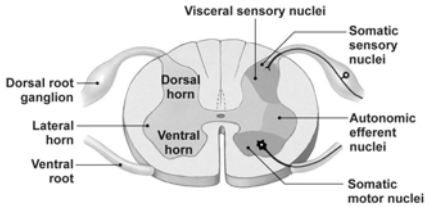
Central Nervous System

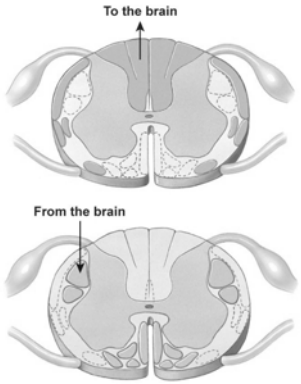
Lecture Outline

- Spinal Cord Design & Function
- Functional Brain Regions
  - Flow of Information
  - Learning

Central Nervous System
Spinal Cord Design & Function

- Design = Function
  - Gray matter =
    - integration of information
  - White matter tracts =
    - flow of information





Central Nervous System
Spinal Cord Design & Function

Efferent Tracts (red)

1.Pyramidal Tracts
- 1a. Lateral corticospinal tract
- 1b. Anterior corticospinal tract

2.Extrapyramidal Tracts
- 2a. Rubrospinal tract
- 2b. Reticulospinal tract
- 2c. Vestibulospinal tract
- 2d. Olivospinal tract

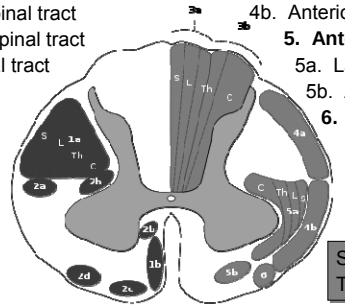
Afferent Tracts (blue)

3. Posterior Column-Medial Lemniscus tract
- 3a. Fasciculus gracilus
- 3b. Fasciculus cuneatus

4. Spinocerebellar Tract
- 4a. Posterior spinocerebellar tract
- 4b. Anterior spinocerebellar tract

5. Anterolateral System
- 5a. Lateral Spinothalamic tract
- 5b. Anterior Spinothalamic tract

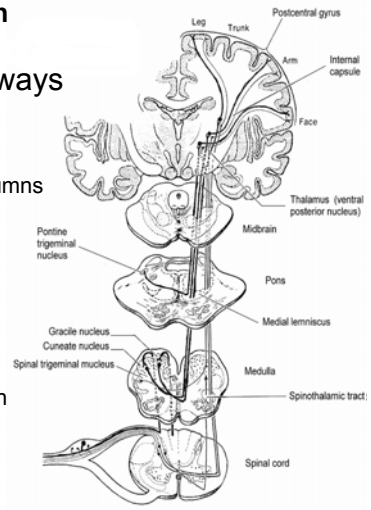
6. Spino-olivary tract



S = sacral, L = lumbar,
Th = thoracic, C = cervical

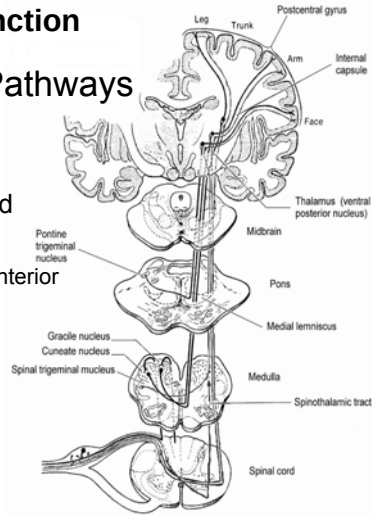
Central Nervous System
Spinal Cord Design & Function

– The Somatosensory Pathways
- Posterior Column-Medial Lemniscus tract (PCML)
  – Ascends in the posterior columns
  – Crosses over in the medial lemniscus of the medulla oblongata
  – Used for
    » Discriminative touch
    » Vibration
    » Conscious proprioception



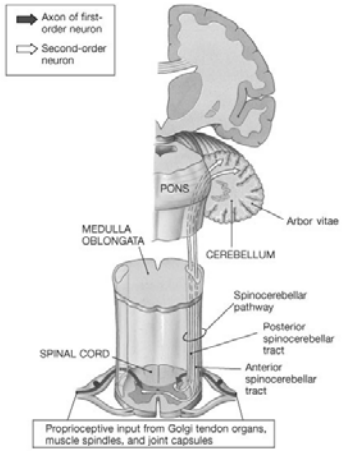
Central Nervous System
Spinal Cord Design & Function

- The Somatosensory Pathways
  – Spinothalamic tracts
    - crosses over at level of entrance into spinal cord
    - Used for
      – simple (crude) touch - anterior
      – pain (most) } lateral
      – temperature }



Central Nervous System
Spinal Cord Design & Function

- The Proprioceptive Pathways (non-conscious)
  – **Spinocerebellar tracts**
    - Relay information from golgi organs and muscle spindles
    - Posterior (dorsal) tract is ipsilateral to cerebellum via cerebellar peduncles
    - Anterior (ventral) tract contains crossed and ipsilateral fibers for lower limbs
    - Some proprioceptive signals are carried in the fasciculus cuneatus pathway – upper limbs

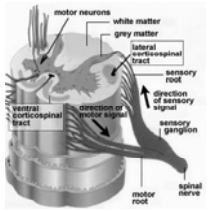


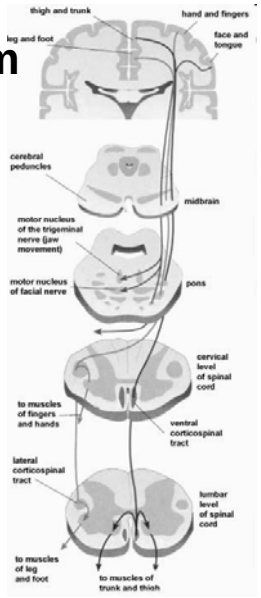
Central Nervous System
Spinal Cord Design & Function

- Spino-Olivary Tracts
  – Contains type Ib afferent sensory fibers
    - Originate from golgi tendon organs
    - Synapse in the olivary nucleus of medulla
    - 2nd order neurons project to the cerebellum

Central Nervous System
Spinal Cord Design & Function

- The Motor Pathways
  - The Pyramidal Tracts
    - Anterior (Ventral) Corticospinal Tract
    - Lateral Corticospinal Tract



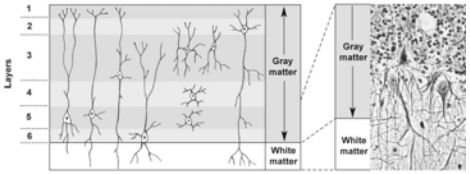


Central Nervous System
Spinal Cord Design & Function

- The Motor Pathways
  - Extrapyramidal Tracts
    - Play a role in coordination of movement and posture
    - All receive input from cerebellum
      - Rubrospinal tract
        - » gross limb movement
        - » Not well formed in humans
      - Reticulospinal tract
        - » coordinates movements of locomotion and posture
        - » Influences muscle tone
        - » Descends from the RAS
      - Tectospinal tract
        - » Coordinates head and eye movements in response to visual and auditory stimuli
      - Vestibulospinal tract
        - » control of muscles for equilibrium including movement of head/neck

Central Nervous System
Brain Design & Function

- The brain is designed with two systems
  - Wired System
    - Neurons & Associated Neural Circuits and Pathways

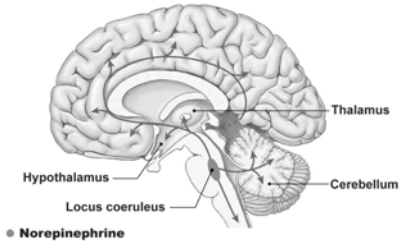


  - Diffuse Modulatory Systems
    - Uses neurohormones to modulate function of the "wired system"
      - Dopamine, Serotonin, Norepinephrine, Acetylcholine

Central Nervous System
Brain Design & Function

- Diffuse Modulatory Systems
  - Norepinephrine

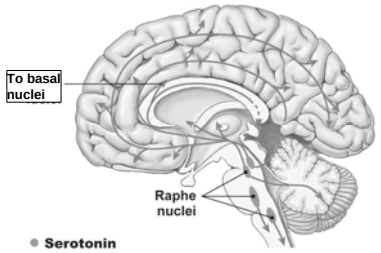
- Locus coeruleus is the origin of cell bodies that secrete norepinephrine to most of the CNS.
- Activated strongly when new sensory stimuli are encountered
- Regulate vigiliance & attentiveness, inactive during sleep
- Overactivity = axiety
- Underactivity = depression



Central Nervous System
Brain Design & Function

- Diffuse Modulatory Systems
  - Serotonin

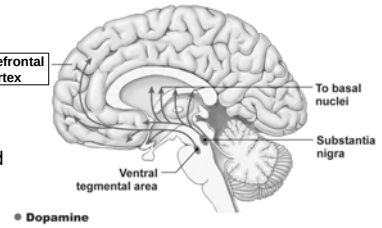
- Serotonin released by neurons of the raphe nuclei in the brain stem
  - Rostral nuclei project to the thalamus and cerebrum
    - Mediate sleep/wake cycles
    - Alter mood
  - Caudal nuclei project to the cerebellum and spinal cord
    - Modulate pain and locomotion



Central Nervous System
Brain Design & Function

- Diffuse Modulatory Systems
  - Dopamine

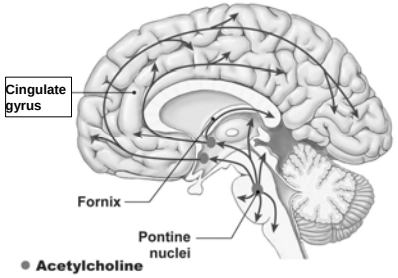
- Dopamine released by the substantia nigra and the ventral tegmental area of the brain stem (midbrain)
  - **Substantia nigra** neurons project to the basal ganglia (caudate nuclei and putamen)
    - Mediate movement
    - Loss = parkinsons
  - **Ventral tegmental area** neurons project to the prefrontal cortex & limbic system
    - Reinforces behaviors associated with pleasure



Central Nervous System
Brain Design & Function

- Diffuse Modulatory Systems
  - Acetylcholine

- Ach secreting neurons have cell bodies located in the ventral telencephalon and the pons
  - Project to the cerebrum, hippocampus and thalamus
  - Linked to
    - learning and memory
    - Sleep wake cycles
    - Arousal & sensory information
  - Alzheimer's disease may be linked to the deterioration of this system



Central Nervous System
Brain Design & Function

REGION	FUNCTION
Cerebrum (Frontal, Parietal, Occipital, and Temporal lobes)	
• Cerebral cortex (See Fig. 9.15)	
Sensory fields	Perception
Motor areas	Skeletal muscle movement
Association areas	Integration of information and direction of voluntary movement
Basal ganglia (See Fig. 9-11)	Movement
Limbic system (See Fig. 9-13)	
Amygdala	Emotion and memory
Hippocampus	Learning and memory

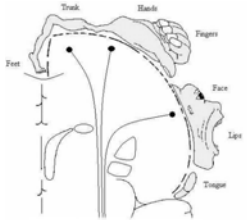
REGION	FUNCTION
Diencephalon (See Fig. 9-10)	
Thalamus	Integrating center and relay station for sensory and motor information
Hypothalamus	Homeostasis and behavioral drives (See Table 9-2)
Pituitary	Hormone secretion
Pineal gland	Melatonin secretion
Cerebellum	Movement coordination
Brain stem	
Midbrain	Eye movement
Pons	Relay station between cerebrum and cerebellum; coordination of breathing
Medulla oblongata	Control of involuntary functions
Reticular formation (See Fig. 9-19)	Arousal, sleep, muscle tone, pain modulation

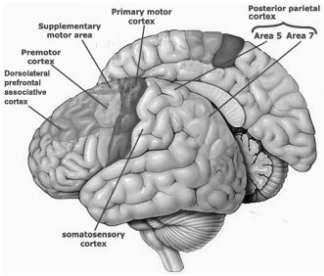
Central Nervous System
Brain Design & Function

- So… how does the brain "do" things?
  - – Create voluntary movements
  - – Forming Memories
  - – Communication: thought → expression
  - – Idea of "self" or consciousness
  - – Create emotions
  - – Experience pain & pleasure
  - – Go to sleep & wake up

Central Nervous System
Brain Design & Function

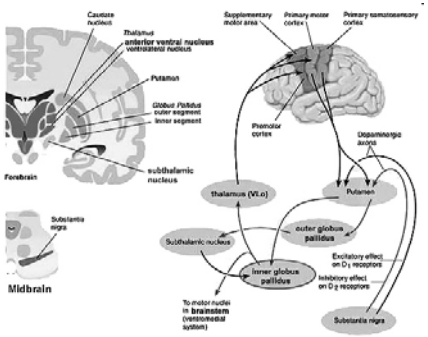
- Voluntary Movement
  - – The players: Cerebral Cortex, Basal Ganglia & Cerebellum
    - Cerebral cortex
      - – Contains the primary motor cortex, supplemental motor areas, pre-motor areas and the prefrontal cortex
        - » The primary motor cortex contains your "motor homunculus"
      - – Also has cortices for all of your other senses which may play a role in your voluntary movement
        - » posterior parietal cortex "asesses" current status with regard to body position and target





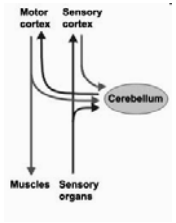
Central Nervous System
Brain Design & Function

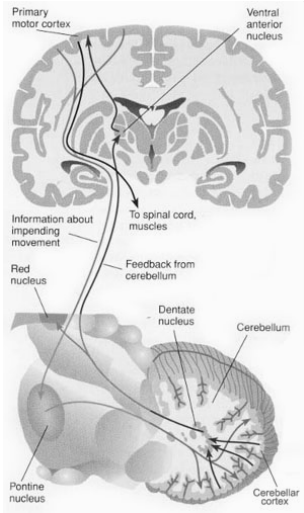
- Voluntary Movement
  - Basal Ganglia
    - – Play an indirect role in movement by forming a processing loop between the basal ganglia, the cortex and thalamus



Central Nervous System
Brain Design & Function

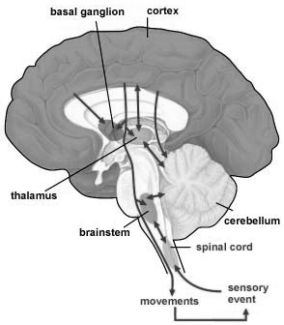
- Voluntary Movement
  - Cerebellum
    - – Cerebellum is the center for proprioception and continually modifies output to meet the goal of the movement
    - – Also stores learned motor skills
    - – Connected to both cortex and brainstem/spinal cord

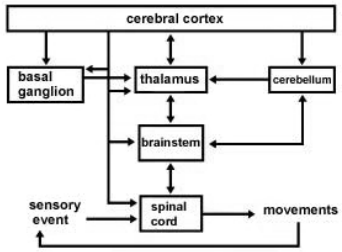




Central Nervous System
Brain Design & Function

- Voluntary Movement
  - The process





Central Nervous System
Brain Design & Function

- Learning
  - Process in the brain differs depending on the type of learning
    - Episodic memory
      - Allows you to remember events and occurrences
      - goes through the hippocampus
        - » Altered by state of mind
        - » Capable of making your own “truth”
    - Spatial memory
      - Strictly located on the hippocampus and on the right side
      - Creates a mental map of space
    - Procedural memory
      - processed in the cerebellum
    - Emotional memory
      - Involves the amygdala
      - Often tied to intense emotional events

Central Nervous System
Brain Design & Function

- Learning
  - So how does all that occur?
    - Formation of neural networks/circuits
    - The more they are used
      - The more “permanent” they become!
    - Integration with other events, memories
      - Consolidation!
  - How does a person with no sight, or no hearing, or no sense of touch, or…. Learn?
  - Did Helen Keller's have a different “wiring” of neural circuits?

Next Time…

- Peripheral Nervous System