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Introductory Lecture

M1 – CNS Sequence

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Winter, 2009

University of Michigan
Medical School

Introduction to today's lecture:

I. Introduction to the faculty and the Normal CNS, Special Senses, Head & Neck Sequence
II. Anatomical planes and major axes of the central nervous system
III. Principal cell types in the CNS
IV. Specialized stains and what they reveal
V. Schematic representation of the functional organization of the CNS
VI. Regional anatomy of the central nervous system
VII. Functional subdivisions, pathways and relevant concepts
VIII. Topographic organization
IX. Blood supply to the CNS
X. The cerebrospinal fluid

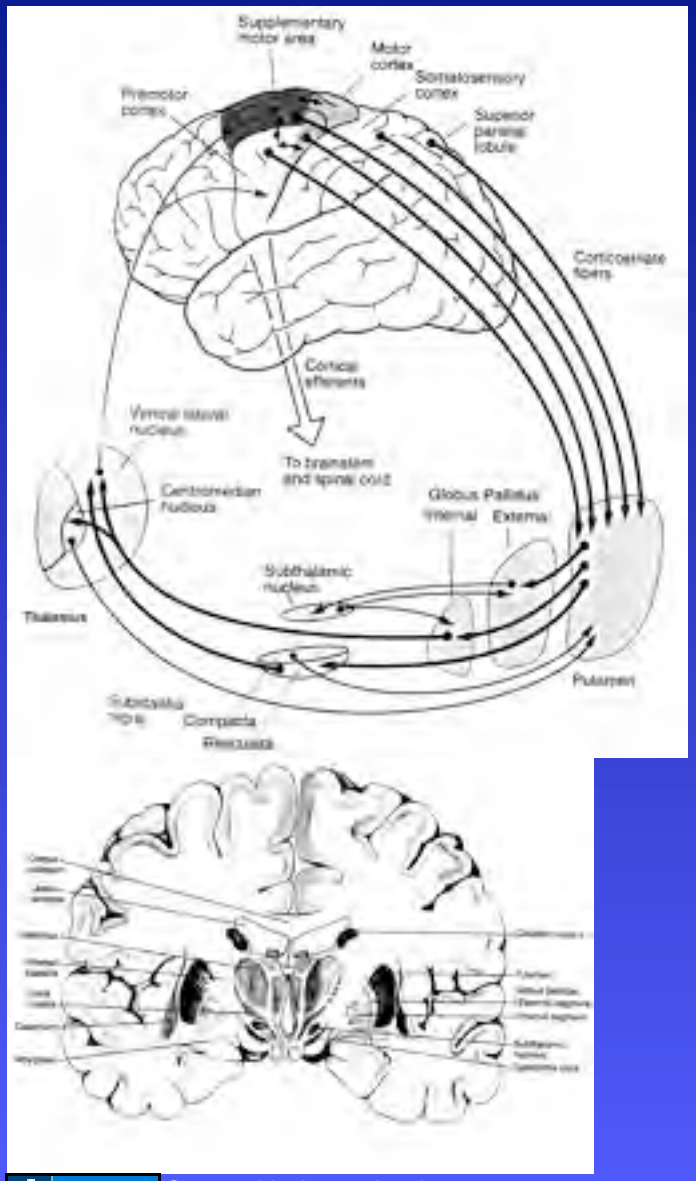
Why is learning neuroanatomy such a challenge?

You will simultaneously learn:

1) regional anatomy (spinal cord, brainstem, etc.)
2. surface (gross) anatomy
3. internal anatomy
4. names and locations of nuclei and tracts and the pathways they form
5. functions of the various pathways in the CNS
6. blood supplyS

neuronal cell biology
nerve development and regeneration
neurotransmitters
chemical neuroanatomy

Gross Anatomy
Histology
Pharmacokinetics



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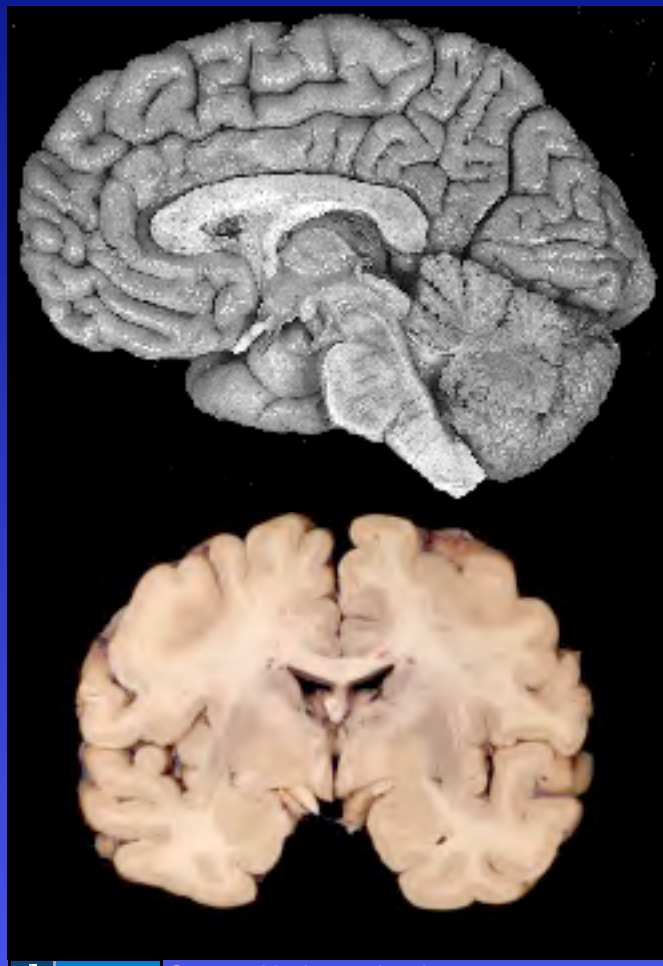

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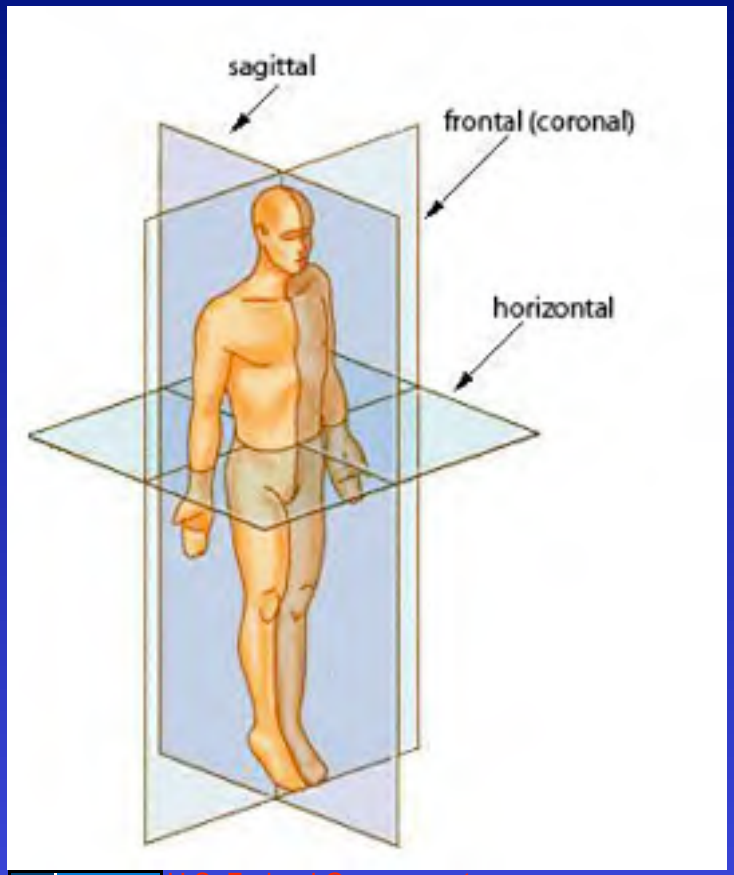
There are three principal planes of section that are used for viewing the brain: **horizontal, frontal (or coronal) and sagittal.**



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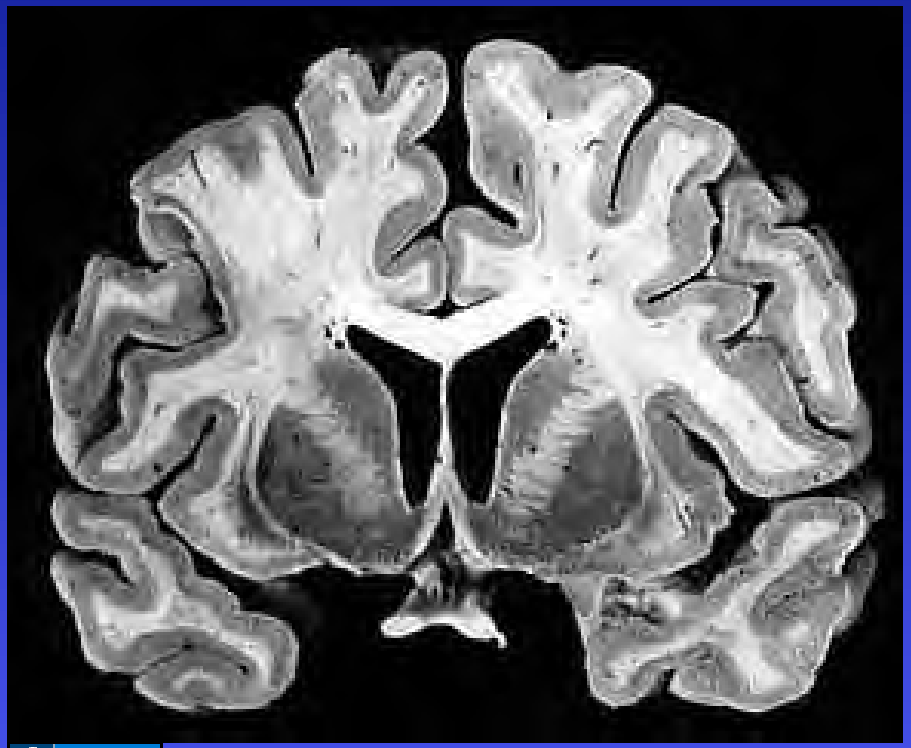

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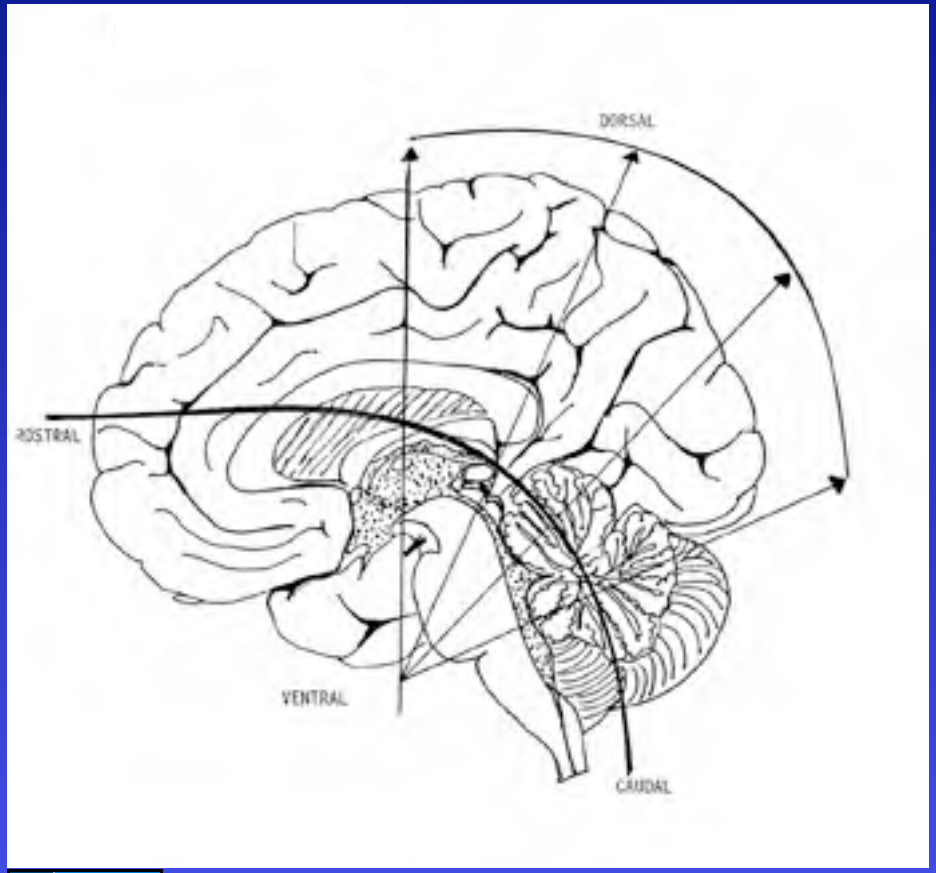
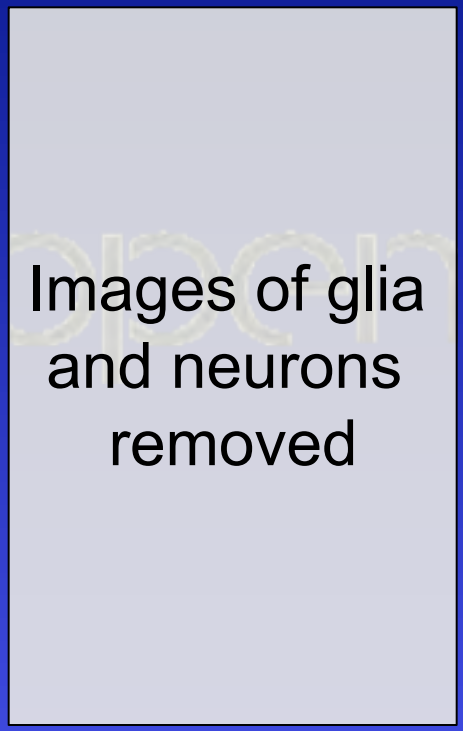
frontal section through the cerebral hemispheres

- There are three principal axes along which the internal anatomy of the nervous system is organized:
  - **rostral-caudal** axis
  - **dorsal ventral** axis
  - **medial-lateral** axis
- During its embryonic development the human brain bends (known as a flexure). As a result, the dorsal-ventral plane changes as one moves along the neuraxis, from rostral telencephalon to the caudal spinal cord.
- Several terms are used to indicate the relative positions of structures or tracts in the brain:
  - **Dorsal** - above or superior
  - **Ventral** -below or inferior
  - **Rostral** -toward the front
  - **Caudal** - toward the back
  - **Medial** - toward the midline
  - **Lateral** - away from the midline
  - **Ipsilateral** - on the same side
  - **Contralateral** - on the opposite side



- There are two fundamental cell types in the CNS: **neurons** ($10X10^9$) and **glia** (10-50X more numerous than neurons).
- Neurons communicate to each other via specialized junctions known as **synapses.**
- Neurons are polarized cells that are specialized to receive **synapses** on **dendrites** and relay electrical impulses to other neurons via their **axons** (also called fibers) and their **synapses**.
- A collection of neuronal cell bodies outside the CNS is called a **ganglion.**
- A collection of neuronal cell bodies within the CNS is called a **nucleus**.
- A discrete bundle of axons outside the CNS is known as a **nerve**.
- A discrete bundle of axons within the CNS is known as a **tract** (**lemniscus, fasciculus**).

  (read the handout for more details on tracts)
- Nuclei and tracts that are **linked by synapses** serve a common function are generally referred to as a **pathway.**



Axons that form a tract:

- have cell bodies in a common nucleus
- synapse onto a common target (or set of targets)
- perform a common function, e.g., somatic sensation, voluntary movement

Tracts are often named based on the site of origin and termination of their axons:

- spinothalamic tract – from the spinal cord to the thalamus
- corticospinal tract – from the cerebral cortex to the spinal cord

The names of tracts often identify their relative location within the CNS white matter:

- lateral spinothalamic tract – lateral in the spinal cord
- medial lemniscus – near the midline

Tracts can carry information either up or down the **neuraxis**

- ascending tract (spinothalamic tract) - sensory function
- descending tract (corticospinal tract) - motor function

Tracts that carry sensory or motor information are generally organized in parallel:

- pain and temperature vs. fine discrimination

The locations and spatial relationships of nuclei and tracts define the internal anatomy of the CNS. The functions subserved by the various nuclei and tracts define the functional anatomy of the CNS.

Regions of the brain that contain cell bodies are given the general descriptive term, **gray matter**.

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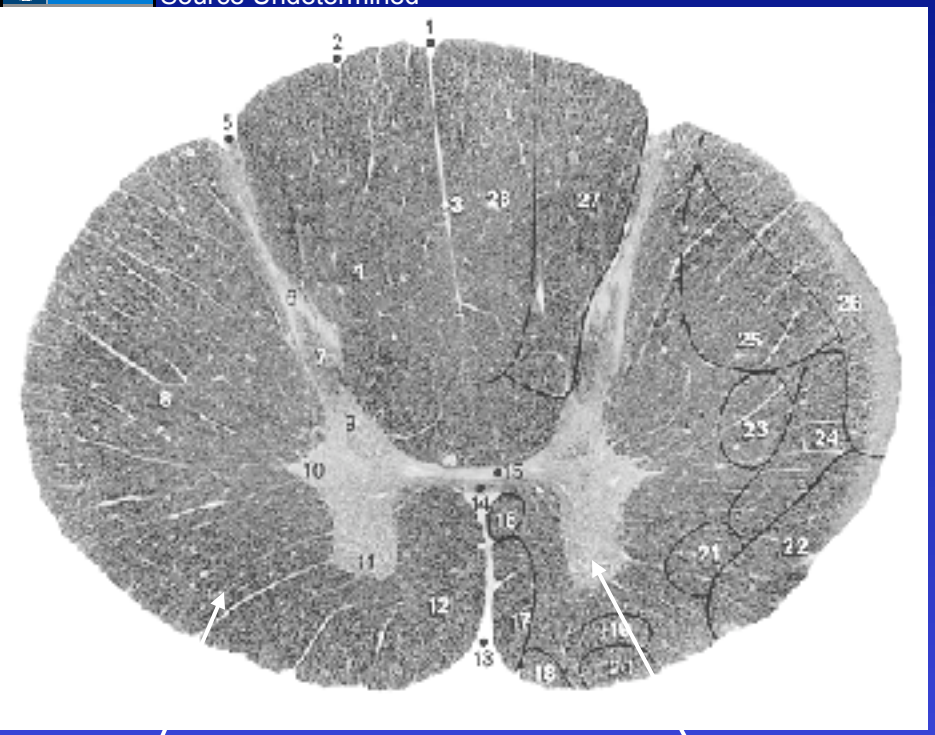

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Spinal cord

white matter

gray matter

cerebral hemispheres

gray matter

white matter

Regions of the brain that contain axons are given the general descriptive term, **white matter**.

Golgi-stained neurons (cortex)

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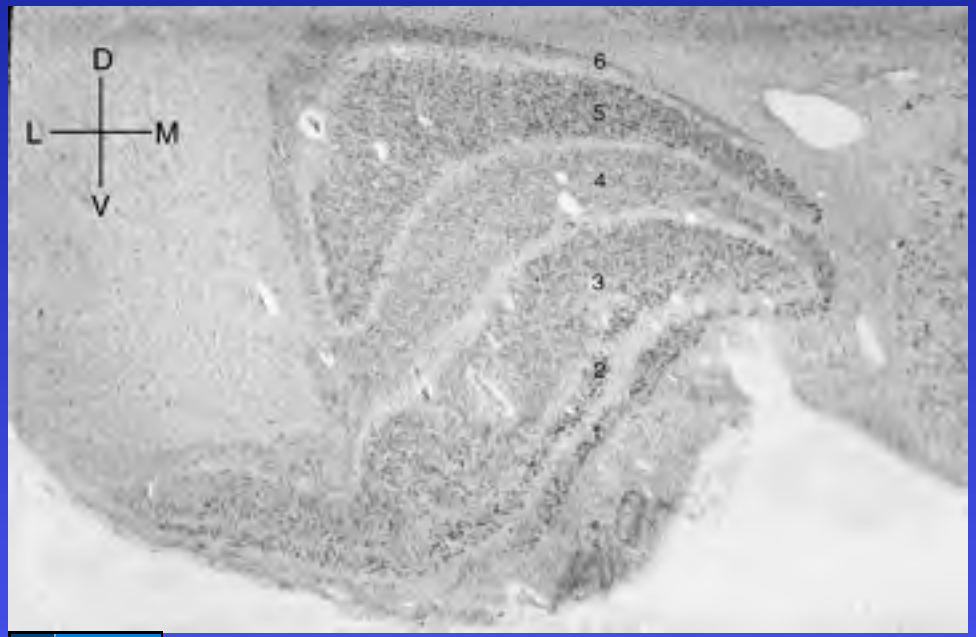
Visualizing neurons and axons in the central nervous system

nucleic acid stain

(lateral geniculate nucleus [dorsal thalamus])



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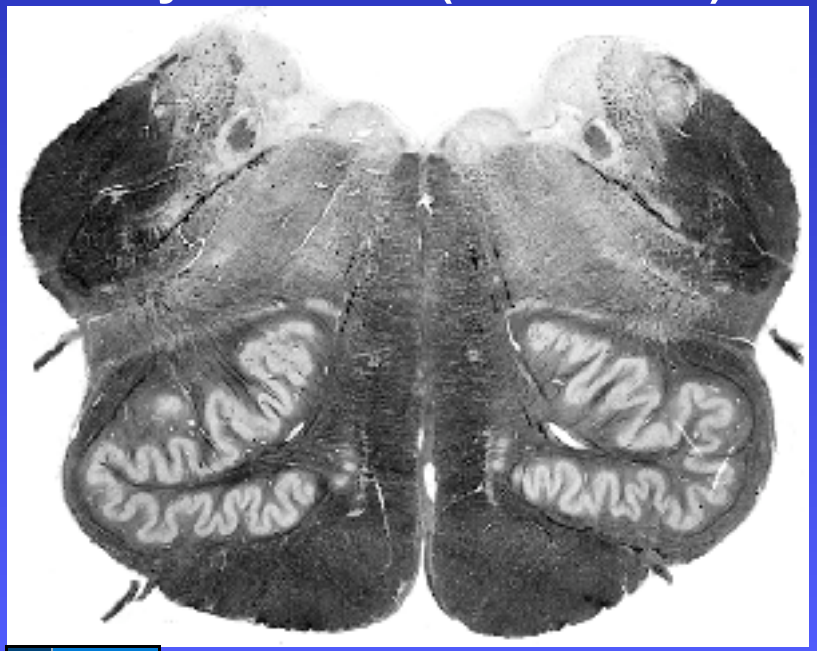
myelin-stain (brainstem)



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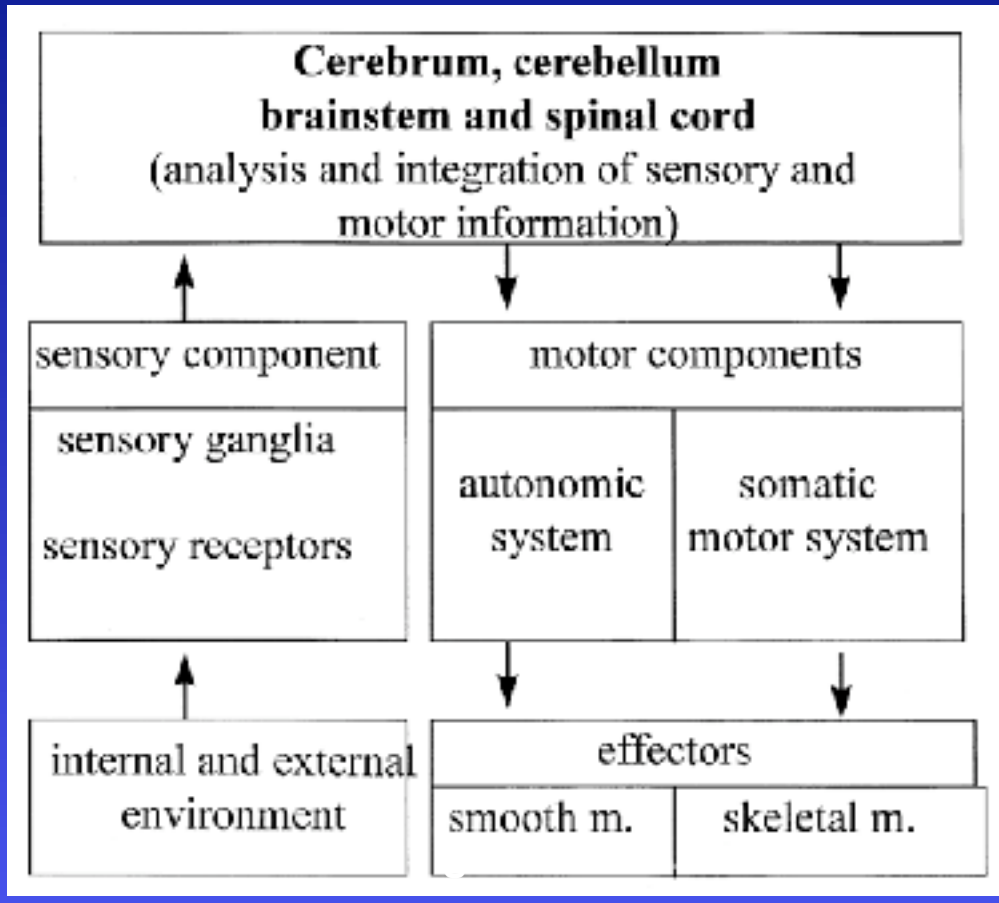
A schematic representation of the nervous system organization and function

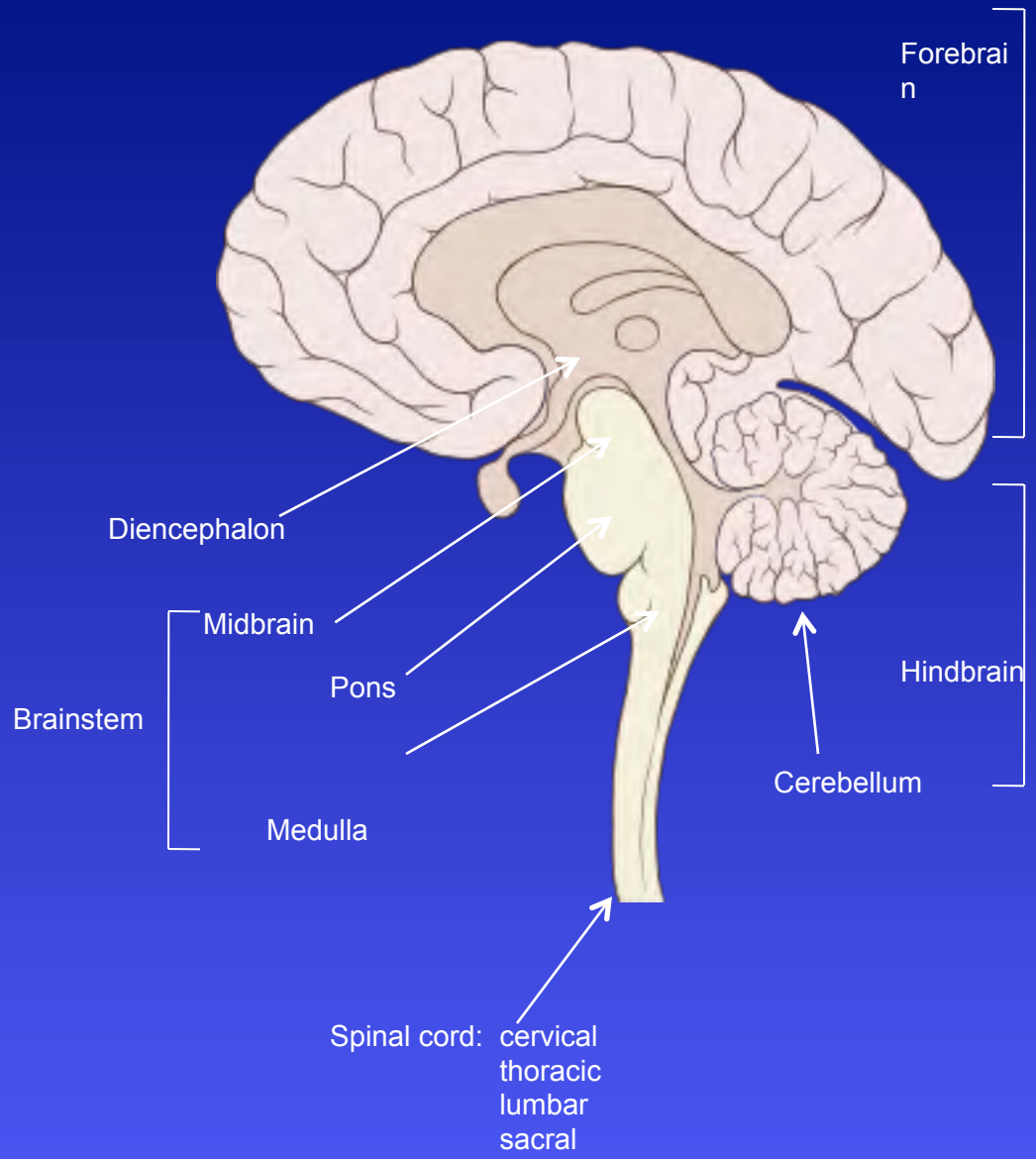
- The nervous system of all animals performs 3 fundamental biological functions:
  - Monitor and regulate the internal environment
  - Monitor the external environment
  - Initiate behaviors based on infor-mation from both the internal and external environments
- You are generally unaware of the majority of the functions performed by your nervous system.



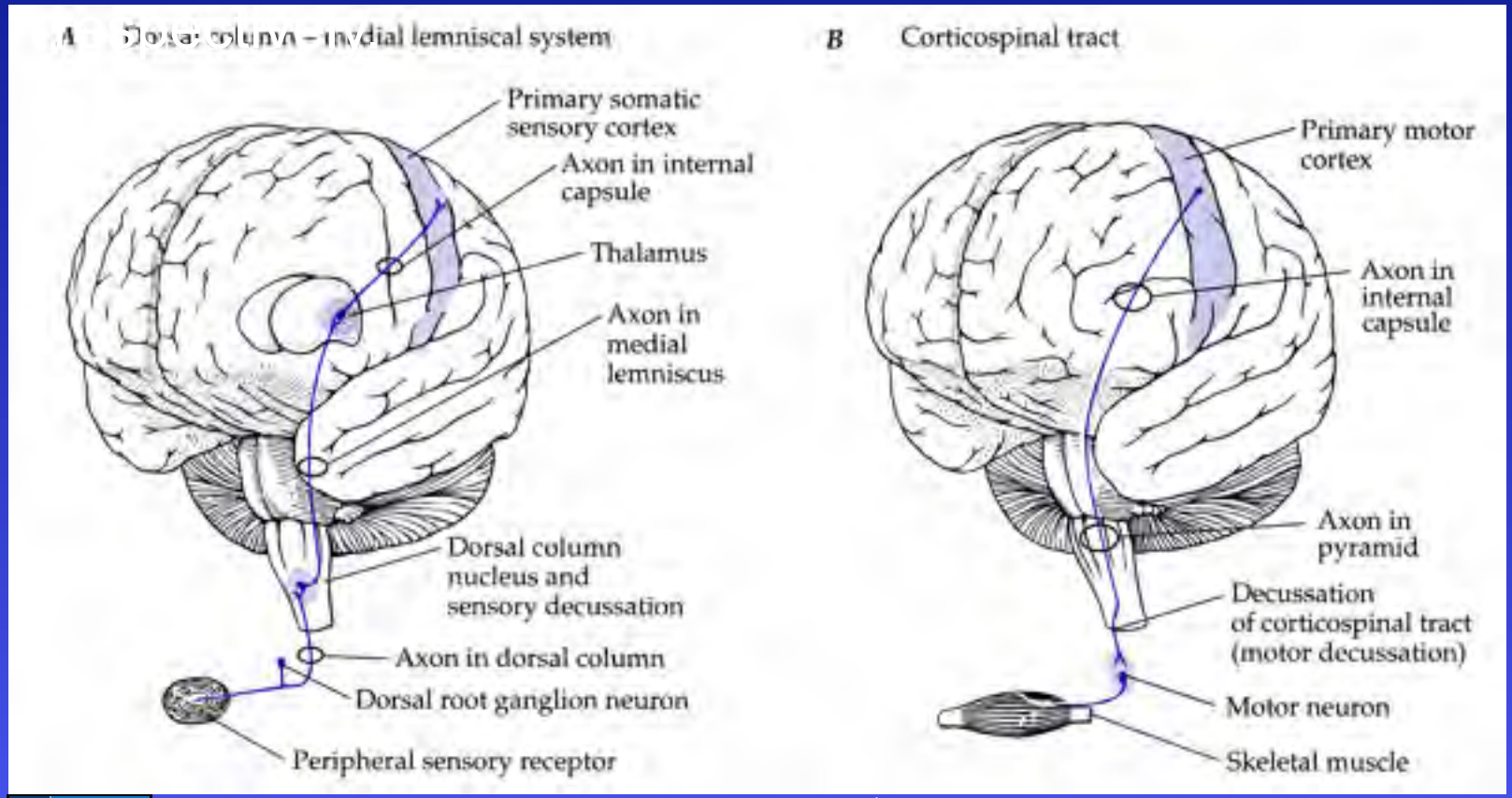
sensory systems: transduction, transmission, perception
motor systems: mentation, transmission, behavior

REGIONAL ANATOMY OF THE CNS

- The CNS can be divided into 6 parts:
  1) spinal cord
  2) medulla (meyelencephalon)
  3) pons (metencephalon)
  4) midbrain (mesencephalon)
  5) thalamus (diencephalon)
  6) cerebral hemispheres (telencephalon)
- These terms may be used interchangeably.



These two diagrams model representative pathways of the somaticsensory and motor systems,



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afferent axons - carry information into the CNS
efferent axons - carry information out of a structure
decussation - site where axons cross the midline

Sensory information from the periphery enters the brain in a very systematic manner. This creates a spatial order, which is preserved throughout the sensory pathways.

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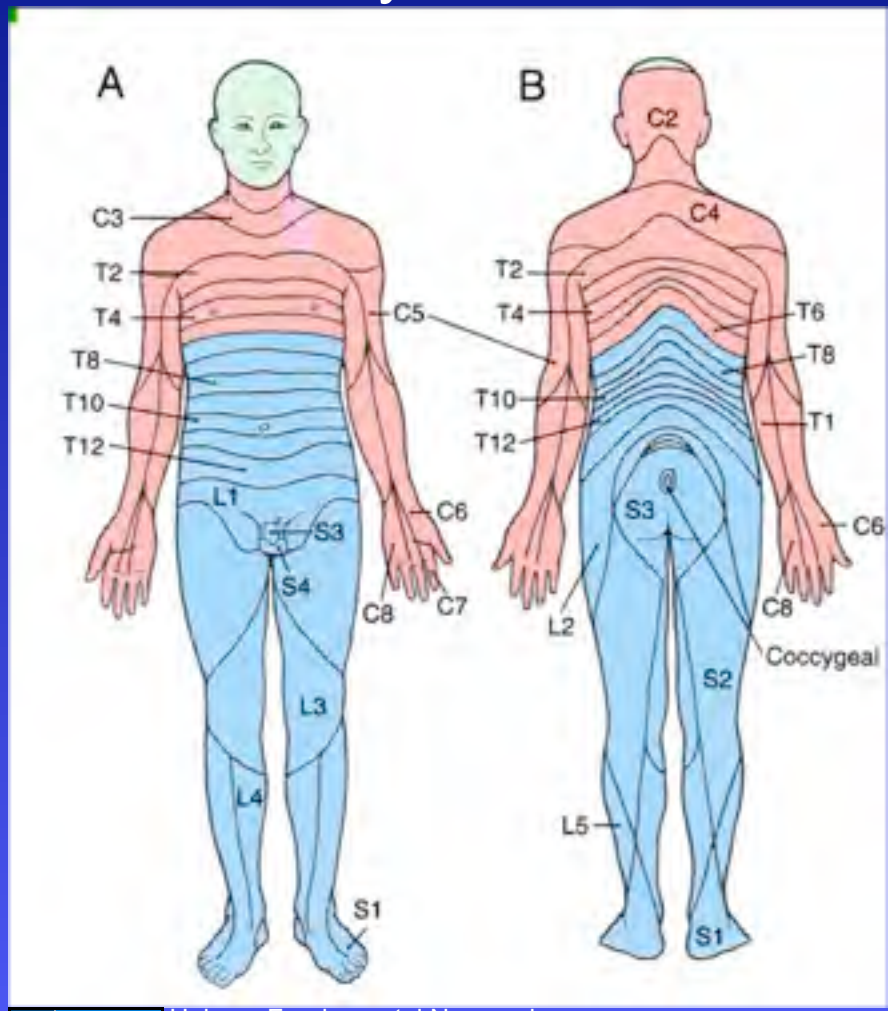
Sensory dermatomes



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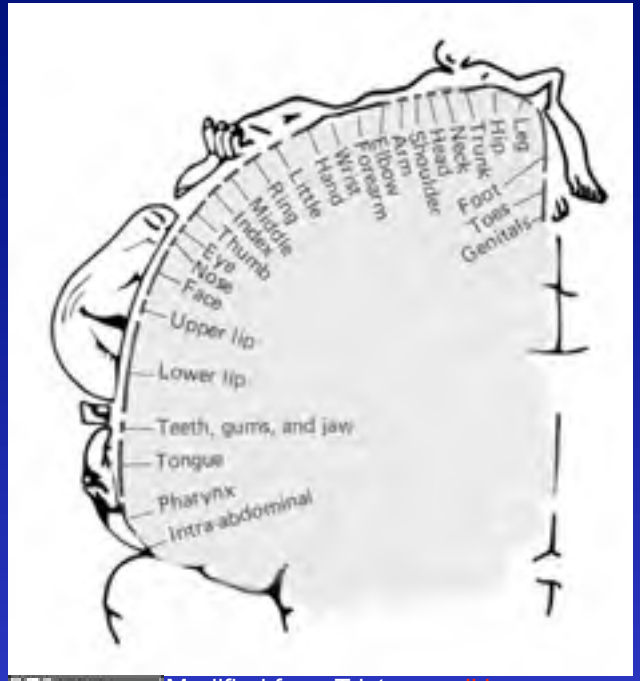
ALL Sensory and Motor pathways are topographically organized.

Sensory: There is a point-to point relationship between a peripheral sensory structure and its pathway in the CNS.

Motor: Pathways in the CNS are organized according to somatic muscle groups in the periphery.

homunculus=little man

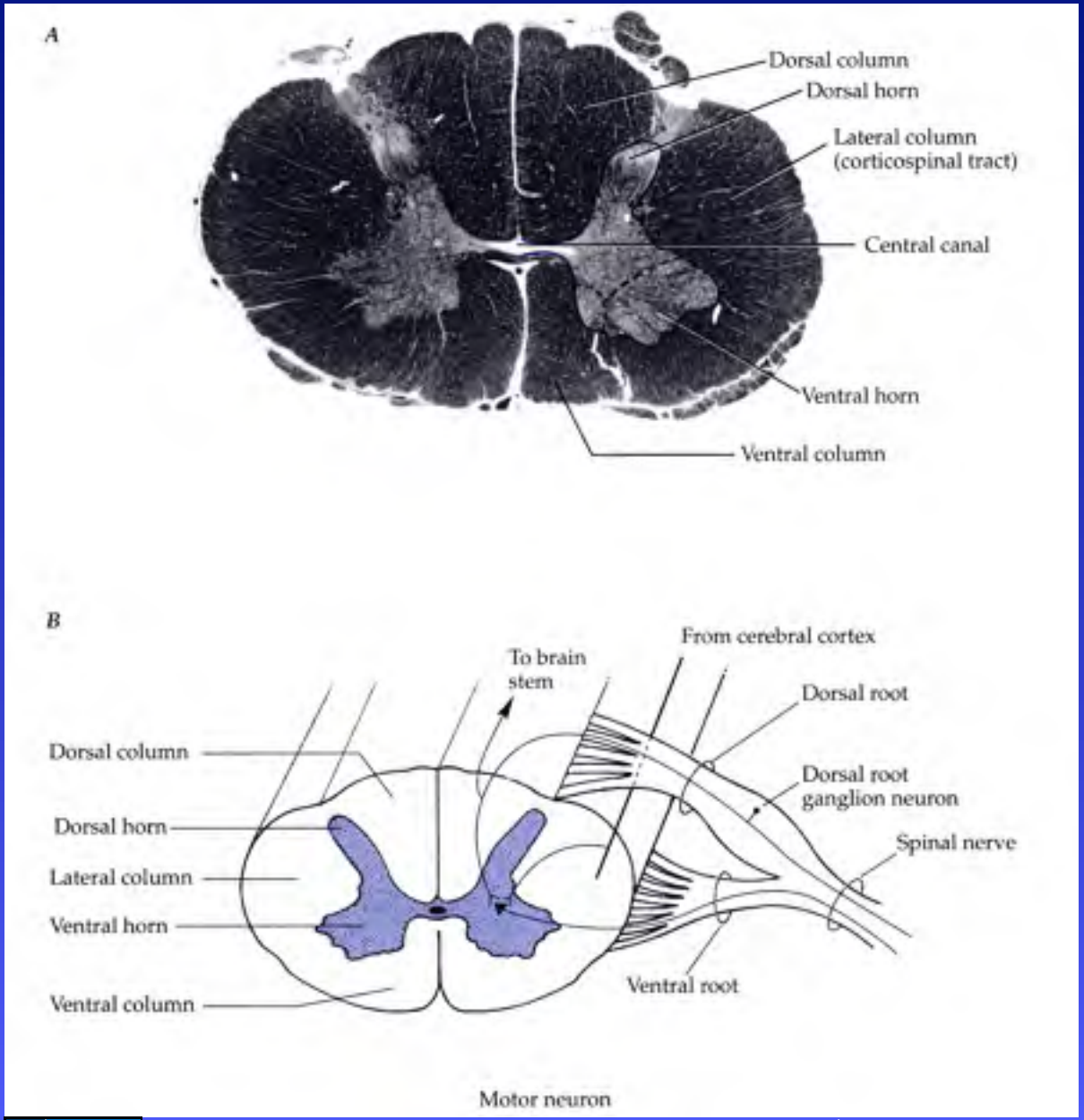


Primary sensory cortex

Primary motor cortex

Sensory from information from the neck and below enters the CNS via spinal nerves, whose axons ascend in white matter tracts.

Depending on the nature of the sensation, axons may or may not synapse in the spinal cord.



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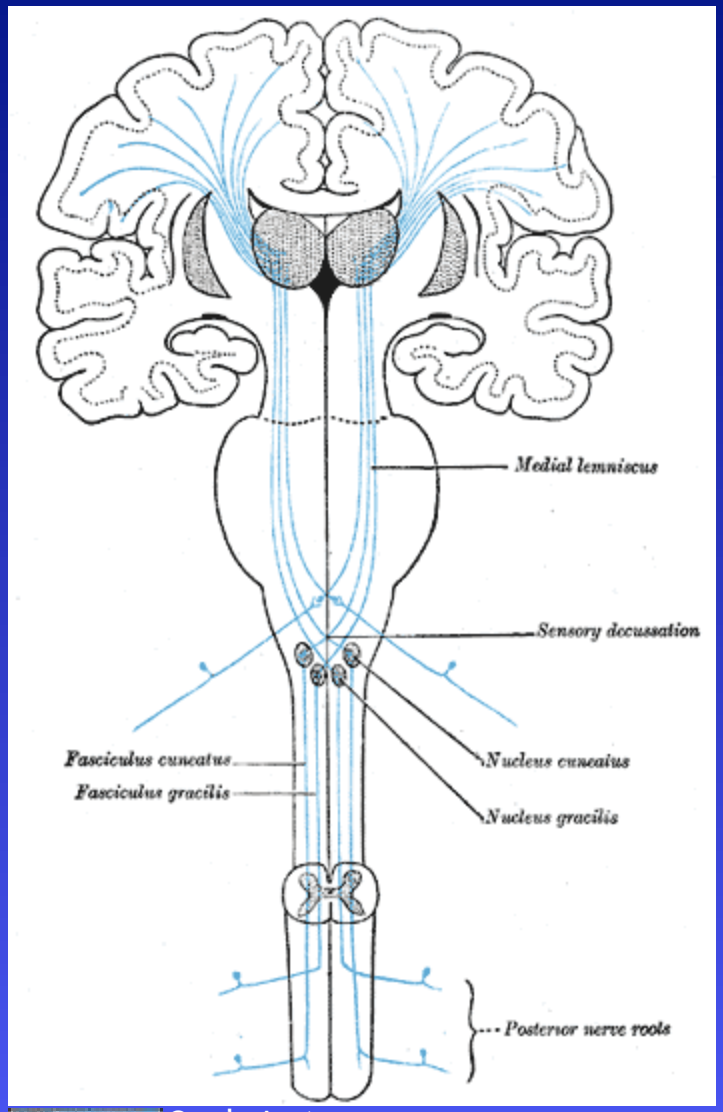
Sensory axons may (or may not) synapse on nuclei in the brainstem. If they do, the name of the tract changes.

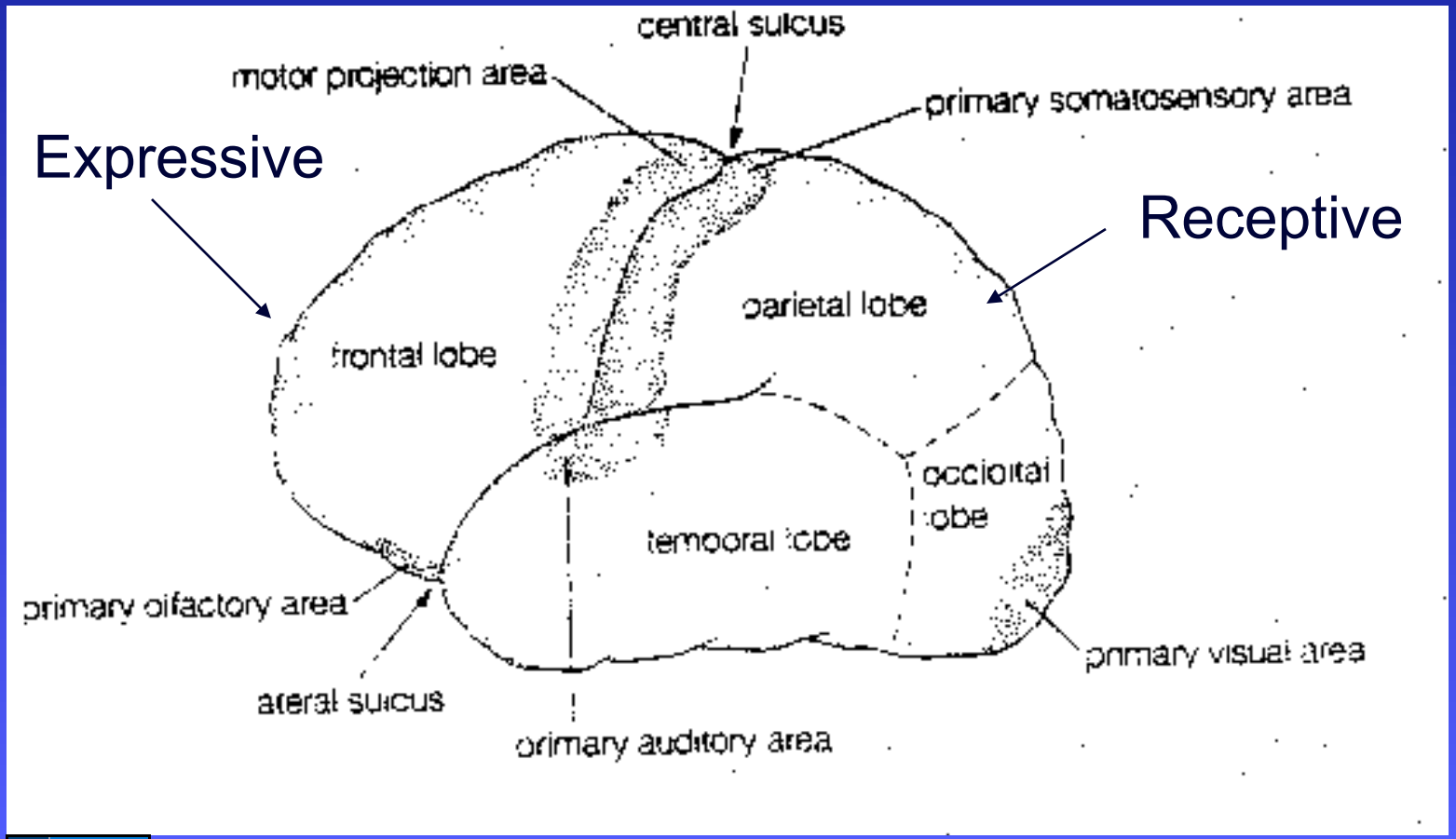
All axons carrying sensory information synapse in discrete nuclei within the dorsal thalamus.



 Gray's Anatomy

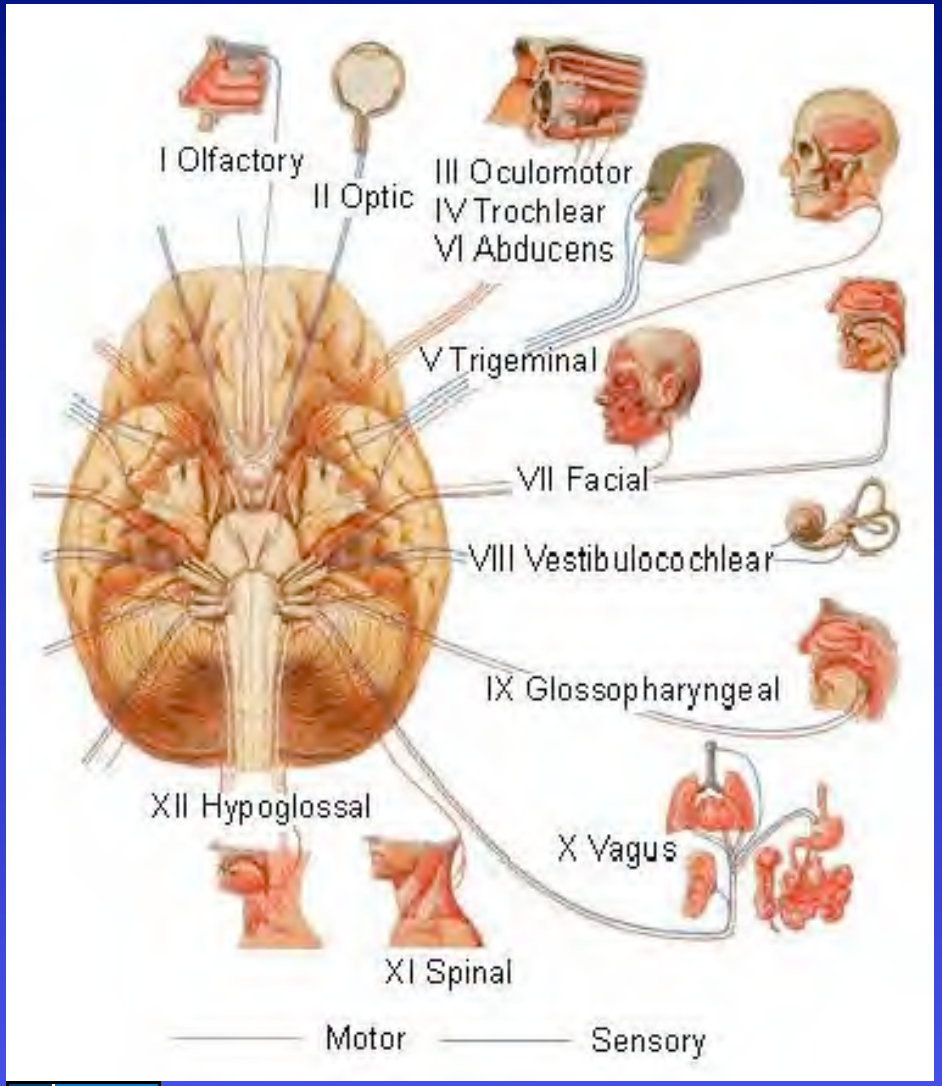
Cerebral cortex is highly specialized.

Somatic sensory information carried by axons from the dorsal thalamus synapse on neurons in the postcentral gyrus (primary somatic sensory cortex) in the parietal lobe.

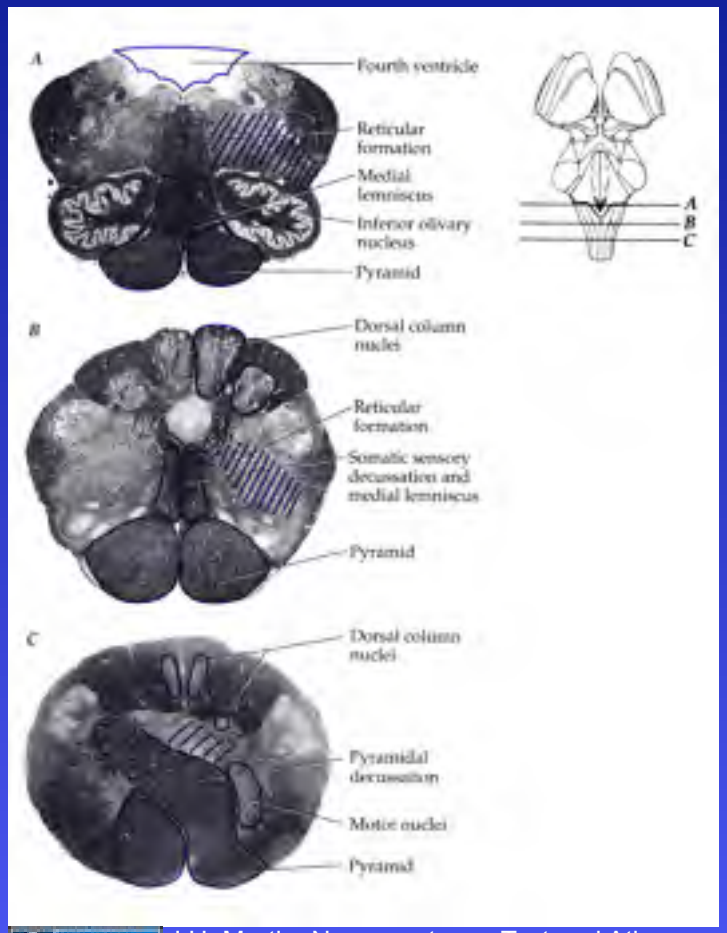


The brainstem controls numerous bodily functions. Injuries to the brainstem can be life threatening.

The brainstem also receives sensory information from the head and contains the motor neurons that innervate muscles of the neck, head and face.



The internal anatomy of the brainstem is complex.



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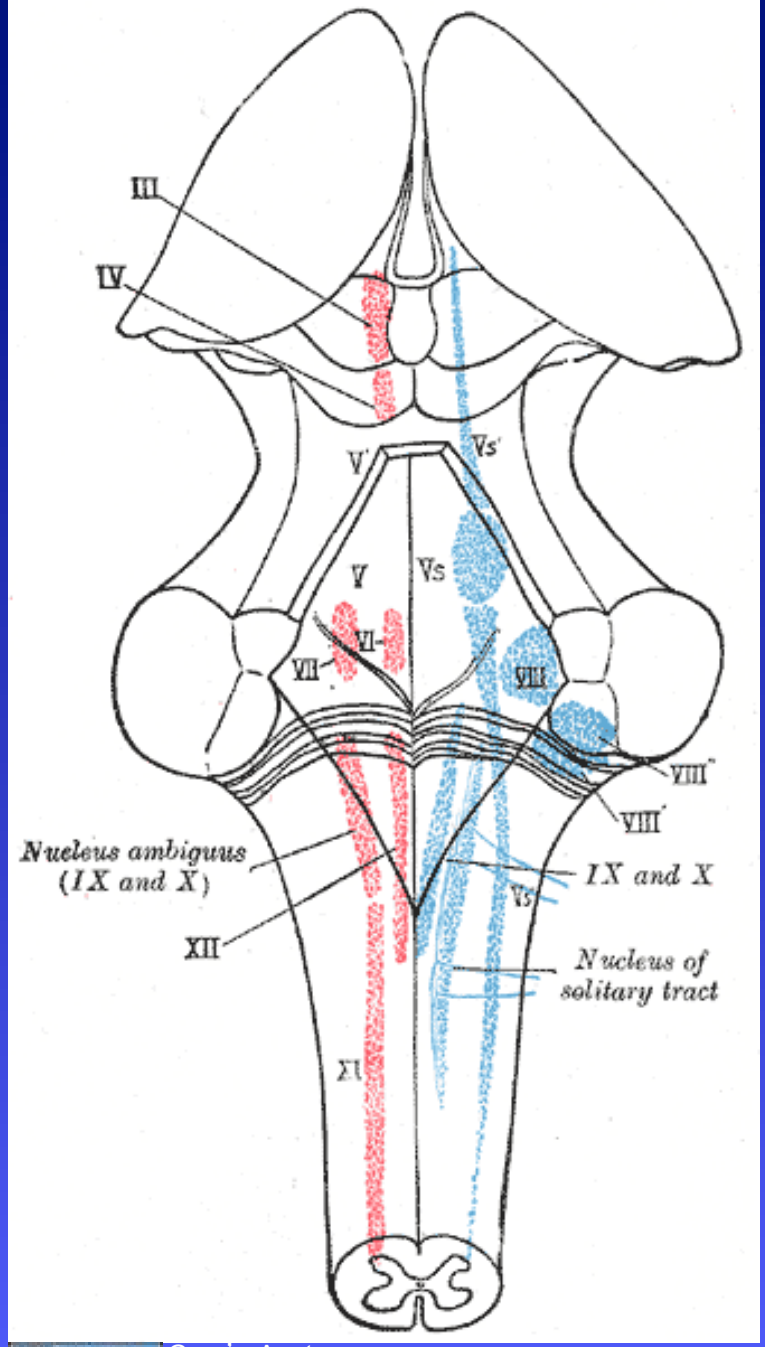

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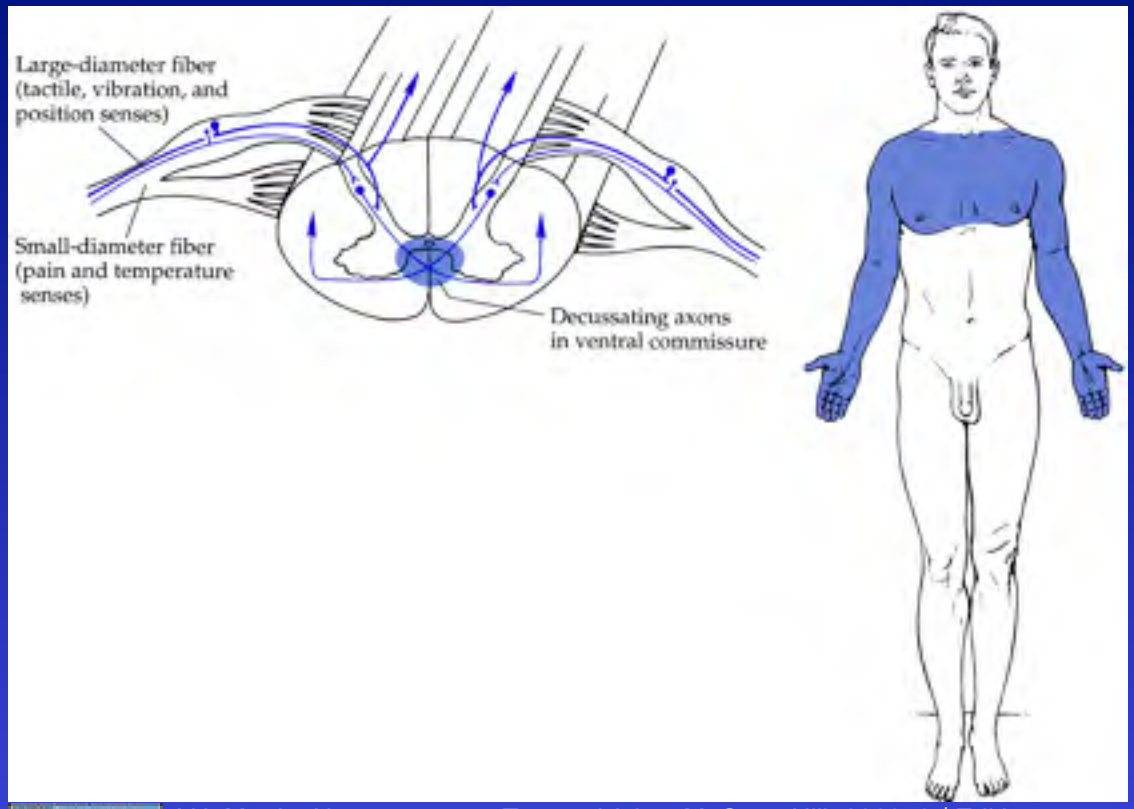
Syringomyelia



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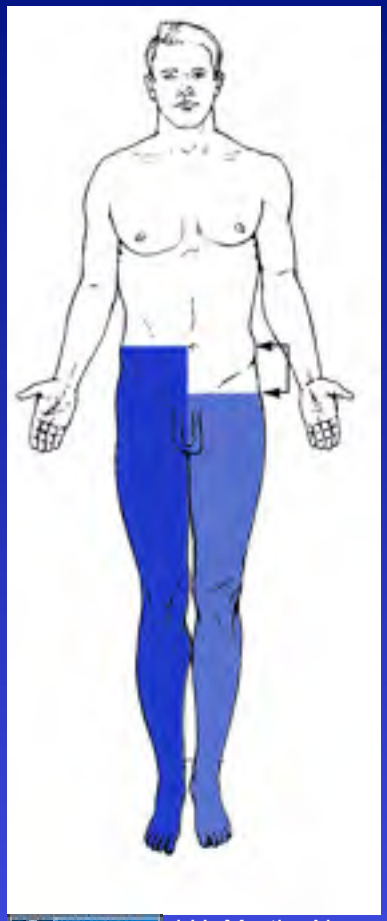
Brown-Séquard syndrome



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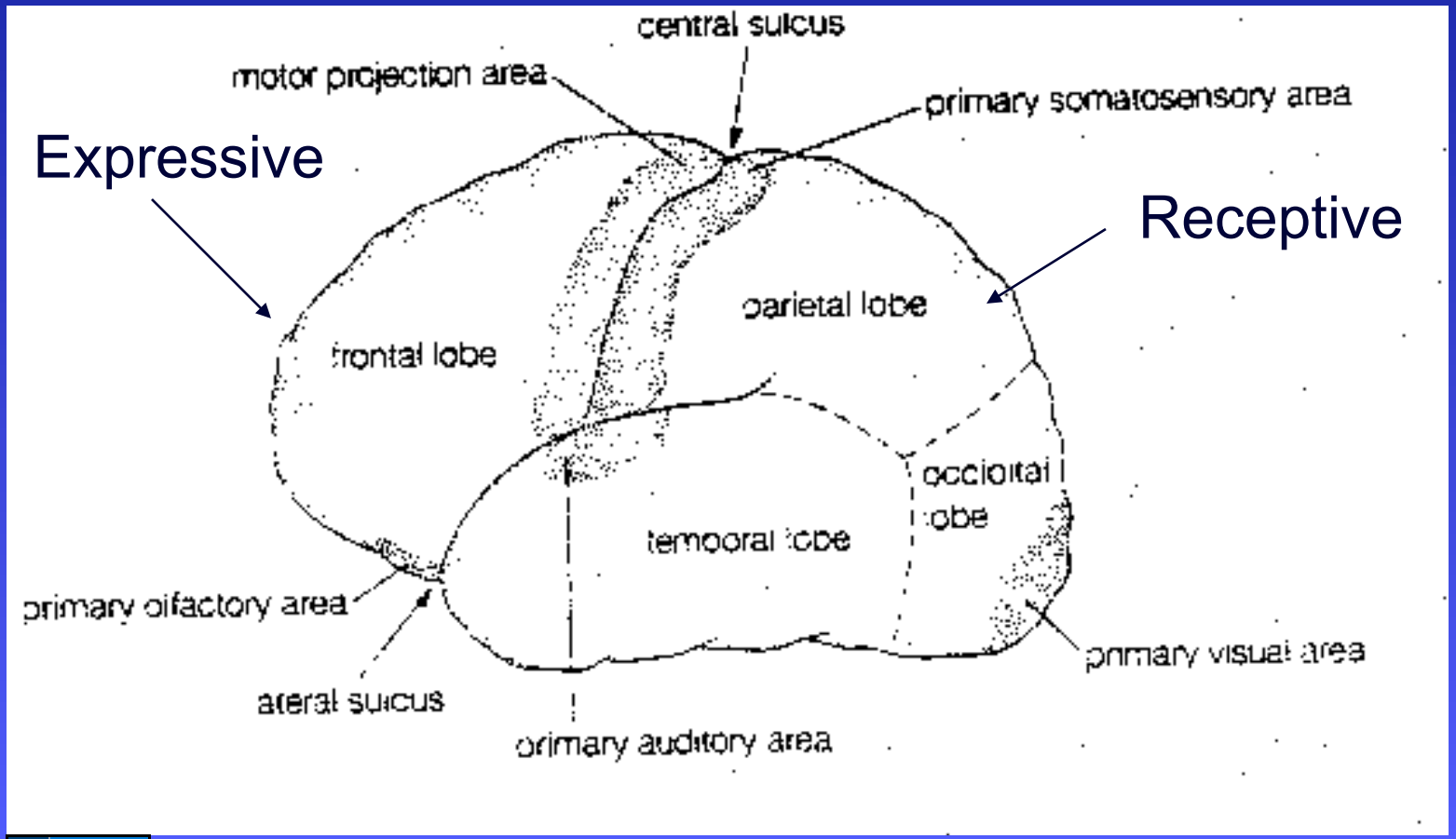
Injures to the brainstem and spinal cord give rise to specific sensory and motor deficits. Injuries to the spinal cord produce sensory deficits that respect myotomal boundaries.

Place a lesion = what are the symptoms?

Describe the symptoms = can you place the lesion?

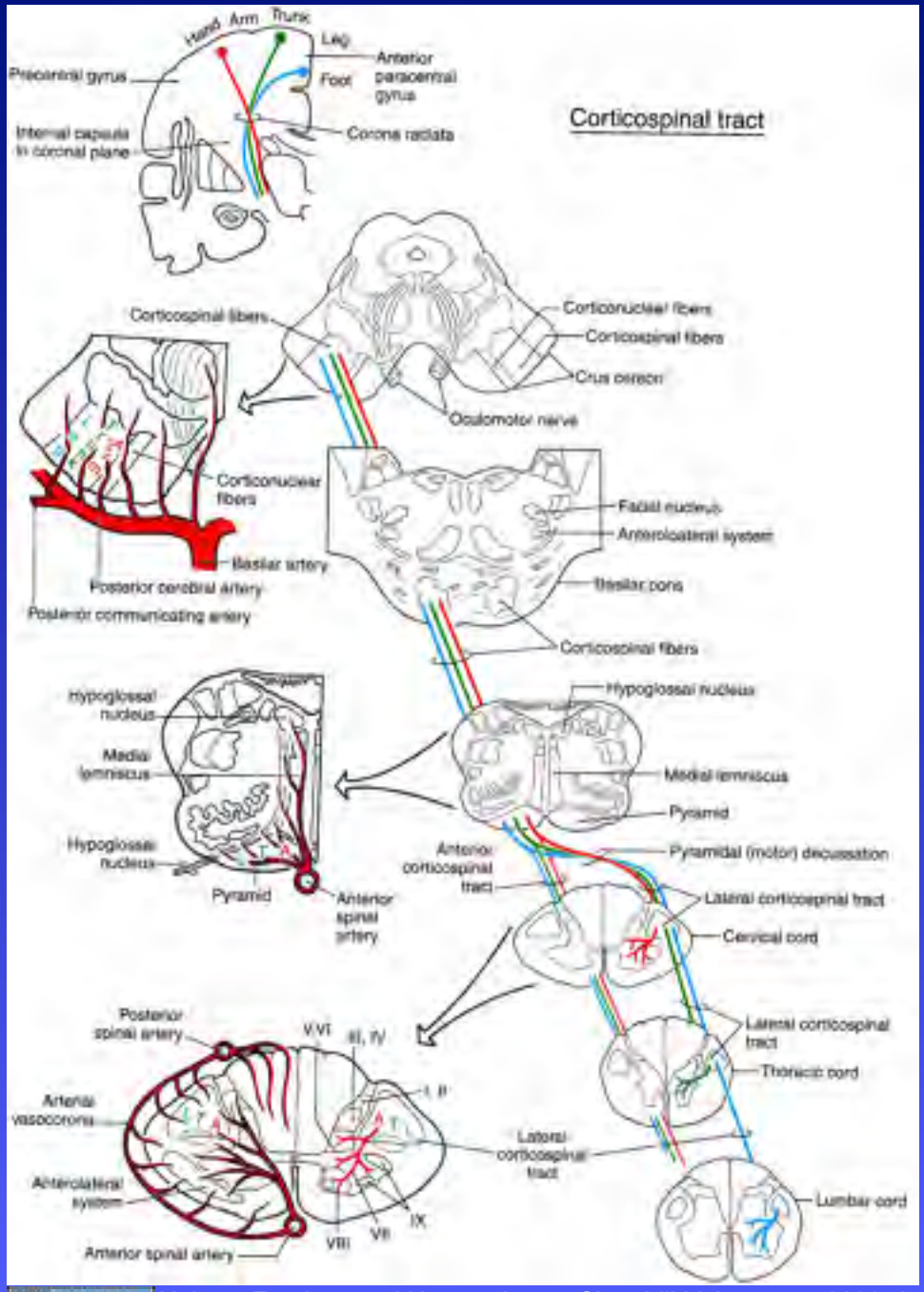
Axons that carry motor commands for voluntary movements originate in the precentral gyrus (primary motor cortex) of the frontal lobe, descend into the brainstem and spinal cord and synapse on motor neurons that innervate skeletal muscles.



An example of a motor pathway.

The corticospinal tract extends from the precentral gyrus to the spinal cord and subserves the voluntary control of skeletal muscles.

Although clinically important, the corticospinal system is numerically a minor component in the control of skeletal muscles.



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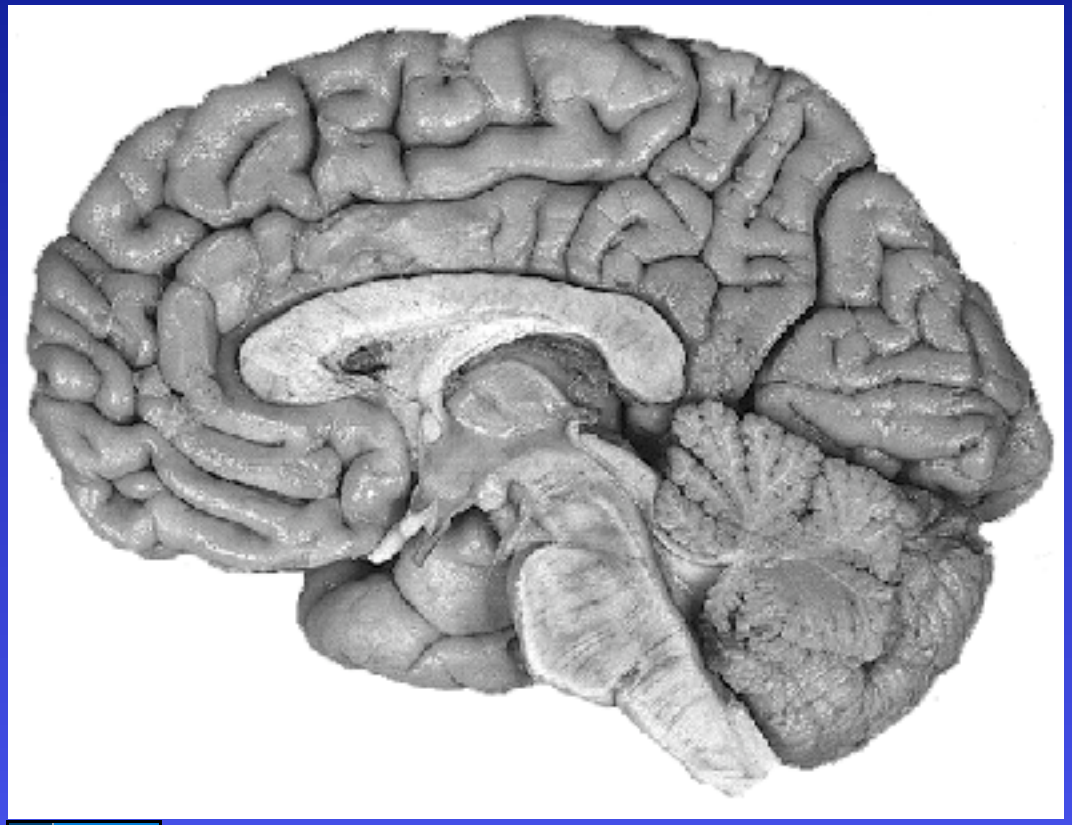
The cerebellum is a component of the motor system that is not involved in unconscious control of skeletal muscle.



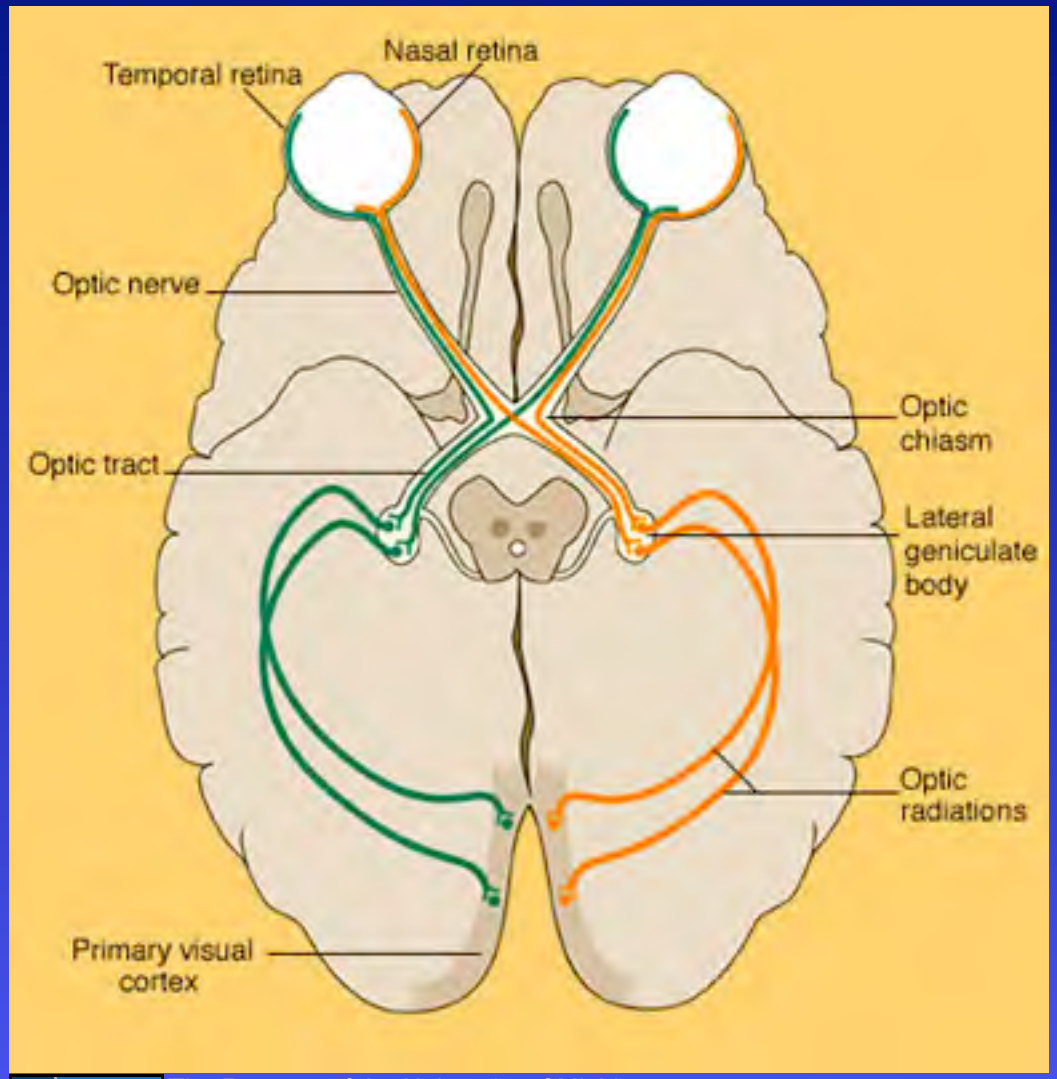
Diseases of the cerebellum are known as ataxias.

Special senses:

Vision

Hearing

Balance



The CNS is highly vascularized and interruption in the blood supply is a common form of nervous system injury

The CNS is filled with and surrounded by
cerebrospinal fluid (csf).

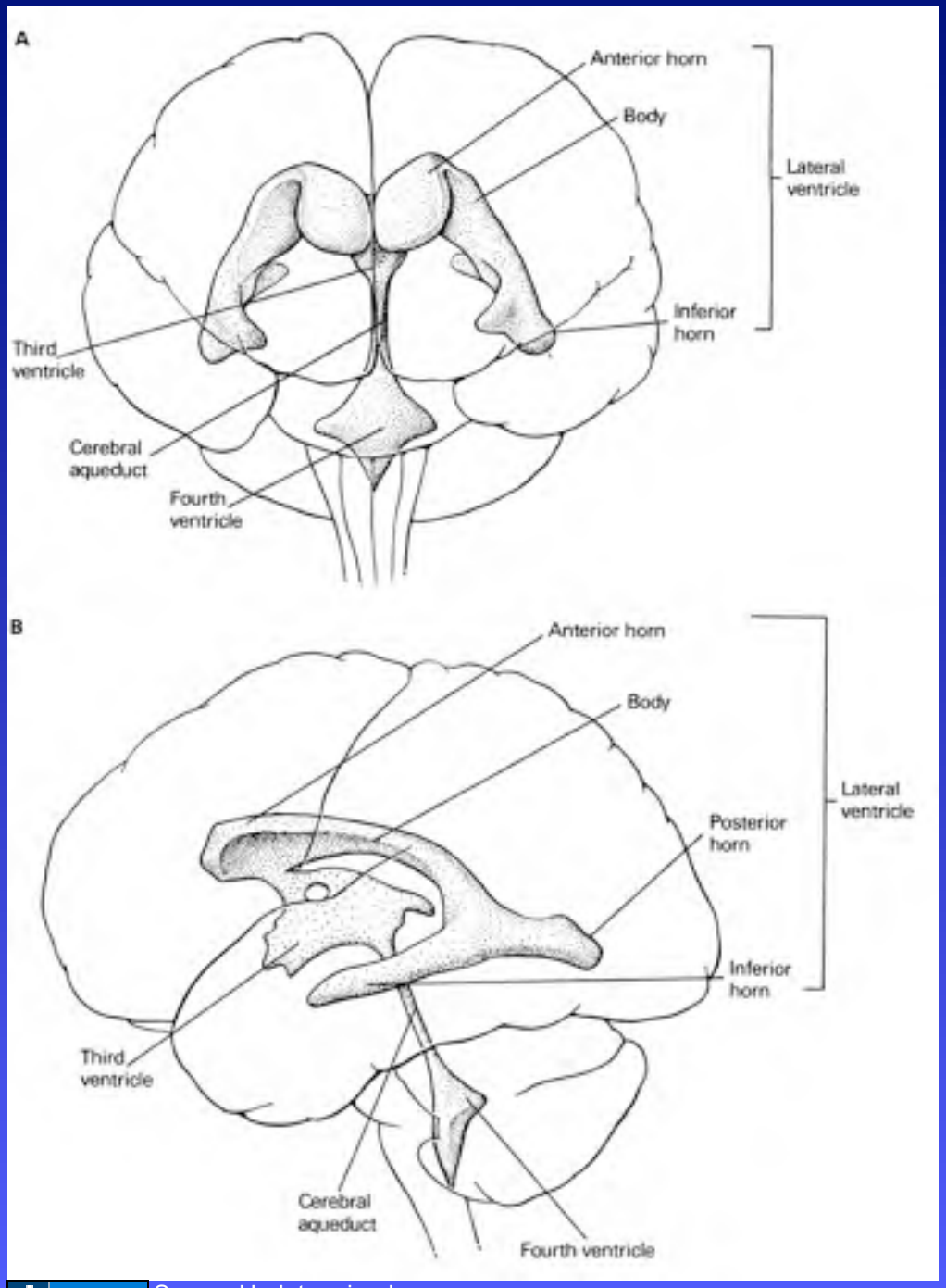
Internally:

-lateral ventricles
-3rd ventricle
-4th ventricle

Externally:

-subarachnoid space

CSF is a secretory product that circulates through the ventricles and returns to the venous side of the brain vasculature



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