The Brain

Introduction to the Organization of the Brain

•≈ 98% of the body's neural tissue is in the brain

•An avg. human brain weighs 1.4 kg (3lbs.) and has a volume of 1200 cc

•♂ brains average about 10% bigger than ♀ brains
There is no correlation btn. brain size and intelligence

•Volume ranges 750-2100 cc are all functionally normal.
(Albert Einstein's brain was in the 760 cc range)

The Brain is Divided into Major Regions

1. Cerebrum
2. Cerebellum
3. Diencephalon
4. Mesencephalon
5. Pons
6. Medulla Oblongata

1) **Cerebrum**

•Largest region of the brain

•It is divide into right and left cerebral hemispheres

•Conscious thoughts, sensations, intellect, memory, & complex movements originate in the cerebrum

•Surface is highly folded and covered w/ neural cortex which is a superficial layer of gray matter

2) **Cerebellum**

•2nd largest region of the brain

•Adjusts ongoing movements (balance), allows for repetition of movement

3) **Diencephalon**

•Right & Left thalamus (relay & processing centers for sensory info)

•Hypothalamus (floor of the diencephalon) contains centers involved w/ emotions, autonomic functions, hormone production

•Structural and functional link btn. cerebral hemispheres and the brain stem

Brain Stem

The brain stem is the oldest part of the brain:

•Mesencephalon

•Pons

•Medulla oblongata

4) **Mesencephalon**

•Mid-brain

•Processes visual & auditory info and controls reflexes concerned with these stimuli. (i.e.-close eyes to loud bang).

•Also has centers concerned with helping to maintain consciousness.

5) **Pons**

•Latin for bridge

•Connects cerebellum to brain stem (relay sensory info)

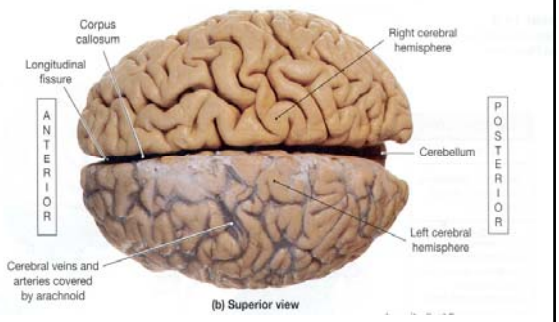
•Subconscious somatic & visceral motor centers.

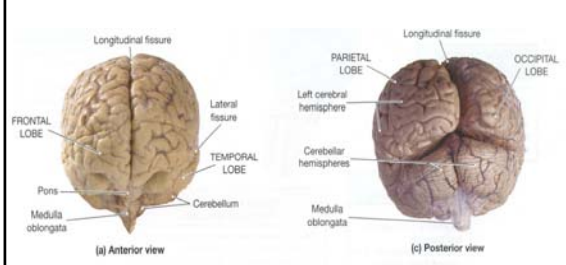
6) **Medulla Oblongata**

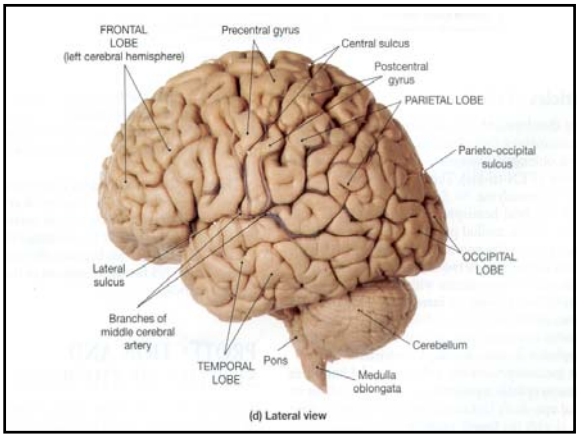
•Connection of spinal cord to brain

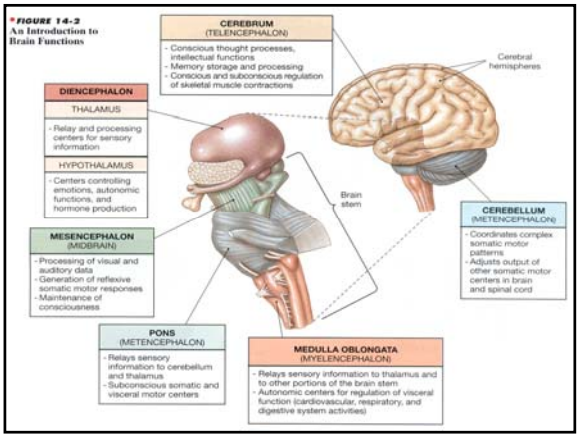
•Relays sensory data to thalamus

•Contains autonomic centers for regulation of visceral function (CV, respiratory, digestive)









The brain normally contains several fluid filled cavities known as ventricles

- •Ventricles are lined with ependymal cells
- •Ventricles are filled w/ CSF
- •There is continuous circulation of CSF btn. the ventricles and the subarachnoid space

There are basically 4 ventricles

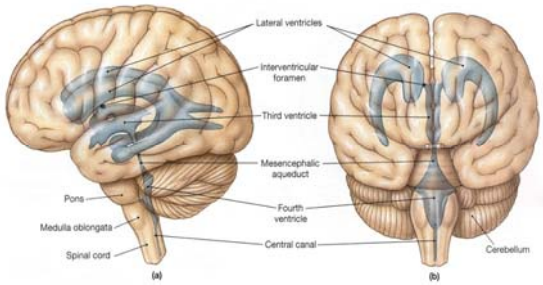
a) a large lateral ventricle in the right hemisphere (1st or 2nd)

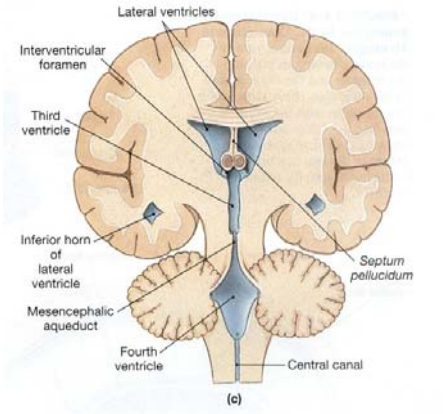
b) a large lateral ventricle in the left hemisphere (1st or 2nd)

c) a ventricle in the diencephalon (3rd)

d) the 4th travels the length of the brainstem and touches the top of the spinal cord

•Lateral ventricles are separated by a partition called the septum pellucidum, but each is independently connected to the 3rd ventricle. The 3rd ventricle is connected to the 4th ventricle via a narrow passage called the mesencephalic aqueduct.





Protection & Support of the Brain
Brain is protected from mechanical forces by

1. Bones of the skull

2. Cranial meninges

3. CSF

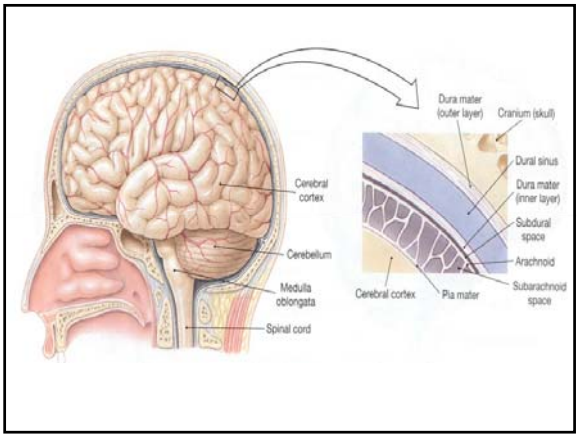
4. Biologically isolated from the rest of the circulation by the Blood Brain Barrier (BBB).

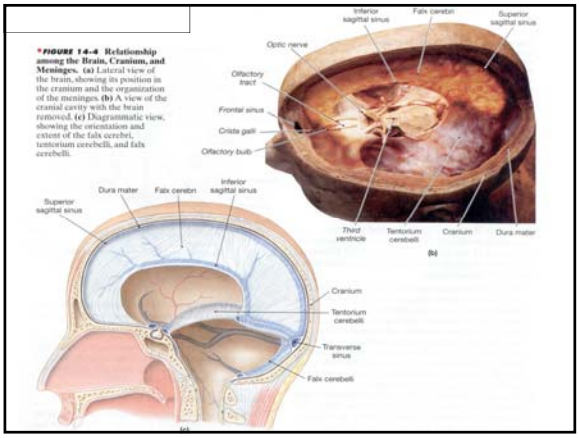
Cranial Meninges

1. **Dura Mater**:
- Fused to bones of cranium, so no epidural space.
- There is a dural sinus inside the dura mater which is which is full of venous blood which drains into the internal jugular veins of the neck.

2. **Arachnoid**
- Surrounds the brain but does not conform to its folds
- Granulations absorb CSF
- Subarachnoid space btn. arachnoid and pia mater

3. **Pia Mater**
- Sticks to surface of brain and follows contours
- Surround blood vessels that penetrate brain tissue.





*The skull is a mixed blessing. It protects the brain from outside mechanical damage, but the brain requires protection from hitting the hard cranial surface. (like a motorist in a car w/out a seat belt).

Cranial Trauma

- Head injury resulting from impact with another object.
- ≈ 8 million cases/yr in the U.S., but only 1 in 8 result in serious brain damage.
- Dural folds act like a seat belt, CSF acts like an air bag.
- Dural folds are places where the dura mater folds down and attaches to the brain.

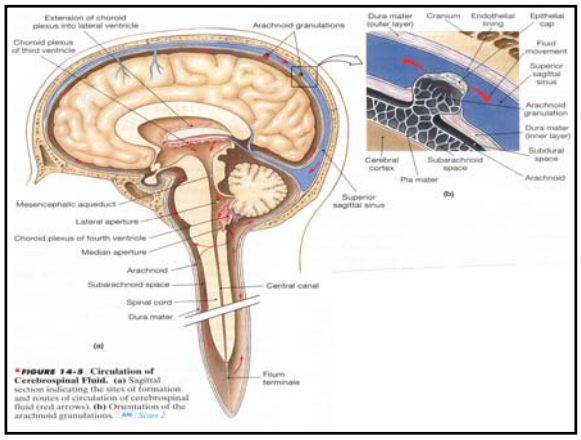
CSF

•Cushions delicate neural structures

•Supports the brain

•Transports nutrients, chemical messengers, & waste products

•Formed by the cells of the choroid plexus (line ventricles)



•CSF produced at a rate of ≈ 500 ml/day

•The total volume of CSF at anyone time is 150 ml, so the entire volume of CSF is replaced roughly every 8 hours.

•CSF is absorbed by arachnoid granulations if these get blocked a variety of things can happen….

Cerebrovascular diseases (Circulatory disorders that interfere with normal circulatory supply to the brain)

•Stroke or CVA

•Epidural hemorrhage

•Subdural hemorrhages

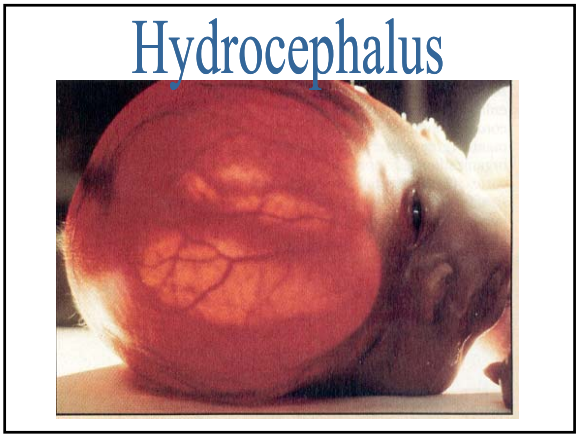
•Hydrocephalus

Hydrocephalus

•The arachnoid granulations that reabsorb CSF in adults don't appear until age 3, so infants are particularly prone to build up of CSF.

•In an infant, the cranial sutures have yet to fuse, and the skull can enlarge to accommodate the extra fluid volume. This enlargement produces an enormously expanded skull.

•The rising intercranial pressure compresses the brain leading to neural dysfunction commonly ends in unconsciousness and ultimately death.



Blood Brain Barrier

•Endothelial tissue lining CNS has lots of tight junctions

•This prevents diffusion of most materials
In general only lipid soluble compounds can get through to the interstitial fluid of CNS:
CO_2, O_2, NH_3, Steroids, & small Alcohols

•The BBB is important and necessary because it keeps excess neurotransmitters from reaching the CNS, causing unwanted firing neurons.

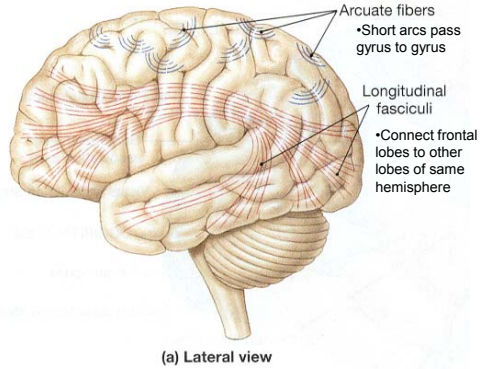
The Cerebrum

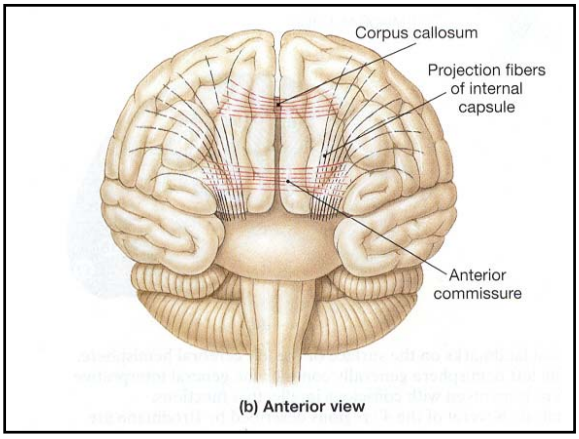
•Mainly divided into 2 hemisphere

•Gray matter found superficially (**cerebral cortex**) and deeper in the cerebral nuclei

•**Gyri** (ridges) & **Sulci** (fissures) inc. SA.

•The central white matter lies beneath the neural cortex and around the cerebral nuclei.





•The left and right cerebral hemispheres are almost completely separated by a deep longitudinal fissure.

•They remain connected by a thick band of white matter called the corpus callosum.

Each hemisphere is divided into lobes with reliable landmarks at their borders:

•**Central sulcus** separates the frontal lobe from the parietal lobe

•**Lateral sulcus** separates the frontal lobe from the temporal lobe

•**Parieto-occipital** lobe separates the parietal lobe from the occipital lobe

•The **insula** is a small island of cerebral cortex under the lateral sulcus

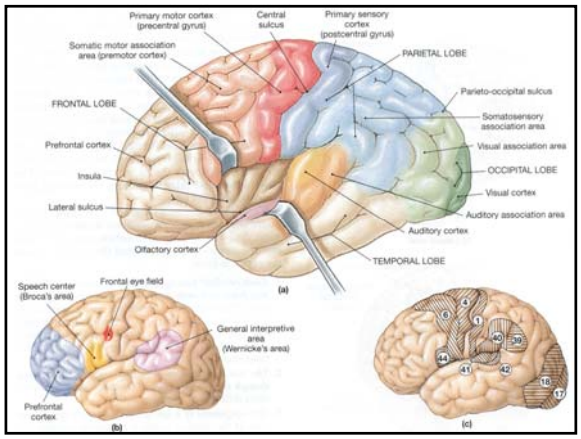


TABLE 14-2 The Cerebral Cortex

Region/Nucleus	Function
Frontal lobe Primary motor cortex	Voluntary control of skeletal muscles
Parietal lobe Primary sensory cortex	Conscious perception of touch, pressure, vibration, pain, temperature, and taste
Occipital lobe Visual cortex	Conscious perception of visual stimuli
Temporal lobe Auditory cortex and olfactory cortex	Conscious perception of auditory and olfactory stimuli
All lobes Association areas	Integration and processing of sensory data; processing and initiation of motor activities

3 points about cerebral lobes

1. **Each cerebral hemisphere receives sensory information from and sends motor commands to the opposite side of the body**. Nobody knows why this should be…No functional significance.

2. **The two hemispheres have different functions, even though they look almost identical**.

3. **The arrangement of a specific function to a specific region of the cerebral cortex is imprecise**, at best.

Central White Matter
Contains 3 groups of axons:

•**Association fibers:** connects areas of the neural cortex with a single cerebral hemisphere.

•**Commissral fibers:** connects and allow communication btn. the cerebral hemispheres.
***corpus callosum:** contains > 200 million axons, 4 billions impulses/sec
***anterior commisure**

•**Projection fibers:** link the cerebral cortex to the diencephalon, brain stem, cerebellum, and spinal cord.

Prefrontal Cortex

•The prefrontal cortex coordinates information from the entire cortex and performs abstract intellectual functions.

•Prefrontal lobotomy

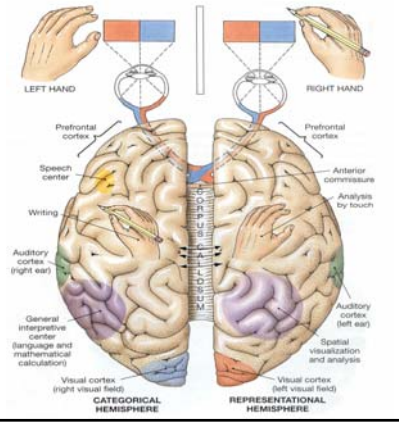
Hemispheric Specialization

•Functional differences between the left and right cerebral hemisphere

•Right Brained *vs.* Left Brained

• The left hemisphere is normally the **categorical hemisphere**; it contains the general interpretative & speech centers and is responsible for language-based skills.

•The right hemisphere or **representational hemisphere**, is responsible for spatial relationships and analyses.

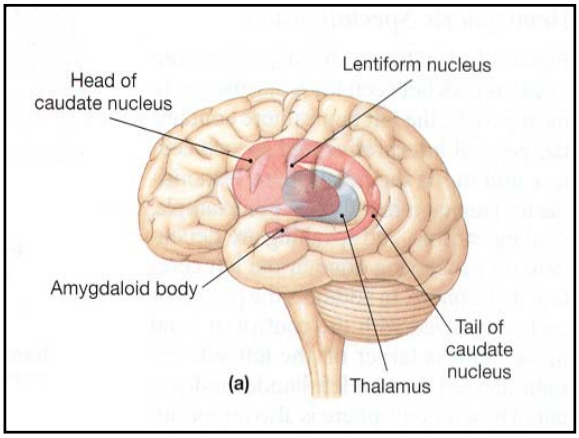


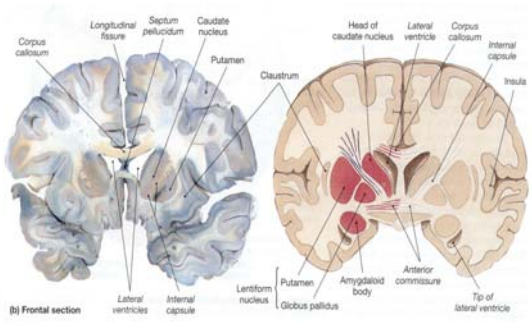
Cerebral Nuclei

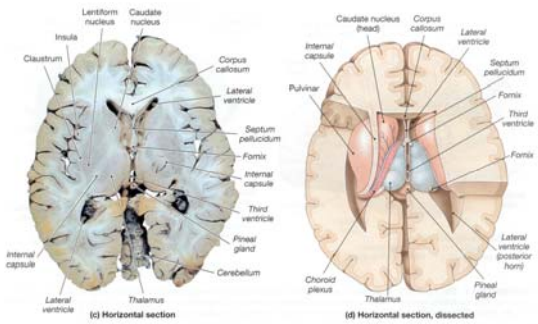
•Direct body functions at the subconscious level.

•Masses of gray matter below the floor of the lateral ventricle, embedded in central white matter.

•Help coordinate the general pattern and rhythm of skeletal muscle movement.







The Limbic System

•A <u>functional grouping</u> (not an anatomical one).

•Consists of components from the cerebrum, diencephalon, and mesencephalon.

Functions include:

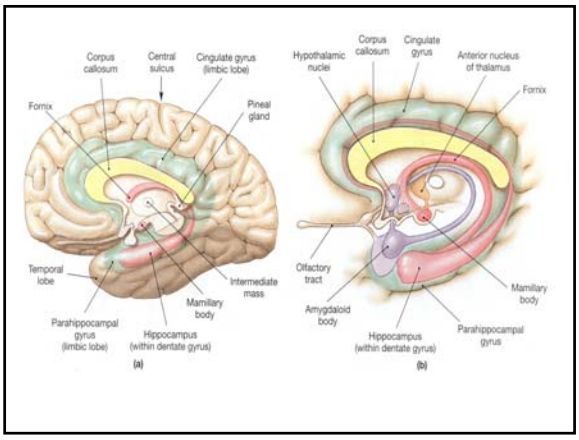
1) Establishing emotional states & related behavioral drives

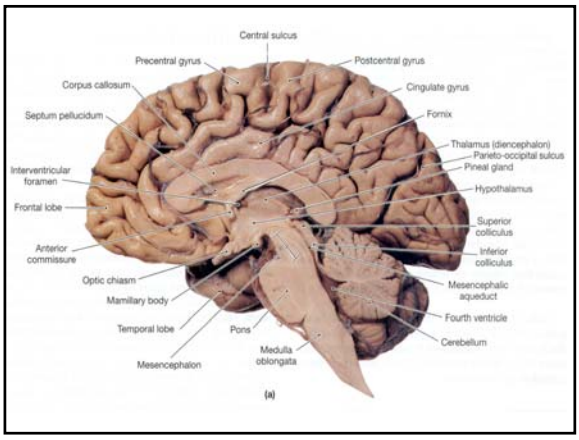
2) Linking conscious intellectual functions of the cerebral cortex with the unconscious and autonomic of the brainstem

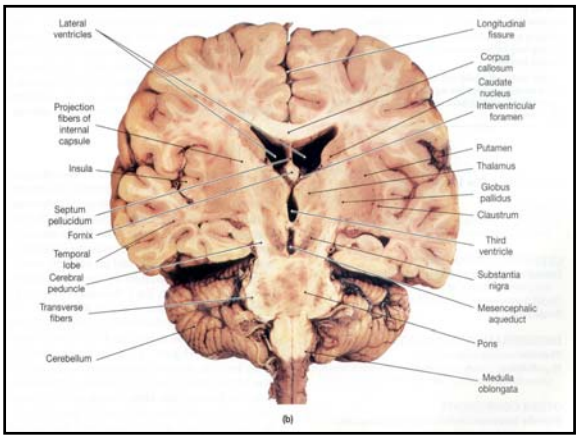
3) Facilitating memory storage and retrieval

Structure	Function
Amygdaloid	regulation of heart rate, “fight or flight” response, linking emotions with memories
Hippocampus	important in learning, storage and retrieval of new, long term memories
Mamillary bodies	process olfactory sensation, control reflex movements associatied with eating (chewing, licking, swallowing)

Hypothalamic nuclei	responsible emotions of rage, fear, pain, sexual arousal and pleasure
Reticular formation	alertness, lethargy, sleep







The Diencephalon

1. **Pineal gland**: secretes melatonin which is important in day/night cycles and reproductive functions.

2. **Thalami** (*pl.* of thalamus)

   *Relay point

   *Filter sensory info

   *Allows for communication btn. the cerebral nuclei and the cerebral cortex.

   * The two thalami are mostly separated by the 3rd ventricle, but in 70% of the population they fuse at the top

TABLE 14-3 The Limbic System

FUNCTION

Processing of memories, creation of emotional states, drives, and associated behaviors

CEREBRAL COMPONENTS

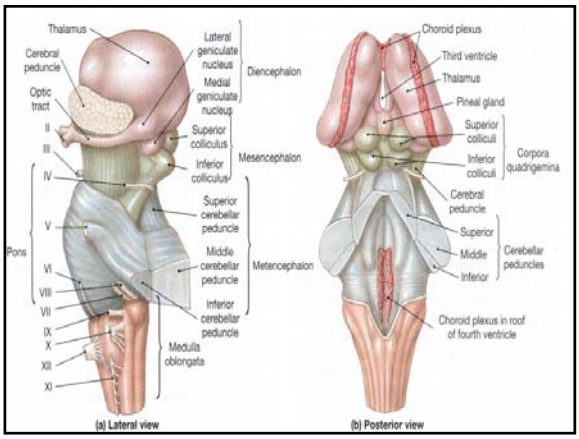
Cortical areas: limbic lobe (cingulate gyrus, dentate gyrus, and parahippocampal gyrus)
Nuclei: hippocampus, amygdaloid body
Tracts: fornix

DIENCEPHALIC COMPONENTS

Thalamus: anterior nuclear group
Hypothalamus: centers concerned with emotions, appetites (thirst, hunger), and related behaviors *(see Table 14-5)*

OTHER COMPONENTS

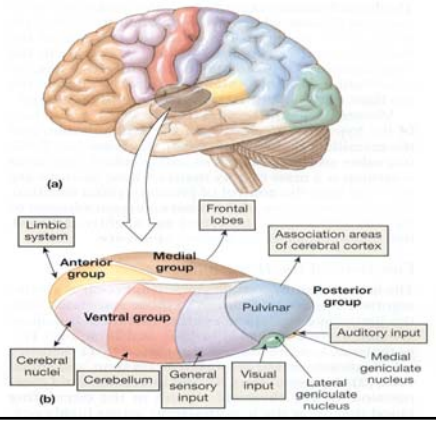
Reticular formation: network of interconnected nuclei throughout brain stem



Each thalamus has centers known as thalami nuclei which control specific types of information

TABLE 14-4 The Thalamus

Group/Nuclei	Function
Anterior group	Part of the limbic system
Medial group	Integrates sensory information for projection to the frontal lobes
Ventral group	Projects sensory information to the primary sensory cortex; relays information from cerebellum and cerebral nuclei to motor area of cerebral cortex
Posterior group	
Pulvinar	Integrates sensory information for projection to association areas of cerebral cortex
Lateral geniculate nuclei	Project visual information to the visual cortex
Medial geniculate nuclei	Project auditory information to the auditory cortex

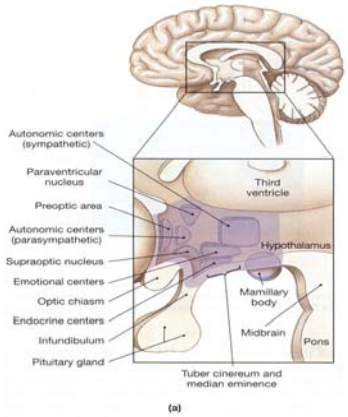


Hypothalamus

- Link between the nervous and endocrine systems.
- Centers controling emotions, autonomic functions, and hormone production.
- **4F**s

TABLE 14-5 Components and Functions of the Hypothalamus

Region/Nucleus	Function
Supraoptic nucleus	Secretes ADH, restricting water loss at the kidneys
Paraventricular nucleus	Secretes oxytocin
Preoptic areas	Regulate body temperature
Tuber cinereum and median eminence	Releases hormones that control endocrine cells of the anterior pituitary
Autonomic centers	Control medullary nuclei that regulate heart rate and blood pressure
Mamillary bodies	Control feeding reflexes (licking, swallowing, etc.)



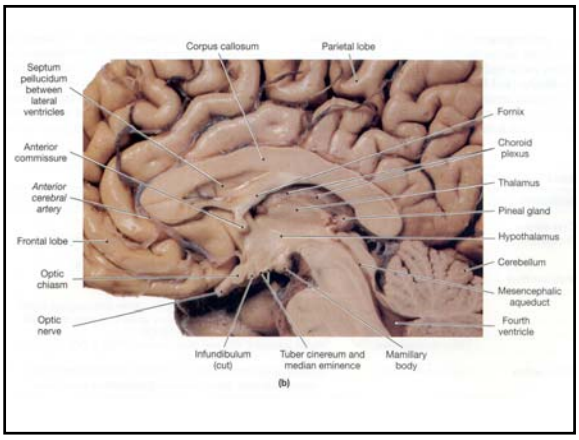


TABLE 14-6 Components and Functions of the Mesencephalon

Subdivision	Region/Nucleus	Function
Gray matter		
Tectum (roof)	Superior colliculi	Integrate visual information with other sensory inputs; initiate involuntary motor responses
	Inferior colliculi	Relay auditory information to medial geniculate nuclei
Walls and floor	Red nuclei	Involuntary control of muscle tone and posture
	Substantia nigra	Regulates activity in the cerebral nuclei
	Reticular formation (headquarters)	Automatic processing of incoming sensations and outgoing motor commands; can initiate involuntary motor responses to stimuli; maintenance of consciousness (RAS)
	Other nuclei/centers	Nuclei associated with two cranial nerves (N III, N IV)
White matter	Cerebral peduncles	Connect primary motor cortex with motor neurons in brain and spinal cord; carry ascending sensory information to thalamus

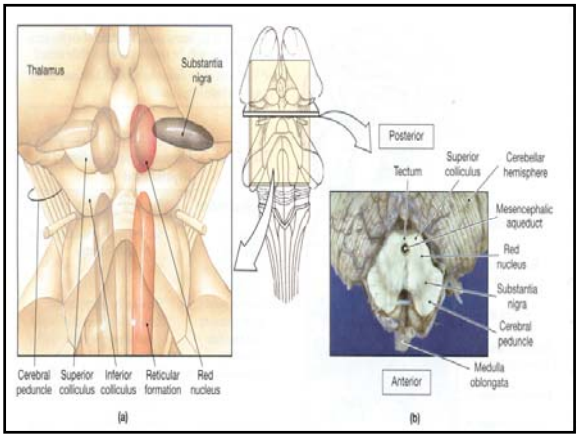
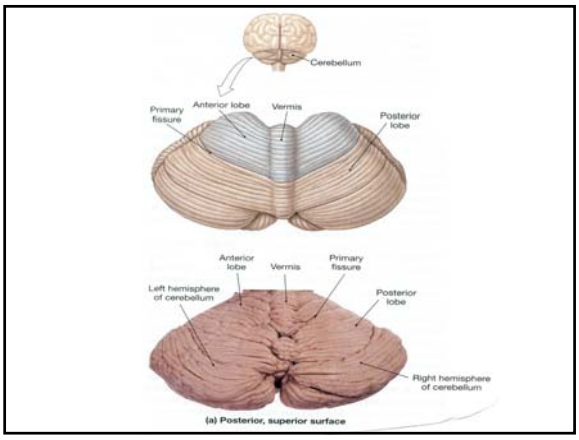


TABLE 14-7 Components of the Cerebellum

Subdivision	Region/Nucleus	Function
Gray matter	Cerebellar cortex	Involuntary coordination and control of ongoing movements of body parts
	Cerebellar nuclei	Same as for cerebellar cortex
White matter	Arbor vitae	Connects cerebellar cortex and nuclei with cerebellar peduncles
	Cerebellar peduncles	
	Superior	Link the cerebellum with mesencephalon, diencephalon, and cerebrum
	Middle	Contain transverse fibers and carry communications between the cerebellum and pons
	Inferior	Link the cerebellum with the medulla oblongata and spinal cord
	Transverse fibers	Interconnect pontine nuclei with the cerebellar hemispheres on the opposite side



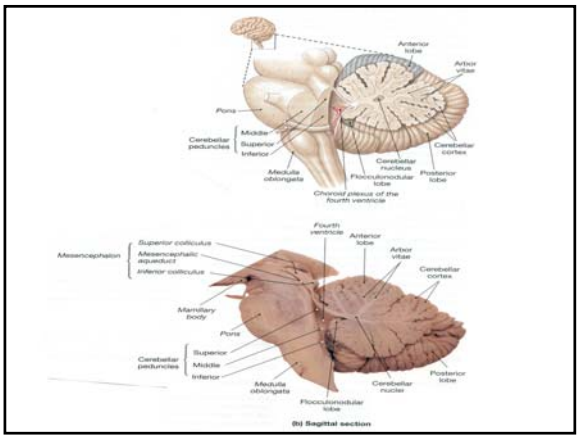


TABLE 14-8 Components and Functions of the Medulla Oblongata

Subdivision	Region/Nucleus	Function
Gray matter	Nucleus gracilis, Nucleus cuneatus	Relay somatic sensory information to the thalamus
	Olivary nuclei	Relay information from the red nucleus, other midbrain nuclei, and the cerebral cortex to the cerebellum
	Reflex centers	
	Cardiac centers	Regulate heart rate and force of contraction
	Vasomotor centers	Regulate distribution of blood flow
	Respiratory rhythmicity centers	Set the pace of respiratory movements
	Other nuclei/centers	Sensory and motor nuclei of five cranial nerves
		Nuclei relaying ascending sensory information from the spinal cord to higher centers
White matter	Ascending and descending tracts	Link the brain with the spinal cord

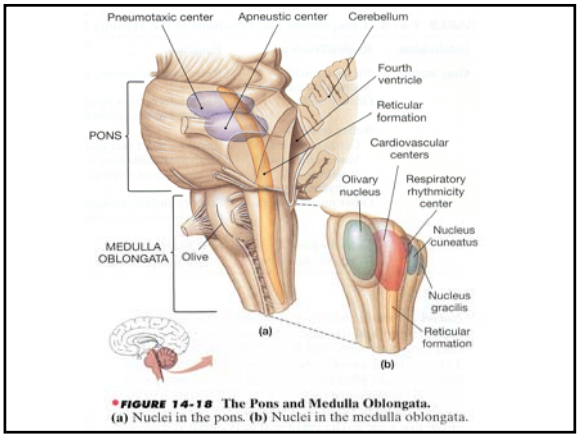


FIGURE 14-18 The Pons and Medulla Oblongata. **(a)** Nuclei in the pons. **(b)** Nuclei in the medulla oblongata.

Cranial Nerves

•There are 12 cranial nerves. Each nerve attaches to the brain's ventrolateral surface near associated sensory or motor nuclei.

I	Olfactory	**VII**	Facial
II	Optic	**VIII**	Vestibulocochlear
III	Oculomotor	**IX**	Glossopharyngeal
IV	Trochlear	**X**	Vagus
V	Trigeminal	**XI**	Spinal Accessory
VI	Abducens	**XII**	Hypoglossal

"**O**n **O**ld **O**lympus **T**owering **T**ops, **A** **F**inn **A**nd **G**erman **V**iewed **S**ome **H**ops"