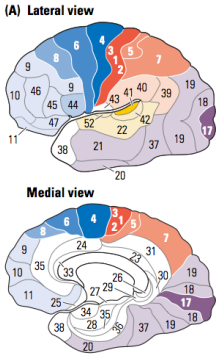
Korbinian Brodmann (1868-1918)

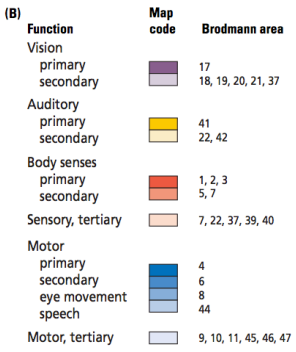
- German Neurologist
- Published cytoarchitectonic map of cortex in 1909
- Worked with Alois Alzheimer



Brodmann's Map

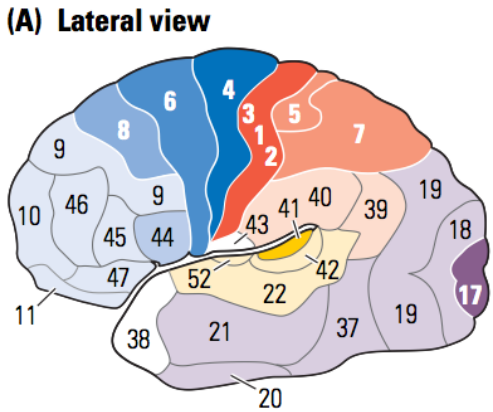
- Based on neural architecture





Brodmann's Map

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



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

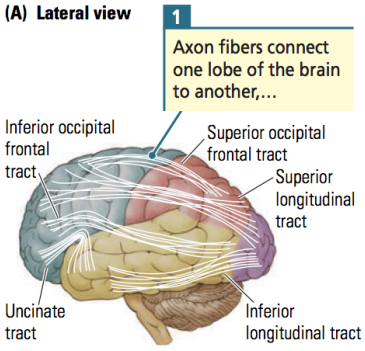


Figure 3.26

Connections Between Various Regions of the Cortex

Inter-Lobe Connections

- Connect one lobe to another

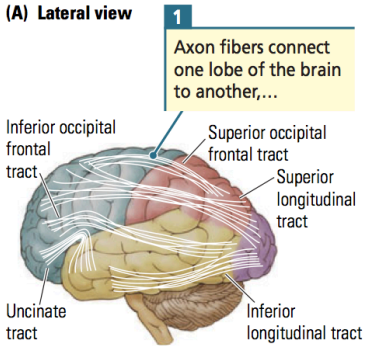
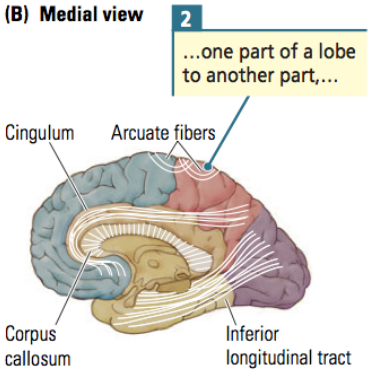


Figure 3.26

Connections Between Various Regions of the Cortex

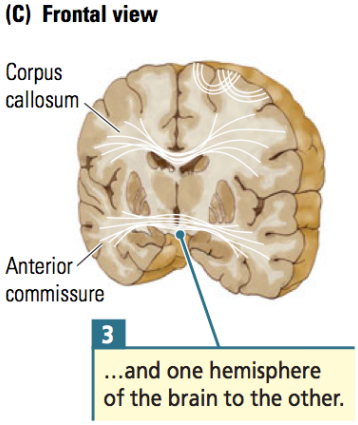
Intra-Lobe Connections

- Connect areas within a single lobe



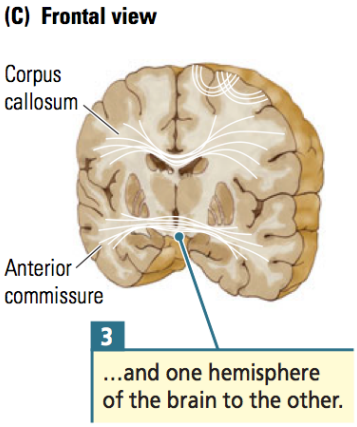
Inter-Hemisphere Connections

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



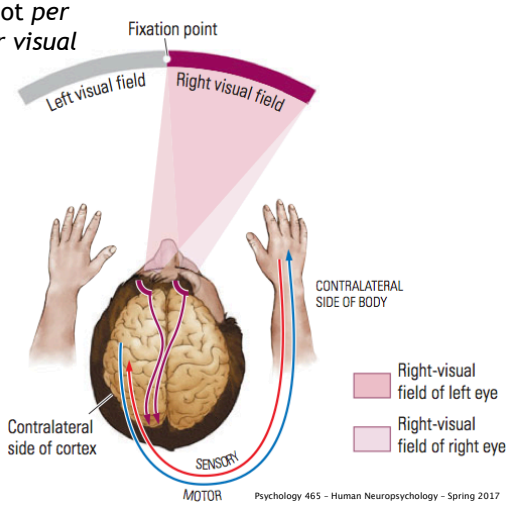
The Crossed Brain

- 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"



The Crossed Brain - Vision

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



Chapter 3 Review

Review: Principles of Organization

- Low to High
  - Old brain --> New Brain
  - Caudal --> Rostral
  - Lower level function --> higher level function
- Left to Right
  - Contralateral organization
  - Left Brain : Language functions
  - Right Brain : Spatial functions
- Back to Front
  - Sensory : back to middle
  - Motor : front to middle

Review: Principles of Organization 2

- Cortical Organization
  - Primary
  - Secondary
  - Association
- Projection Maps
- Cytoarchitectonic