

# **The Central Nervous System**

# Protection of The Brain

- **Meanings:**

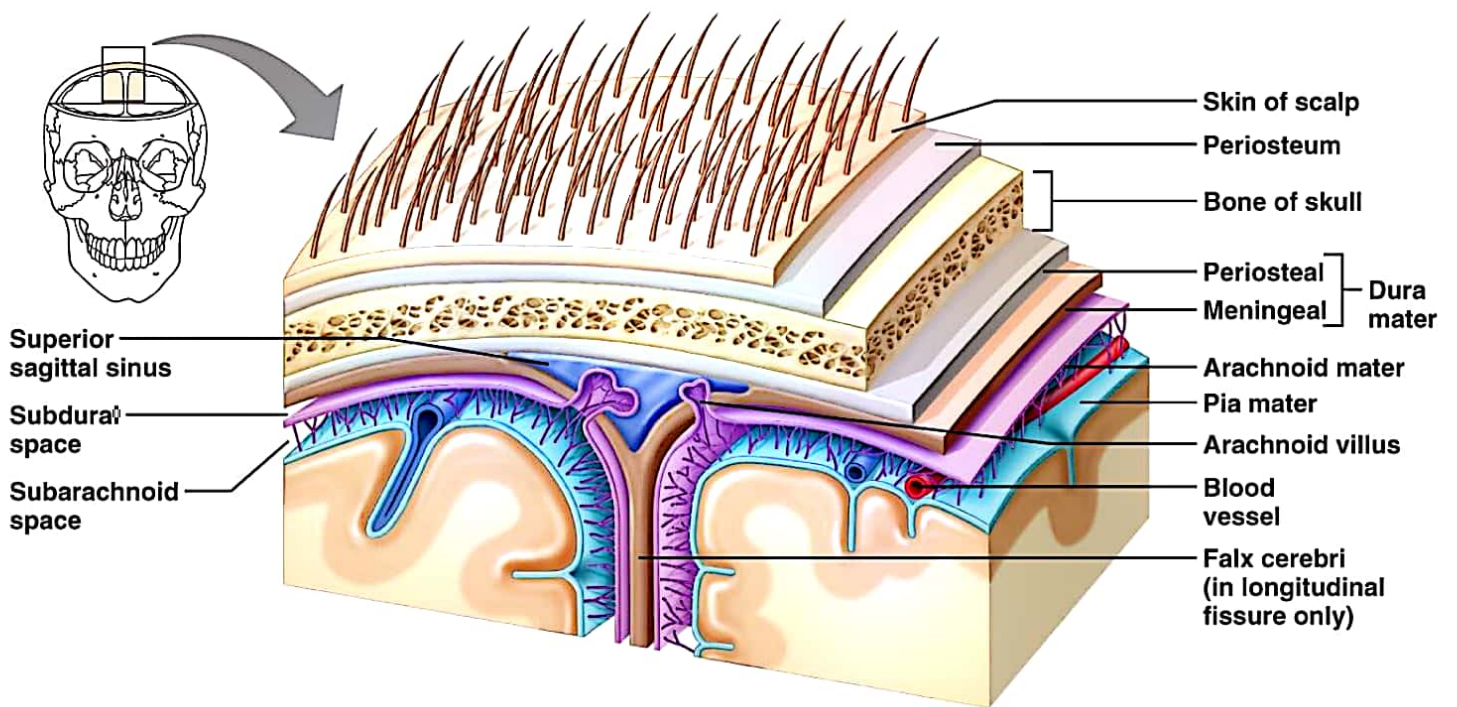
1. Body membranes that cover the brain and spinal cord for protection and nourishing purposes.

2. Consists of 3 layers: (each layer is a "menix")

- a) **Dura mater** ("tough mother"): outermost layer that attaches the brain to cranial bones, and the spinal cord to vertebrae. Made up of fibrous connective tissue that protects the CNS.

- b) **Arachnoid mater** ("web like mother"): middle layer made up of thin membranes that lack blood vessels. It reabsorbs cerebrospinal fluid (CSF).

- c) **Pia mater** ("gentle mother") innermost layer made of thin membranes that contain capillaries for providing nourishment to the brain and spinal cord. Forms capillary networks called plexuses which produce CSF .

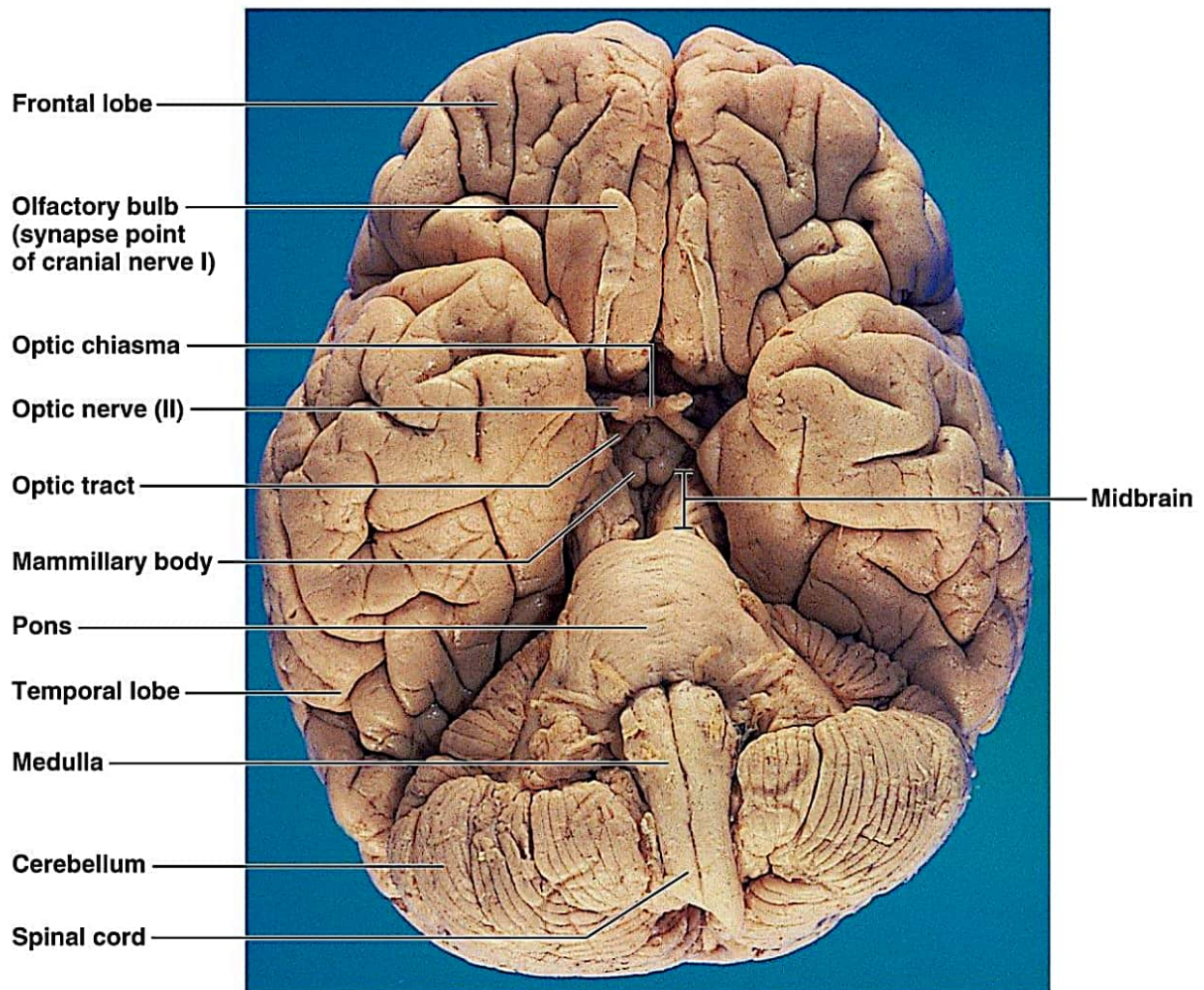


**(a)**

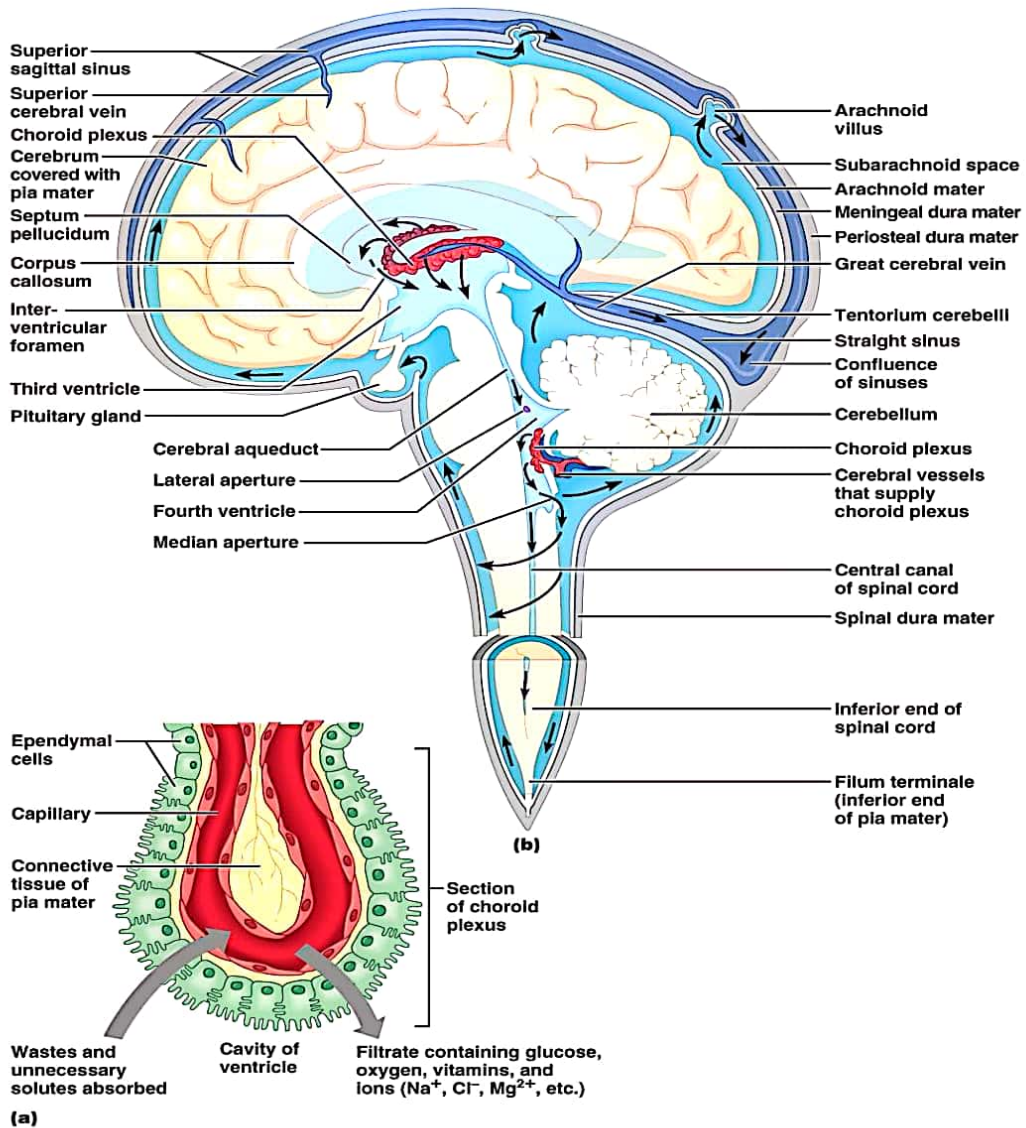
Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

# The Brain

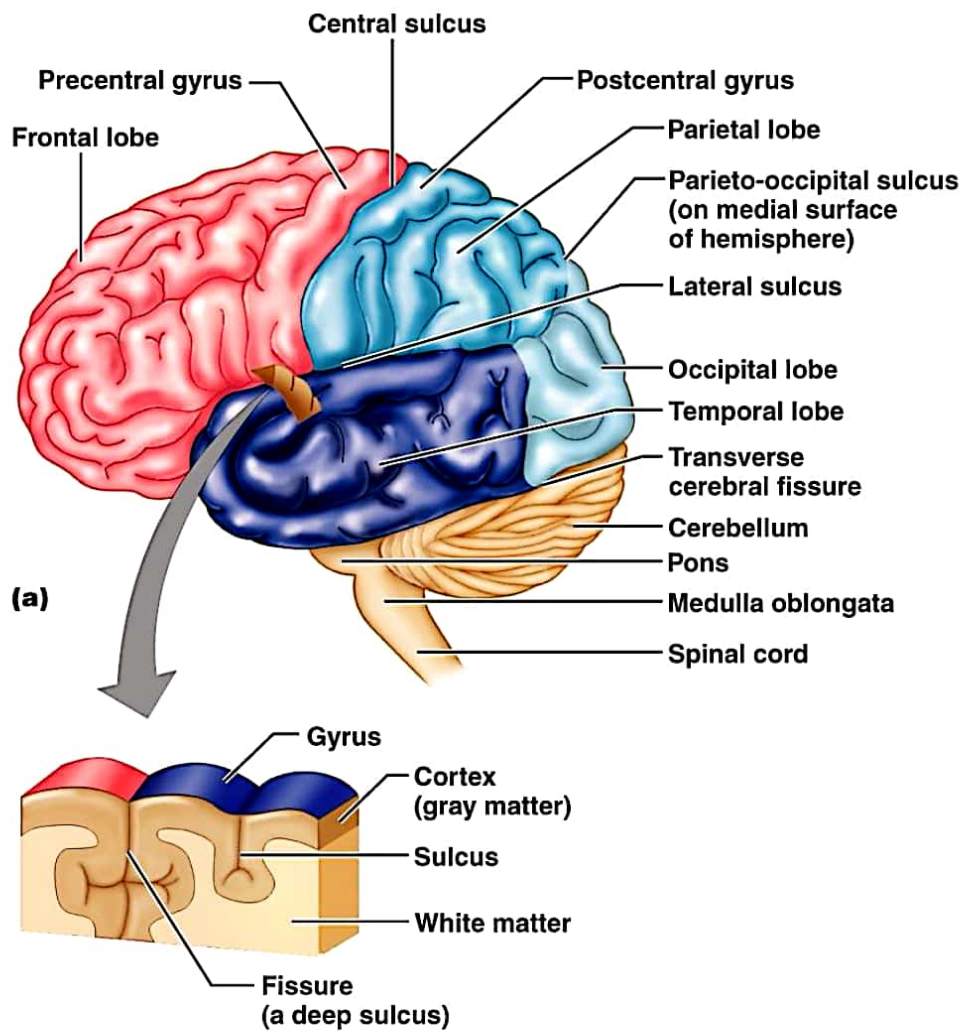
1. The largest organ in the nervous system; composed of about 100 billion neurons (interestingly, although the neurons contain **DNA**, there is no DNA replication or mitosis in the brain, as a result the number of neurons decreases as a person ages).
2. Divided into 3 main regions: **Cerebrum**, **Cerebellum**, and the **Brain Stem**.
3. Contains spaces called **ventricles** where choroid plexuses of pia mater produce cerebrospinal fluid (CSF), and these ventricles allow CSF to circulate around the brain and into the spinal cord (through the central canal).



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

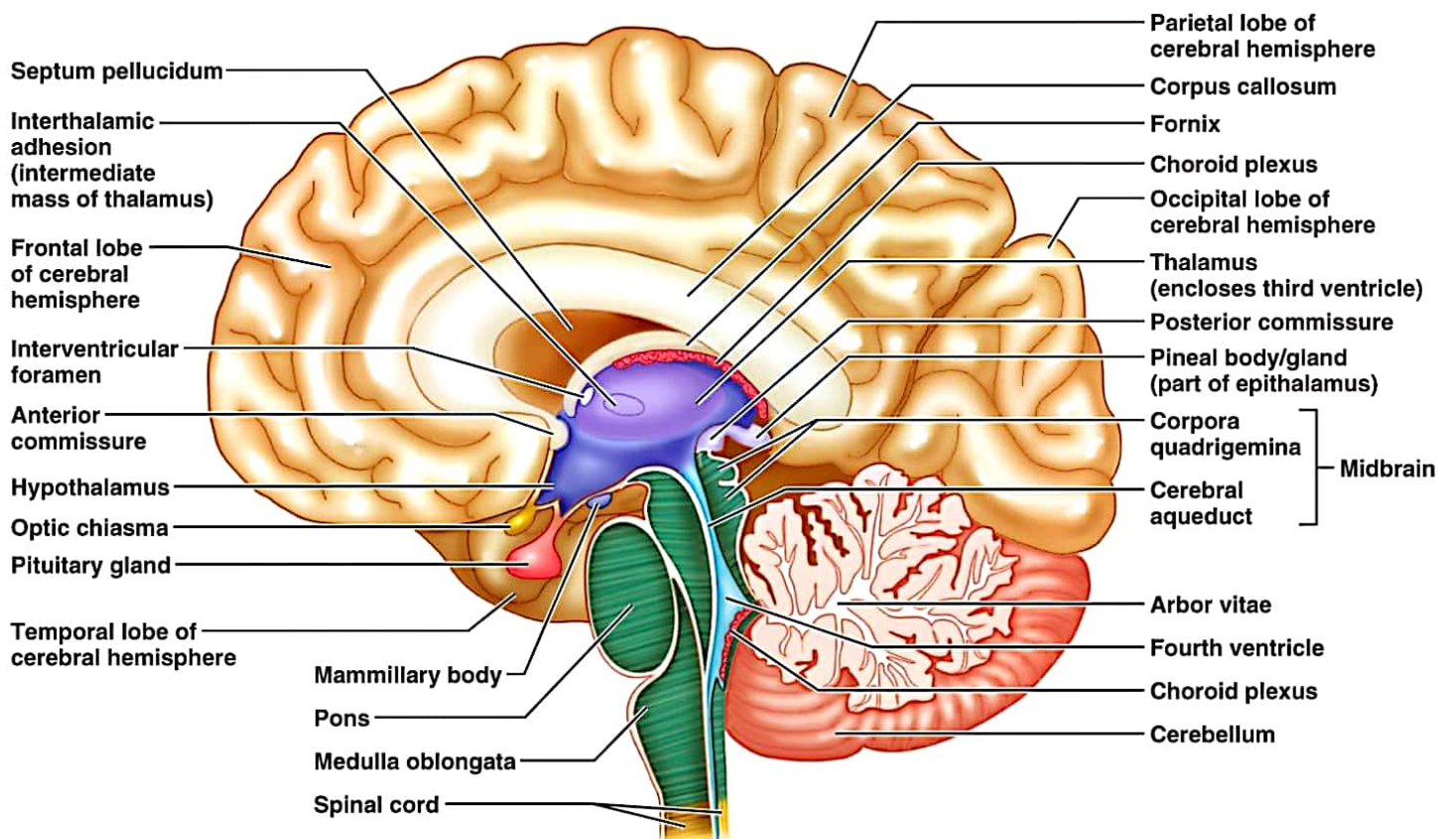


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

#### 4. **Cerebrum:**

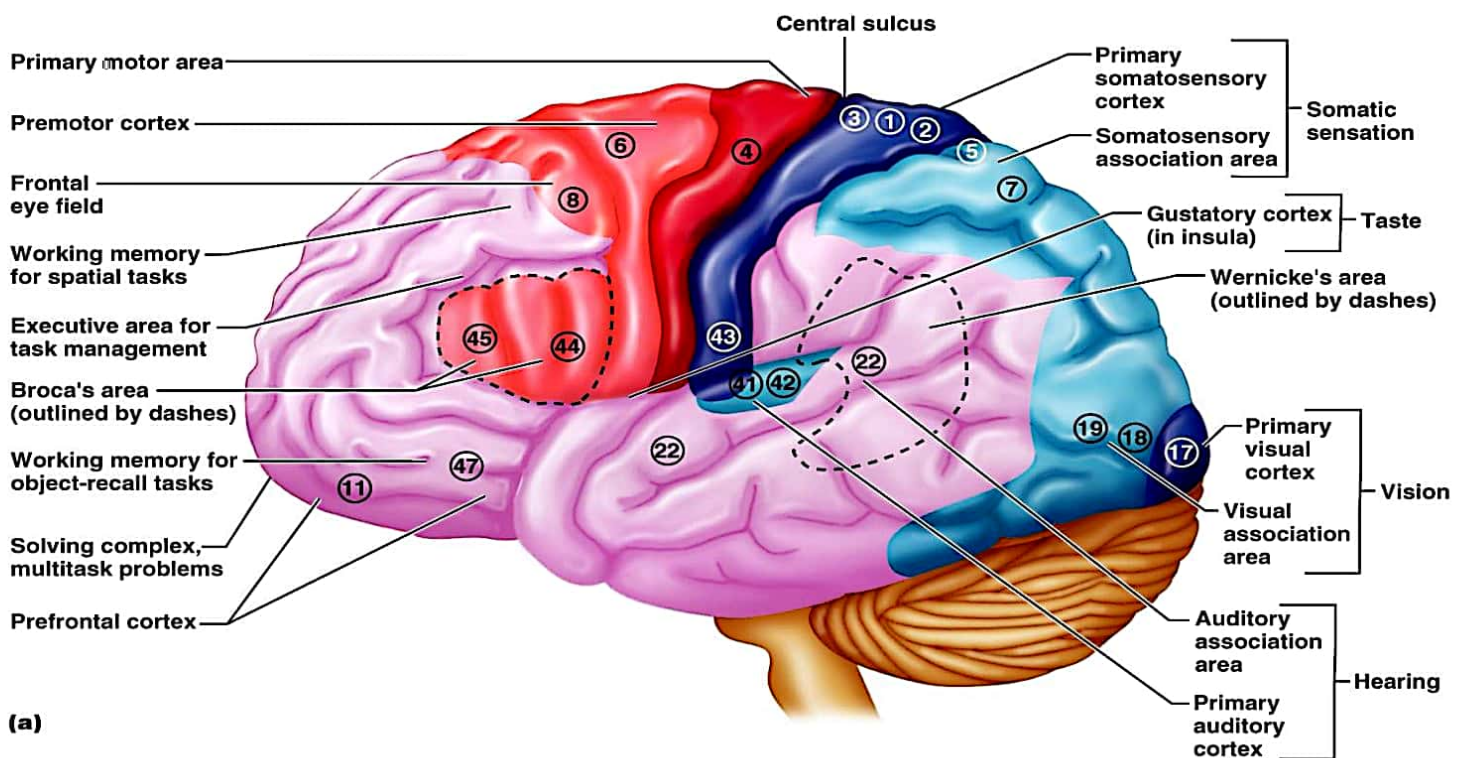
- a) **Cerebral Cortex** (outer region) is made of **gray** matter (unmyelinated neurons) which contains up to 75% of all neurons in the nervous system, while **Cerebral Medulla** (inner region) is made of **white** matter (myelinated neurons).
  
- b) Consists of left and right hemispheres, created by the longitudinal fissure at the center of cerebrum, and are connected by the **corpus callosum**.
  
- c) Its surface is marked by ridges called **convolutions** (**gyri**) which are separated by grooves called **sulcus** ( or **fissure**, if the grooves are deeper).





Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

- d) **Frontal lobe** controls skeletal muscle movement and intellectual processes.
- e) **Parietal lobe** controls sensations and speech.
- f) **Temporal lobe** controls hearing and memory.
- g) **Occipital lobe** controls vision.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings

h) Functional regions of cerebral cortex:

**Motor areas:** located in frontal lobe, to control voluntary muscles.

**Motor speech area ("Broca's area"):** located in frontal lobe, to control muscles of mouth, tongue, and larynx for speech.

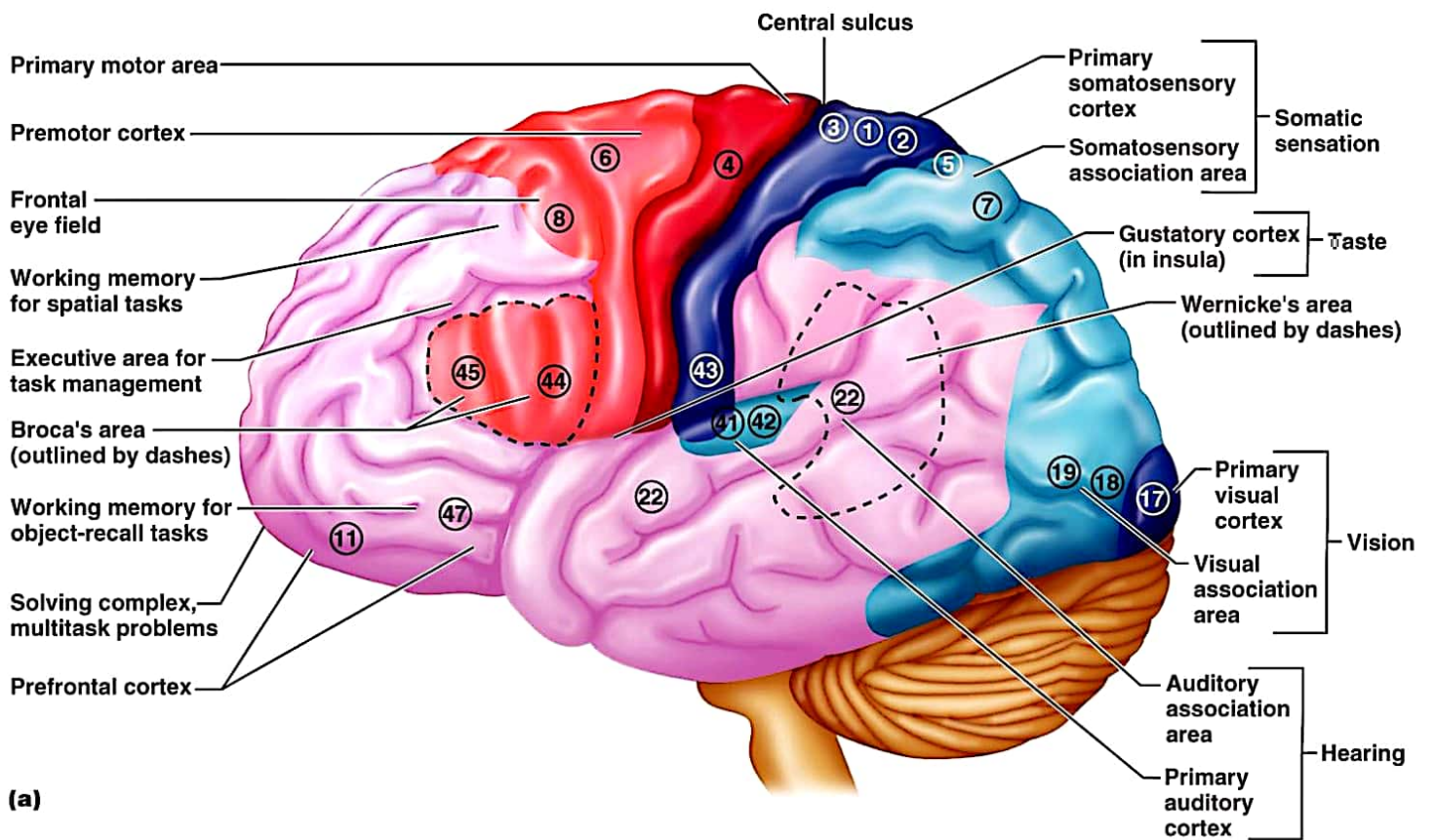
**Frontal eye field:** located in frontal lobes just above the Broca's area, to control muscles of the eye and eyelid.

**Auditory area:** located in temporal lobe, to control hearing.

**Visual area:** located in occipital lobe, to control visual recognition of objects and combine visual images.

**Sensory areas:** located in parietal lobe, to be involved in cutaneous sensations of temperature, touch, pressure and pain.

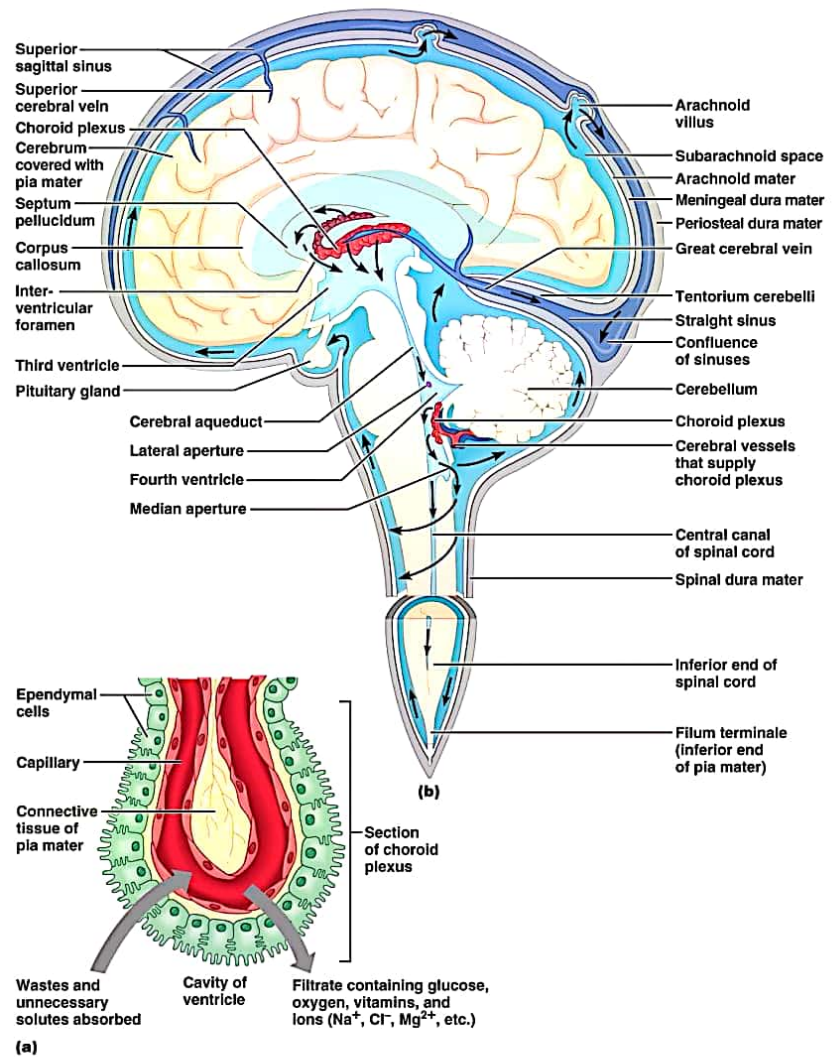
**Association areas:** located in all of cerebral cortex, to interconnect sensory and motor functions of all lobes of the cerebrum.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

## 5. Cerebellum

- Coordinates and controls muscular movement and muscle tone.
- Maintains body posture, by working with the equilibrium receptors in the inner ear.
- New data suggest that it also functions as the "thesaurus" for speech, finding the right words to use.

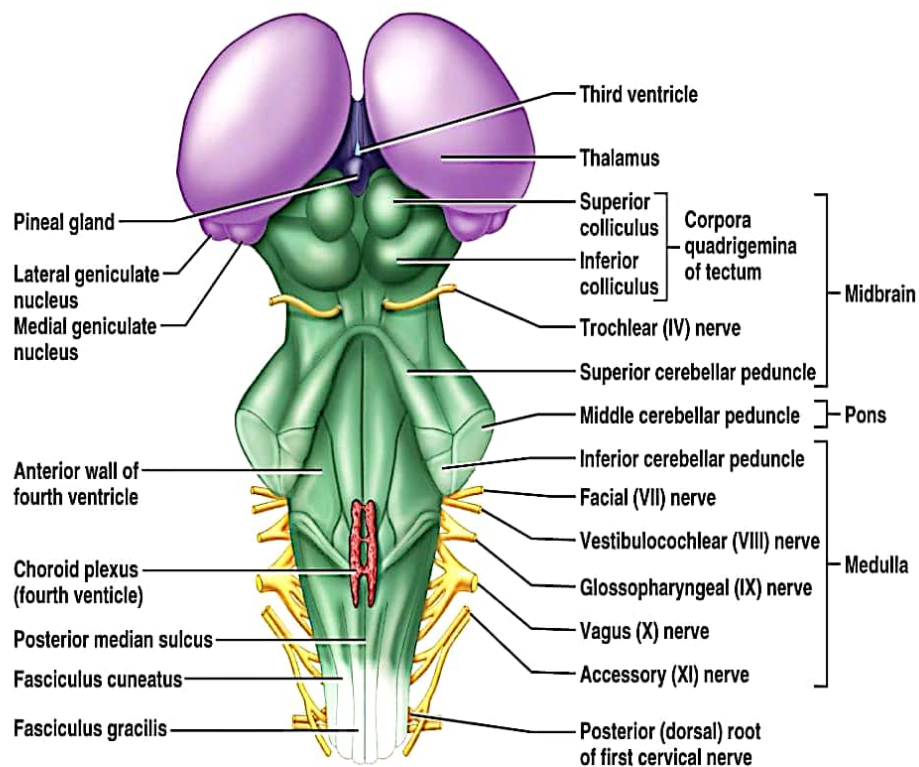


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

# Brain Stem

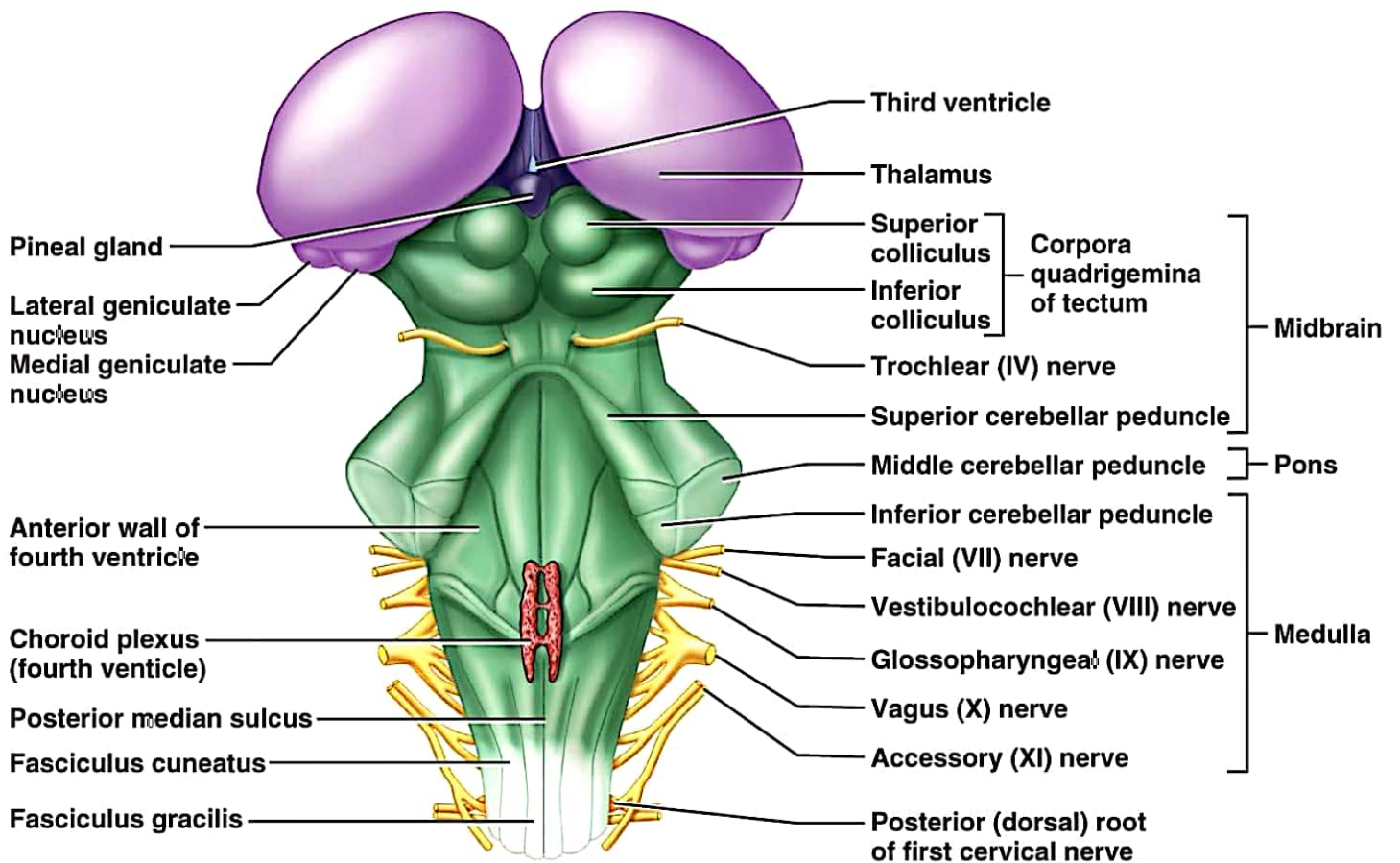
6. Made of brain tissue at the base of cerebrum, connecting the cerebrum to the spinal cord.

- Functions largely for autonomous activities.
- Subdivided into **diencephalon, midbrain, pons** and **medulla oblongata**.



(c) Dorsal view

Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



**(c) Dorsal view**

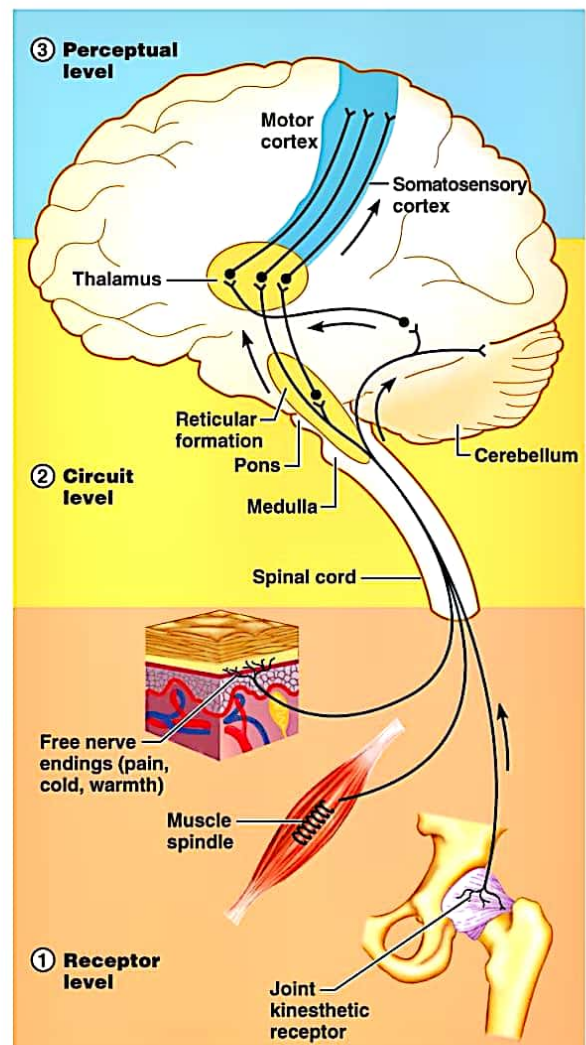
Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

## I. Diencephalon:

consists of **Thalamus** and **Hypothalamus**.

a) **Thalamus**- It is a major relay center to direct nerve impulses from various sources to the proper destinations.

b) **hypothalamus** (an important area for regulating homeostatic activities, such as hunger, thirst, sex drive, and even addictions).

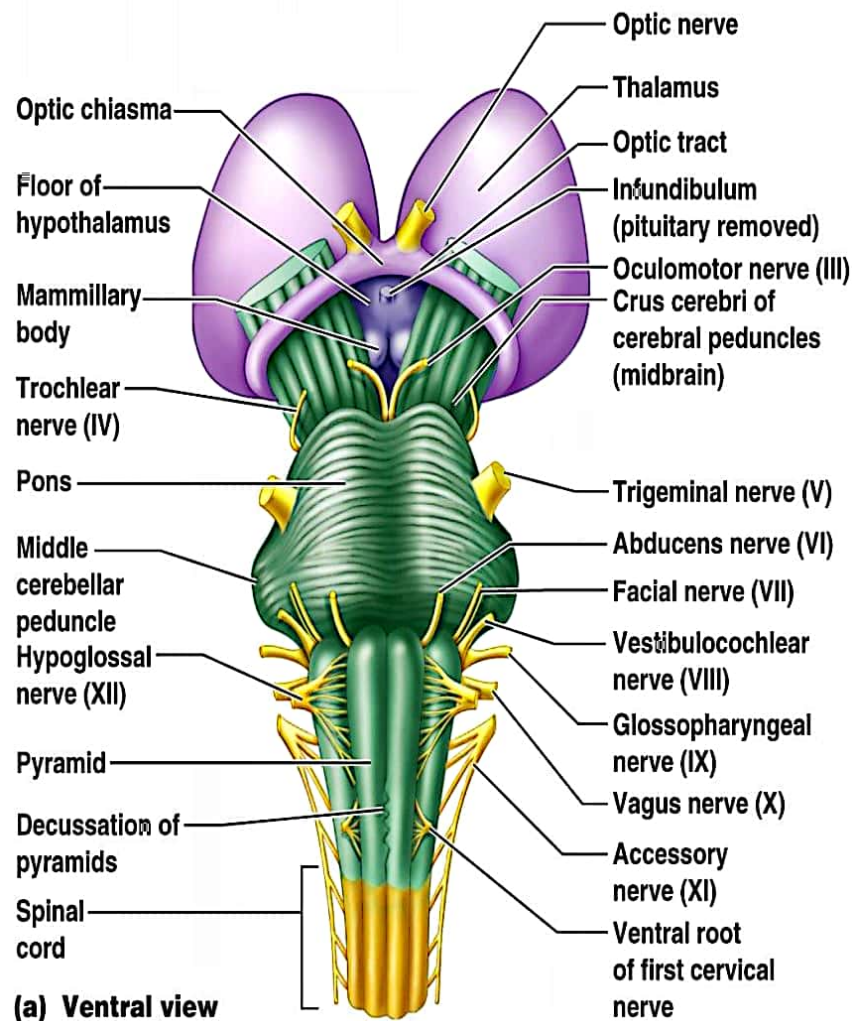


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

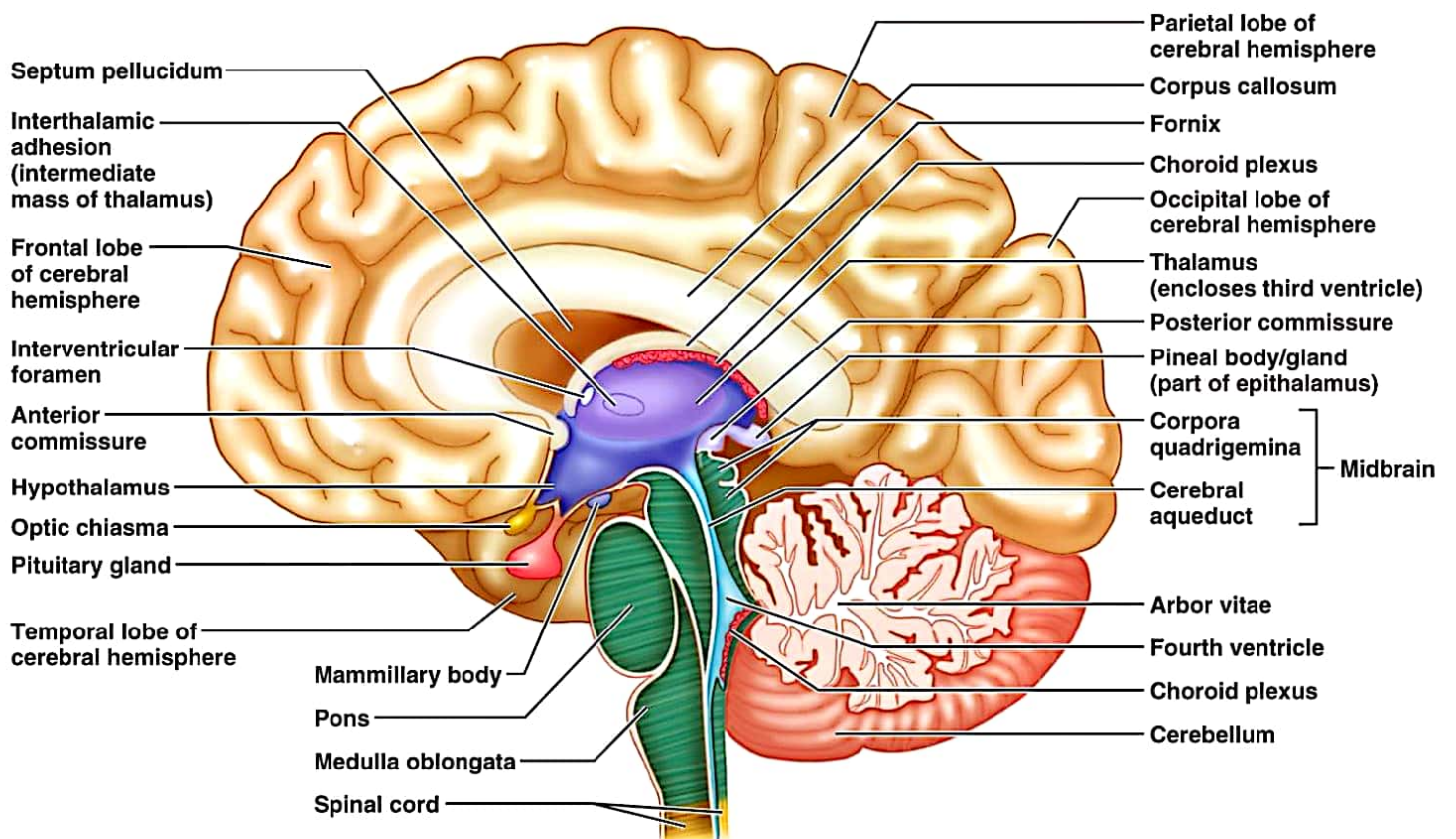


Hypothalamus regulates:

- 1) Heart rate and arterial blood pressure.
- 2) body temp.
- 3) water & electrolyte balance.
- 4) control of hunger & body weight.
- 5) control of movements and glandular secretion of the stomach & intestines.
- 6) production of neurosecretory substances that stimulate the pituitary gland to release hormones that help regulate growth and influence reproduction
- 7) sleep and wakefulness.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Other parts of diencephalons:

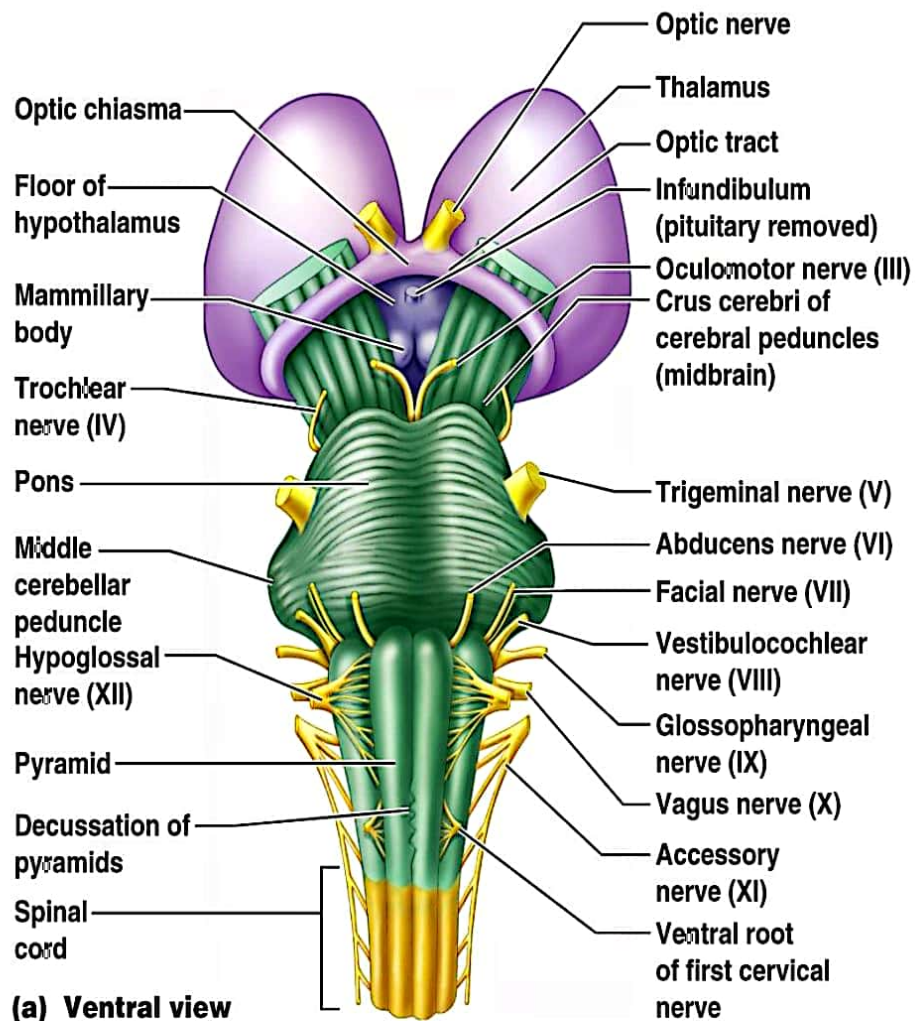
1) optic tracts and optic chiasma that is formed by optic nerves crossing over.

2) infundibulum - site of attachment of pituitary gland

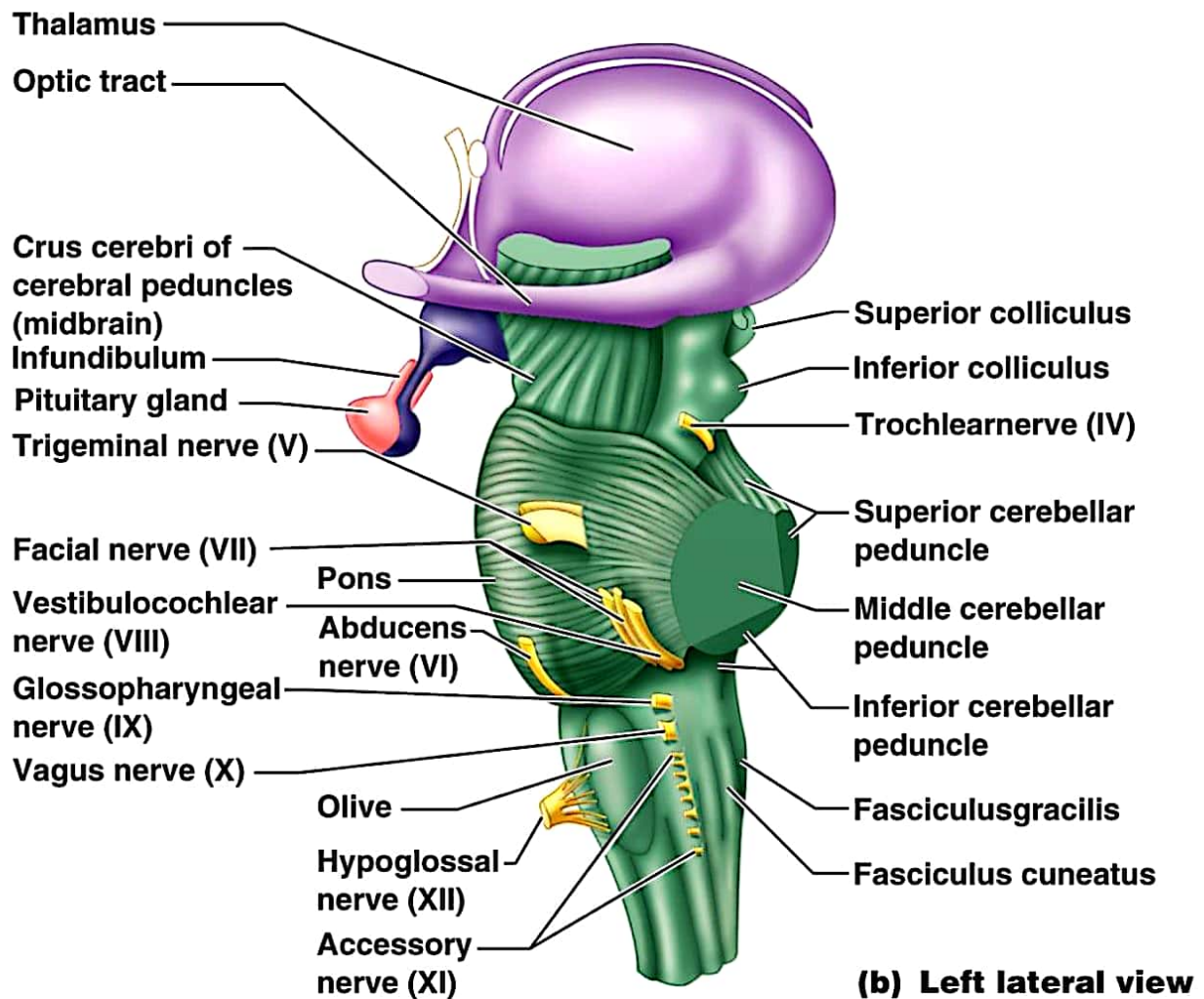
3) post. Pituitary gland- hangs from the floor of hypothalamus

4) mammillary bodies- Relay station in olfactory pathway.

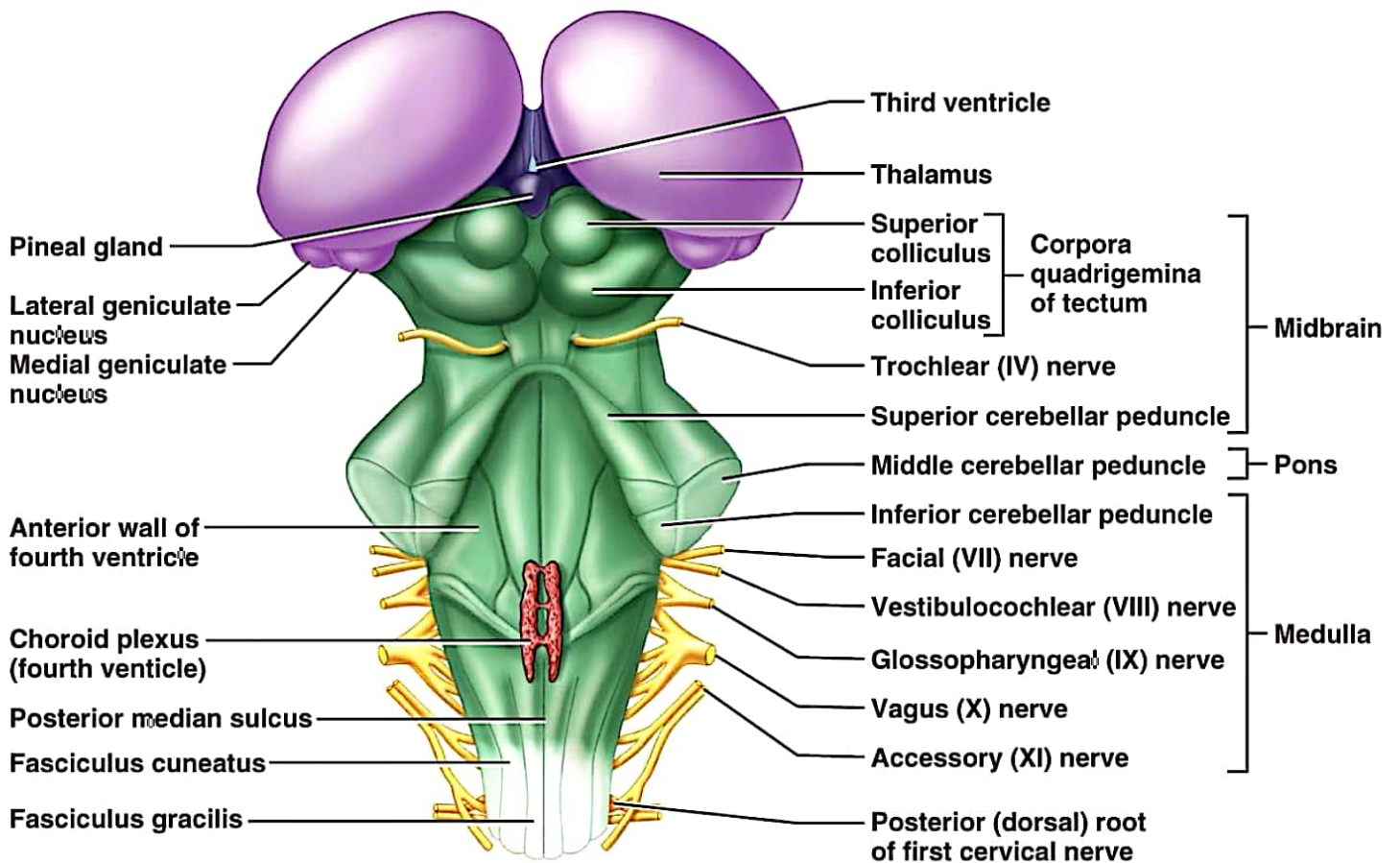
5) pineal gland- produce melatonin that controls sleep - awake cycle.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



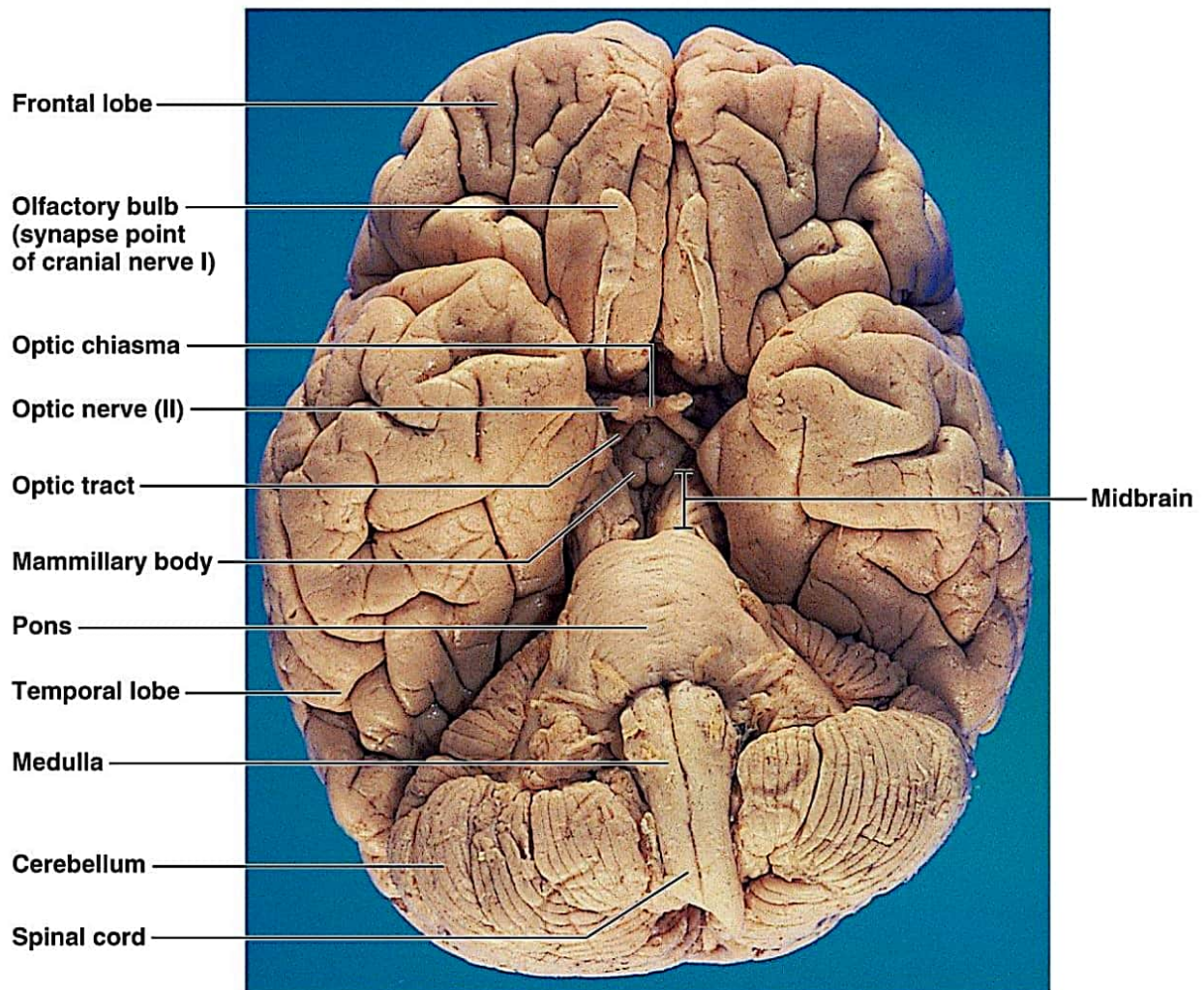
**(c) Dorsal view**

Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

**II. Midbrain:** serves as a major cerebral reflex center, and also helps direct **CSF** from the third ventricle to fourth ventricle.

**III. Pons:** contains at least 2 "respiratory centers" (groups of specialized neurons) which regulate the duration and depth of breathing.

**IV. Medulla oblongata:** at the base of base of brain stem and continuous to become spinal cord. It contains specialized neurons that form "cardiac centers" (to control heart rate), "vasomotor centers" (to control blood flow and blood pressure), and "respiratory centers" (to control respiratory rhythms).

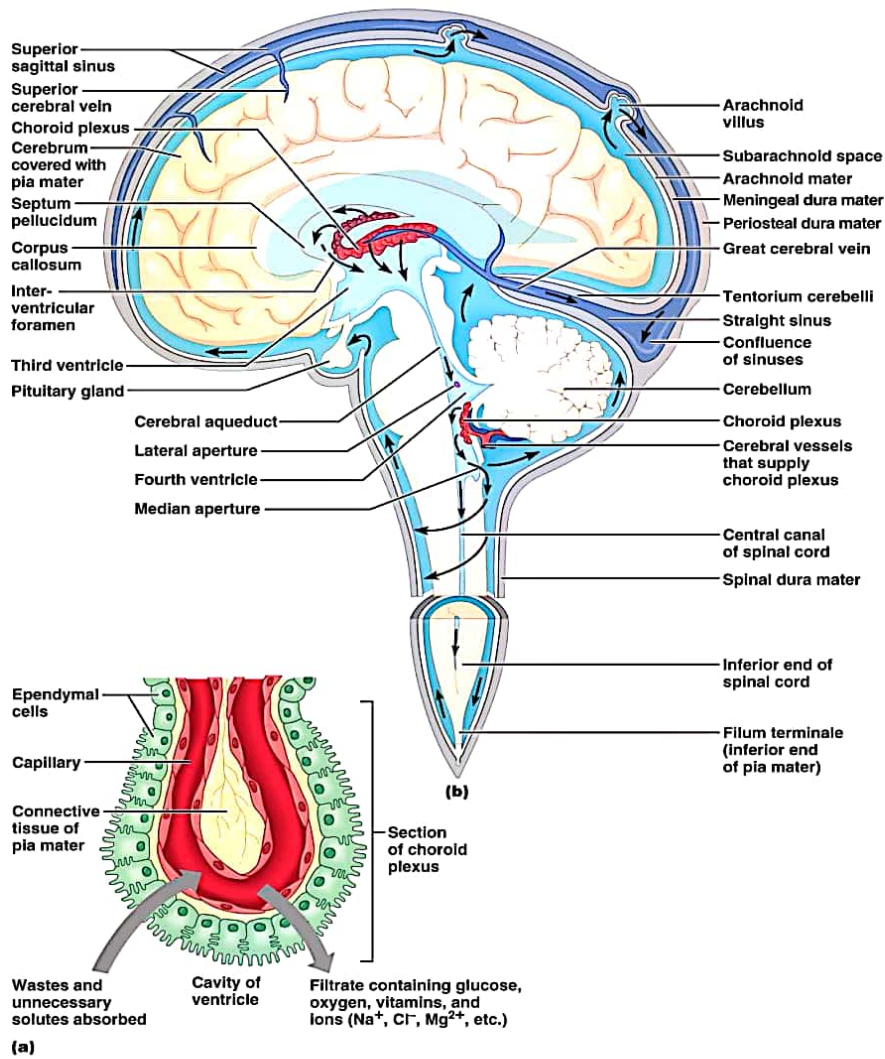


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

## 7. **Cerebrospinal fluid ( CSF):**

- Its chemical composition is similar to **blood plasma**, since it is derived from blood plasma.
- Made by **choroids plexuses** (clusters of capillaries in pia mater) in cerebral ventricles.
- Circulates in the brain (through the ventricles), spinal cord (through central canal ), and between arachnoid and pia mater layers of meninges around the central nervous system.
- Reabsorbed constantly by arachnoid mater and drained into veins.
- Mainly designed to protect **CNS** by serving as a cushion , and as a relatively stable solution in maintaining ionic concentrations and waste removal.
- When too much CSF accumulates in the skull, it can result in **hydrocephalus** where the excess volume creates dangerously high pressure exerting onto brain tissue.





Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

## Structural Development of The Brain

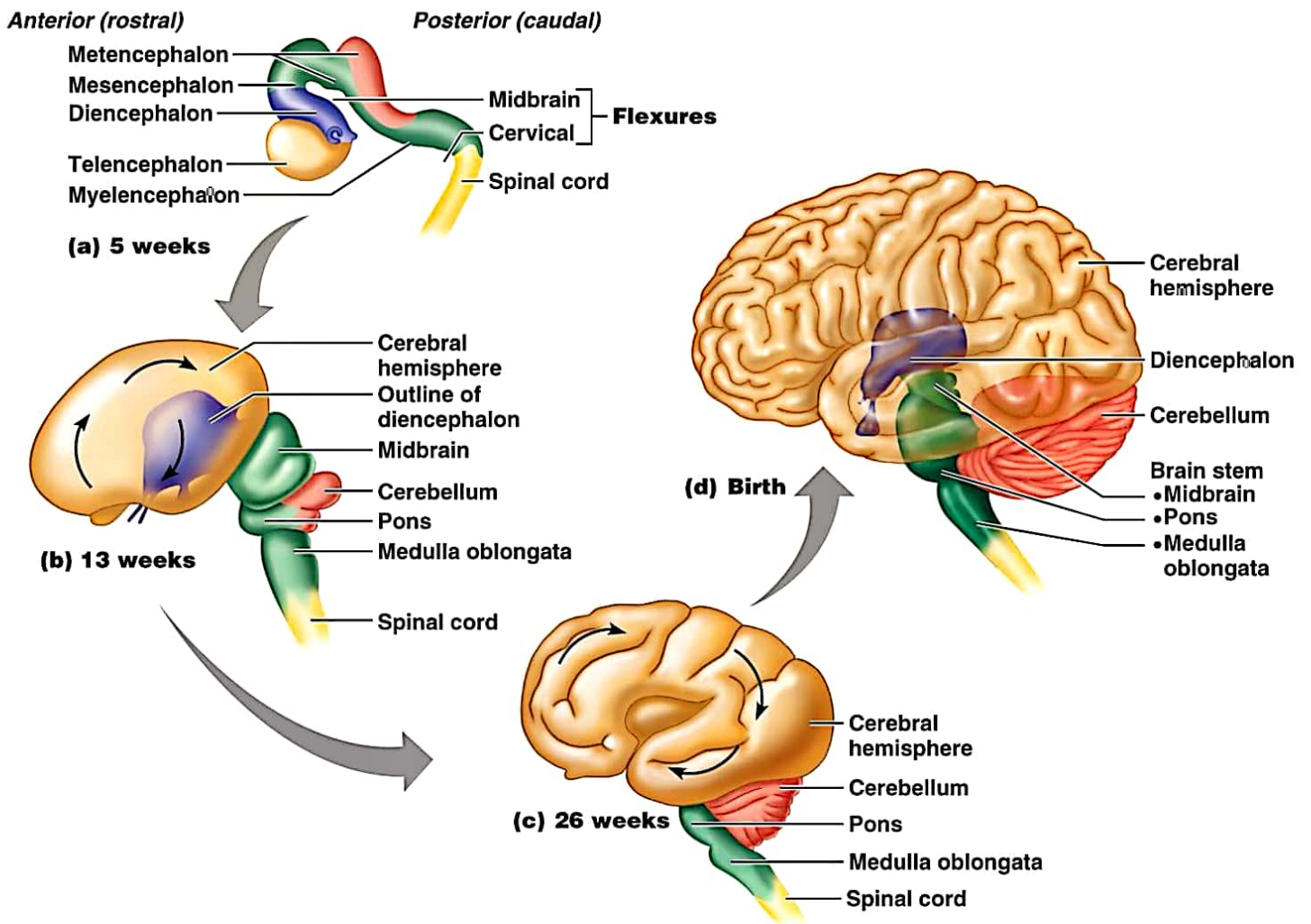
### Embryonic vesicle: **Forebrain (Prosencephalon)**

- a. Anterior portion (Telencephalon) produces Lateral Ventricles, cerebrum and basal ganglia.
- b. Posterior portion (Diencephalon) produces Third Ventricle, Thalamus, Hypothalamus, post. Pituitary gland, and pineal gland.

Embryonic vesicle: **Midbrain (Mesencephalon)** produces cerebral aqueduct, and midbrain.

### Embryonic vesicle: **Hindbrain (Rhombencephalon)**

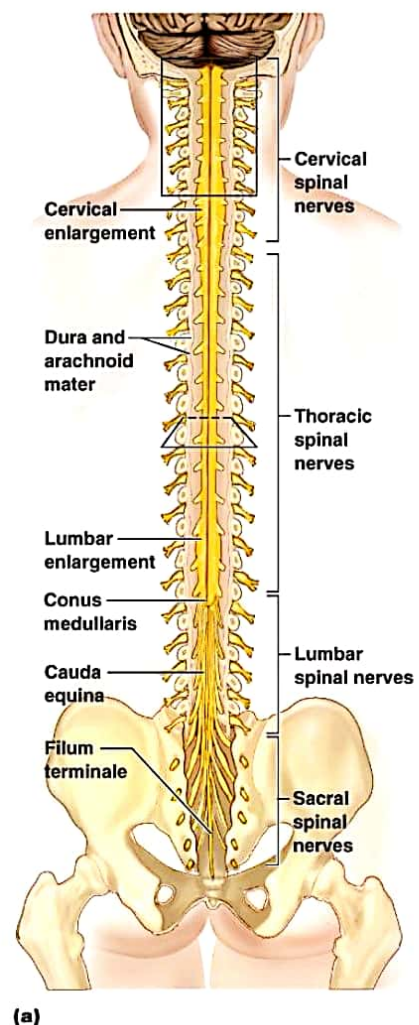
- a. Anterior portion (Metencephalon) produces fourth ventricle, cerebellum, and pons.
- b. Posterior portion (Myelencephalon) produces fourth ventricle, and medulla oblongata.



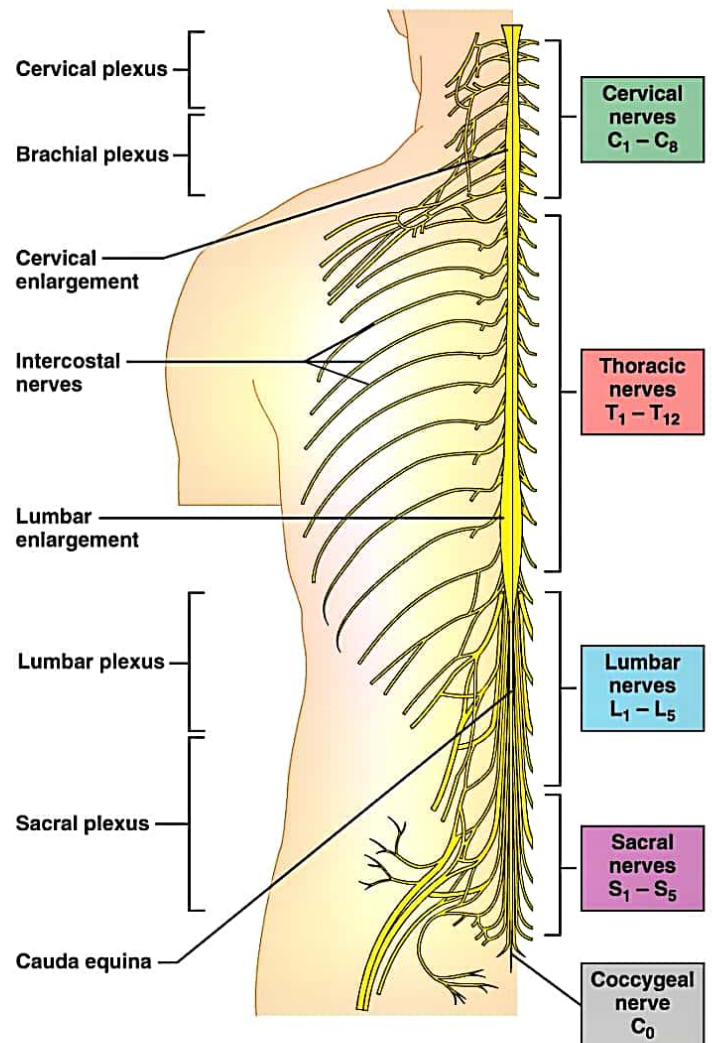
Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

# Spinal cord

- A long nerve cord that begins at the foramen magnum and ends at the first or second lumbar vertebra.
- Divided into **31** segments (named after the vertebral regions), each segment gives rise to a pair of spinal nerves (part of the PNS).
- In general, the location of the spinal nerve corresponds with the location of the effector organ (e.g. cervical nerves connect to muscles and glands on the head, face, and neck).

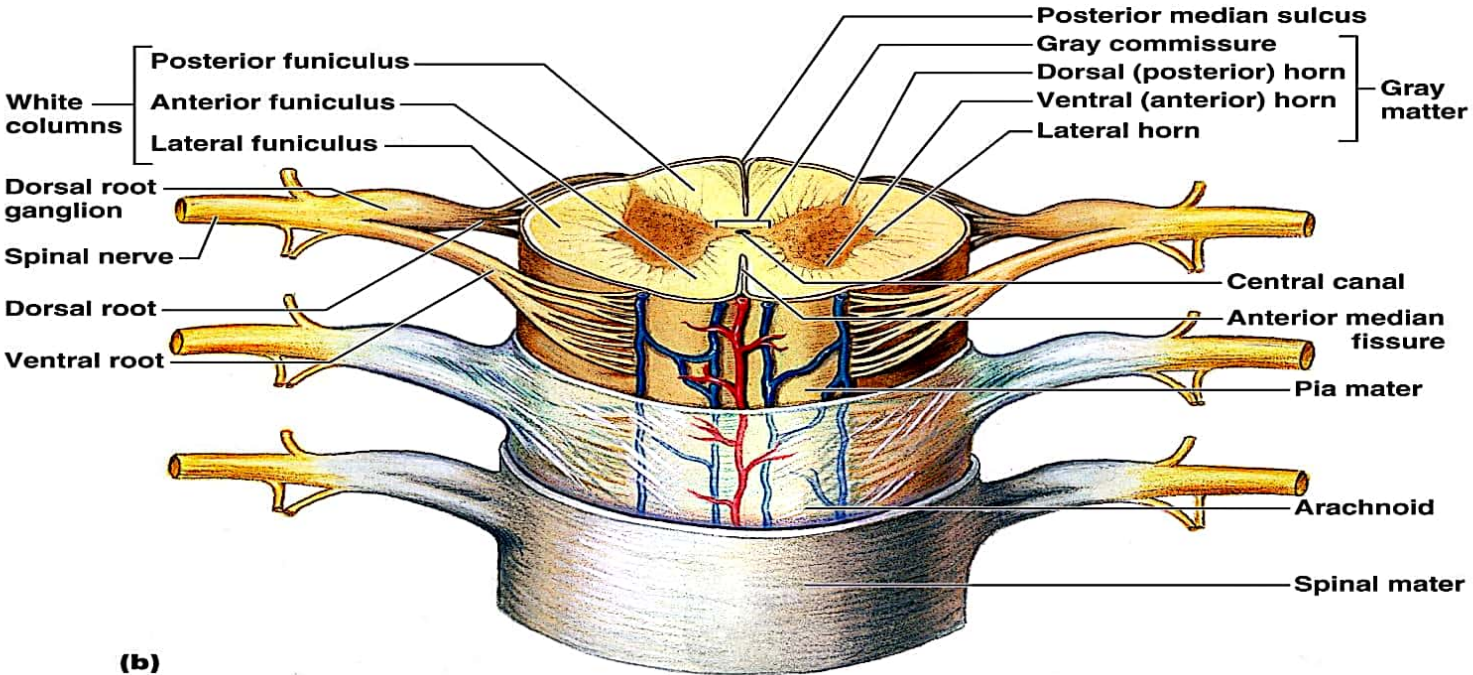


- Most spinal nerves form networks called plexuses.
- **C<sub>1</sub> to C<sub>4</sub>** from **cervical** plexus which serves the head, face, and neck.
- **C<sub>5</sub> to T<sub>1</sub>** from **brachial** plexus which serves the shoulder, arm, and hands.
- **T<sub>2</sub> to T<sub>11</sub>** do not form any plexus.
- **T<sub>12</sub> to S<sub>5</sub>** form **lumbosacral** plexus which serves the lower body and lower limbs.
- **Coccygeal** nerves do not form any plexus.

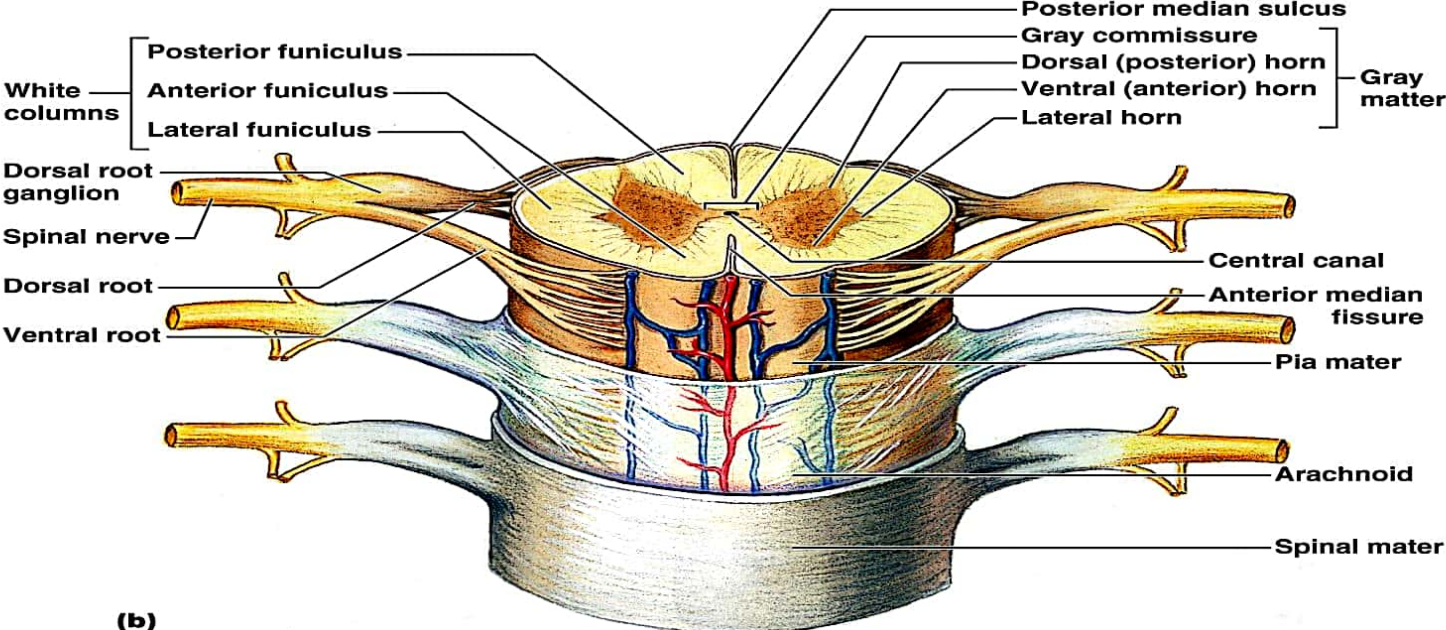


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

- Cross sectional anatomy of the spinal cord:** two grooves divide spinal cord into right left halves.
  - Ant. median fissure or groove (deep).
  - post median sulcus (shallow groove).
- The spinal cord consist of white matter surrounded by gray matter. Gray matter resembles a butterfly. The upper and lower wings of gray matter are called **posterior horn** and **anterior horn** respectively.

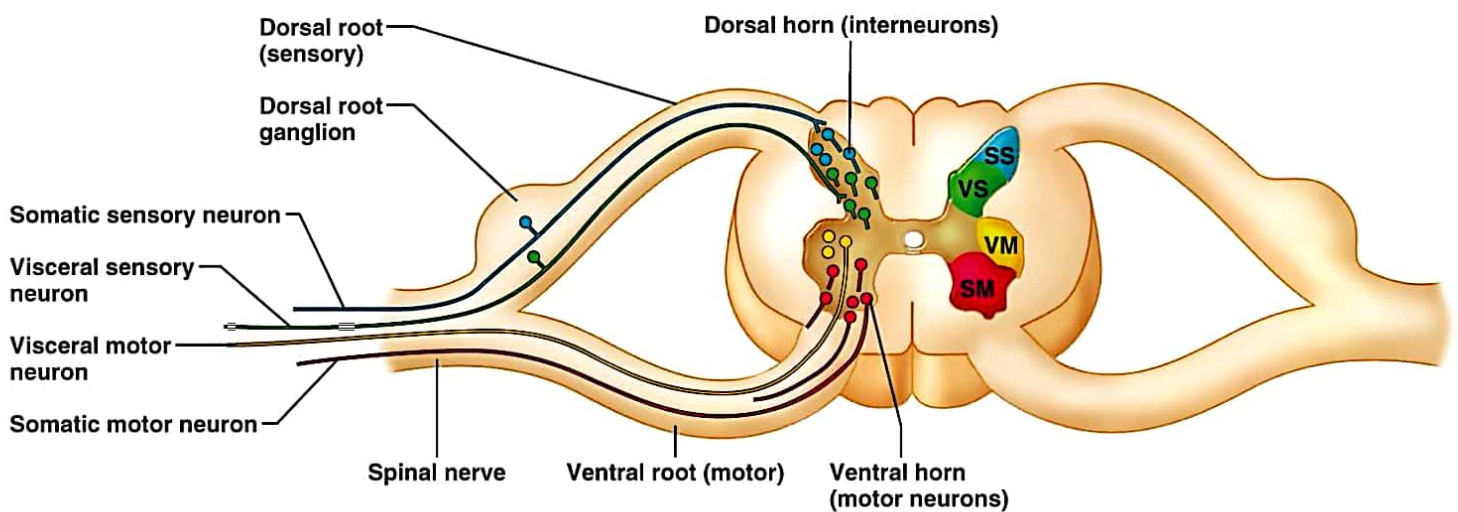


- **Lat. horn** is located between post. and ant. horns on either side.
- Central canal contains **CSF**.
- The gray matter further divides the white matter into **3** regions on each side.
  - a) The anterior column (or Funiculi)
  - b) The lateral column (or Funiculi)
  - c) The posterior column (or Funiculi)



Ant. horn mostly house nerve cells bodies of somatic motor neurons. These send their axons out via the **ventral root** of the spinal cord to skeletal muscles.

Afferent fibers carrying impulses from peripheral sensory receptors form the **dorsal root**. Their nerve cell bodies are found in an enlarged area called **dorsal root ganglion**.

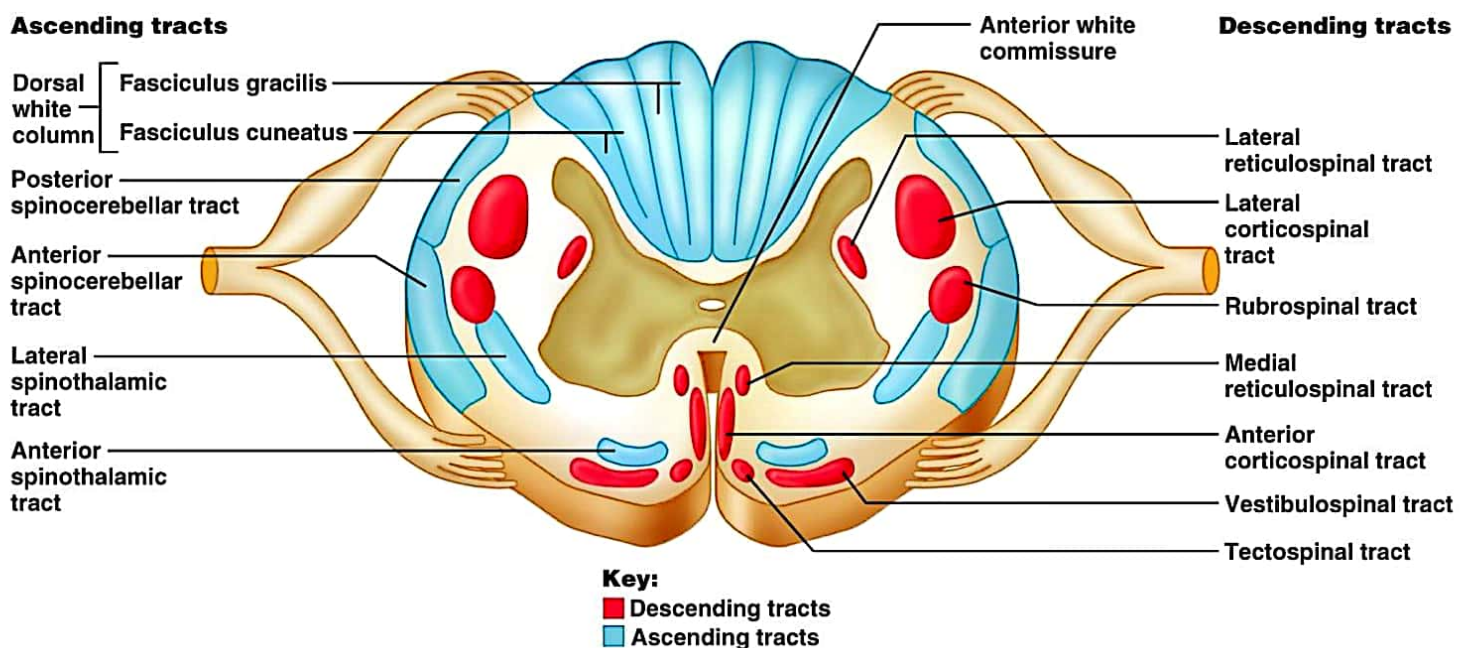


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



# Tracts of The Spinal Cord

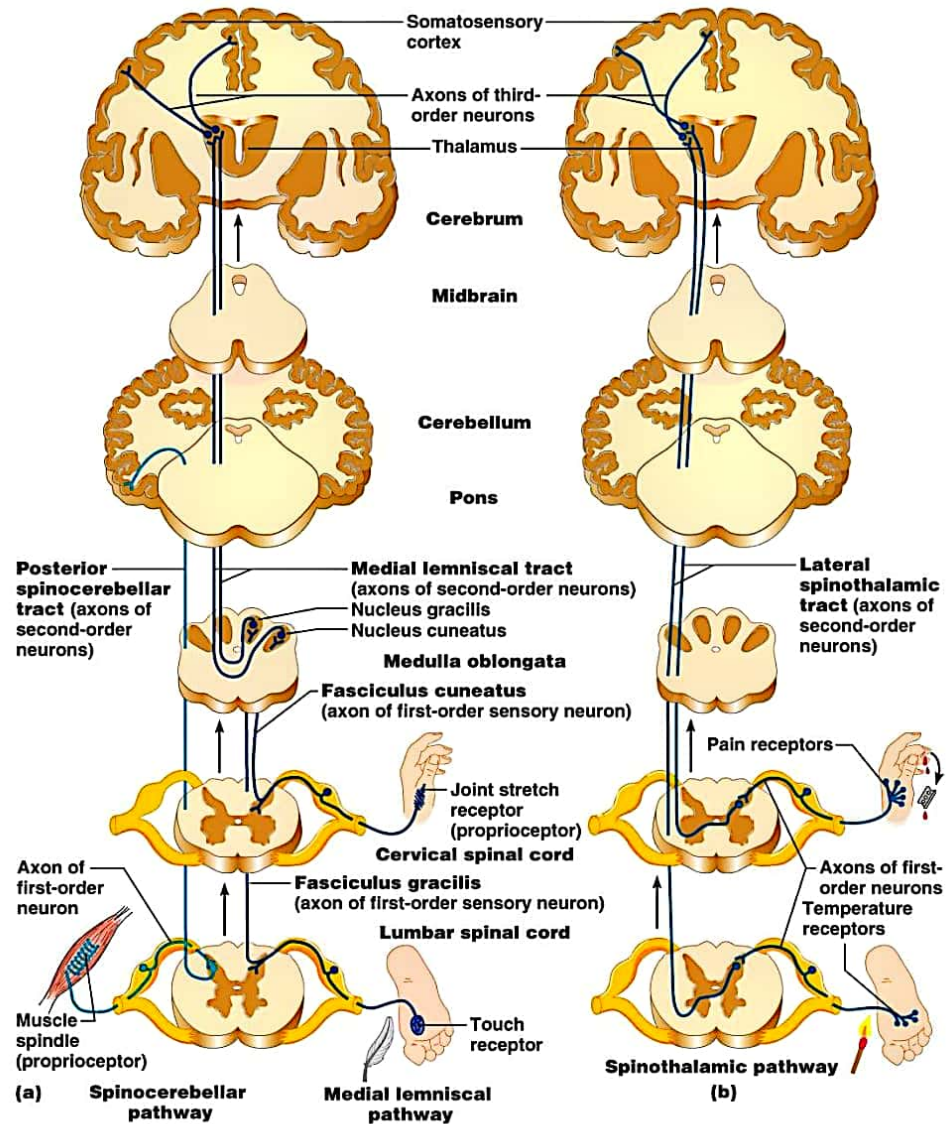
- **Tracts:** The nerve tracts of the spinal cord provide a two-way communication system between the brain and the body.
  - a) **Ascending tract:** conduct sensory impulses to the brain.
  - b) **Descending tract:** conduct motor impulses from the brain to motor neurons reaching muscles, glands, etc.



- **A) Ascending Tracts**

1. **Fasciculus gracilis**

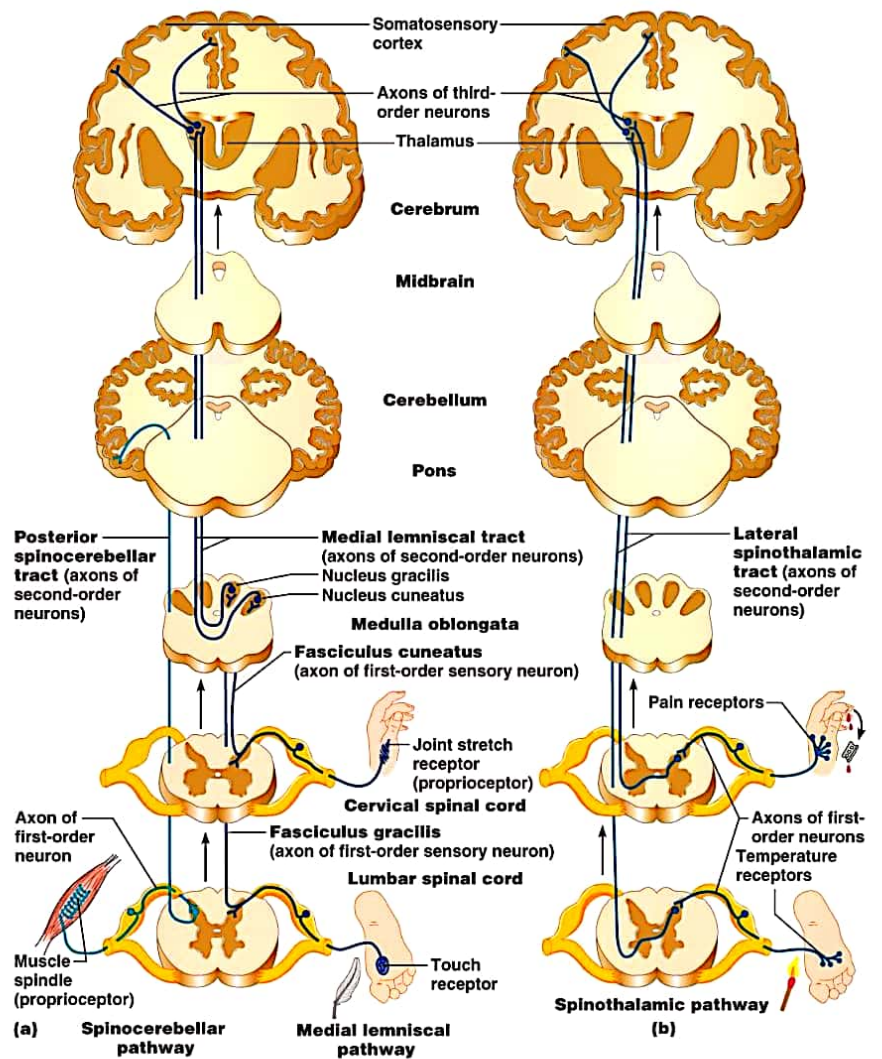
(transmits sensory impulses from lower limbs) and **Fasciculus Cuneatus** (transmits sensory impulses from upper limbs): Located in posterior funiculi and conduct sensory impulses associated with senses of touch, pressure and body movement from skin, muscles, tendons, and joints to the brain.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

**2. Spinocerebellar tract:** conduct impulses (sensory) required for coordination of muscle movements from lower limb and trunk muscles to cerebellum.

**3. Spinothalamic tract:** conduct sensory impulses for pain and temperature to brain.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

## B. Descending Tracts

### 1. Corticospinal tract:

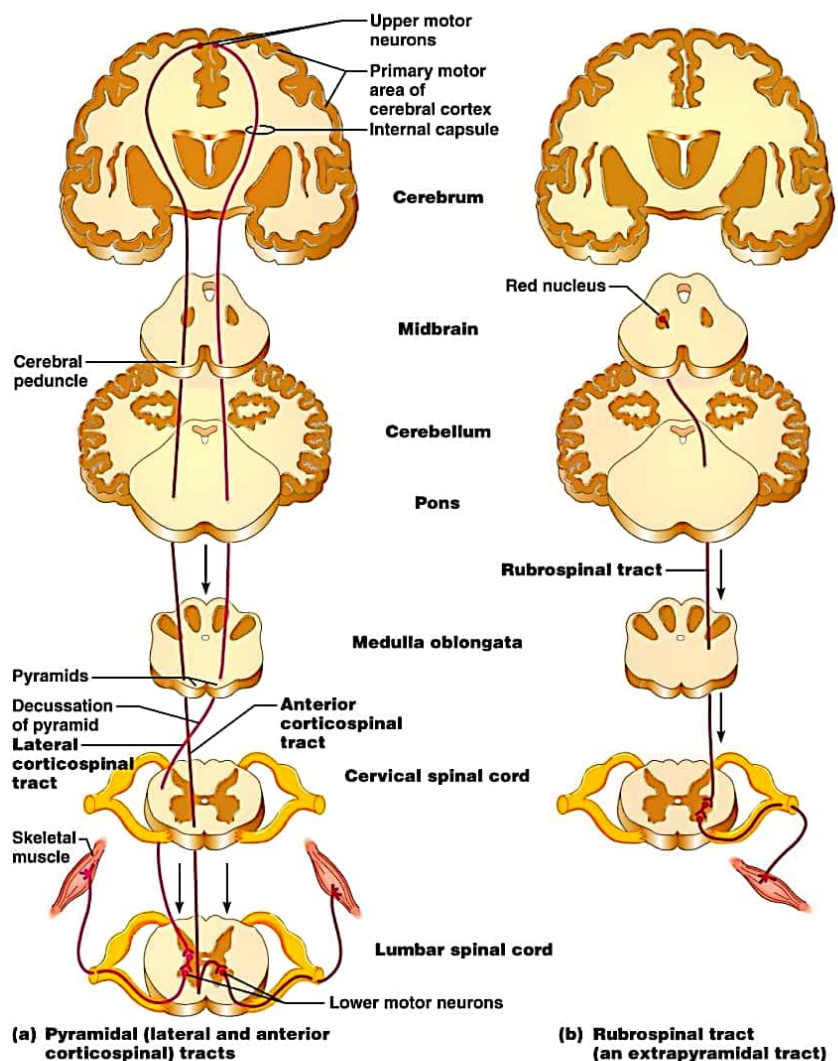
conducts motor impulses associated with voluntary movement from the brain to skeletal muscles.

### 2. Reticulospinal tract:

conducts motor impulses associated with maintenance of muscle tone and the activity of sweat glands from the brain.

### 3. Rubrospinal tract:

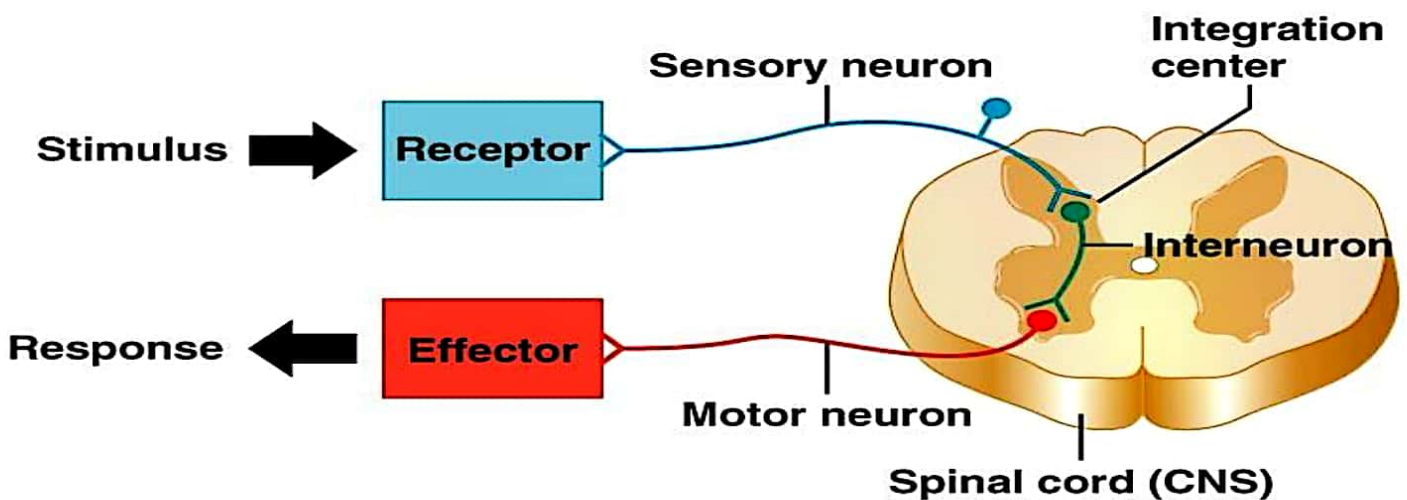
conducts motor impulses associated with muscular coordination and the maintenance of posture from the brain.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

# Reflex Arc

In a **spinal reflex arc**, a stimulus ( i.e. heat, sharp objects) has to be detected by a **receptor** which sends a nerve impulse to the **sensory neuron**, which relays the impulse through the dorsal root of the spinal cord, to the **interneuron** in the gray matter of spinal cord. The impulse is now relayed to the **motor neuron** through the ventral root of the spinal cord, and finally causes a quick action at the **effector organ** (muscle or gland) to react to the stimulus.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

# Clinical Terms

- Neurologist: doctor who specializes in nervous system disorders.
- Concussion: slight brain injury causing dizziness & loss of consciousness.
- Cerebrovascular accident: commonly known as stroke occurs when blood flow to brain is blocked.
- Alzheimer's disease: progressive disease causing degeneration of brain, loss of memory, language and disorientation.
- Epilepsy: disorder of the CNS That is caused by temporary disturbances in normal brain function (impulses) and is accompanied by seizures and loss of consciousness.
- Parkinson's disease : disorder of brain causing pill-rolling movement of fingers tremor, head nodding, and lack of facial expression.
- Encephalopathy: any disorder of the brain.
- Neuralgia: sharp recurring pain associated with a nerve, usually caused by inflammation or injury.