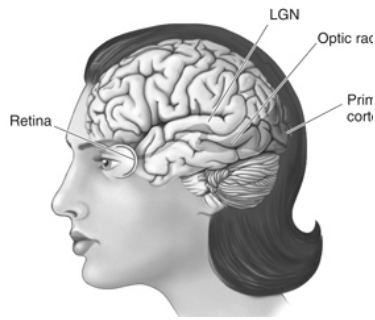


Chapter 07: The Structure of the Nervous System

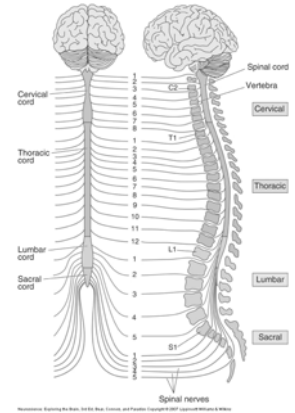


Slide 1

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Introduction

- ◆ Nervous System
 - ◆ The structure will tell us about function
- ◆ Brain organization
 - ◆ organization and terms
 - ◆ 3D structure arises through development
 - ◆ Cerebral neocortex

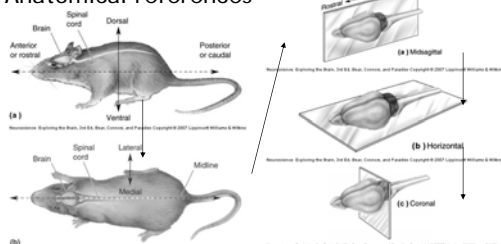


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Gross Organization of the Mammalian Nervous System

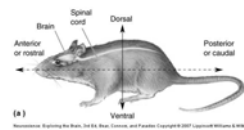
- ◆ Nervous system divisions
 - ◆ CNS (central) and PNS (peripheral)
- ◆ Anatomical references



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Our neuroaxis bends



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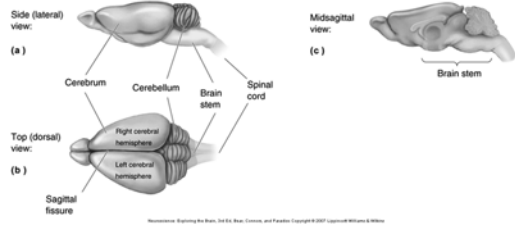
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Gross Organization of the Mammalian Nervous System

◆ The Central Nervous System

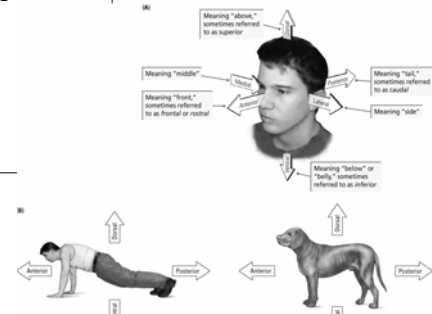
- ✦ Cerebrum, cerebellum, brain stem
- ✦ Spinal Cord



Slide 5

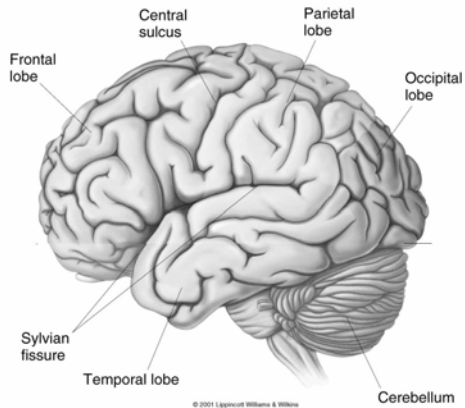
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Rostral, caudal
Coronal; saggital;
Ipsilateral,
contralateral
transverse
horizontal



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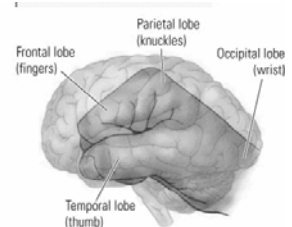


Gyrus, gyri; sulcus, sulci Deep sulci are fissures

Slide 7

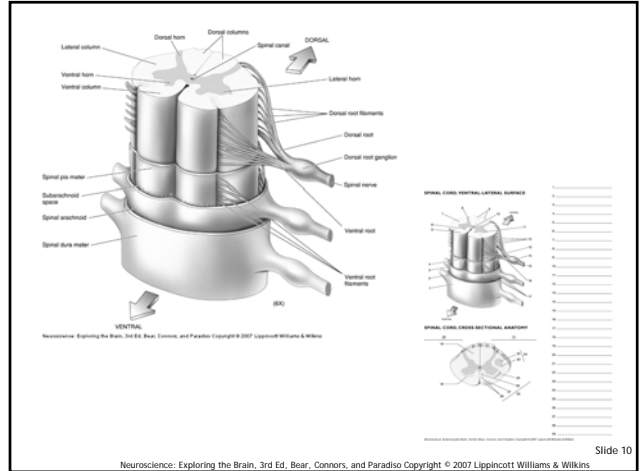
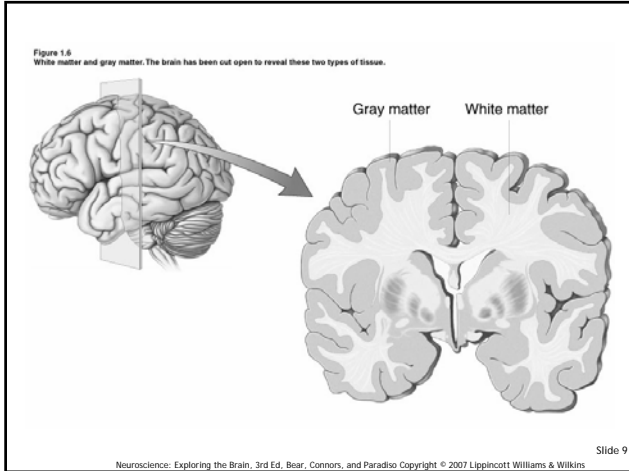
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Anterior, posterior
Dorsal, ventral
Superior, inferior
Lateral, medial
Rostral, caudal
Coronal; saggital;
midsagittal
Ipsilateral, contralateral
Transverse, horizontal



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Gross Organization of the Mammalian Nervous System

- ◆ The Spinal Cord
 - ◆ Location: Surrounded by bone
 - ◆ attached to the brain stem
 - ◆ Conduit of information (brain body)
 - ◆ Skin, joints, muscles

The diagram shows a human figure with the nervous system highlighted. Labels include: Brain, Cerebrum, Cerebellum, Brain stem, Spinal cord, and Peripheral nervous system. The text 'NEUROSCIENCE: Exploring the Brain, 3rd Ed. Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins' is at the bottom.

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Gross Organization of the Mammalian Nervous System

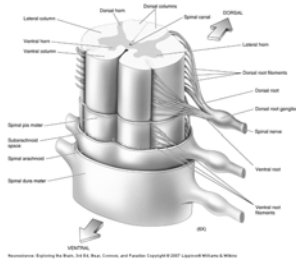
- ◆ The Peripheral Nervous System
 - ◆ Nervous system outside of the brain and spinal cord
 - ◆ Somatic PNS: Innervates skin, joints, muscles
 - ◆ Visceral PNS: Innervates internal organs, blood vessels, glands

The diagram shows a human figure with the nervous system highlighted. Labels include: Cerebrum, Cerebellum, Brain stem, Spinal cord, and Peripheral nervous system. The text 'NEUROSCIENCE: Exploring the Brain, 3rd Ed. Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins' is at the bottom.

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Communication with body

Spinal nerves
Dorsal root
Ventral root



Dorsal root ganglia: Clusters of neuronal cell bodies outside the spinal cord

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Gross Organization of the Mammalian Nervous System

- ◆ Afferent and Efferent Axons
 - ✦ Afferent (carry to): Carry information toward a particular point
 - ✦ Efferent (carry from): Carry information away from a point

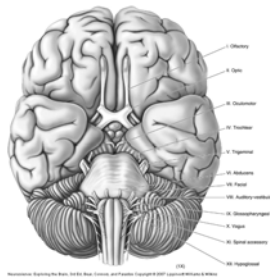
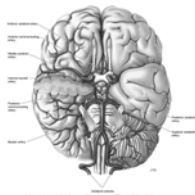
same

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◆ The Cranial Nerves

- ✦ 12 nerves from brain stem
- ✦ Mostly innervate the head
- ✦ Composition: Axons from CNS, somatic PNS, visceral

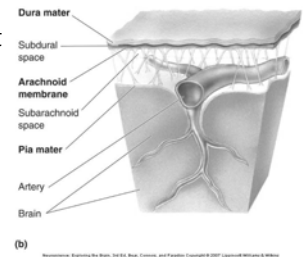


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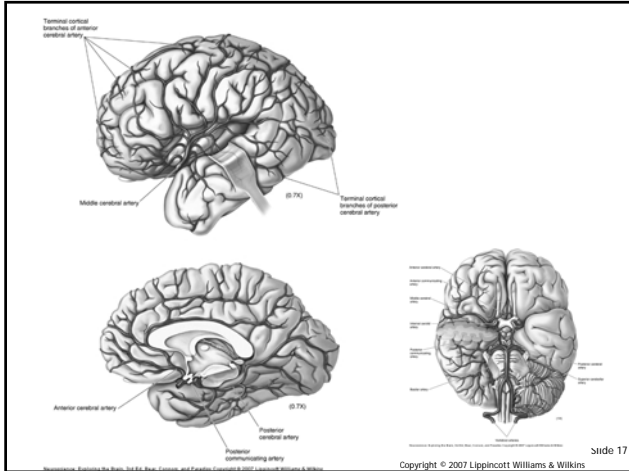
Gross Organization of the Mammalian Nervous System

- ◆ Meninges
 - ✦ Three membranes that surround the brain
 - ✦ Dura mater
 - ✦ Arachnoid membrane
 - ✦ Pia mater



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Gross Organization of the Mammalian Nervous System

- ◆ Brain floats in cerebrospinal fluid (CSF)
 - Subarachnoid space filled with salty clear liquid

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Gross Organization of the Mammalian Nervous System

- ◆ The Ventricular System
 - CSF-filled caverns and canals inside brain
 - Choroid plexus - specialized tissue in ventricles that secretes CSF
 - Path: Cerebrum → brain stem core → subarachnoid space → special structures called arachnoid villi absorb CSF

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CNS - encased in bone

- coup – impact
- countercoup – pressure
- blood trapped in skull hemotoma
- swelling - edema

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Gross Organization of the Mammalian Nervous System

- ◆ Computed Tomography (CT)
 - ✦ Hounsfields and Cormack (1979 Nobel Prize)
 - ✦ Generates an image of a brain slice
 - ✦ X-ray beams are used to generate data that generates a digitally reconstructed image



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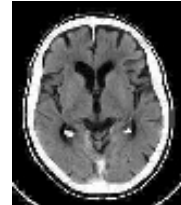
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- Distinguish between bone, fluid, and brain tissue

- White matter and gray matter not well distinguished

(MS lesions not clearly visible)

- intracranial hemorrhage and calcified structures well defined



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Gross Organization of the Mammalian Nervous System

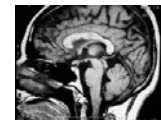
- ◆ Magnetic Resonance Imaging (MRI)
 - ✦ Advantages of MRI over CT
 - ✦ More detail
 - ✦ Does not require X-irradiation
 - ✦ Brain slice image in any angle
 - ✦ Uses information on how hydrogen atoms respond in the brain to perturbations of a strong magnetic field - signals mapped by computer

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MRI conventional- images are static

fMRI - REAL TIME



Protons (nuclei of hydrogen atoms) usually rotate randomly

Head placed in magnetic field, protons line up



Radio frequency pulse makes aligned protons wobble (precession)

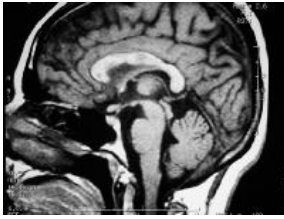
When pulse stops, protons relax and realign to original magnetic field

MRI measures the electrical signal as protons return to original state

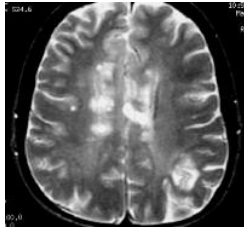
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T1 weighted



T2 weighted



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Gross Organization of the Mammalian Nervous System

- ◆ Functional Brain Imaging
 - ◆ Positron emission tomography (PET)
 - ◆ Functional MRI (fMRI)
 - ◆ Basic Principles
 - ◆ Detect changes in regional blood flow and metabolism within the brain
 - ◆ Active neurons demand more glucose and oxygen, more blood to active regions, techniques detect changes in blood flow



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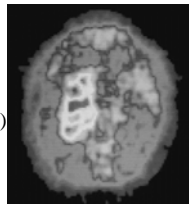
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PET-- short-lived isotopes

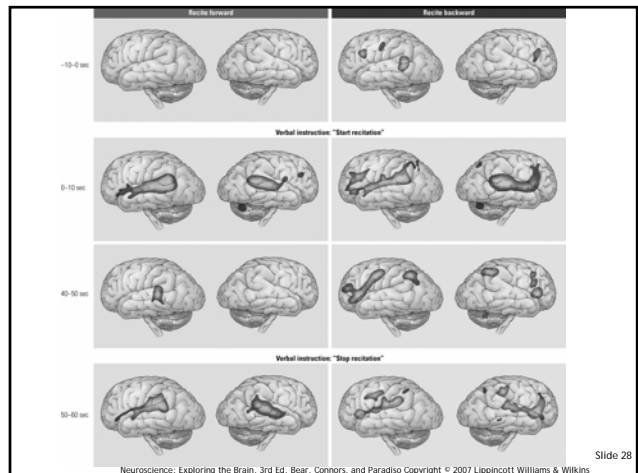
Isotope attached to molecule used to locate changes in blood flow, areas of high metabolic activity

Example: radioactive oxygen (^{15}O) use measured (principle -high oxygen use = high metabolic activity.)

- superimposed on MRI image.
- High spatial resolution (poor temporal)
- high cost (cyclotron needed to create the isotope)
- invasive (limited used in children)



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Understanding CNS Structure Through Development

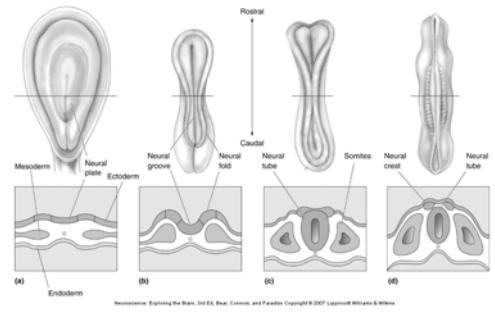
- ◆ Ventricular System and the CNS
 - ✦ The CNS forms from walls of a fluid-filled tube
 - ✦ The tube becomes ventricular system
 - ✦ The neural tube
 - * Endoderm, mesoderm, ectoderm
 - * Neural plate → neural groove
 - * Fusion of neural folds
 - * Neural tube (forms CNS neurons)
 - * Neural crest (forms PNS neurons)

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Understanding CNS Structure Through Development

◆ Formation of the Neural Tube

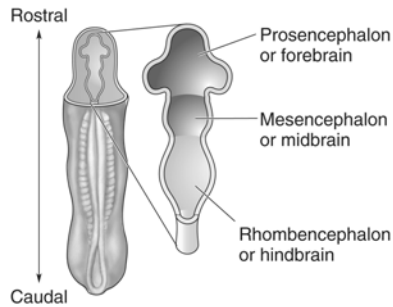


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Understanding CNS Structure Through Development

◆ Three Primary Brain Vesicles



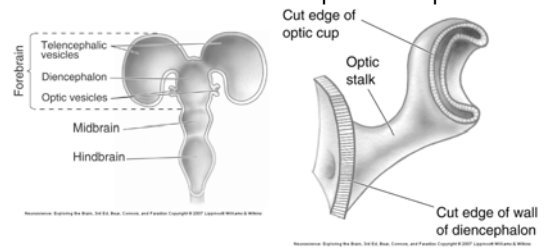
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Understanding CNS Structure Through Development

◆ Differentiation of the Forebrain

- ✦ Differentiation: Process by which structures become complex and specialized



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Understanding CNS Structure Through Development

- ◆ Differentiation of the Telencephalon and Diencephalon
 - ✦ Telencephalon
 - * Forms cerebral hemispheres, olfactory bulbs, basal telencephalon
 - ✦ Diencephalon
 - * Thalamus and hypothalamus

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Understanding CNS Structure Through Development

- ◆ Major white matter systems
 - ✦ Axons extend from developing forebrain to other parts of the NS
 - * Cortical white matter
 - * Corpus callosum
 - * Internal capsule

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Understanding CNS Structure Through Development

- ◆ Forebrain Structure-Function Relationships
 - ✦ Cerebral cortex
 - * Analyze sensory input and command motor output
 - ✦ Thalamus: Gateway of the cortex
 - * Axons from thalamus to cortex pass through the internal capsule
 - * Carry information from contralateral side of the body

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Understanding CNS Structure Through Development

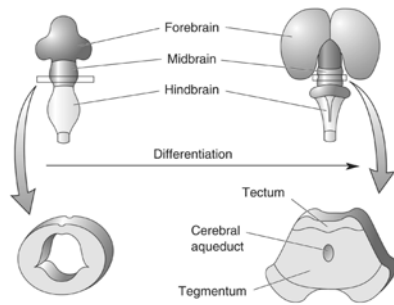
- ◆ Forebrain Structure-Function Relationships (Cont'd)
 - ✦ Axons from cortex to thalamus also pass through internal capsule
 - ✦ Hypothalamus
 - * Control of visceral nervous system

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Understanding CNS Structure Through Development

◆ Differentiation of the Midbrain



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Understanding CNS Structure Through Development

◆ Midbrain Structure-Function Relationships

- ◆ Contains axons descending from cortex to brain stem and spinal cord
 - * E.g., Corticospinal tract
- ◆ Information conduit from spinal cord to forebrain and vice versa, sensory systems, control of movements

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Understanding CNS Structure Through Development

◆ Midbrain Structure-Function Relationships (Cont'd)

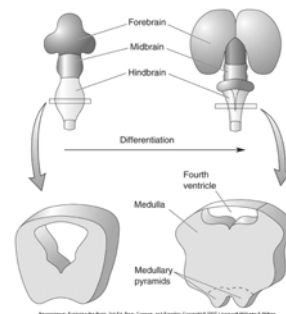
- ◆ Tectum → Superior colliculus (receives sensory info from eye), inferior colliculus (receives sensory info from ear)
- ◆ Tegmentum
 - * Substantia nigra (black substance) and red nucleus - control voluntary movement

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Understanding CNS Structure Through Development

◆ Differentiation of the Hindbrain



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Understanding CNS Structure Through Development

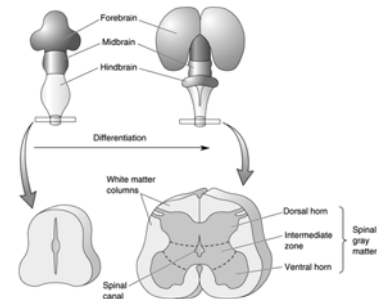
- ◆ Hindbrain Structure-Function Relationships
 - ✦ Cerebellum: Movement control
 - ✦ Pons: Switchboard connecting cerebral cortex to cerebellum
 - ✦ Cochlear Nuclei: Project axons to different structures (e.g., inferior colliculus)
 - ✦ Decussation: Crossing of axons from one side to the other

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Understanding CNS Structure Through Development

- ◆ Differentiation of the Spinal Cord

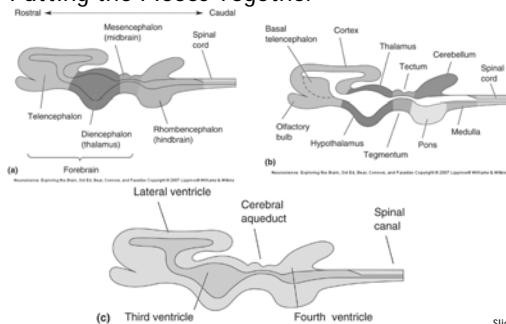


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Understanding CNS Structure Through Development

- ◆ Putting the Pieces Together

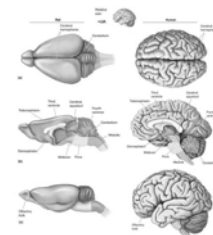


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Understanding CNS Structure Through Development

- ◆ Special Features of the Human CNS
 - ✦ Similarities in rat and human brain
 - ✦ Basic arrangement of various structures



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Understanding CNS Structure Through Development

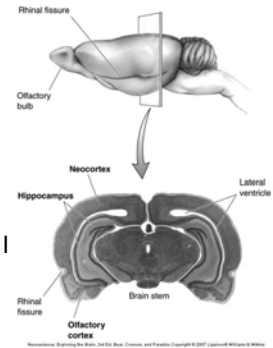
- ◆ Special Features of the Human CNS
 - ✦ Differences
 - * Convolutions on human cerebrum surface called sulci and gyri
 - * Size of olfactory bulb
 - * Growth of cerebral hemisphere: Temporal, frontal, parietal, occipital

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A Guide to the Cerebral Cortex

- ◆ Types of Cerebral Cortex
 - ✦ Common Features
 - * Cell bodies in layers or sheets
 - * Surface layer separated from pia mater, layer I
 - * Apical dendrites form multiple branches



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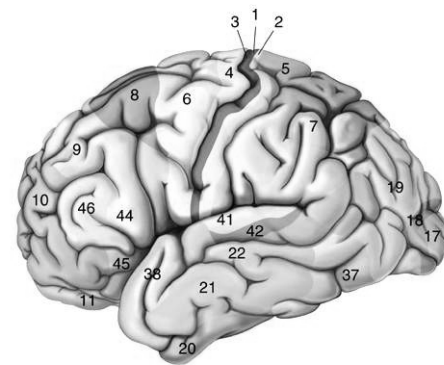
A Guide to the Cerebral Cortex

- ◆ Areas of Neocortex
 - ✦ Brodmann
- ◆ Neocortical Evolution and Structure-Function Relationships
 - ✦ Cortex amount has changed, not structure
 - ✦ Leah Krubitzer: Primary sensory areas, secondary sensory areas, motor areas
 - ✦ Jon Kaas: Expansion of secondary sensory areas



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Concluding Remarks

- ◆ Understanding Neuroanatomy
 - ◆ Important to understand how the brain works
 - ◆ We have looked at a “shell” or “scaffold” of the nervous system
 - ◆ The advent of methods to image the living brain has given a new relevance to neuroanatomy
 - ◆ More powerful techniques for understanding structure

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◆ End of Presentation

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