Brain and Nervous System
Gleitman *et al*. (2011), Chapter 3, Part 3

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Psych 9A / Psy Beh 11A
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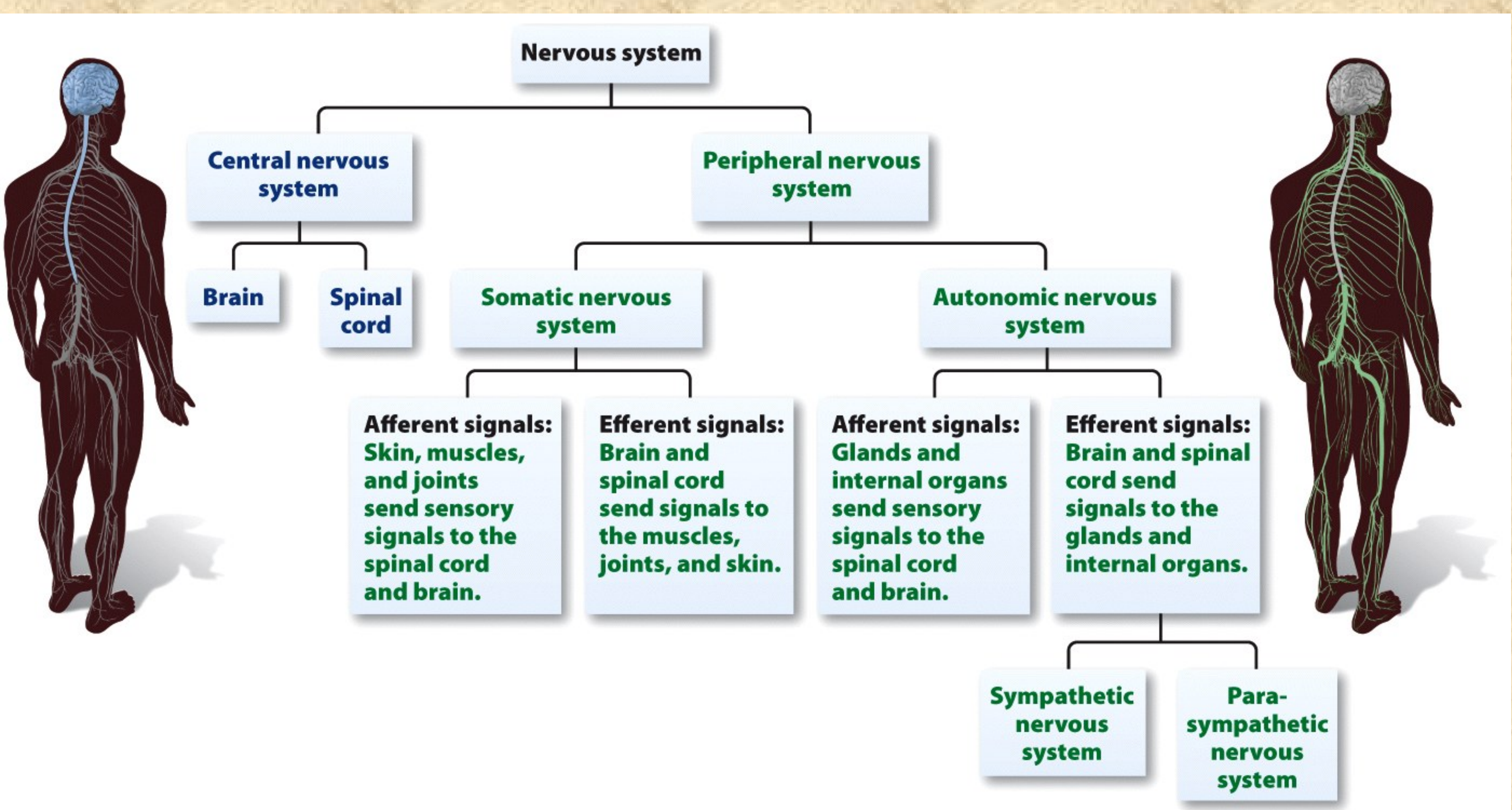
Parts of the Nervous System

- *Central nervous system (CNS)*—brain and spinal cord
- *Peripheral nervous system (PNS)*—includes both *efferent* and *afferent nerves*
  - The PNS is divided into the *somatic nervous system* and the *autonomic nervous system.*
  - The autonomic nervous system has both *sympathetic* and *parasympathetic* components



Psychology, 8/e Figure 3.25

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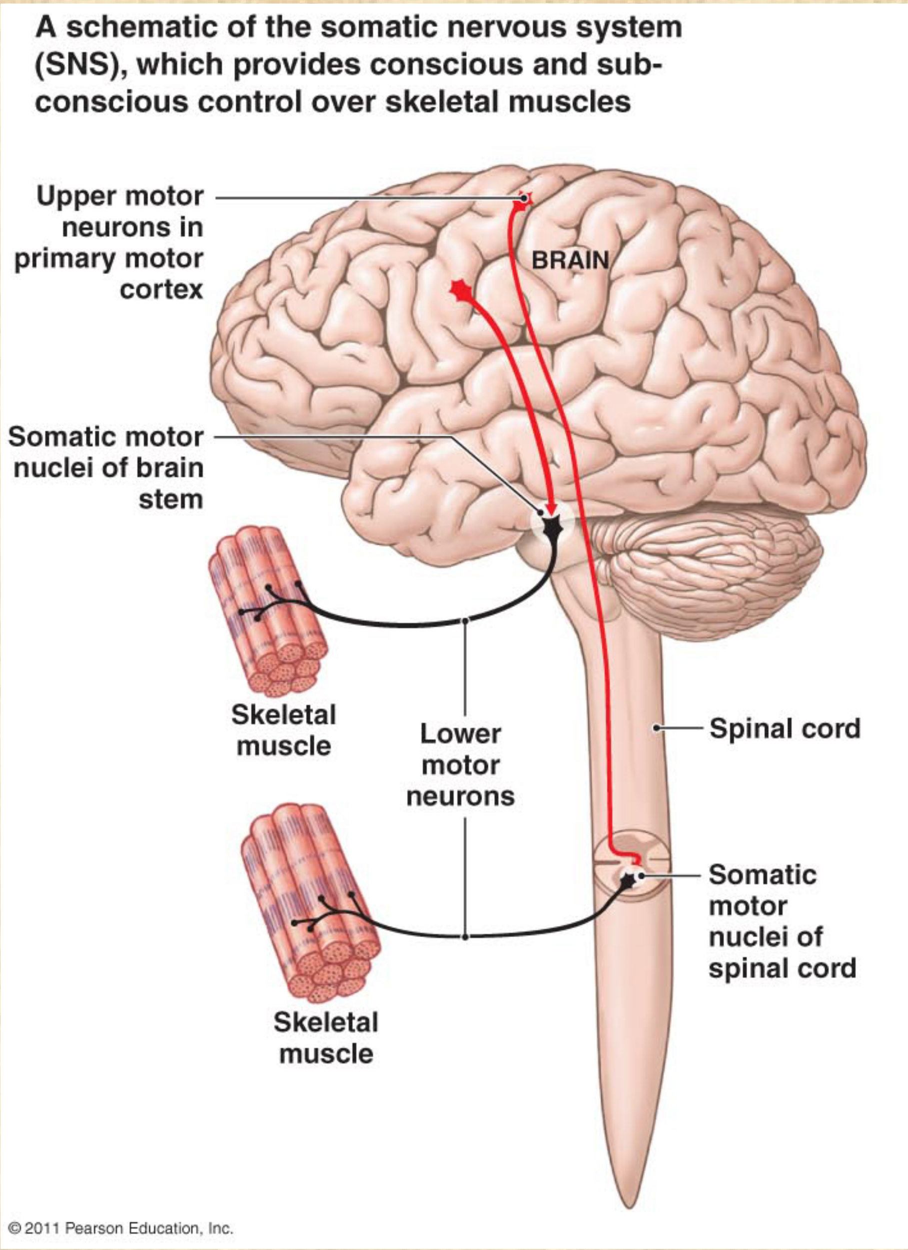
A schematic of the somatic nervous system (SNS), which provides conscious and subconscious control over skeletal muscles
Upper motor neurons in primary motor cortex
BRAIN
Somatic motor nuclei of brain stem
Skeletal muscle
Lower motor neurons
Spinal cord
Somatic motor nuclei of spinal cord
Skeletal muscle
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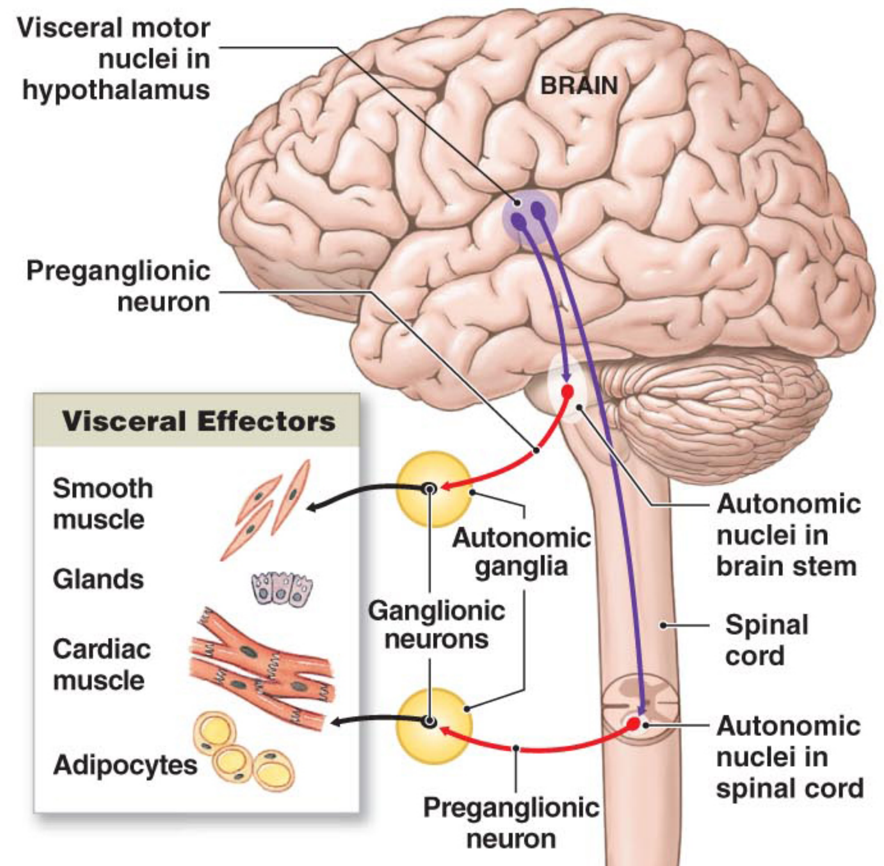
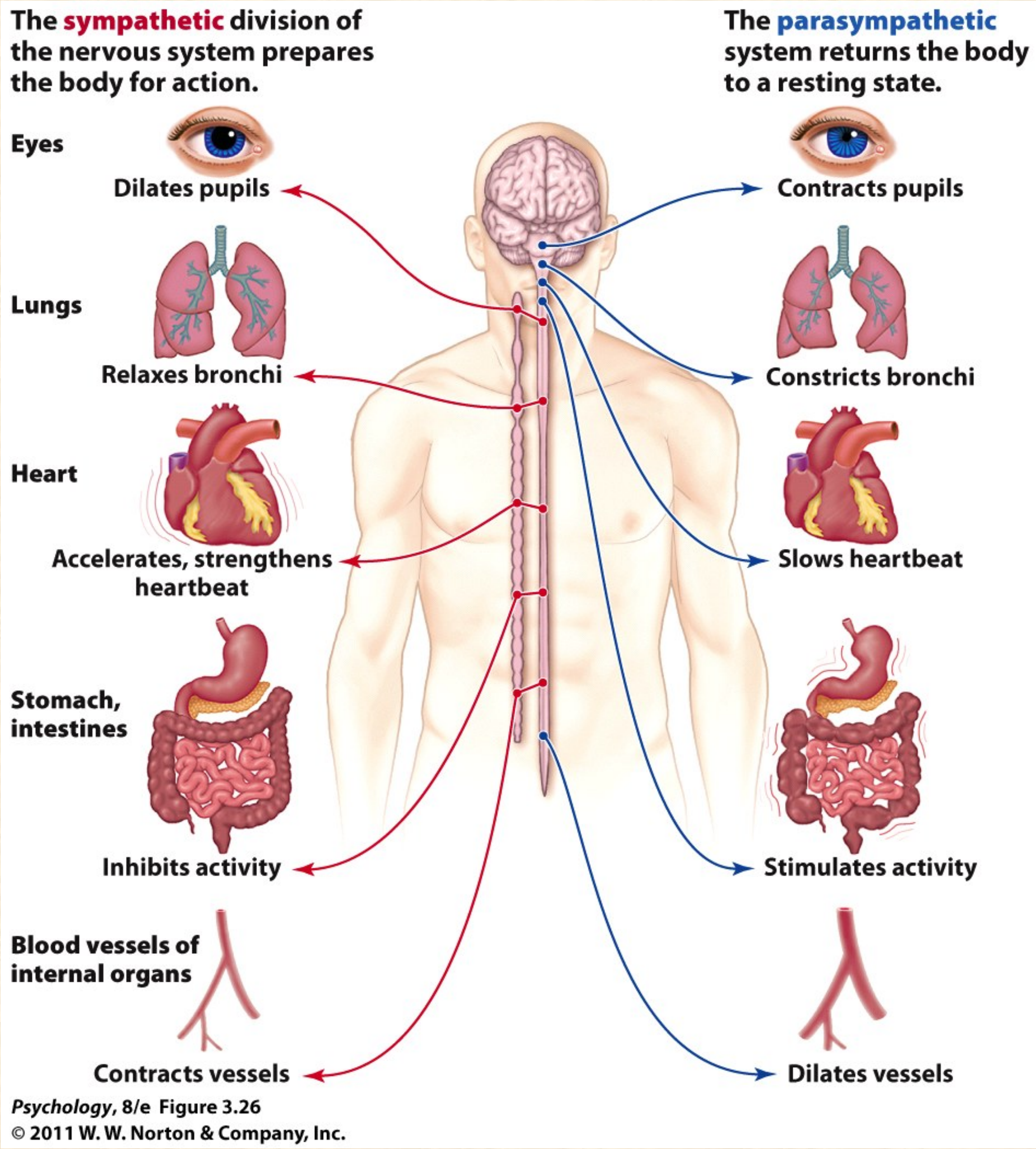


A schematic of the autonomic nervous system (ANS), which controls visceral functions largely outside our awareness


The sympathetic division of the nervous system prepares the body for action.
The parasympathetic system returns the body to a resting state.
Eyes
Dilates pupils
Contracts pupils
Lungs
Relaxes bronchi
Constricts bronchi
Heart
Accelerates, strengthens heartbeat
Slows heartbeat
Stomach, intestines
Inhibits activity
Stimulates activity
Blood vessels of internal organs
Contracts vessels
Dilates vessels
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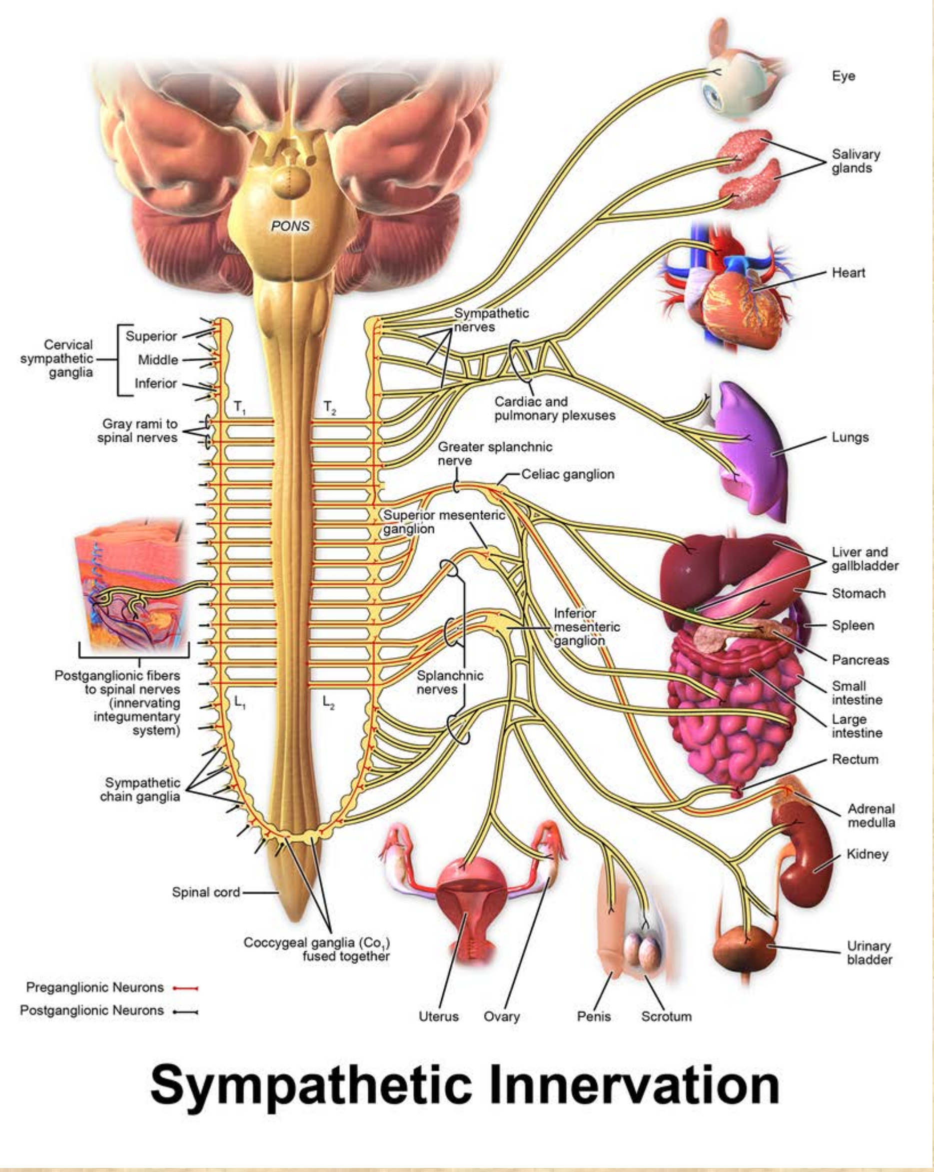
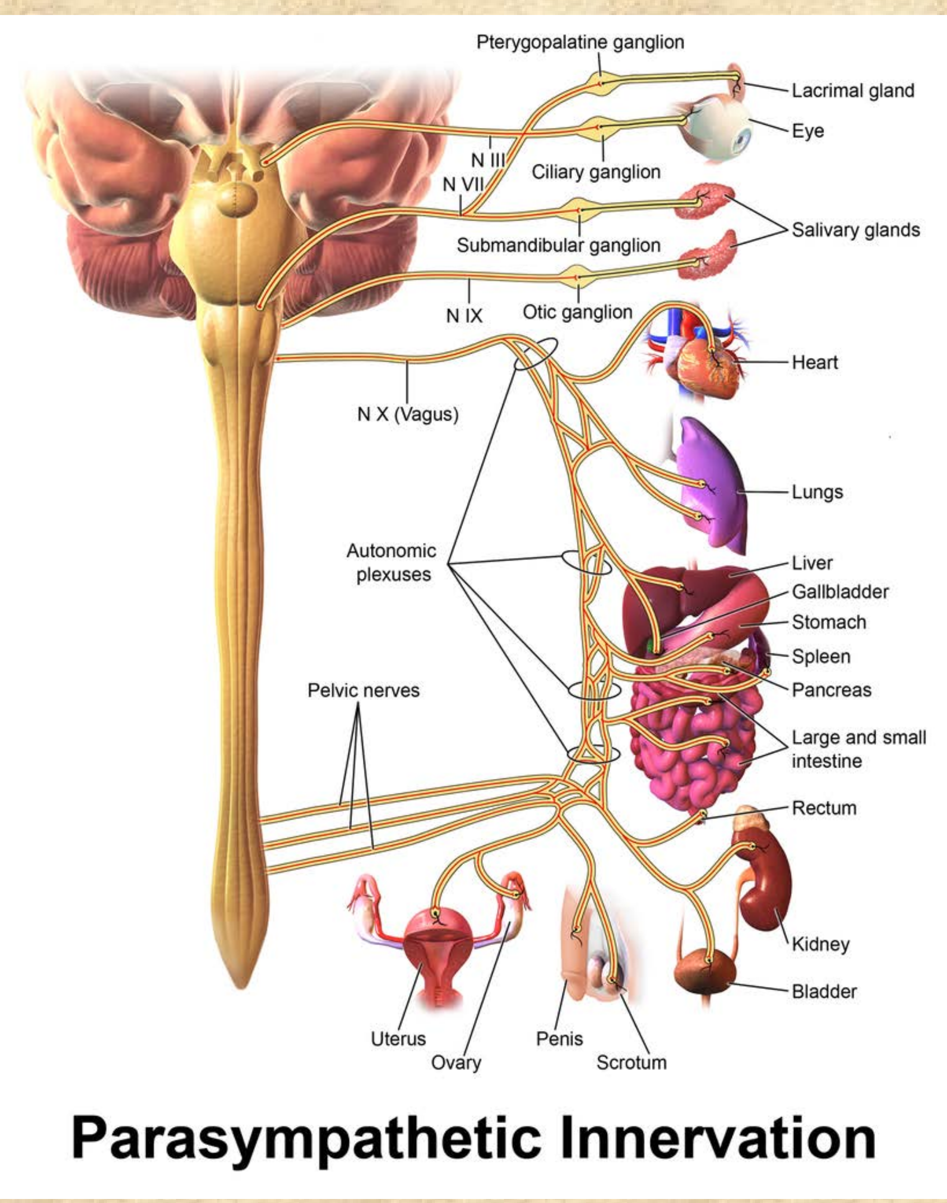
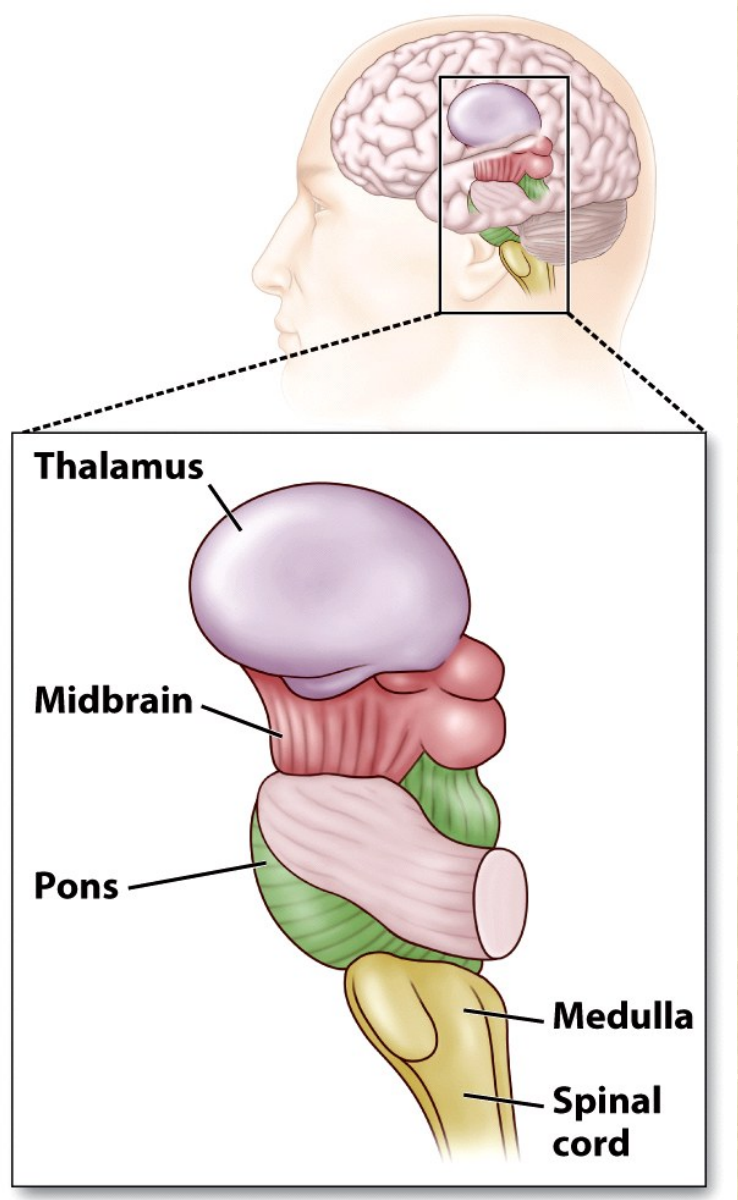

PONS
Cervical sympathetic ganglia
Superior
Middle
Inferior
Gray rami to spinal nerves
Postganglionic fibers to spinal nerves (innervating integumentary system)
Sympathetic chain ganglia
Spinal cord
Coccygeal ganglia (Co1) fused together
Preganglionic Neurons
Postganglionic Neurons
T1
T2
L1
L2
Sympathetic nerves
Cardiac and pulmonary plexuses
Greater splanchnic nerve
Celiac ganglion
Superior mesenteric ganglion
Inferior mesenteric ganglion
Splanchnic nerves
Eye
Salivary glands
Heart
Lungs
Liver and gallbladder
Stomach
Spleen
Pancreas
Small intestine
Large intestine
Rectum
Adrenal medulla
Kidney
Urinary bladder
Uterus
Ovary
Penis
Scrotum
Sympathetic Innervation


Pterygopalatine ganglion
Lacrimal gland
Eye
N III
N VII
Ciliary ganglion
Salivary glands
Submandibular ganglion
N IX
Otic ganglion
Heart
N X (Vagus)
Lungs
Autonomic
plexuses
Liver
Gallbladder
Stomach
Spleen
Pancreas
Pelvic nerves
Large and small
intestine
Rectum
Kidney
Bladder
Uterus
Ovary
Penis
Scrotum
Parasympathetic Innervation

- The very top of the spinal cord forms the *brain stem.*
  - It includes the *medulla* and the *pons* (life-sustaining functions)
  - Just behind these is the *cerebellum* (movement, timing, sensory integration)
- The *midbrain* is on top of the *pons*, and on top of them all is the *thalamus* (sensory information processing +)



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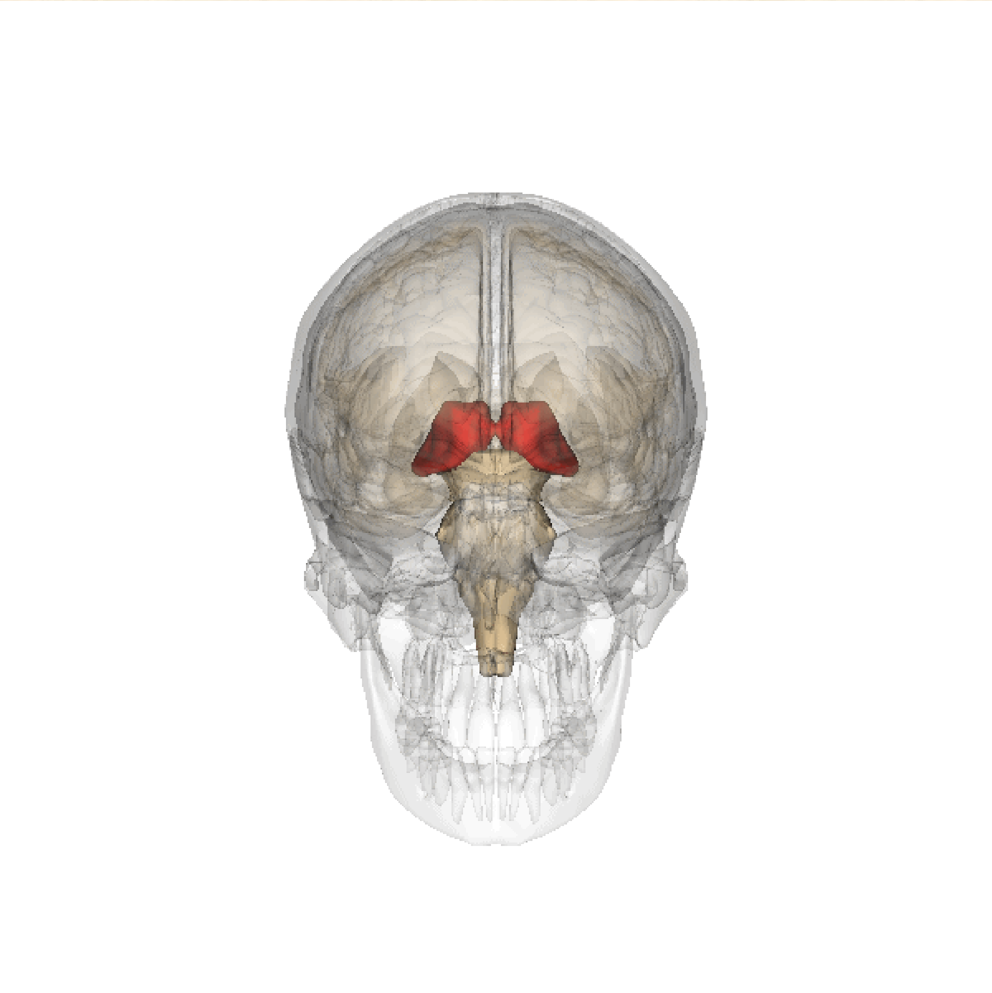
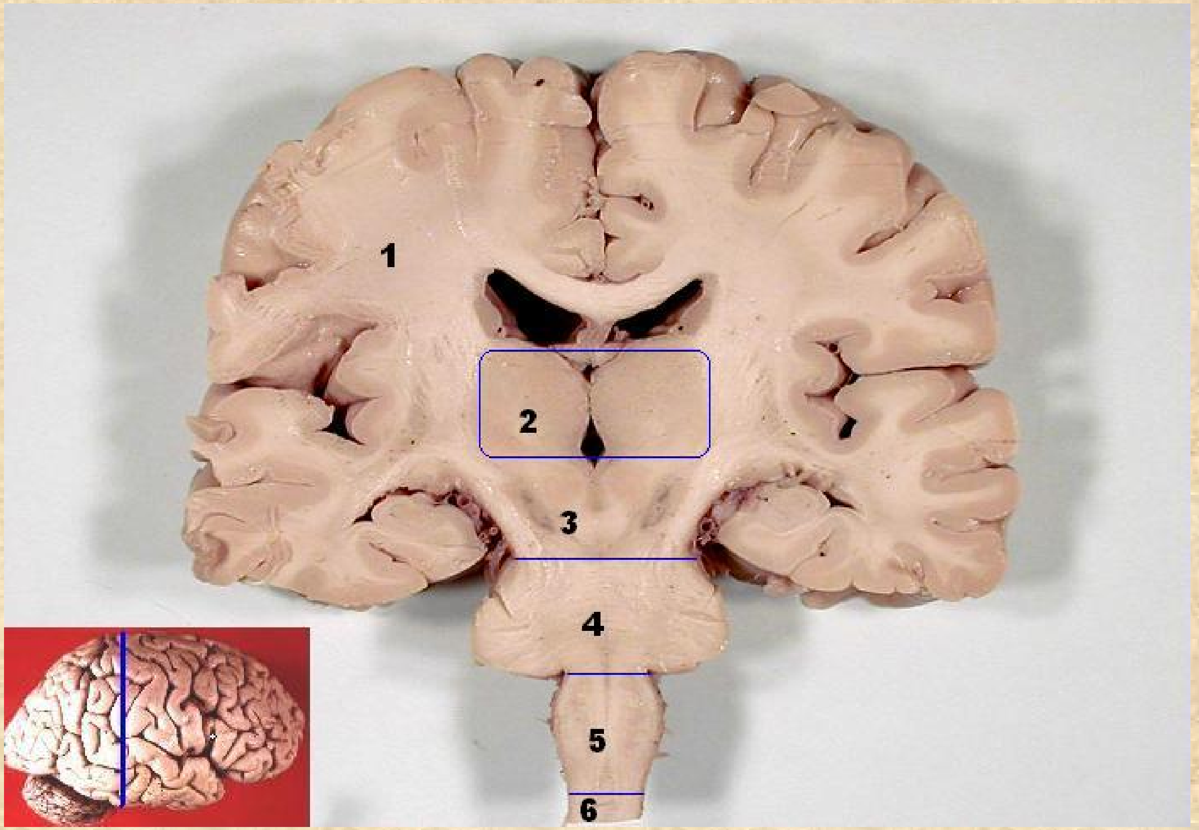
Thalamus



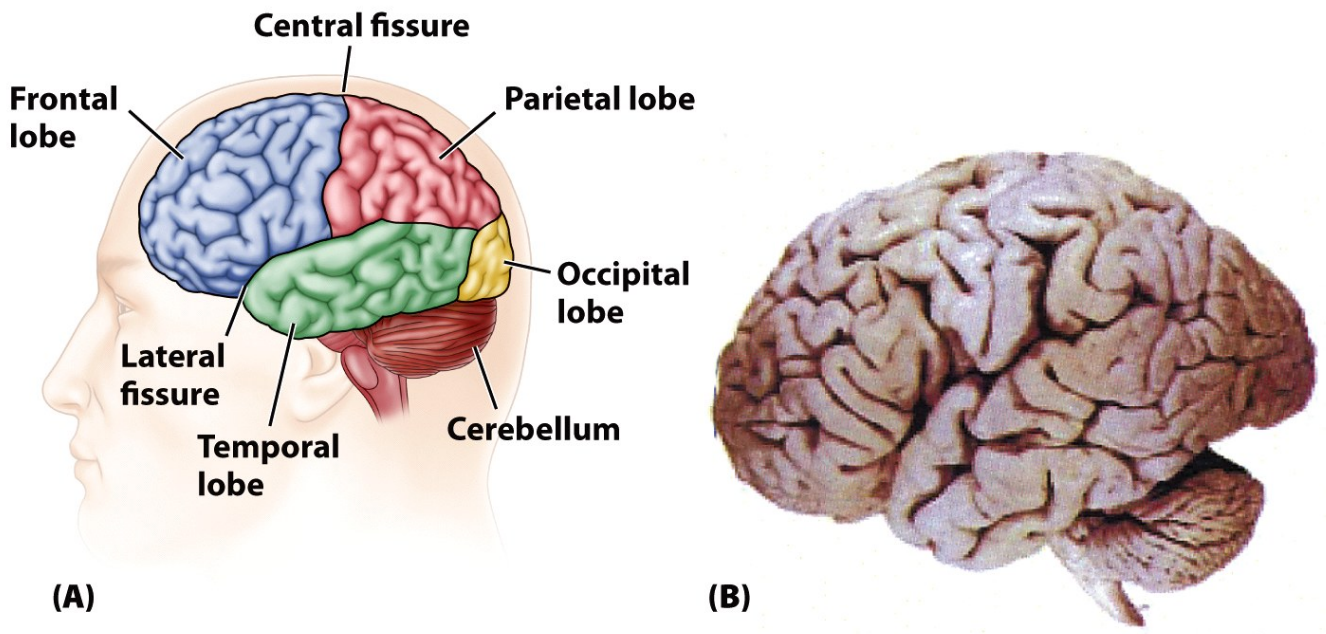
BodyParts3D/Anatomography

1. Cerebrum
2. Thalamus
3. Midbrain
4. Pons
5. Medulla
6. Spinal cord



The Cortex

- The outer surface of forebrain is the *cerebral cortex.*
  - The cortex is a large, thin sheet of tissue crumpled inside the skull.
  - Some of the *convolutions* divide the brain into sections:
    - The *frontal lobes,* the *parietal lobes*, the *occipital lobes*, and the *temporal lobes*



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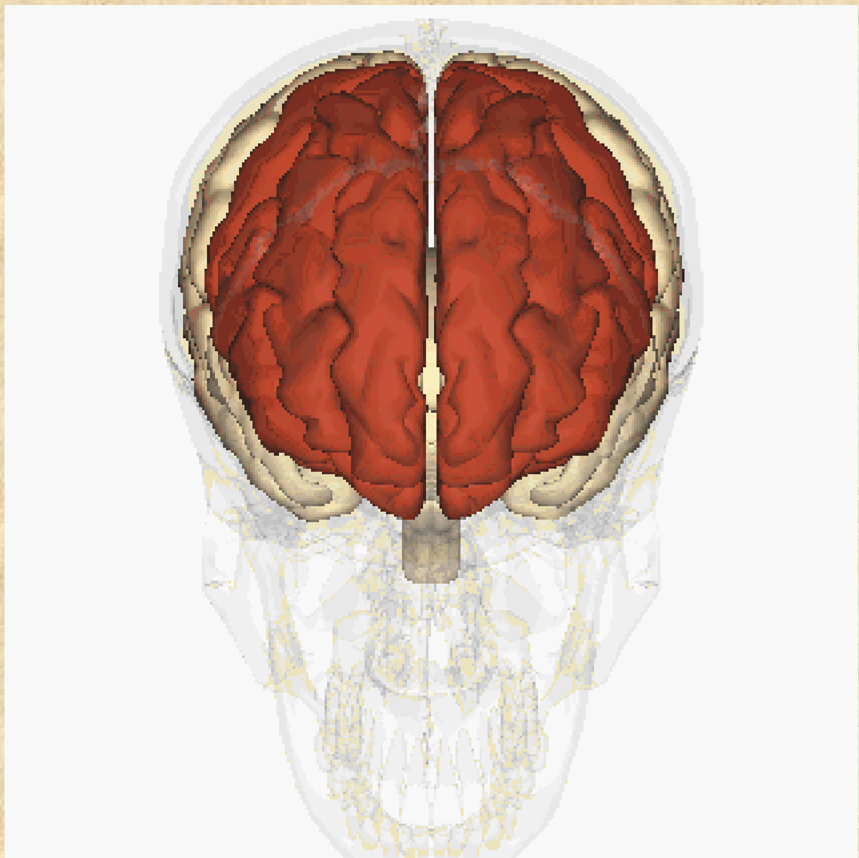
The Cortex

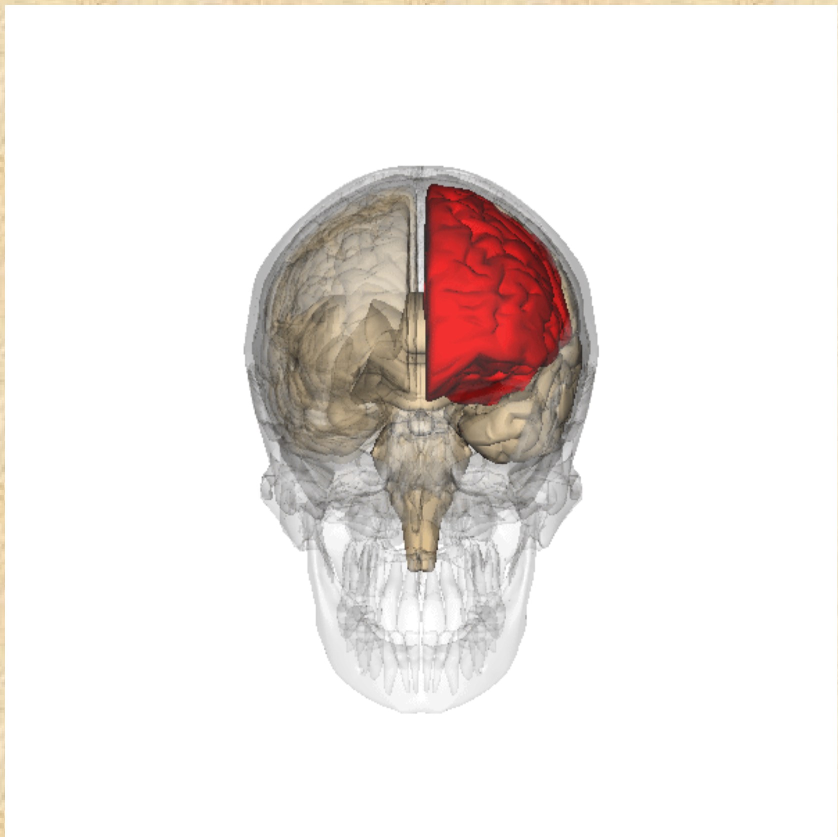
- The *frontal lobes*



BodyParts3D/Anatomography

The Cortex

- The *frontal lobes*



BodyParts3D/Anatomography

The Cortex

- The *temporal lobes*

BodyParts3D/Anatomography

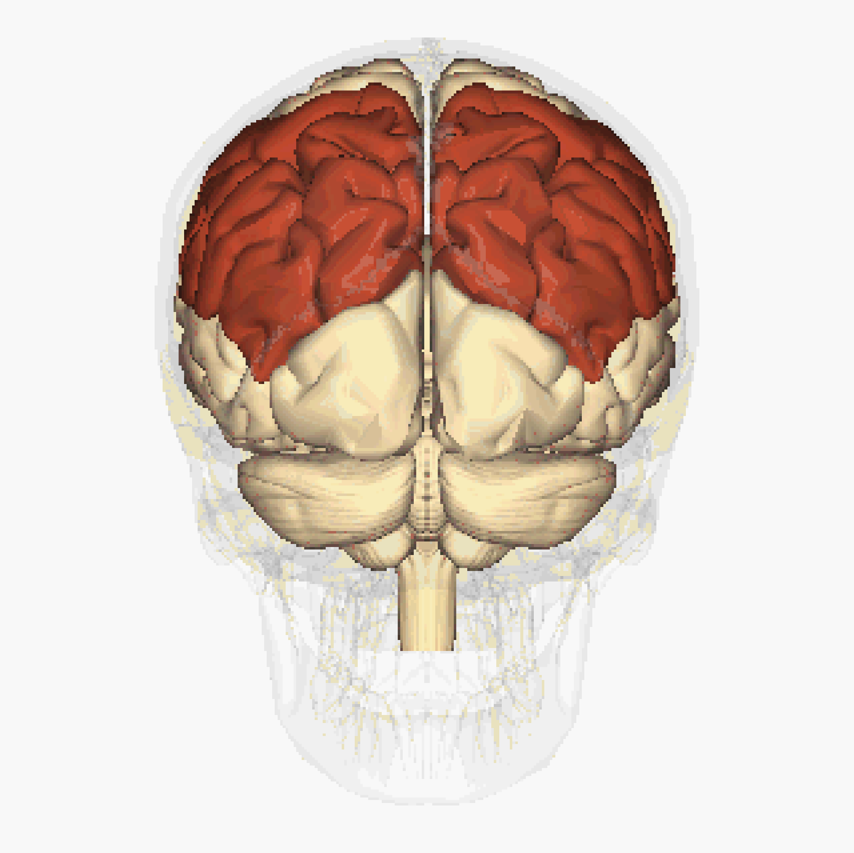
The Cortex

- The *temporal lobes*

BodyParts3D/Anatomography

The Cortex

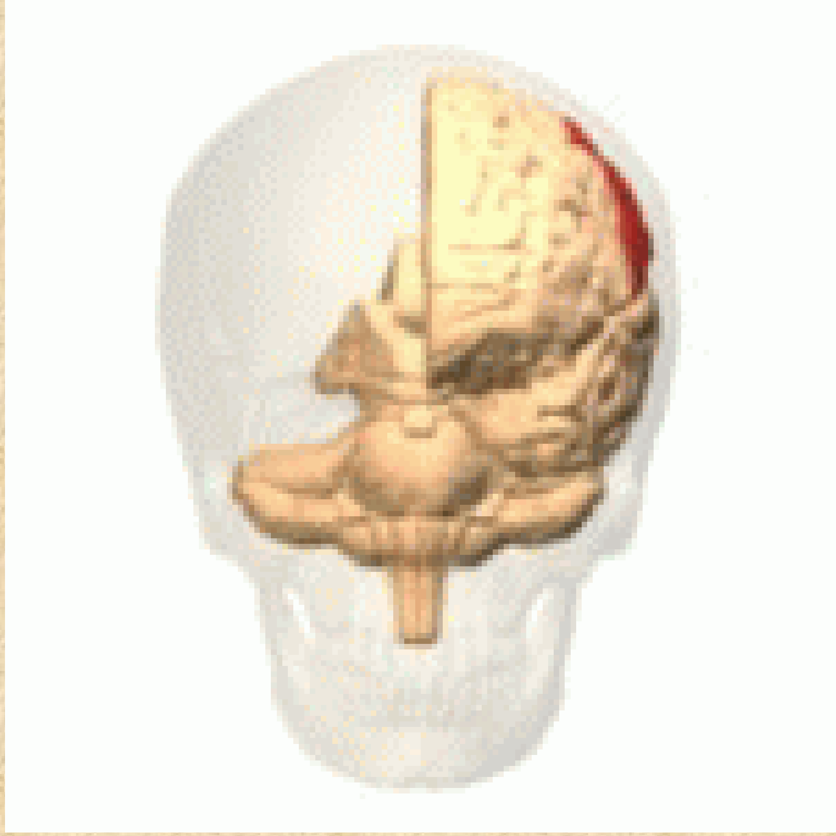
- The *parietal lobes*



BodyParts3D/Anatomography

The Cortex

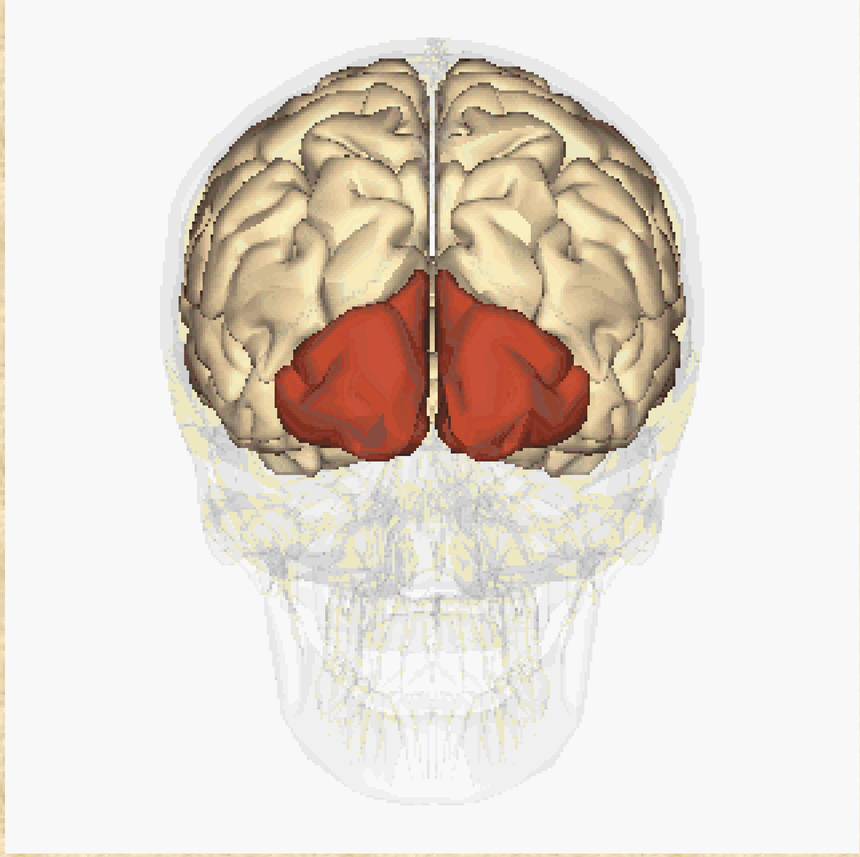
- The *parietal lobes*



BodyParts3D/Anatomography

The Cortex

- The *occipital lobes*



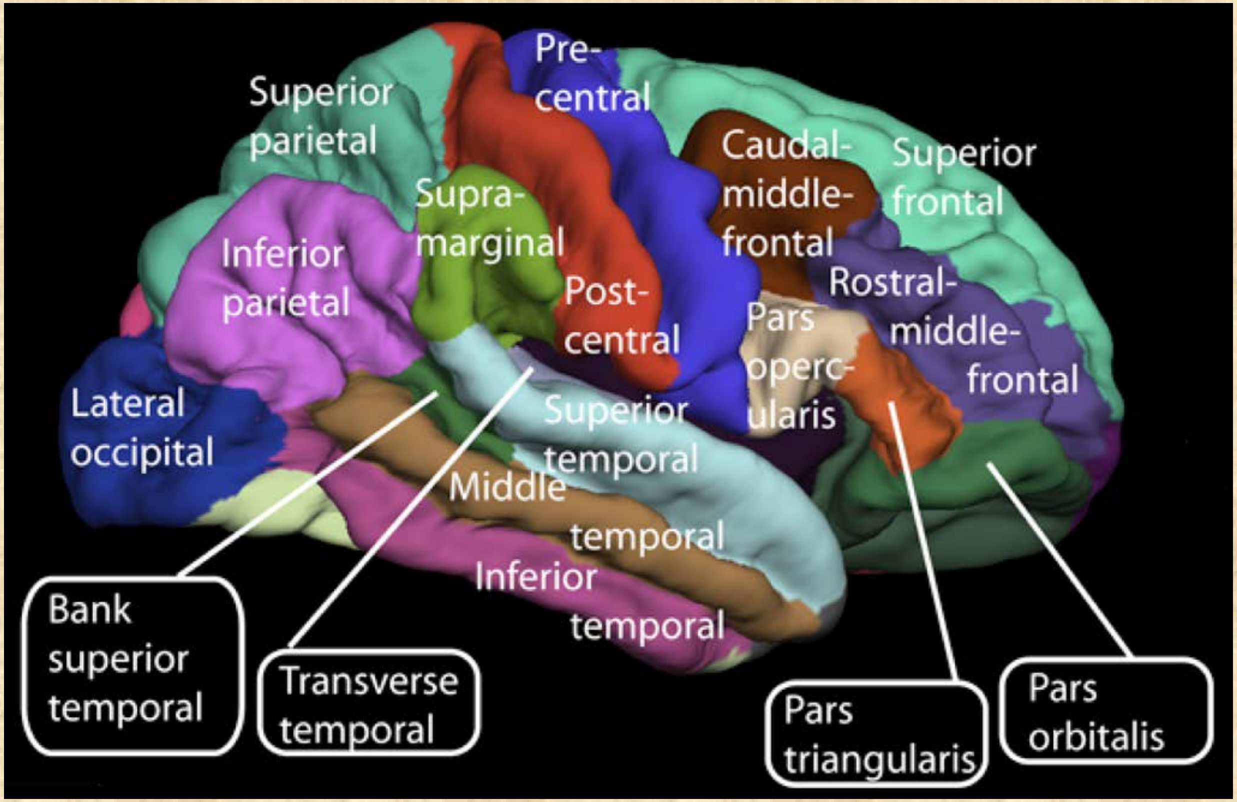
BodyParts3D/Anatomography

The Cortex

- The *occipital lobes*

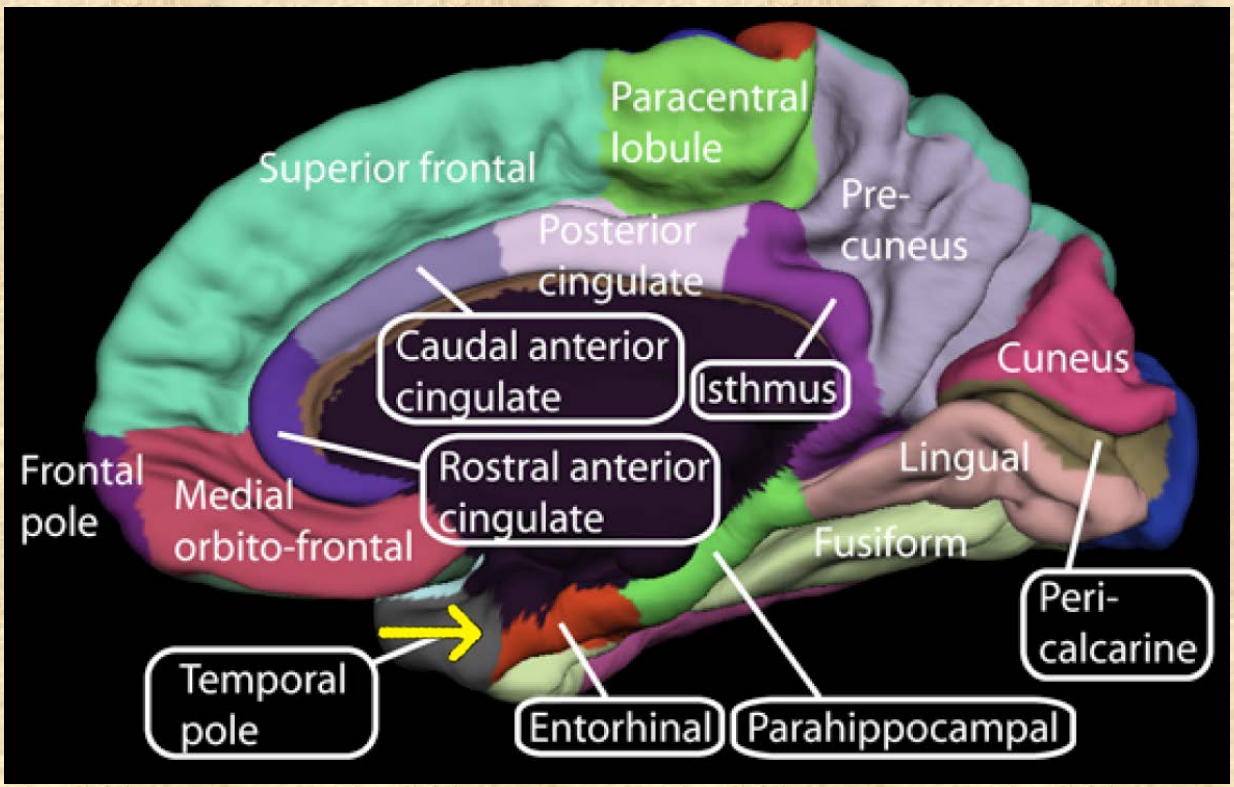
BodyParts3D/Anatomography

Cerebral Cortex



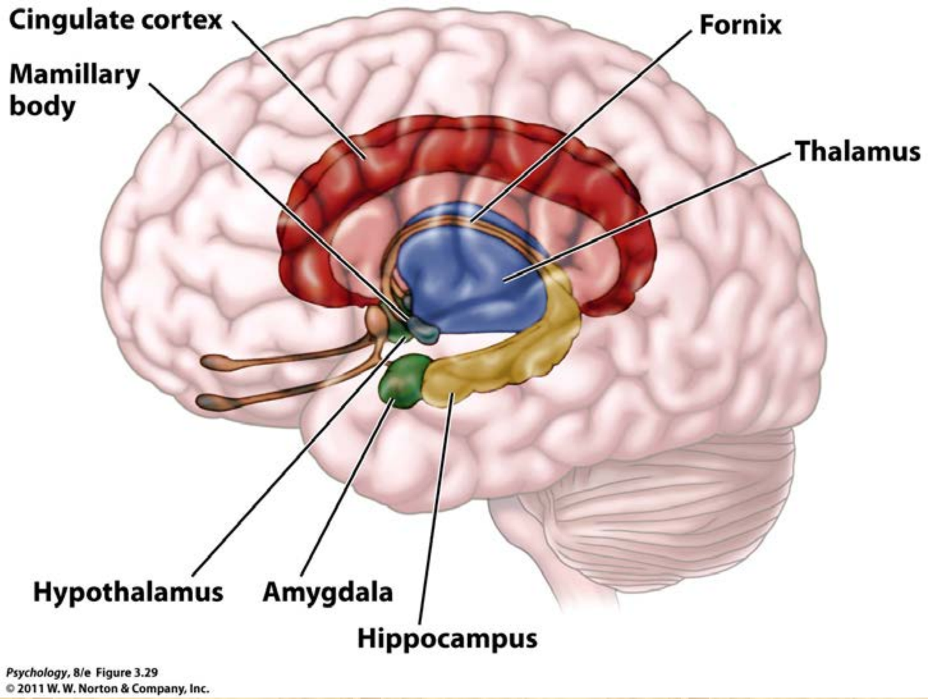
Lateral surface

Cerebral Cortex



Medial surface

Subcortical structures are also important



Subcortical structures are also important

- The *hippocampus* plays a key role in long-term memory formation as well as in spatial navigation

BodyParts3D/Anatomography

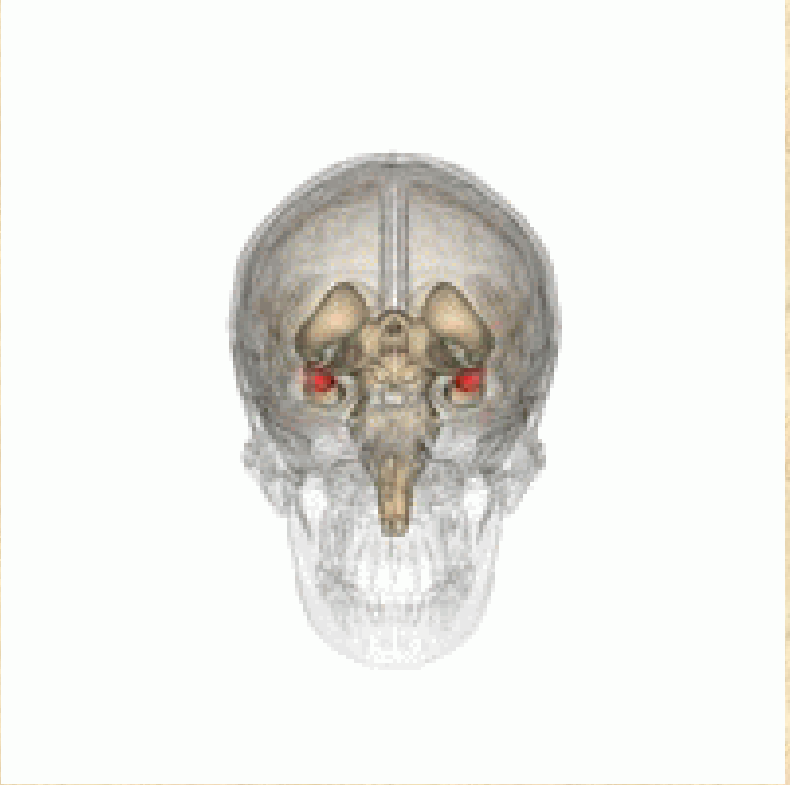
Subcortical structures are also important

- The *hypothalamus* plays a key role in motivated behaviors (eating, drinking, sexual activity)

BodyParts3D/Anatomography

Subcortical structures are also important

- The *amygdala* plays an important role in emotional reactions and helps in stimulus evaluation, learning



BodyParts3D/Anatomography

Left and Right Hemispheres

- The brain is roughly symmetrical around the midline.
- Most brain areas come in pairs:
  - One on the left side
  - One on the right side
- There are many axons that cross the midline, connecting neurons on left and right sides via *commissures*

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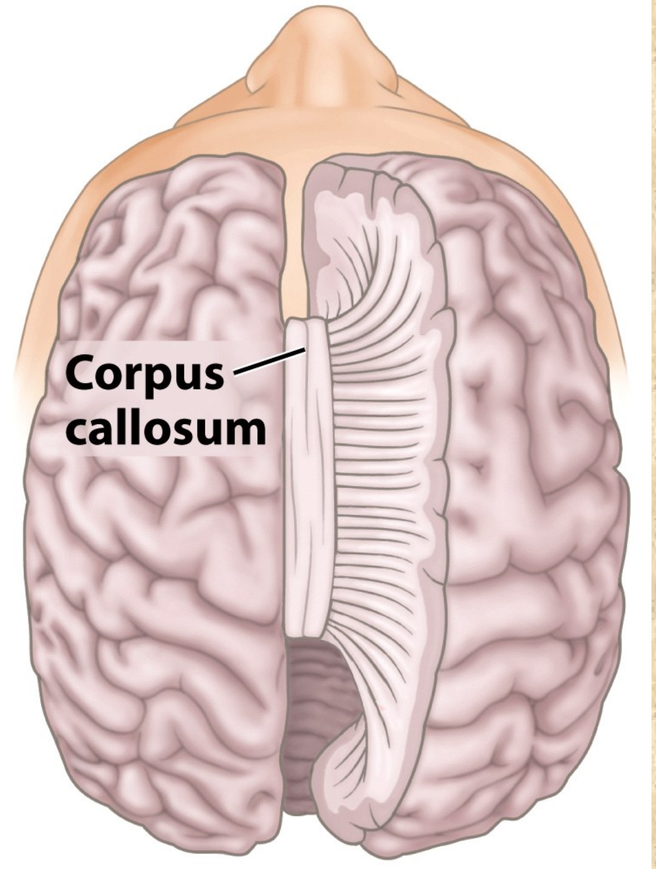
- There are many axons that cross the midline, connecting neurons on left and right sides via *commissures*
- The *corpus callosum* is a large bundle of axons crossing the midline and connecting the two hemispheres



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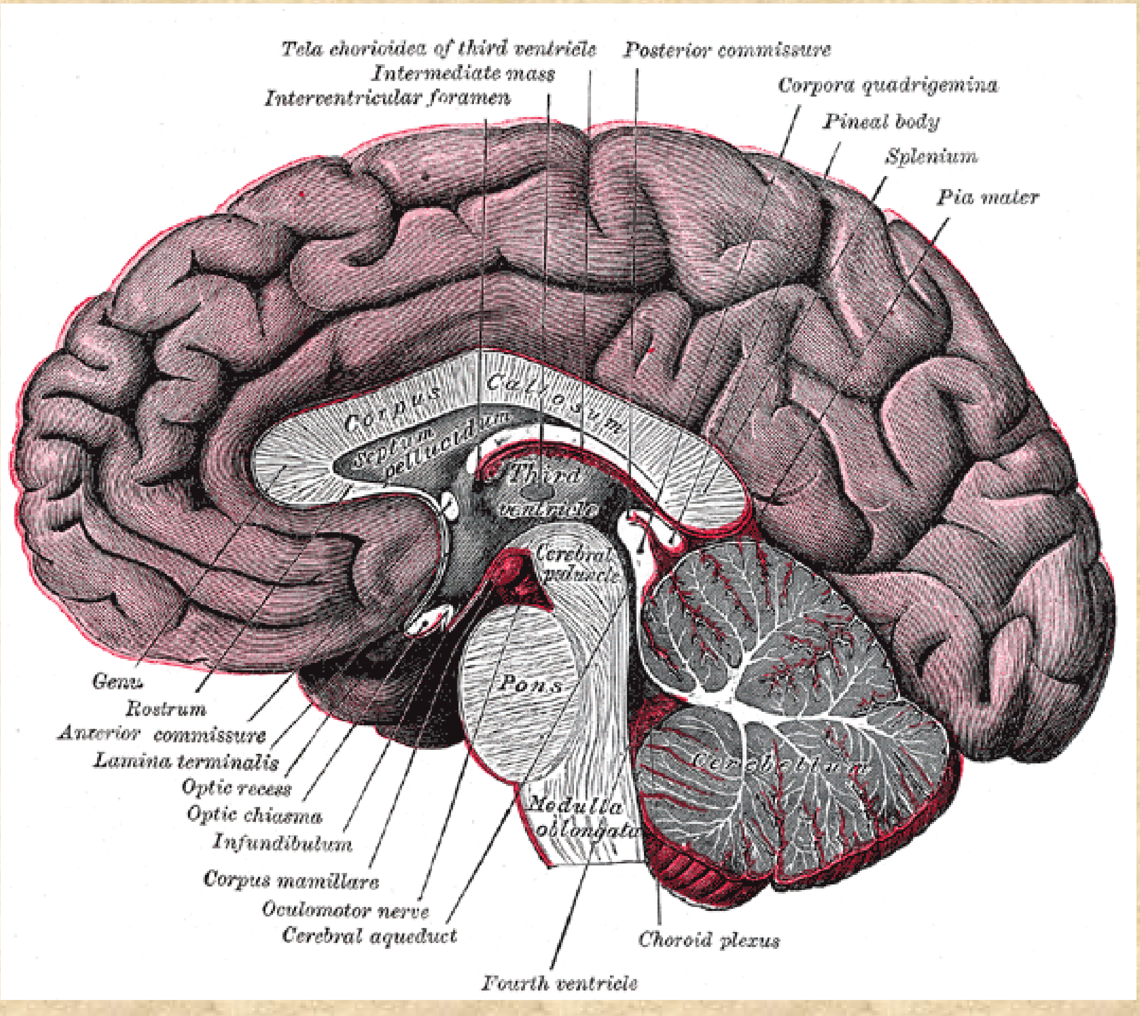
Corpus Callosum



From Gray's Anatomy

Left and Right Hemispheres

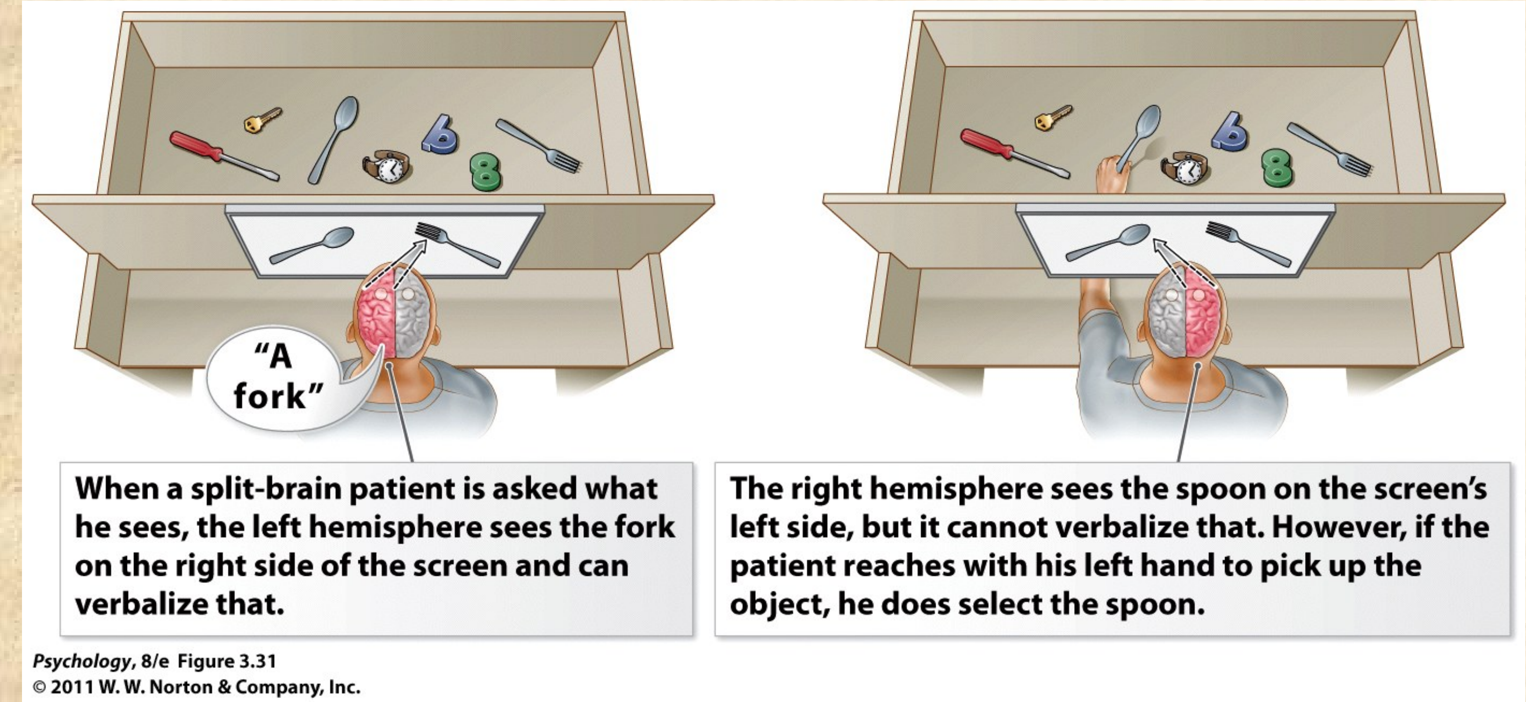
- The left and right structures are generally similar.
- The two halves of the brain work as an integrated whole.

- **Important fact**. On the whole, the right side of the brain processes sensory information from the left side of the body and issues motor commands to the left side of the body. Likewise, the left side of the brain processes sensory information from the right side of the body and issues motor commands to the right side of the body.

- Terminology: **ipsilateral** (same side) and **contralateral** (opposite side).

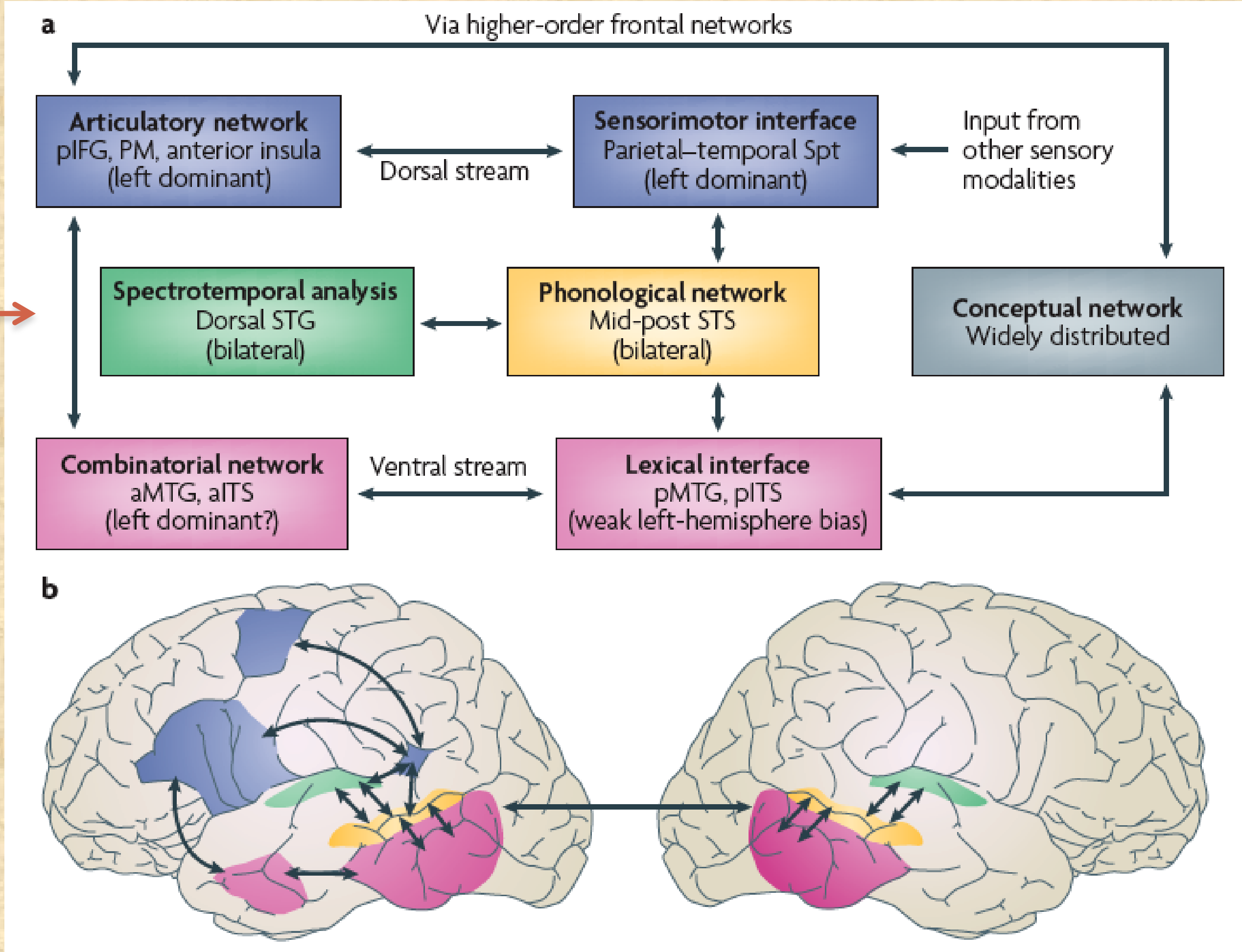
Sperry's Split Brain Patients

- Sever the corpus callosum surgically in an attempt stop epileptic activity.
- Severing communication can reveal the ways in which the two hemispheres differ.
- Nobel prize for studies of the effects on information processing among such patients.



Language is *lateralized* in humans

heard input

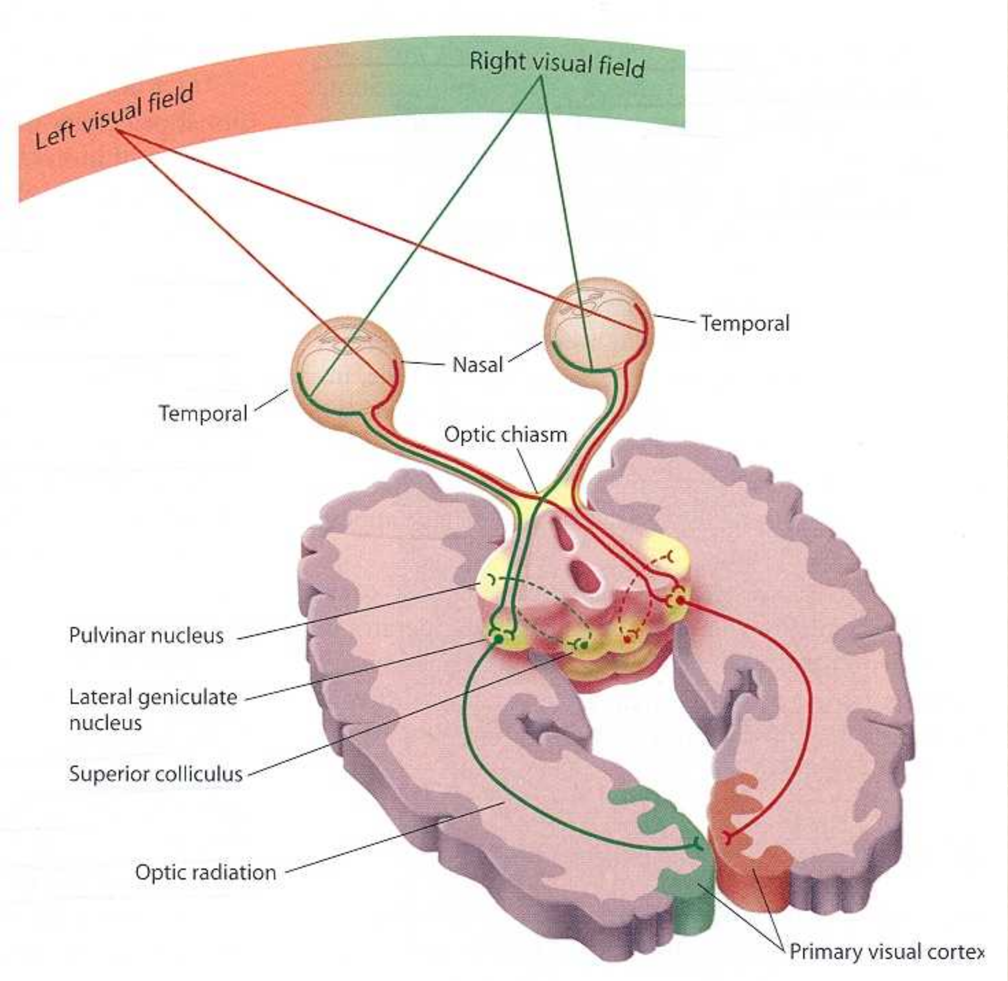


Hickok & Poeppel (2000) Trends Cog Sci; (2004) Cognition; (2007) Nat Rev Neurosci

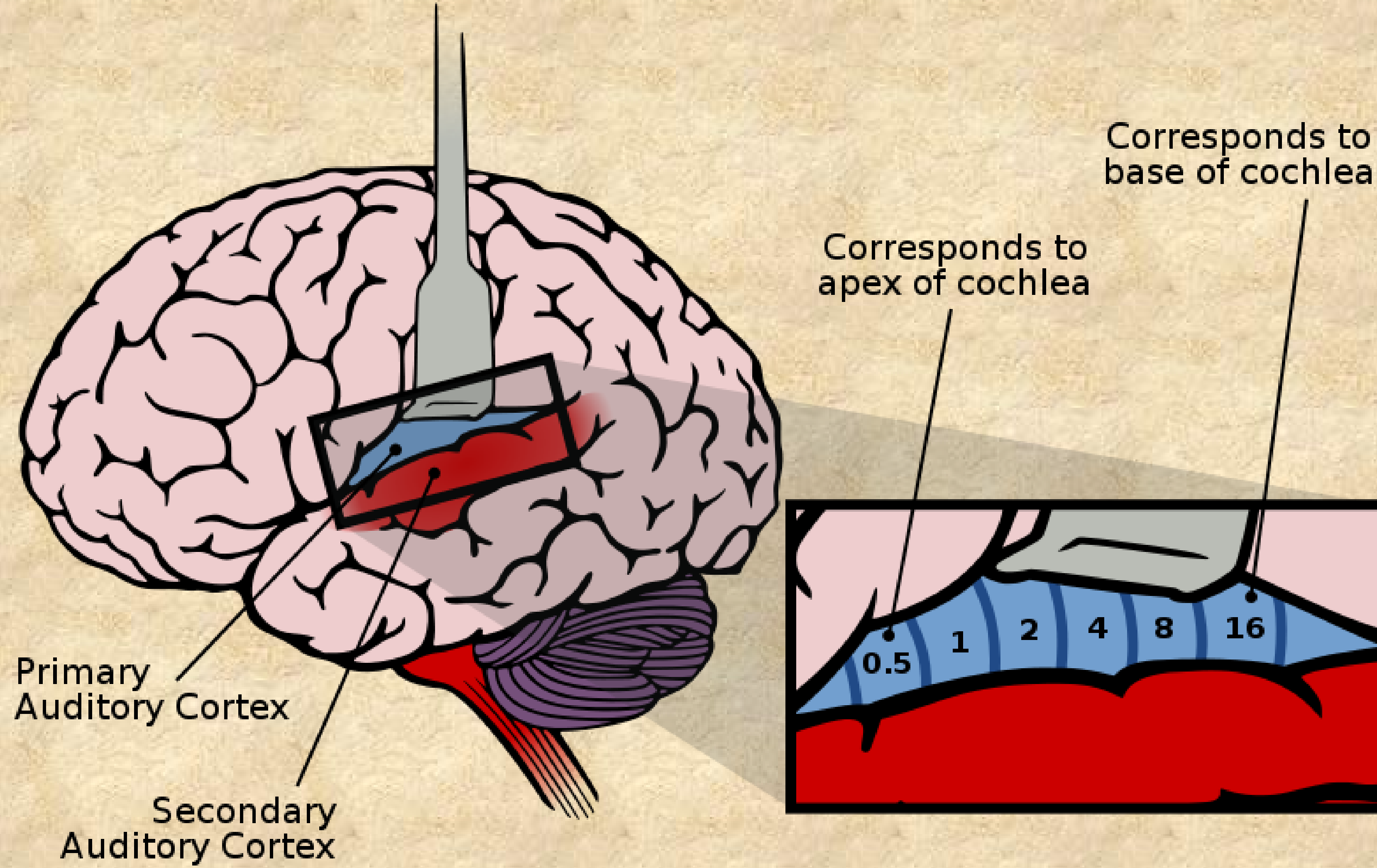
Cerebral Cortex

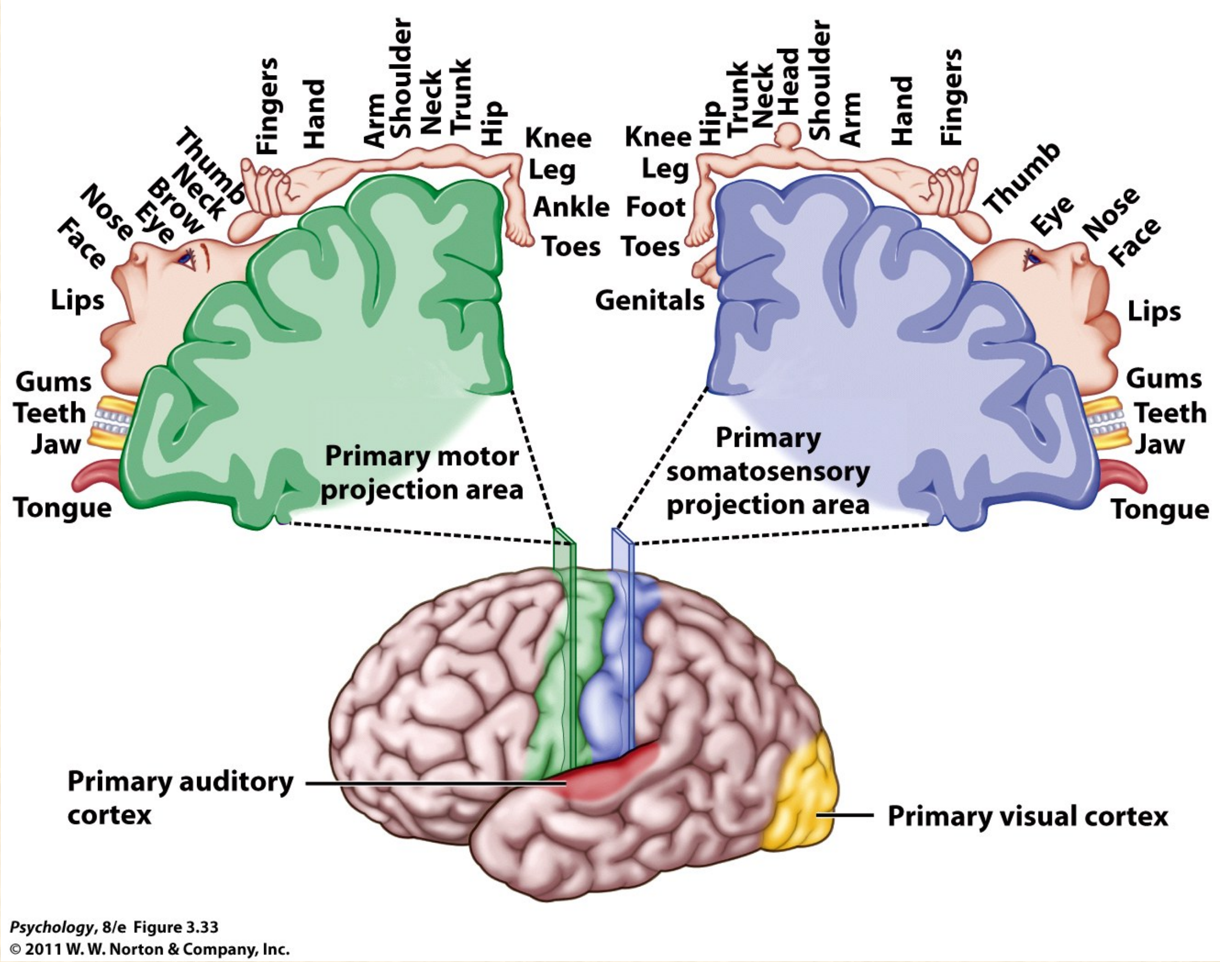
- *Localization of function*:
  - Determining the function of each brain area
- Some parts serve as *projection areas:*
  - The first receiving stations for information coming from the sense organs
    - primary visual cortex, area V1
    - primary auditory cortex, area A1
    - primary somatosensory cortex, area S1
  - Departure points for signals going to the muscles (e.g. primary motor cortex, area M1)

Primary Visual Cortex (V1)



Primary Auditory Cortex (A1)

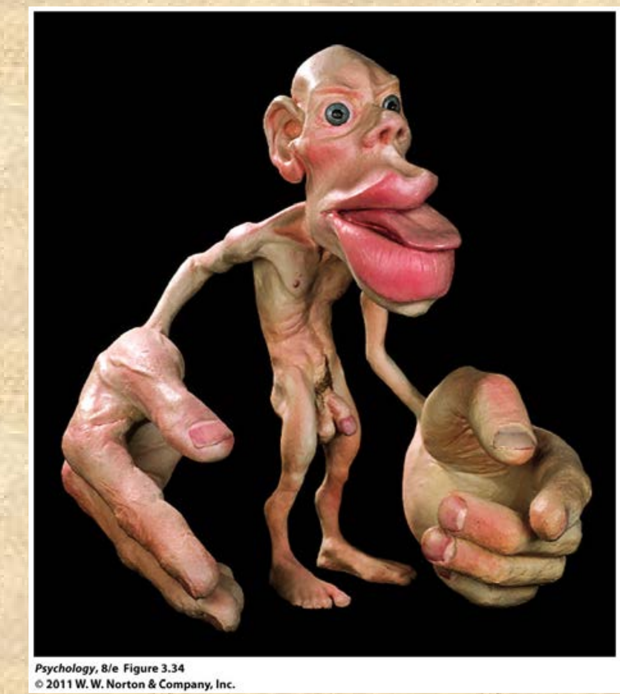




The areas of cortex pictured are on the left hemisphere. These neurons are primarily responsible for processing information from and controlling movement on the right side of the body.

Cortical Somatosensory Representation

- Most projection areas lie on the side of the brain opposite to that side sensed or controlled.
- Adjacent sites in the brain usually represent adjacent parts of the body (for somatosensation).
- Assignment of space is disproportionate:
  - For touch, the parts of the body that are most sensitive to touch receive the most space.

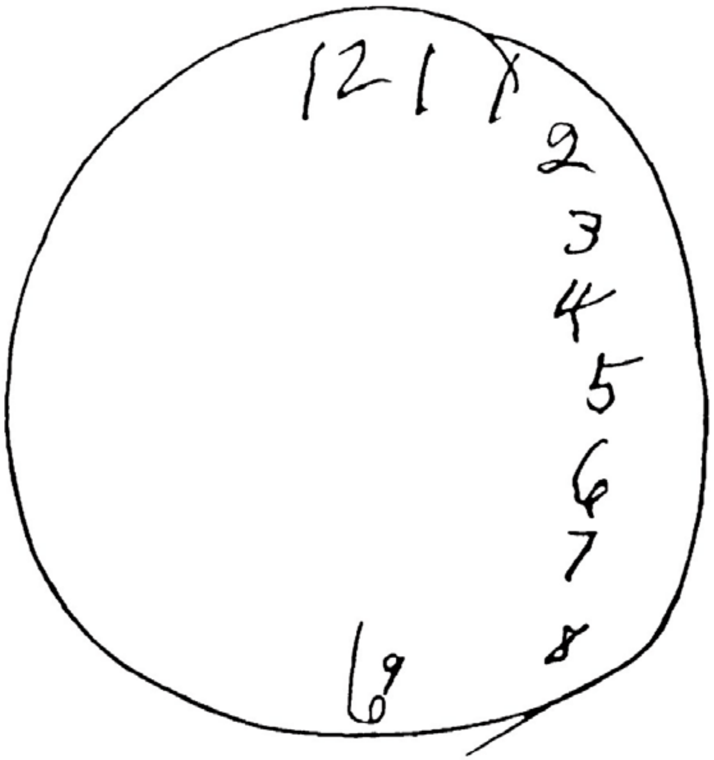


Somatosensory Homunculus

Cortical Damage

- Much of what we know about the cortex comes from studying brain damage.
- Damage at identifiable sites can produce:
  - *Apraxias* (disorders in action – frontal lobe damage)
  - *Agnosias* (inability to recognize objects and their properties – occipital, parietal, temporal cortex damage)
  - *Prosopagnosia* (inability to recognize faces)
  - *Aphasias* (disorders of language – Broca's and Wernicke's areas)
  - Disorders of planning or social cognition (prefrontal cortex – like Phineas Gage)

Right hemisphere parietal damage can lead to *neglect syndrome*, a systematic neglect of the left side of the visual field.



Psychology, 8/e Figure 3.35

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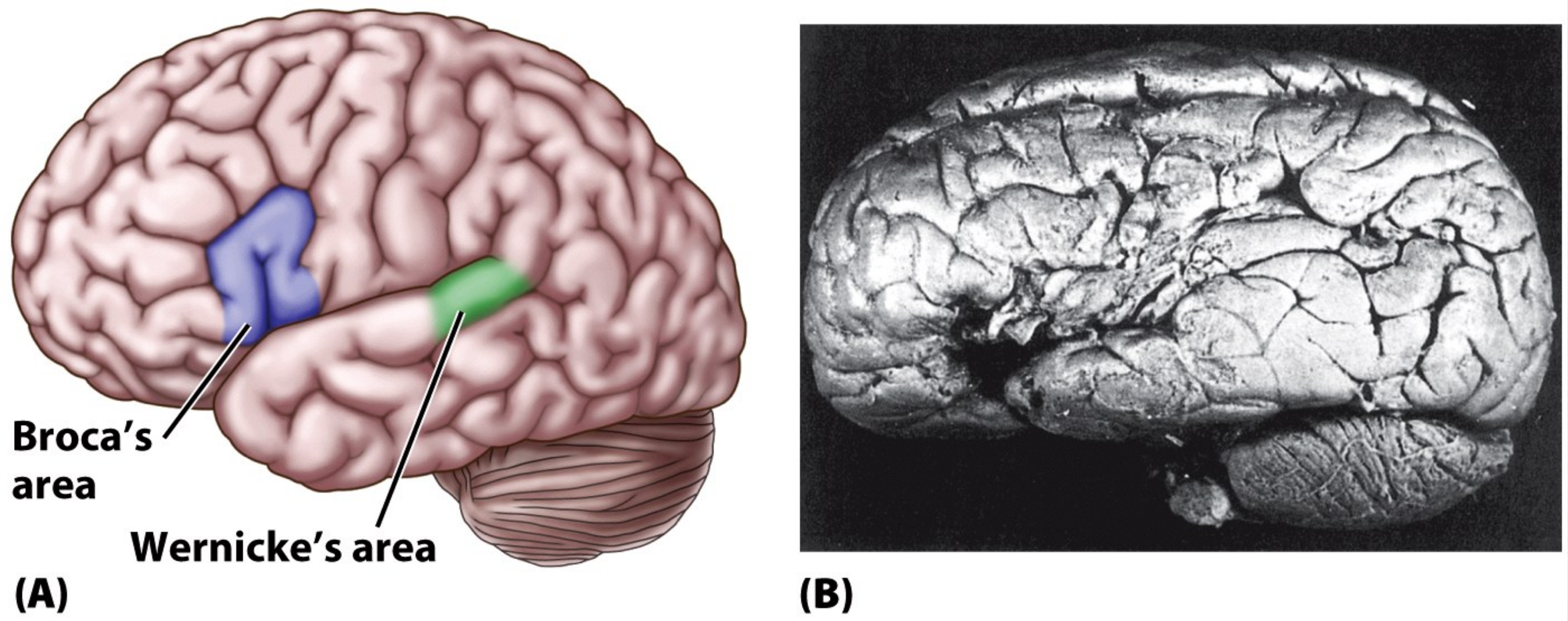
Damage to Broca's and/or Wernicke's areas can cause aphasia. For right-handed people, these sensitive areas are located on the brain's left hemisphere.

Broca's area: helps to convert phonemic information into motor commands and lies close to motor areas controlling the vocal articulature
Wernicke's area: plays a central role in speech comprehension and is located close to areas involved in hearing (audition)



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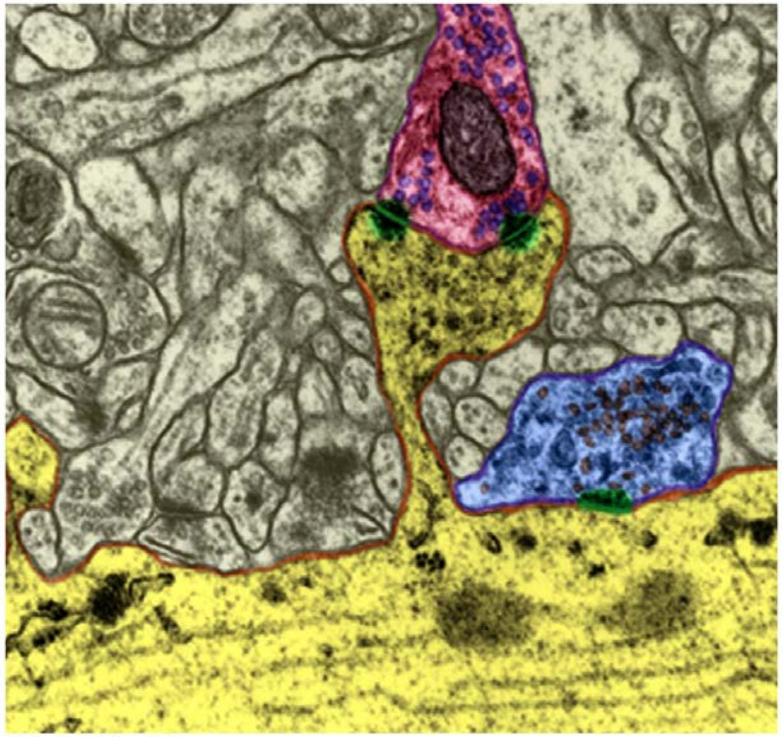
Plasticity

- The nervous system is *plastic*—subject to alteration in the way it functions, such as:
  - Changes in how much neurotransmitter a presynaptic neuron releases
  - Changes in neuron sensitivity to neurotransmitters
  - Creating new connections by growing new *dendritic spines*



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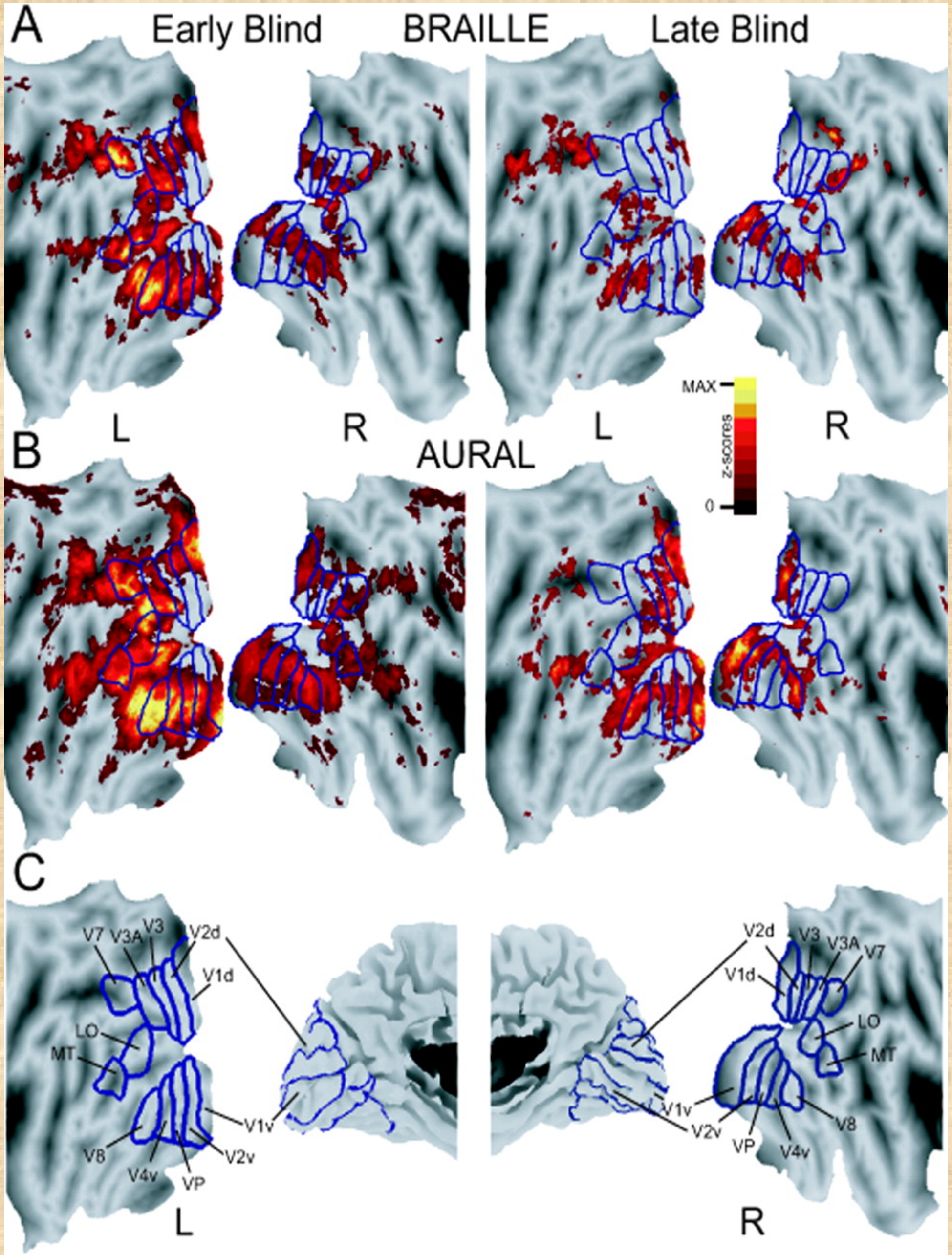
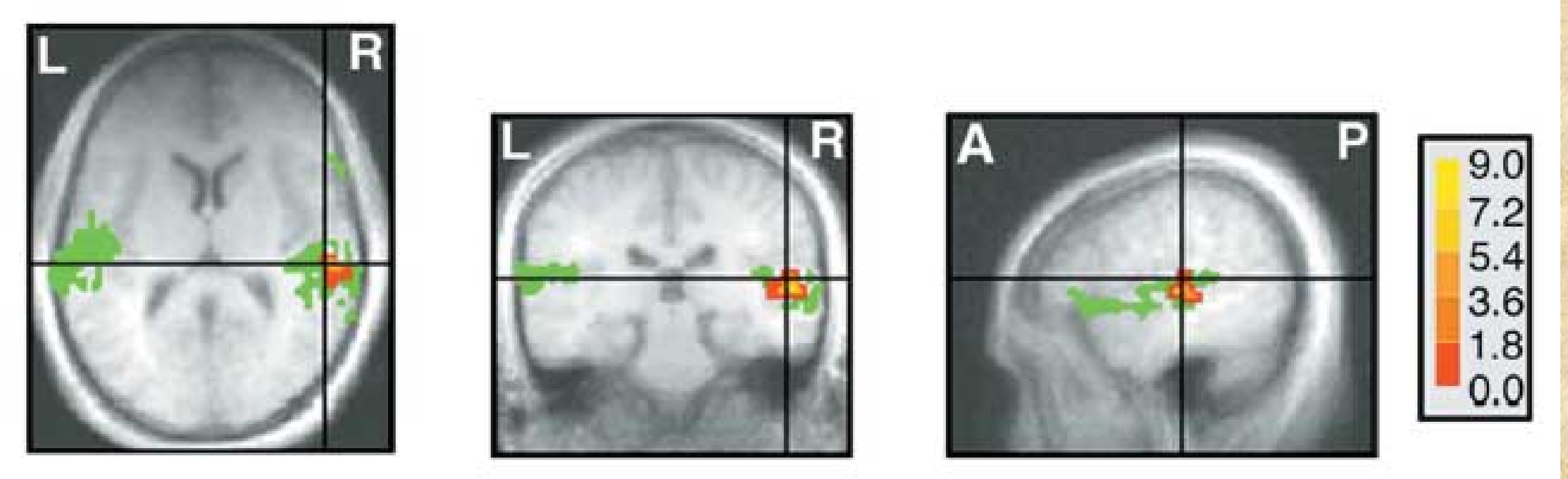
Plasticity

- Plasticity can involve larger-scale changes:
  - Changes in the brain's overall architecture
  - Example: occipital cortical neurons, specializing normally for visual stimulation, can become sensitive to auditory and somatosensory stimulation in people blind since birth

Blind people use visual cortex to process verbal information (Sadato *et al*., 1996)



Deaf people use auditory cortex to process visual information (Finney *et al*., 2001, moving dot stimuli)



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- The central nervous system can grow new neurons:
  - But appears unable to do so with cortical injury
  - This promotes stability in the brain's connections but is an obstacle to recovery from brain damage.

- There is tremendous work on promoting nervous system plasticity and recovery from lesions (for example, spinal cord lesions).