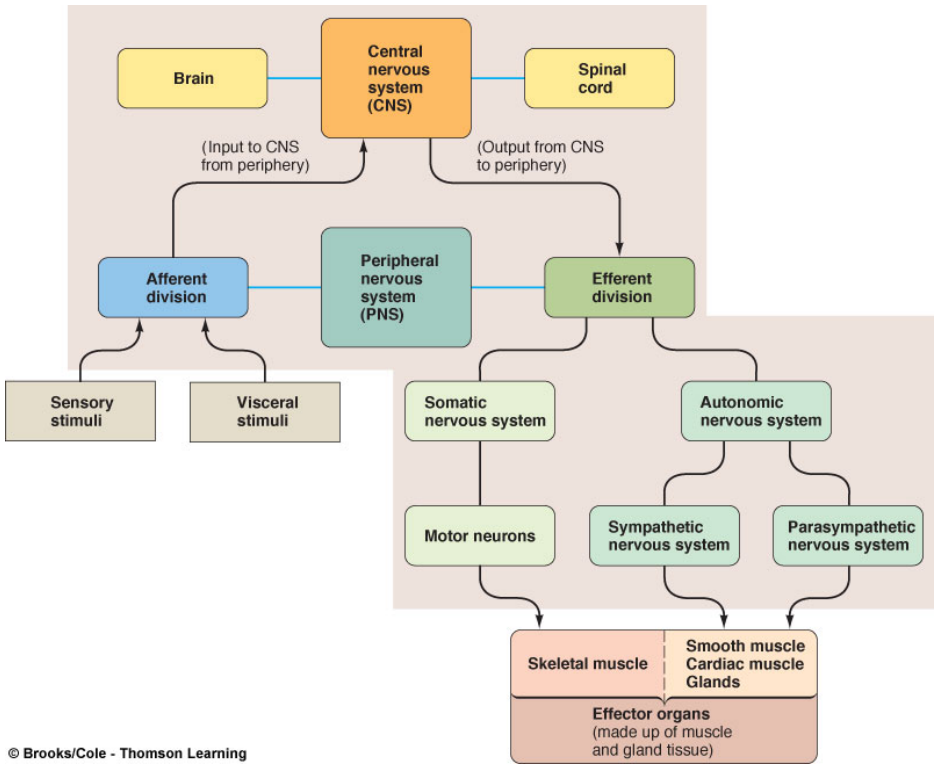
Νευροφυσιολογία και Αισθήσεις

Διάλεξη 7

Νευροανατομία (Neuroanatomy)

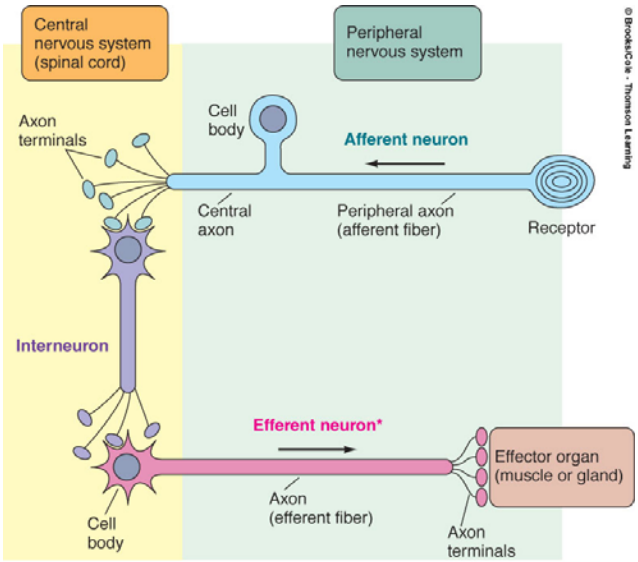
(Chapter 7 APPENDIX and Slides)

Organization of the Nervous System



Organization of the Nervous System

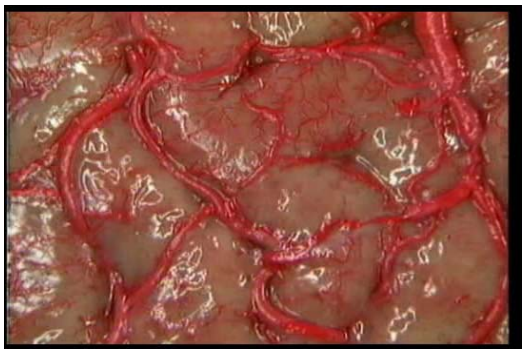
- **Afferent neurons**
  - Inform CNS about conditions in both the external and internal environment
- **Efferent neurons**
  - Carry instructions from CNS to effector organs – muscles and glands
- **Interneurons**
  - Found entirely within CNS
  - Responsible for
  - Integrating afferent information and formulating an efferent response
  - Higher mental functions associated with the “mind”

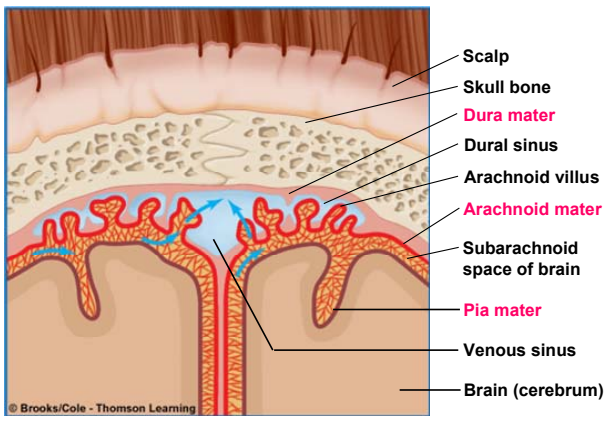


* Efferent autonomic nerve pathways consist of a two-neuron chain between the CNS and the effector organ.

Meninges and the CSF

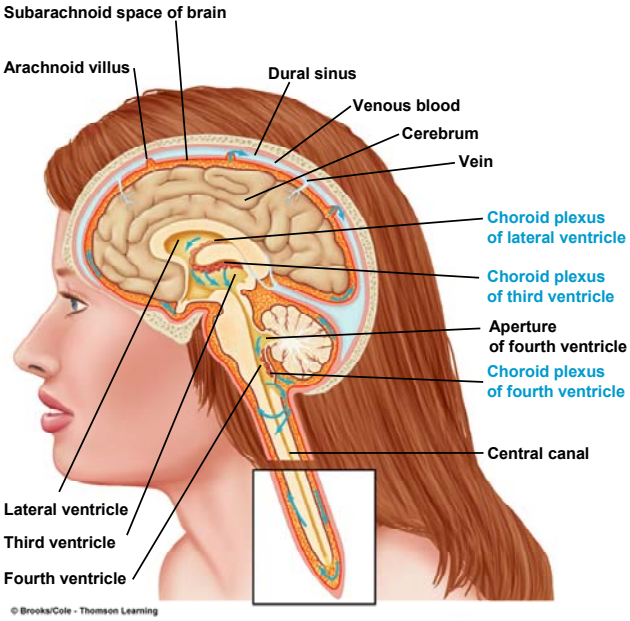
- **Protection of the CNS**
  - Hard bony structures (cranium and vertebral column) protect it
  - Three membranes (the meninges) protect and nourish it
  - The brain floats in the cerebrospinal fluid (CSF)
  - The blood-brain barrier (highly selective) limits access to harmful blood born substances
- **Meningial Membranes**
  - Dura matter
    - Two layers mostly attached
    - Dural and Venous sinuses return venous blood and CSF
  - Arachnoid matter
    - Richly vascularized layer
    - Arachnoid villi (CSF reabsorbed into venous circulation here)
  - Pia matter
    - Layer closer to the brain and ependymal cells





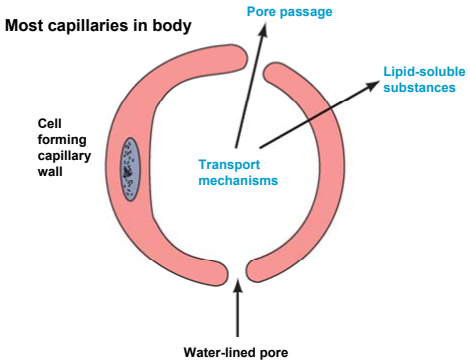
Meninges and the CSF

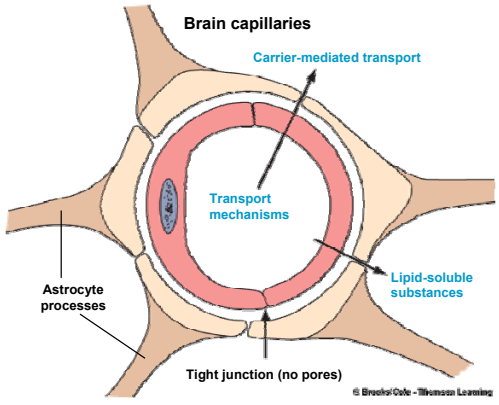
- **Cerebrospinal Fluid (CSF)**
  - Characteristics
    - Same density as brain →Brain floats in and is cushioned by the CSF
    - CSF and interstitial fluid of the brain cells are free to exchange materials → CSF composition must be carefully regulated
  - Formed by ***choroid plexuses*** in the ventricles
    - Richly vascular cauliflower-like masses
    - Selective and regulated transport
    - Differs from plasma (e.g. lower K^+ and higher Na^+)
    - 125-150 ml per day
  - Flow
    - Through the ventricles → 4th ventricle → Out to subarachnoid space → Over the entire brain → Top of the brain → Subarachnoid villi → Reabsorbed into the dural sinuses
  - Pressure
    - 10 mm Hg.
    - Even small reduction (e.g. during spinal tabs) can lead to severe headaches



Meninges and the CSF

- **Blood-Brain Barrier (BBB)**
  - Tight junctions between endothelial cells of brain capillaries (anatomical restriction)
  - Few materials allowed to freely diffuse
    - Lipid soluble substances (O2, CO2, alcohol, steroid hormones
    - Water
  - Careful and controlled exchange between blood and CSF for everything else
  - Advantage
    - Brain shielded from changes in the ECF and harmful blood borne materials
  - Disadvantage
    - Limited types of drugs can pass through BBB
- **Brain Nourishment**
  - Brain can only use glucose and can only metabolize aerobically (O_2 present)
  - Highly dependent on blood supply
  - Very sensitive to blood supply variations
    - Damage if O2 deprived for > 4-5 mins

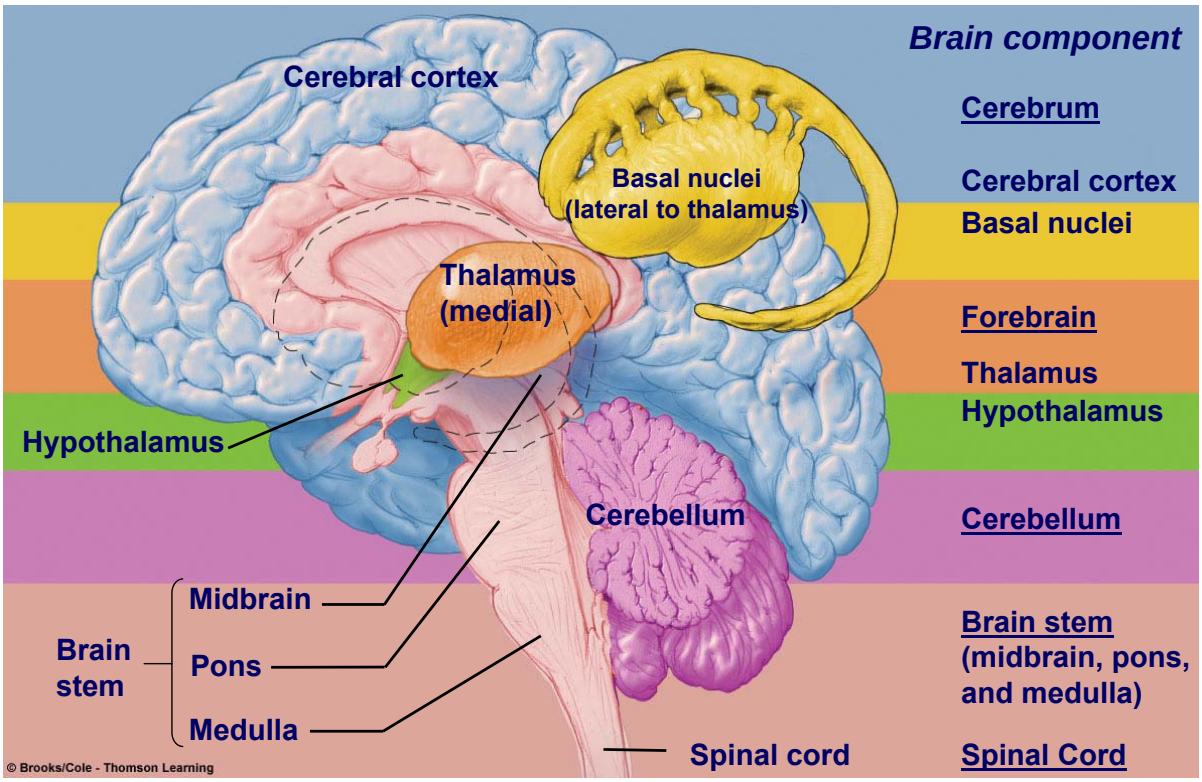




Biomedical Imaging and Applied Optics Laboratory

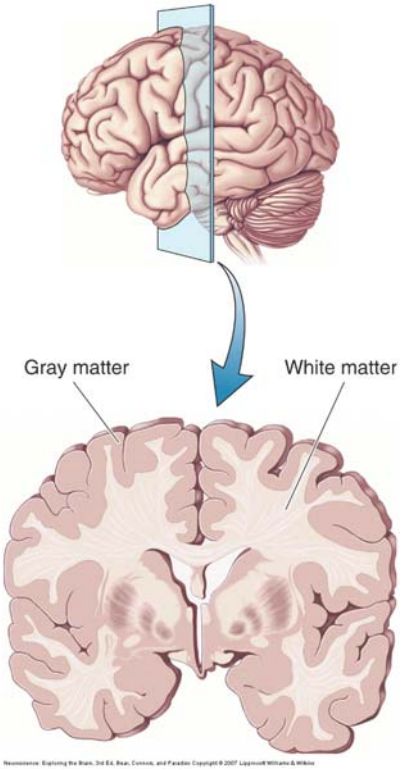
Overview of the CNS

Overview of the CNS



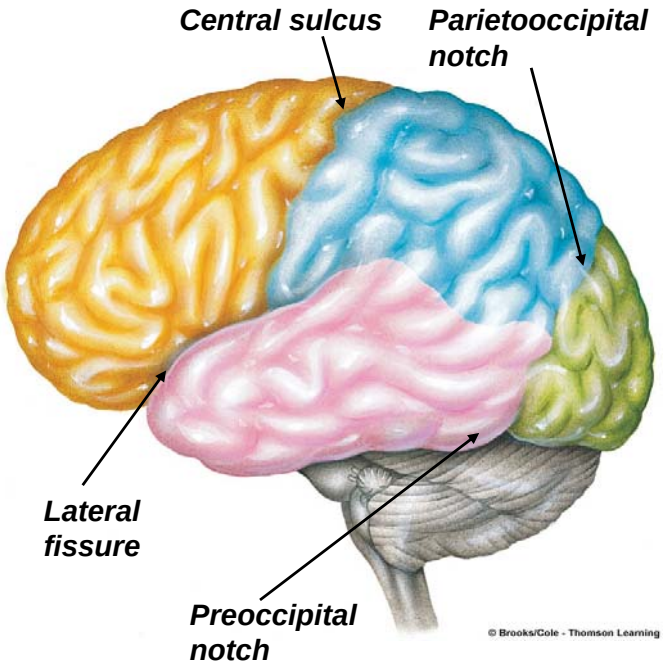
Cerebral Cortex

- **Cerebrum**
  - Left and right hemispheres
    - Gyri and sulci
  - Corpus callosum connects left and right
- **White matter (myelinated axons)**
  - Inner most layer
  - Interconnects
- **Cerebral cortex or Gray matter (cell bodies)**
  - Outermost layer
  - Organized in functional vertical columns (6 layers)
  - Each column is a team with distinct function
  - Differences are a result of different input/output and different layering patterns
  - Divided into four pairs of lobes

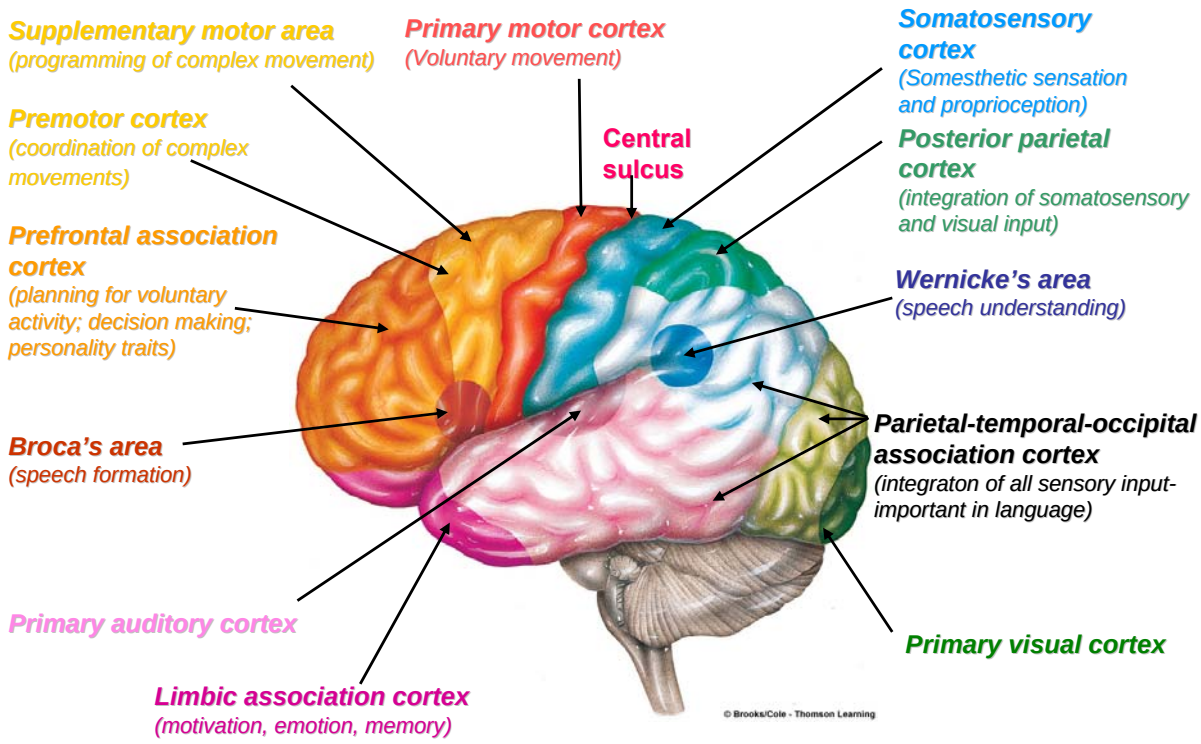


Cerebral Cortex

- **Cerebral cortex lobes**
  - Frontal
    - Voluntary motor activity, speaking ability, and elaboration of thought
    - Stimulation of different areas of its primary motor cortex moves different body regions, again primarily on the opposite side of the body.
  - Parietal
    - Somatosensory processing
    - Each region of its cortex receives somesthetic (feel) and proprioceptive (awareness of body position) input from a specific body area, primarily from the opposite body side.
  - Temporal
    - Receives sound sensation
  - Occipital
    - Initial processing of visual input

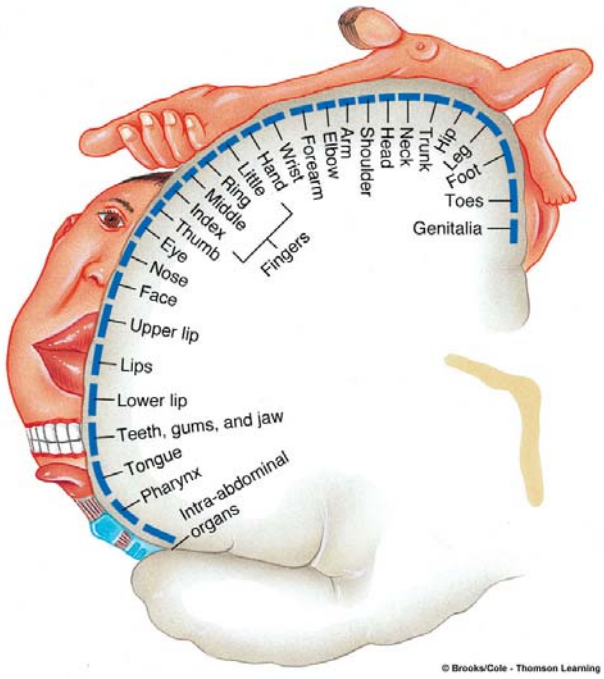


Cerebral Cortex

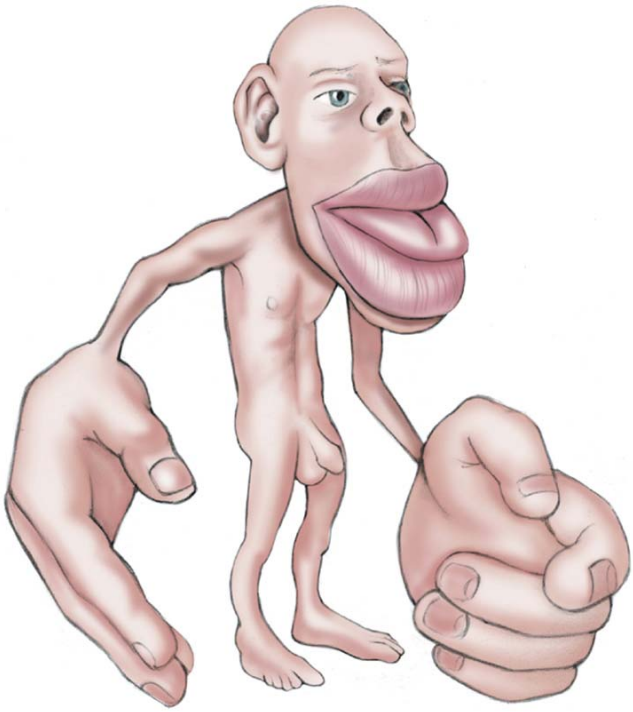


Cerebral Cortex

- **Parietal Lobe – Primary Somatosensory Cortex**
  - Somesthetic sensation → sensations from the surface of the body - touch, pain, pressure, heat and cold- and proprioception (awareness of body position)
  - Projected to the somatosensory cortex (initial cortical processing and perception)
  - Body regions are topographically mapped
    - Different parts of the body are not equally represented
    - Sensory Homonculus
    - Proportional to precision and sensitivity
  - Receives information from the opposite side of the body
    - damage on right side results in sensory loss on left side)



Cerebral Cortex



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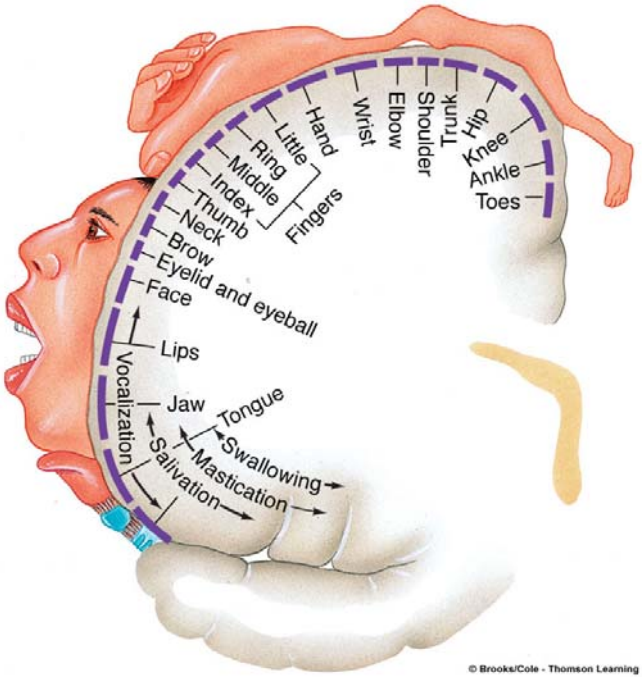
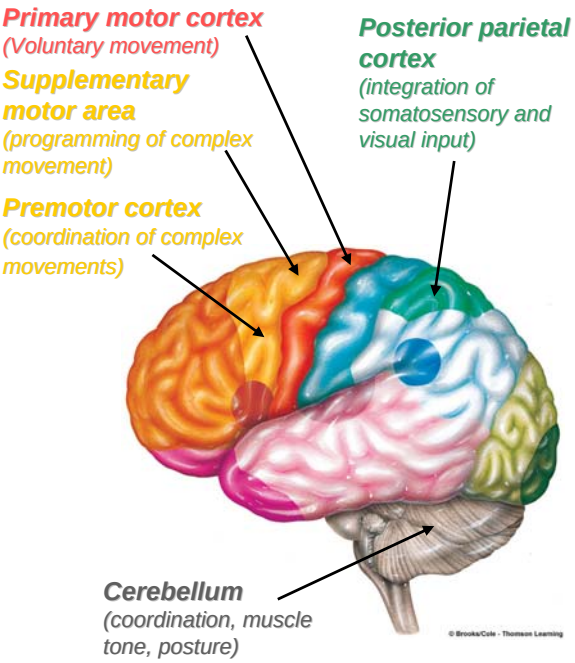
Cerebral Cortex

- **Frontal lobe – Primary Motor Cortex**
  - Voluntary control for muscle movement
  - Motor cortex on each side controls muscles on the opposite side of the body
    - Tracts originating in the cortex cross (at level of pyramids) before continuing down spinal cord to terminate muscle
  - Body regions are topographically mapped
    - Different parts of the body are not equally represented
    - Motor Homonculus
    - Proportional to precision and complexity of motor skills
  - Controls the opposite side of the body
    - Damage on right side results in motor deficit on left side



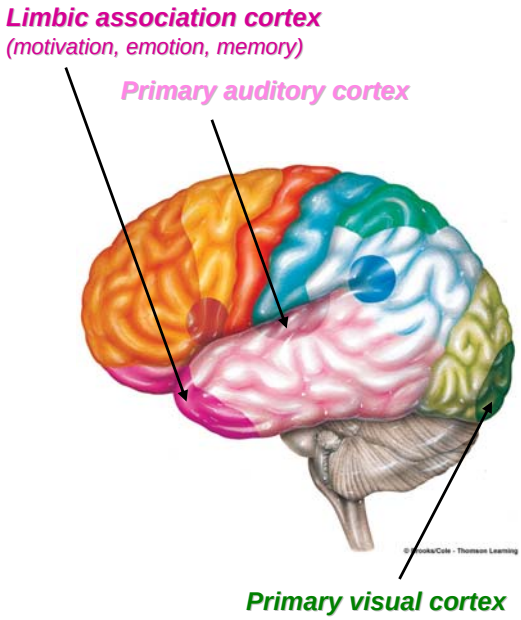
Cerebral Cortex

- **Movement**
  - The motor cortex itself does not initiate movement
  - Premotor cortex
    - Directs body orientation
    - Must be informed of body's position in relation to target
    - Acts in response to external cues
  - Supplementary motor cortex
    - Plays a preparatory role in programming complex sequences of movement
    - Responds to internal cues
  - Posterior parietal cortex
    - Posterior to the primary somatosensory cortex
    - Informs premotor cortex of position
  - Cerebellum
    - Motor coordination
    - (see more later)



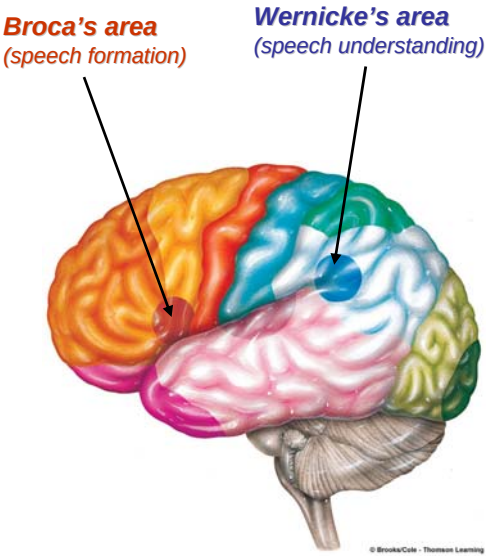
Cerebral Cortex

- **Occipital Lobe**
  - Primary visual cortex
  - Receives input from the eyes via optic nerve and optic projections to occipital lobe
  - Important for coordination of eye movements as well
- **Temporal Lobe**
  - Contains auditory centers that receive sensory fibers from the cochlea of each ear
  - Also involved in the interpretation and association of auditory and visual information
  - Temporal lobe contains the hippocampus and the amygdala
  - Involved in memory



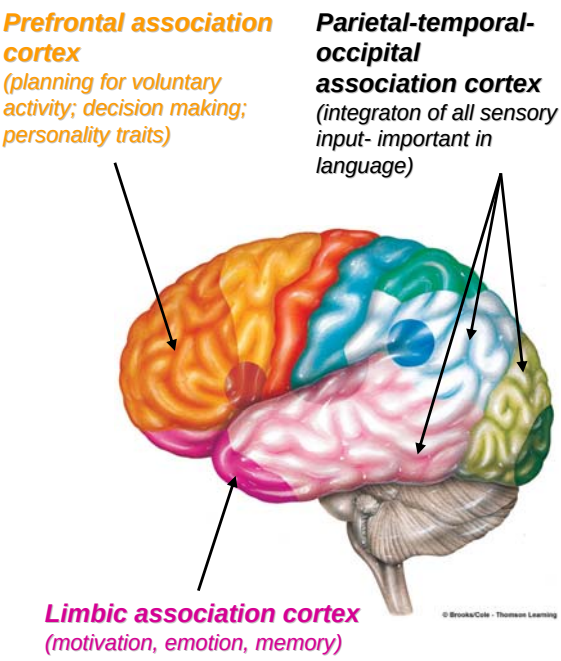
Cerebral Cortex

- **Language**
  - Areas responsible for language ability are found in only 1 hemisphere (usually the left)
  - Language involves the integration of 2 distinct capabilities
    - Expression (speaking ability)
    - Comprehension (understanding ability)
  - Broca's area
    - Responsible for speaking ability
    - Frontal lobe - in association with the motor area that controls the muscles necessary for articulation
  - Wernicke's area
    - Functions for language comprehension
    - Parietal-temporal-occipital association cortex - critical role in understanding both written and spoken language



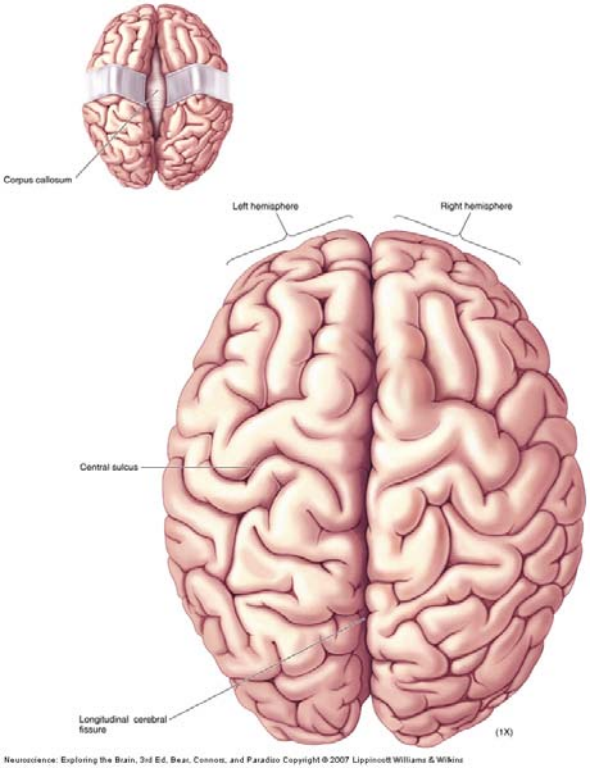
Cerebral Cortex

- **Cortical Association areas**
  - Prefrontal association cortex
    - Planning for voluntary activity, decision-making, creativity, and developing personality traits.
    - Site of operation of working memory
      - Temporary storage and active manipulation of information used in reasoning and planning
    - Deficits result in personality changes
  - Parietal-temporal-occipital association cortex
    - Integration of somatic, auditory, and visual sensations from the three lobes
    - Involved in connecting Broca's and Wernicke's area
  - Limbic association cortex
    - Motivation, emotion, and memory



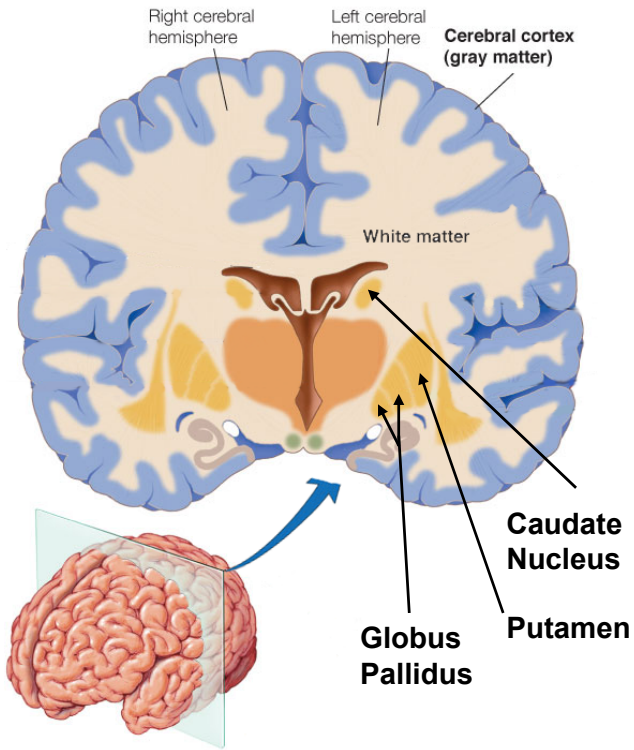
Cerebral Cortex

- **Lateralization/dominance of the cerebral hemispheres**
  - Each cerebral hemisphere receives information from both sides of the body due to connections via the corpus callosum
  - The left cerebral hemisphere excels in performing logical, analytical, sequential, and verbal tasks
    - Better at describing facial appearances
  - The right cerebral hemisphere excels in spatial perception and artistic and musical talents
    - Better at recognizing faces



Basal Nuclei

- **A.k.a. basal ganglia**
- **Masses of grey matter deep inside the white matter**
- **Act by modifying ongoing activity in motor pathways**
  - Inhibit muscle tone
    - Proper tone - balance of excitatory and inhibitory inputs to motor neurons that innervate skeletal muscle
  - Select and maintain purposeful motor activity while suppressing unwanted patterns of movement
  - Monitor and coordinate slow and sustained contractions
    - Especially those related to posture and support



Diencephalon

- **Diencephalon**
  - Thalamus
  - Hypothalamus
- **Thalamus**
  - A relay station
  - A synaptic integrating center for processing sensory input on its way to the cerebral cortex.
    - Directs attention (e.g. when a baby cries parents wake up)
  - Also integrates information important for motor control
  - Receives sensory information from different areas of the body
  - Information is processed by specific thalamic nuclei

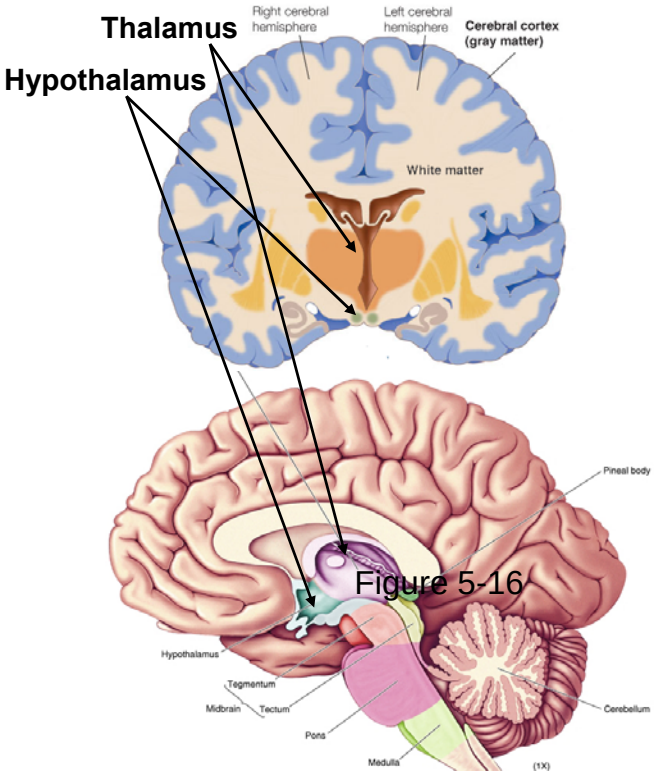


Figure 5-16

Diencephalon

- **Hypothalamus**
  - Homeostatic control
    - body temperature
    - thirst and urine production
    - food intake
    - anterior pituitary hormone secretion
    - production of posterior pituitary hormones
    - uterine contractions and milk ejection
  - Serves as an ANS coordinating center
  - Plays a role in emotional and behavioral patterns
  - Participates in sleep-wake cycle

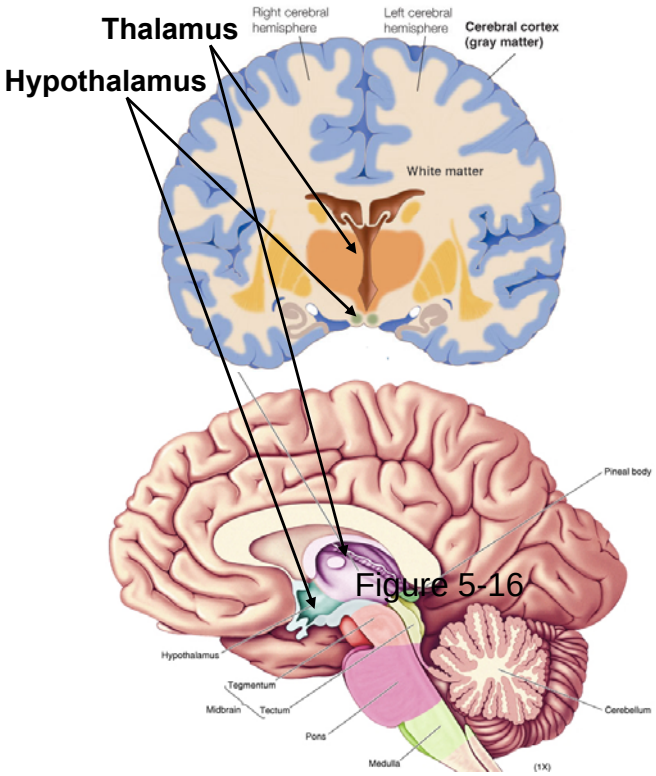
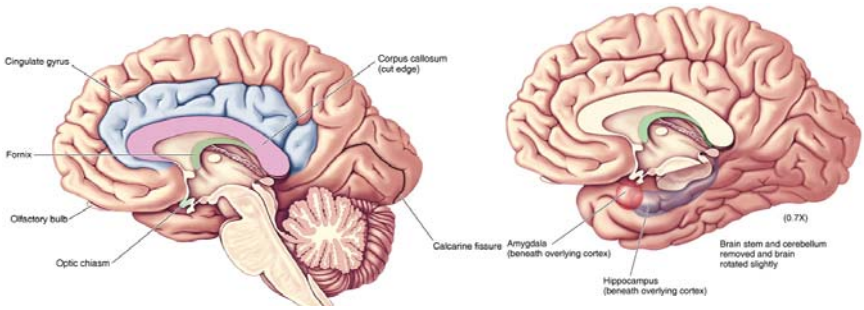
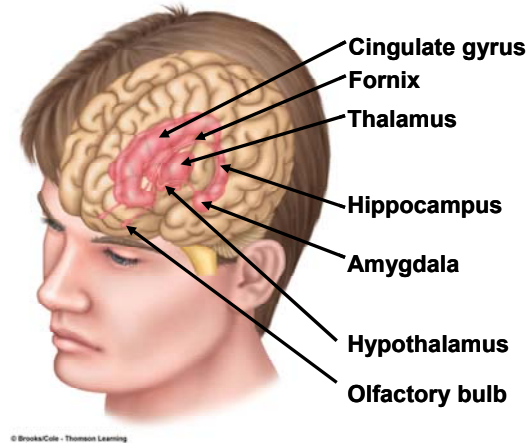


Figure 5-16

Limbic System

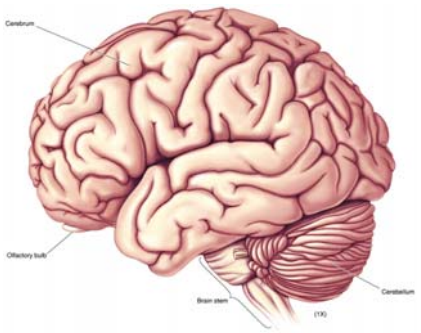
- **Several forebrain structures that function together**
  - Cortex (limbic association cortex)
    - Cingulate gyrus
    - Hippocampus
    - Amygdala
  - Basal Nuclei
  - Thalamus
  - Hypothalamus
- **Plays a role in**
  - Emotional state and basic behavioral patterns
  - Learning and memory

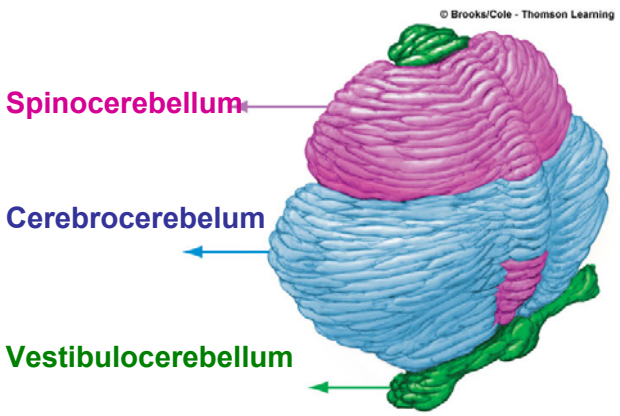




Cerebellum

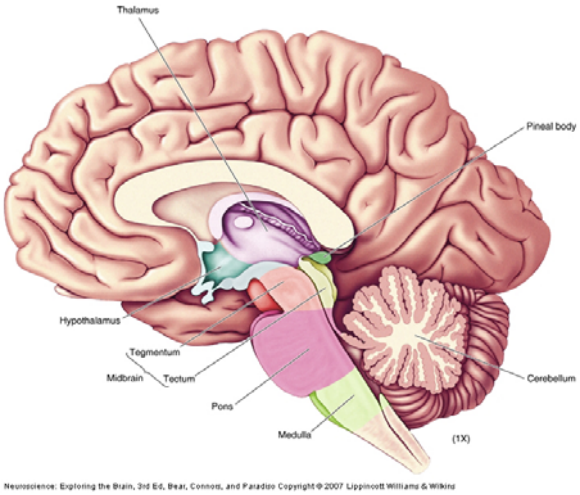
- **Highly folded, posterior, part of brain**
- **Important in**
  - Balance
  - Planning and executing voluntary movement
- **Three parts**
  - Vestibulocerebellum
    - Maintenance of balance, control of eye movements
  - Spinocerebellum
    - Regulation of muscle tone (enhancement, opposite of basal nuclei), coordination of skilled voluntary movement
  - Cerebrocerebelum
    - Planning and initiation of voluntary activity
- **Cerebellar disease**
  - Intention tremor → present only during voluntary activity





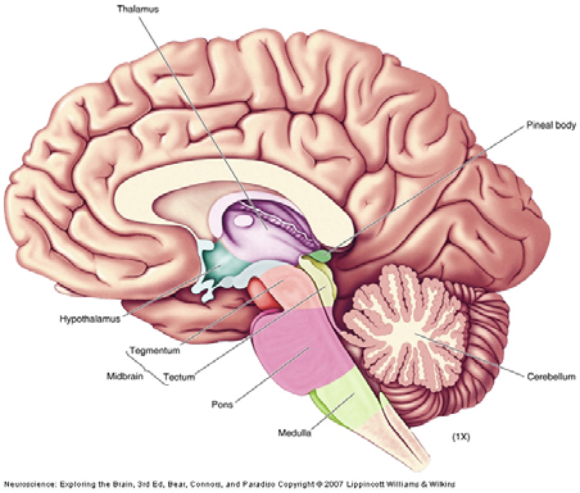
Brain Stem

- **Critical connecting link between rest of brain and spinal cord**
- **Functions**
  - Most of cranial nerves arise from brain stem
  - Neuronal clusters within brain stem control heart and blood vessel function, respiration, and many digestive functions
  - Plays role in regulating muscle reflexes involved in equilibrium and posture
  - Reticular formation within brain stem receives and integrates all incoming sensory synaptic input
    - Plays a role in modulating sensitivity of spinal reflexes and regulating transmission of sensory info (esp pain) into ascending pathways
  - Centers that govern sleep are in brain stem (evidence suggests center promoting slow-wave sleep lies in hypothalamus)



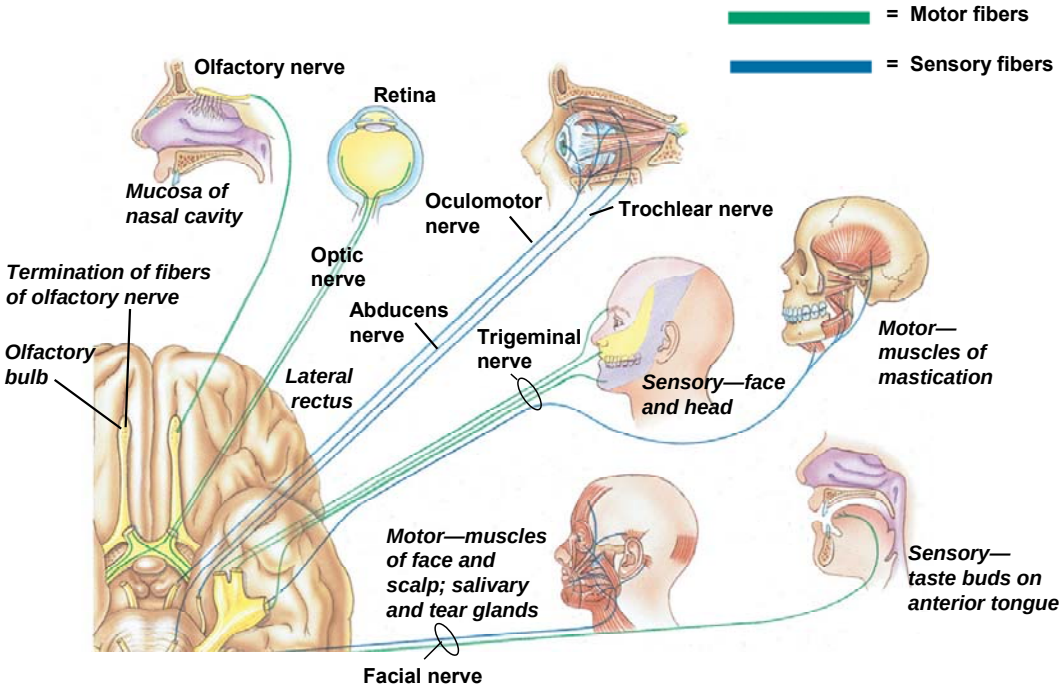
Brain Stem

- **Consists of**
  - Midbrain
    - Nerve pathway of cerebral hemispheres
    - Auditory and Visual reflex centers
    - Cranial Nerves III, IV
  - Pons
    - Respiratory Center
    - Cranial Nerves V-VIII
  - Medulla
    - Crossing of motor tracts
    - Cardiac Center
    - Respiratory Center
    - Vasomotor (nerves having muscular control of the blood vessel walls) Center
    - Centers for cough, gag, swallow, and vomit
    - Cranial Nerves IX-XII

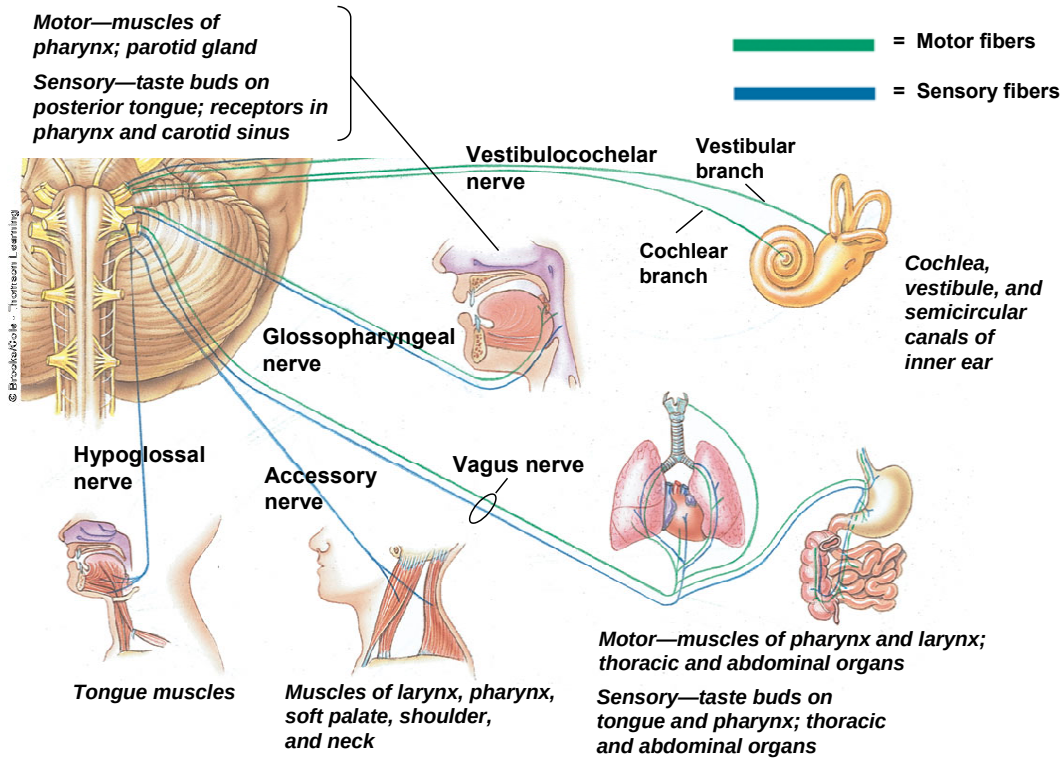


Brain Stem

- **Cranial Nerves**



Brain Stem



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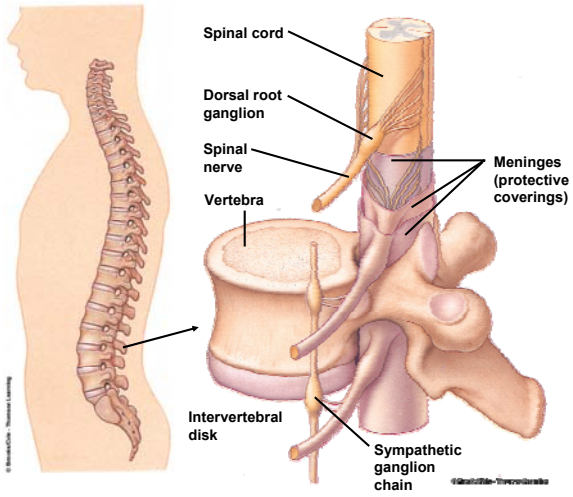
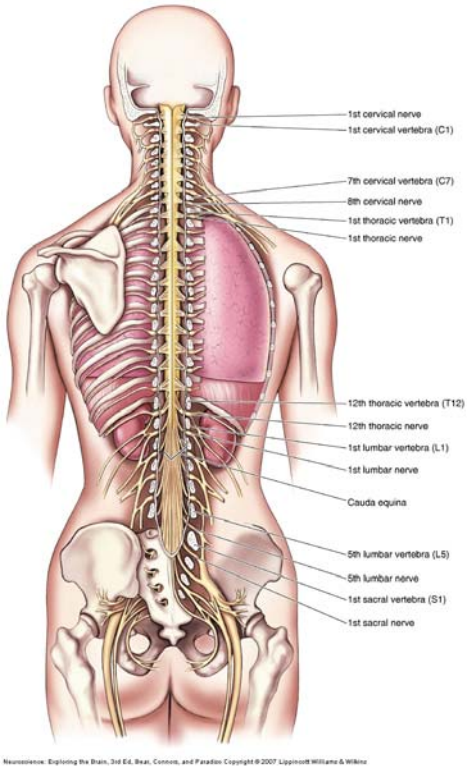
Spinal Cord

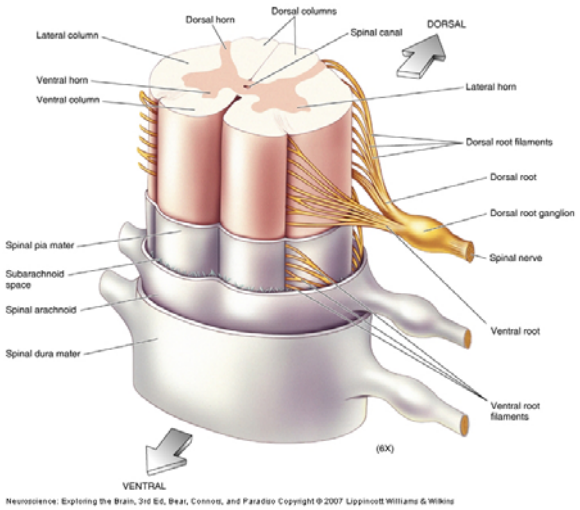
- **Extends from brain stem through vertebral canal**
  - Below L2 turns into a bundle of nerves
    - *Cauda equina*
    - Spinal tabs are taken below this point
- **Two vital functions**
  - Neuronal link between brain and PNS
  - Integrating center for spinal reflexes

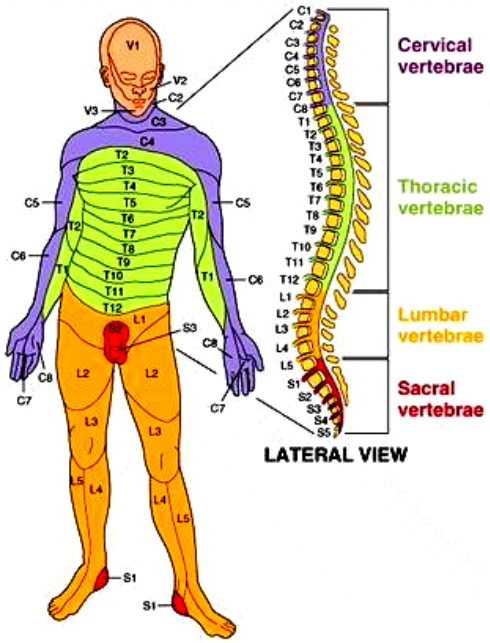




Spinal Cord

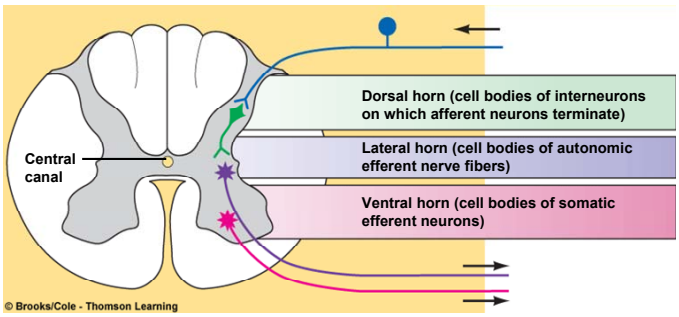
- **31 pairs of spinal nerves emerge from spinal cord through spaces formed between arches of adjacent vertebrae**
  - Named for region of vertebral column from which they emerge
    - 8 pairs cervical (neck) nerves
    - 12 pairs thoracic (chest) nerves
    - 5 pairs lumbar (abdominal) nerves
    - 5 pairs sacral (pelvic) nerves
    - 1 pair coccygeal (tailbone) nerves

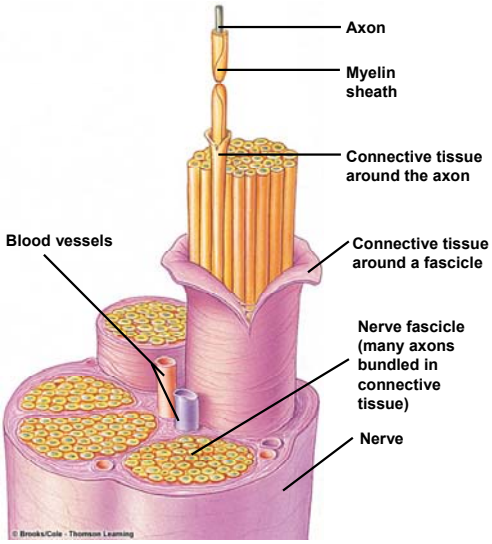




Spinal Cord

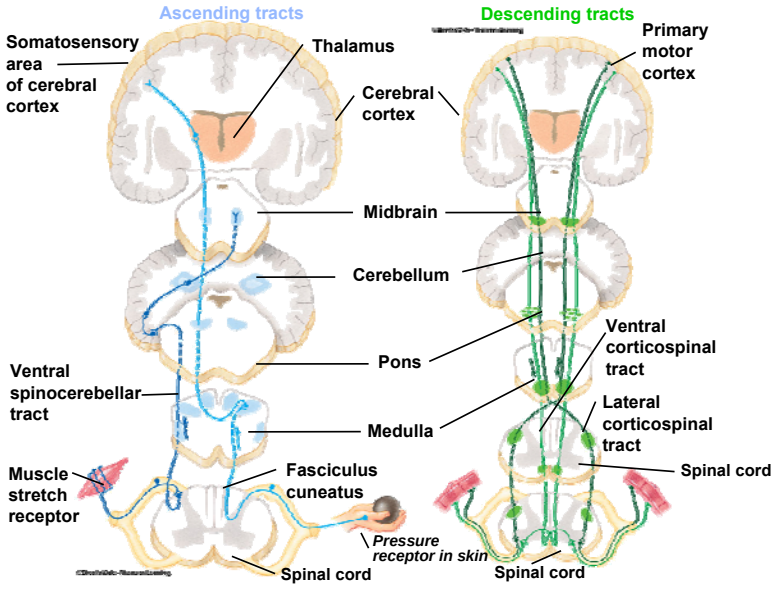
- **Fairly uniform cross-section**
  - Gray matter in the core
    - Cell bodies
    - Each horn houses different types of neurons
  - White matter in the outer segment
    - Axons organized into bundles
    - Bundles organized into tracts



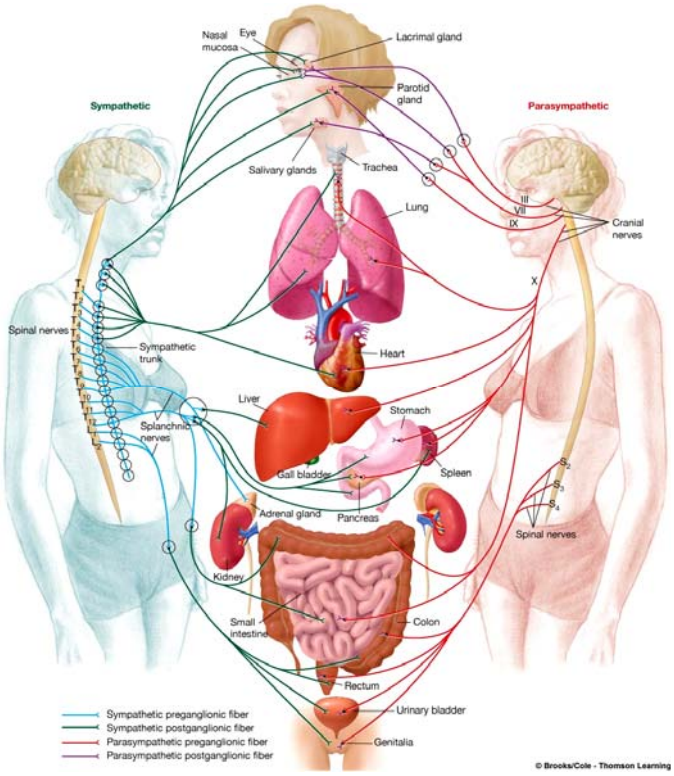


Spinal Cord

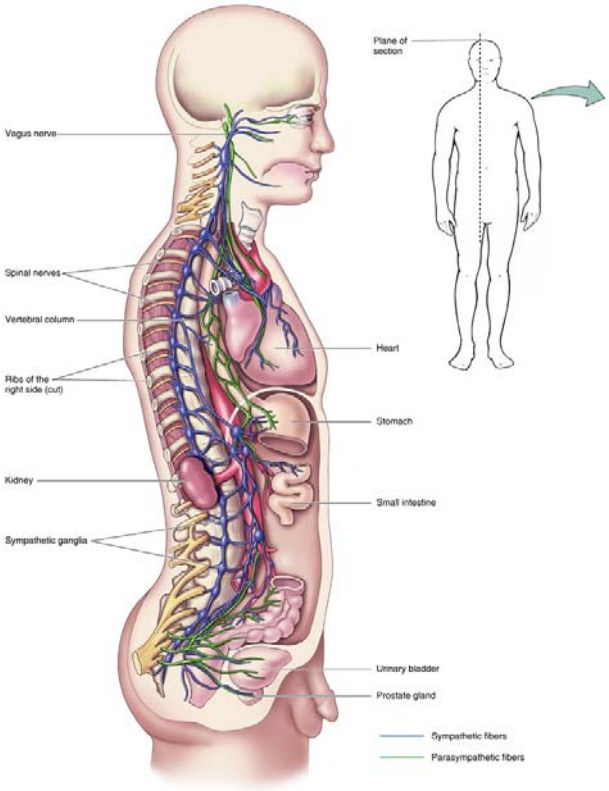
- **Bidirectional information**
  - Ascending tracts (PNS to brain)
  - Descending tracts (brain to PNS)



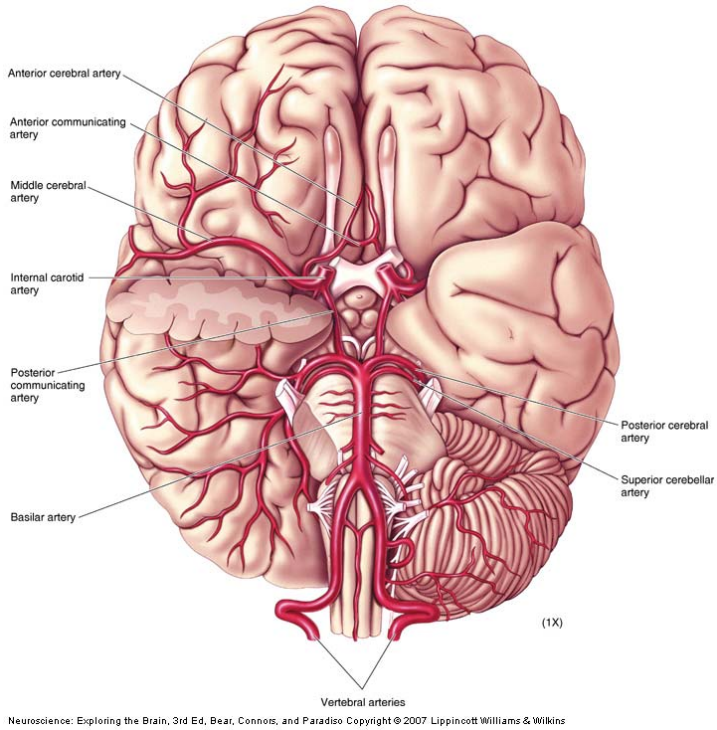
Autonomic Nervous System



Autonomic Nervous System



Blood Supply



Επόμενη Διάλεξη …

Διάλεξη 8

The Eye (Το Μάτι)