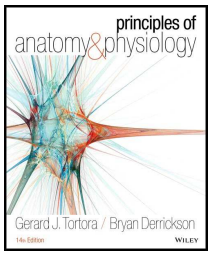


Principles of Anatomy and Physiology

14th Edition

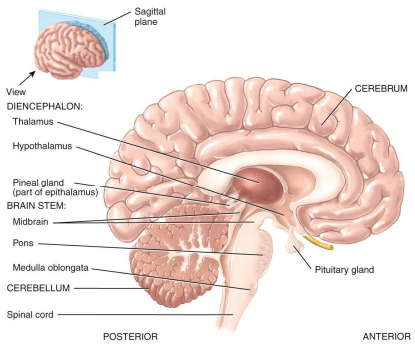
CHAPTER 14
The Brain and Cranial Nerves

Introduction

The purpose of the chapter is to:

1. Understand how the brain is organized, protected, and supplied with blood
2. Compare and contrast the various areas of the brain and their functions
3. Discuss the functional organization of the brain
4. Learn about cranial nerve structure and function

Principal Parts of the Brain



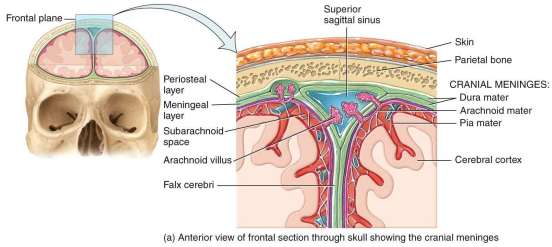
(a) Sagittal section, medial view

Protection

The brain is protected by:

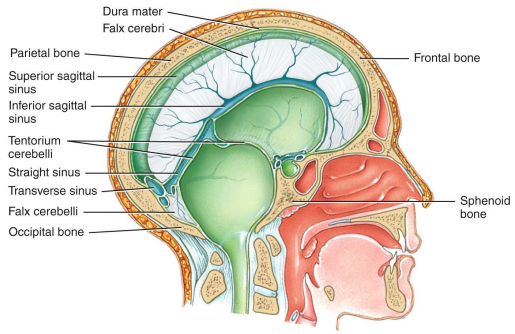
- Cranial bones
- Cranial meninges
  - Pia, arachnoid, and dura mater
    - Cranial dura mater is composed of 2 layers
- Cerebrospinal fluid

Cranial Bones and Meninges



(a) Anterior view of frontal section through skull showing the cranial meninges

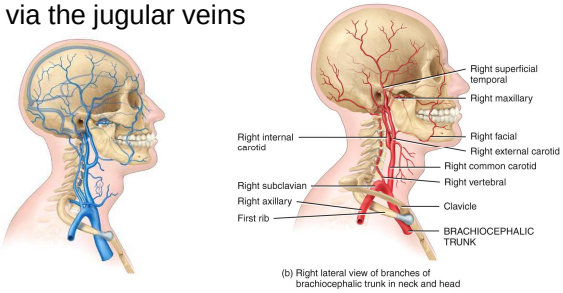
Extensions of the Dura Mater



(b) Sagittal section of extensions of the dura mater

Blood Flow to the Brain

Blood flows to the brain via the vertebral and carotid arteries and flows back to the heart via the jugular veins



(b) Right lateral view of branches of brachiocephalic trunk in neck and head

Importance of Blood Flow to the Brain

The brain utilizes about 20% of the body's oxygen supply

- Any interruption of the oxygen supply can result in weakening, permanent damage, or death of brain cells
- Glucose deficiency my produce mental confusion, dizziness, convulsions, and unconsciousness

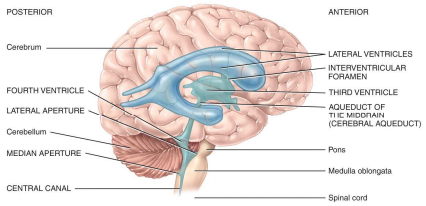
Blood –Brain Barrier (BBB)

The BBB protects brain cells from harmful substances and pathogens by serving as a selective barrier to prevent passage of many substances from the blood into the brain

- The BBB can prevent the entry of therapeutic drugs
- Injury to the brain may cause a breakdown of the BBB, permitting the passage of normally restricted substances into the brain tissue

Cerebrospinal Fluid (CSF)

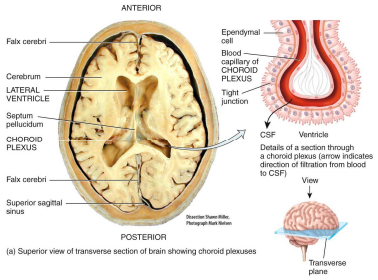
CSF is a liquid that protects the brain and spinal cord against chemical and physical injuries and it carries oxygen, glucose, and other important substances from the blood to nervous tissue cells



Right lateral view of brain

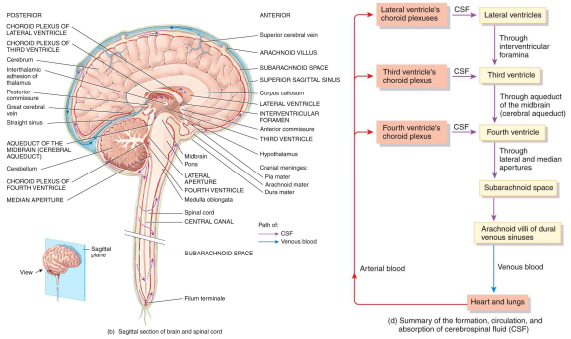
Ventricles and the Choroid Plexus

- The ventricles of the brain contain CSF
- The choroid plexuses make CSF



(a) Superior view of transverse section of brain showing choroid plexuses

CSF Flow



(b) Sagittal section of brain and spinal cord

(d) Summary of the formation, circulation, and absorption of cerebrospinal fluid (CSF)

Regions of the Brain

Anatomy Overview:

- The Nervous System: Overview

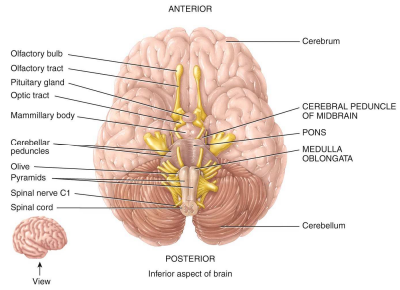
  Once in the animation, click on "brain"

You must be connected to the Internet and in Slideshow Mode to run this animation.

The Brain Stem

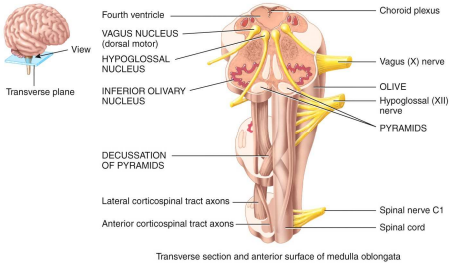
The brain stem is composed of the:

- Medulla oblongata
- Pons
- Midbrain



Medulla Oblongata

The medulla oblongata is continuous with the superior aspect of the spinal cord and contains portions of both motor and sensory tracts



Transverse section and anterior surface of medulla oblongata

Medulla Oblongata

Cranial nerves

- Vestibulocochlear and hypoglossal

Structural regions

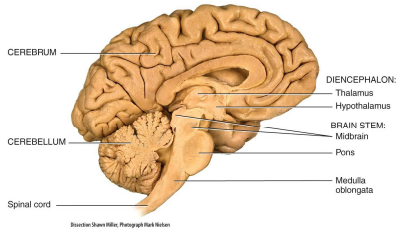
- Pyramids
- Inferior olivary nuclei

Functional regions

- Heart rate, respiratory rate, vasoconstriction, swallowing, coughing, vomiting, sneezing, hiccupping

Pons

The pons is located superior to the medulla oblongata and it links parts of the brain with one another by way of tracts



(b) Sagittal section, medial view

Pons

Cranial nerves

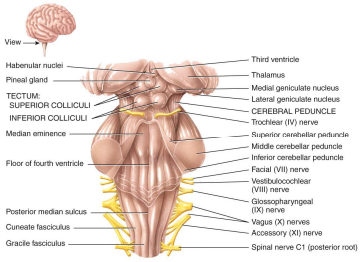
- Trigeminal, abducens, facial, and vestibular branch of vestibulocochlear

Functional regions

- Relays nerve impulses related to voluntary skeletal muscle movements from cerebrum to cerebellum
- Pneumotaxic and apneustic areas (control of respiration)

Midbrain

The midbrain is located superior to the medulla oblongata and extends from the pons to the diencephalon

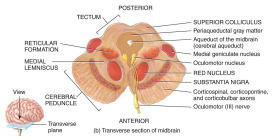


(a) Posterior view of midbrain in relation to brain stem

Midbrain

Cranial nerves

- Oculomotor and trochlear



(b) Transverse section of midbrain

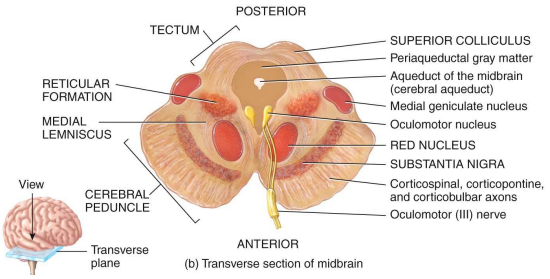
Structural regions

- Cerebral peduncles, corpora quadrigemina, substantia nigra, red nuclei, and medial lemniscus

Functional regions

- Conveys motor impulses from the cerebrum to the cerebellum and spinal cord, sends sensory impulses from the spinal cord to the thalamus, and regulates auditory and visual reflexes

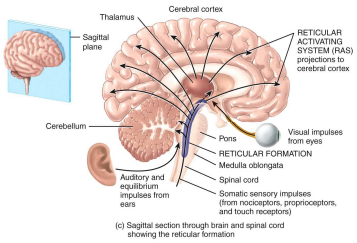
Midbrain



(b) Transverse section of midbrain

Reticular Formation

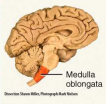
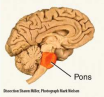
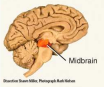
The reticular formation helps regulate muscle tone, alerts the cortex to incoming sensory signals, and is responsible for maintaining consciousness and awakening from sleep



(c) Sagittal section through brain and spinal cord showing the reticular formation

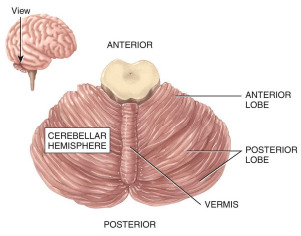
TABLE 14.2

Summary of Functions of Principal Parts of the Brain

PART	FUNCTION
BRAIN STEM	
 Medulla oblongata	***Medulla oblongata:*** Contains sensory (ascending) and motor (descending) tracts. Cardiovascular center regulates heartbeat and blood vessel diameter. Medullary respiratory center (together with pons) regulates breathing. Contains gracile nucleus, cuneate nucleus, gustatory nucleus, cochlear nuclei, and vestibular nuclei (components of sensory pathways to brain). Inferior olivary nucleus provides instructions that cerebellum uses to adjust muscle activity when learning new motor skills. Other nuclei coordinate vomiting, swallowing, sneezing, coughing, and hiccupping. Contains nuclei of origin for vestibulocochlear (VIII), glossopharyngeal (IX), vagus (X), accessory (XI), and hypoglossal (XII) nerves. Reticular formation (also in pons, midbrain, and diencephalon) functions in consciousness and arousal.
 Pons	***Pons:*** Contains sensory and motor tracts. Pontine nuclei relay nerve impulses from motor areas of cerebral cortex to cerebellum. Contains vestibular nuclei (along with medulla) that are part of equilibrium pathway to brain. Pontine respiratory group (together with the medulla) helps control breathing. Contains nuclei of origin for trigeminal (V), abducens (VI), facial (VII), and vestibulocochlear (VIII) nerves.
 Midbrain	***Midbrain:*** Contains sensory and motor tracts. Superior colliculi coordinate movements of head, eyes, and trunk in response to visual stimuli. Inferior colliculi coordinate movements of head, eyes, and trunk in response to auditory stimuli. Substantia nigra and red nucleus contribute to control of movement. Contains nuclei of origin for oculomotor (III) and trochlear (IV) nerves.

The Cerebellum

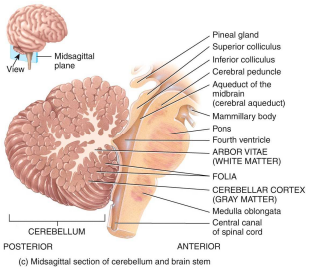
The cerebellum occupies the inferior and posterior aspects of the cranial cavity and consists of two hemispheres and a central vermis



(a) Superior view

The Cerebellum

The cerebellum functions in the coordination of skeletal muscle contractions and in the maintenance of normal muscle tone, posture, and balance

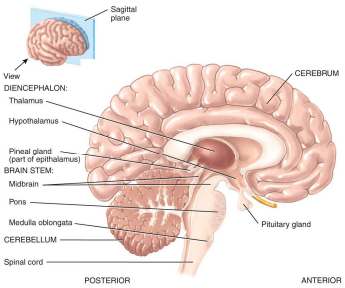


(c) Midsagittal section of cerebellum and brain stem

The Diencephalon

The diencephalon is composed of the:

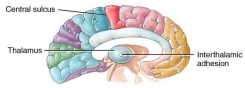
- Thalamus
- Hypothalamus
- Epithalamus



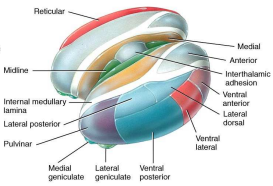
(a) Sagittal section, medial view

Thalamus

The thalamus is located superior to the midbrain and contains nuclei that serve as relay stations for all sensory impulses (except smell) to the cerebral cortex



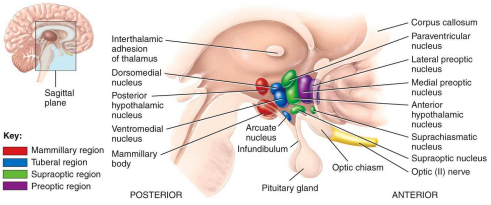
(b) Medial view of left cerebral hemisphere



(c) Superolateral view of thalamus showing locations of thalamic nuclei (reticular nucleus is shown on the left side only; all other nuclei are shown on the right side)

Hypothalamus

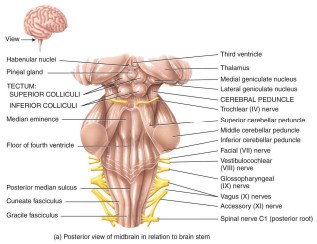
The hypothalamus is found inferior to the thalamus, has four major regions, controls many body activities, and is one of the major regulators of homeostasis



Sagittal section of brain showing hypothalamic nuclei

Epithalamus

The epithalamus lies superior and posterior to the thalamus and contains the pineal gland which secretes melatonin and habenular nuclei which are involved in olfaction



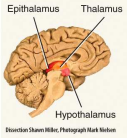
(a) Posterior view of midbrain in relation to brain stem

Circumventricular Organs (CVOs) of the Diencephalon

- Parts of the diencephalon, the CVOs, can monitor chemical changes in the blood because they lack a blood-brain barrier
- CVOs include the hypothalamus (a portion of it), pineal gland, and the pituitary gland
  - CVOs coordinate homeostatic activities of the endocrine and nervous systems

TABLE 14.2

Summary of Functions of Principal Parts of the Brain

PART	FUNCTION
DIENCEPHALON	
Epithalamus, Thalamus, Hypothalamus  Dissection Shawn Miller, Photograph Mark Nielsen	***Thalamus:*** Relays almost all sensory input to cerebral cortex. Contributes to motor functions by transmitting information from cerebellum and basal nuclei to primary motor area of cerebral cortex. Plays role in maintenance of consciousness. ***Hypothalamus:*** Controls and integrates activities of autonomic nervous system. Produces hormones, including releasing hormones, inhibiting hormones, oxytocin, and antidiuretic hormone (ADH). Regulates emotional and behavioral patterns (together with limbic system). Contains feeding and satiety centers (regulate eating), thirst center (regulates drinking), and suprachiasmatic nucleus (regulates circadian rhythms). Controls body temperature by serving as body's thermostat. ***Epithalamus:*** Consists of pineal gland (secretes melatonin) and habenular nuclei (involved in olfaction).

The Cerebrum

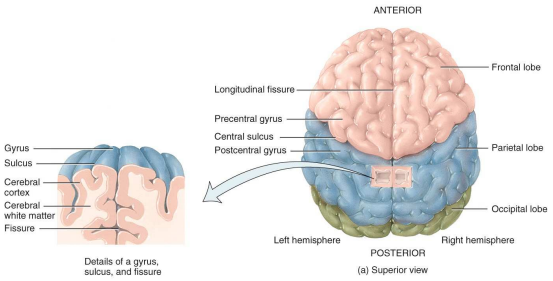
The cerebral cortex is composed of gray matter which contains billions of neurons

- Gyri, fissures, and sulci can be identified on the cortex

Deep to the cortex is white matter composed of tracts of neurons that connect parts of the brain to each other and the spinal cord

- A bundle of white matter tracts called the corpus callosum connects the right and left hemispheres of the cerebrum

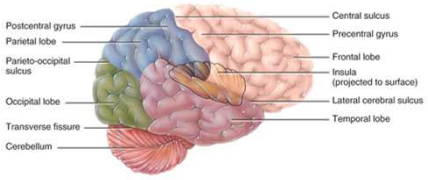
Anatomical Details of the Cerebral Cortex



Lobes of the Cerebrum

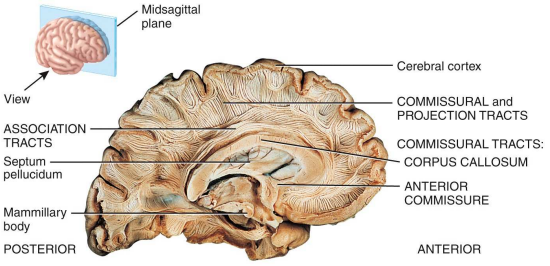
The cerebrum can be divided into the:

- Frontal lobe
- Parietal lobe
- Temporal lobe
- Occipital lobe
- Insula



(b) Right lateral view

Cerebral White Matter

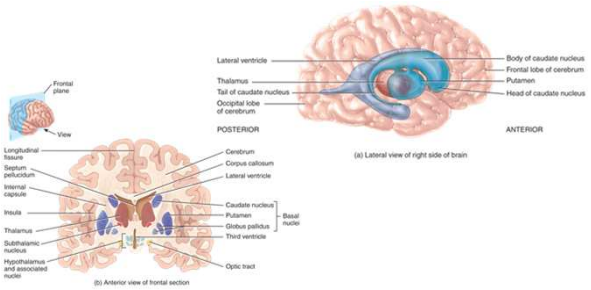


Medial view of tracts revealed by removing gray matter from a midsagittal section

From N. Gluhbegovic and T.H. Williams, The Human Brain: A Photographic Guide, Harper and Row, Publishers, Inc. Hagerstown, MD, 1980. Reproduced with permission

Basal Nuclei of the Cerebrum

The basal nuclei are paired masses of gray matter in each cerebral hemisphere

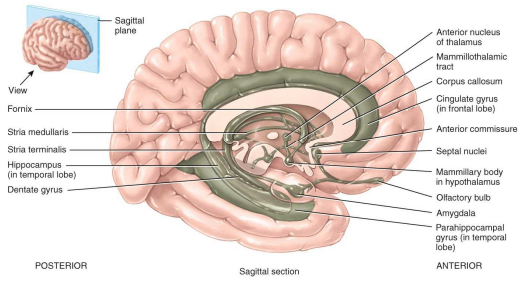


(a) Lateral view of right side of brain

(b) Anterior view of frontal section

The Limbic System

The limbic system is found in the cerebral hemispheres and diencephalon

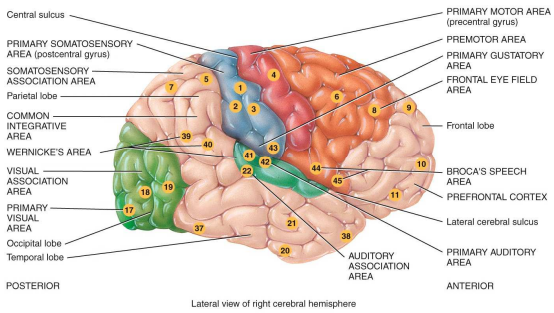


Functional Organization of the Cerebral Cortex

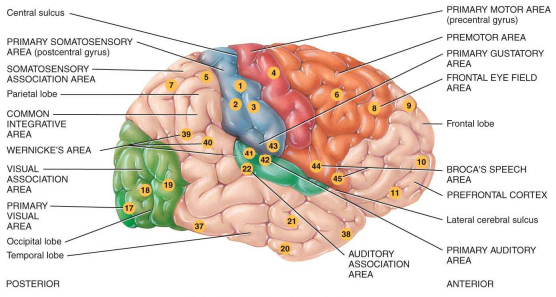
Specific types of sensory, motor, and integrative signals are processed in certain regions of the cerebral cortex. There are:

- Sensory areas
- Motor areas
- Association areas

Sensory Areas of the Cerebral Cortex

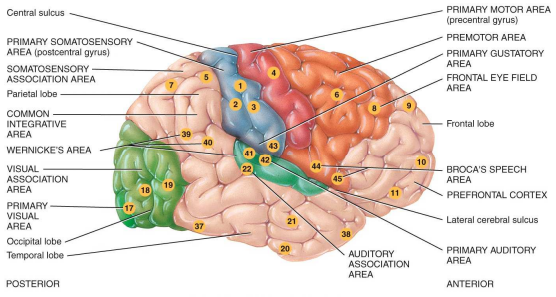


Motor Areas of the Cerebral Cortex



Lateral view of right cerebral hemisphere

Association Areas of the Cerebral Cortex



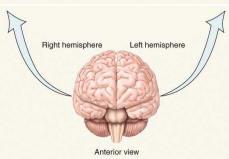
Lateral view of right cerebral hemisphere

Hemispheric Lateralization

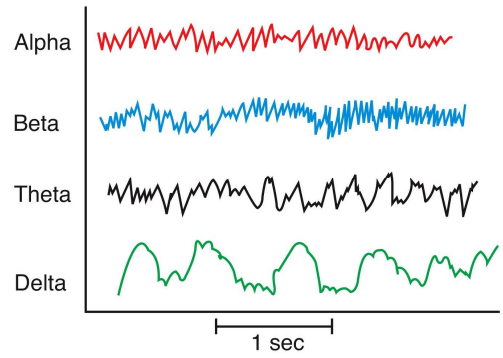
TABLE 14.3

Functional Differences between Right and Left Hemispheres

RIGHT HEMISPHERE FUNCTIONS	LEFT HEMISPHERE FUNCTIONS
Receives somatic sensory signals from, and controls muscles on, left side of body.	Receives somatic sensory signals from, and controls muscles on, right side of body.
Musical and artistic awareness.	Reasoning.
Space and pattern perception.	Numerical and scientific skills.
Recognition of faces and emotional content of facial expressions.	Ability to use and understand sign language.
Generating emotional content of language.	Spoken and written language.
Generating mental images to compare spatial relationships.	Persons with damage in the left hemisphere often exhibit aphasia.
Identifying and discriminating among odors.	
Patients with damage in right hemisphere regions that correspond to Broca's and Wernicke's areas in the left hemisphere speak in a monotonous voice, having lost the ability to impart emotional inflection to what they say.	



Brain Waves



Cranial Nerves

TABLE 14.4
Summary of Cranial Nerves*

CRANIAL NERVE	COMPONENTS	PRINCIPAL FUNCTIONS
Olfactory (I)	*Special sensory*	Olfaction (smell).
Optic (II)	*Special sensory*	Vision (sight).
Oculomotor (III)	*Motor*	
	Somatic	Movement of eyeballs and upper eyelid.
	Motor (autonomic)	Adjusts lens for near vision (accommodation).
		Constriction of pupil.
Trochlear (IV)	*Motor*	
	Somatic	Movement of eyeballs.
Trigeminal (V)	*Mixed*	
	Sensory	Touch, pain, and thermal sensations from scalp, face, and oral cavity (including teeth and anterior two-thirds of tongue).
	Motor (branchial)	Chewing and controls middle ear muscle.
Abducens (VI)	*Motor*	
	Somatic	Movement of eyeballs.
Facial (VII)	*Mixed*	
	Sensory	Taste from anterior two-thirds of tongue.
		Touch, pain, and thermal sensations from skin in external ear canal.
	Motor (branchial)	Control of muscles of facial expression and middle ear muscle.
	Motor (autonomic)	Secretion of tears and saliva.
Vestibulocochlear (VIII)	*Special sensory*	Hearing and equilibrium.

Cranial Nerves

TABLE 14.4
Summary of Cranial Nerves*

CRANIAL NERVE	COMPONENTS	PRINCIPAL FUNCTIONS
Glossopharyngeal (IX)	*Mixed*	
	Sensory	Taste from posterior one-third of tongue.
		Proprioception in some swallowing muscles.
		Monitors blood pressure and oxygen and carbon dioxide levels in blood.
		Touch, pain, and thermal sensations from skin of external ear and upper pharynx.
	Motor (branchial)	Assists in swallowing.
	Motor (autonomic)	Secretion of saliva.
Vagus (X)	*Mixed*	
	Sensory	Taste from epiglottis.
		Proprioception from throat and voice box muscles.
		Monitors blood pressure and oxygen and carbon dioxide levels in blood.
		Touch, pain, and thermal sensations from skin of external ear.
		Sensations from thoracic and abdominal organs.
	Motor (branchial)	Swallowing, vocalization, and coughing.
	Motor (autonomic)	Motility and secretion of gastrointestinal organs.
		Constriction of respiratory passageways.
		Decreases heart rate.
Accessory (XI)	*Motor*	
	Branchial	Movement of head and pectoral girdle.
Hypoglossal (XII)	*Motor*	
	Somatic	Speech, manipulation of food, and swallowing.

*MNEMONIC FOR CRANIAL NERVES:

Oh	Oh	Oh	To	Touch	And	Feel	Very	Green	Vegetables	AH!	
Olfactory	Optic	Oculomotor	Trochlear	Trigeminal	Abducens	Facial	Vestibulocochlear	Glossopharyngeal	Vagus	Accessory	Hypoglossal

Cranial Nerve

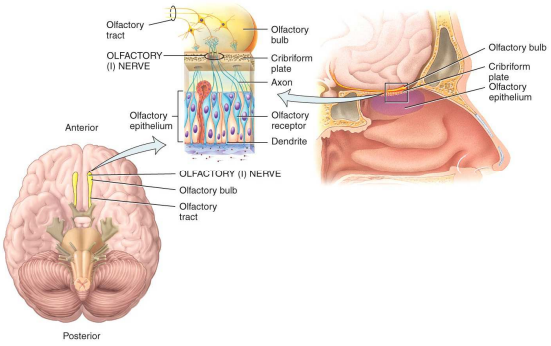
Anatomy Overview:

- The Nervous System: Overview

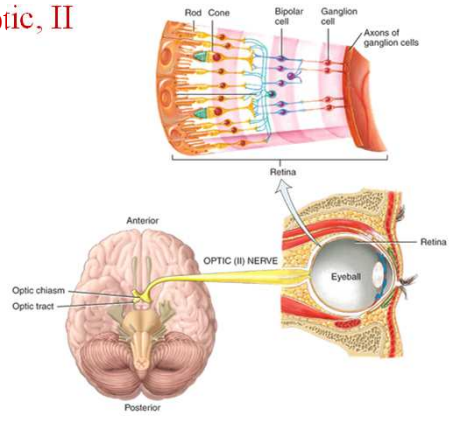
  Once in the animation, click on "cranial nerves"

You must be connected to the Internet and in Slideshow Mode to run this animation.

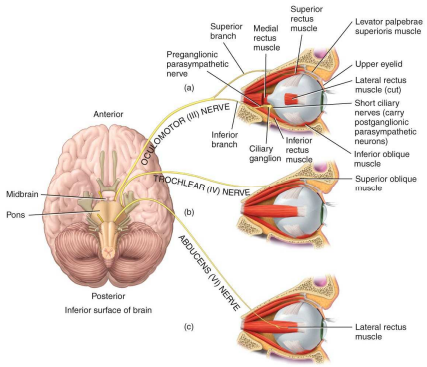
Olfactory, I



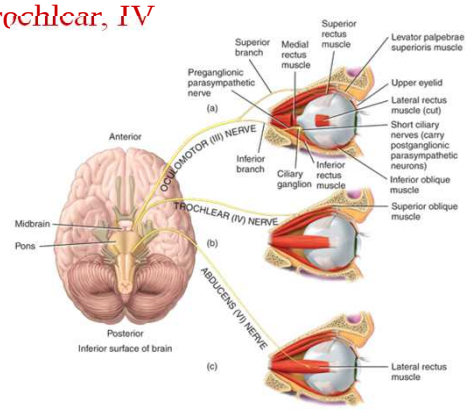
Optic, II



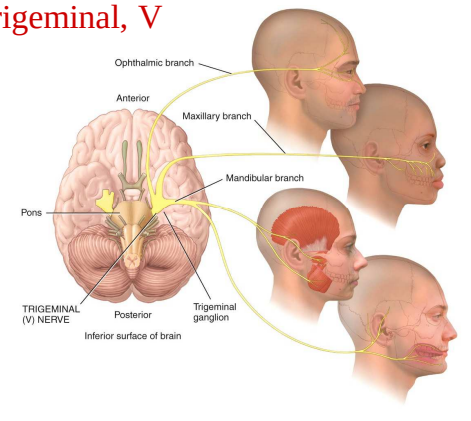
Oculomotor, III



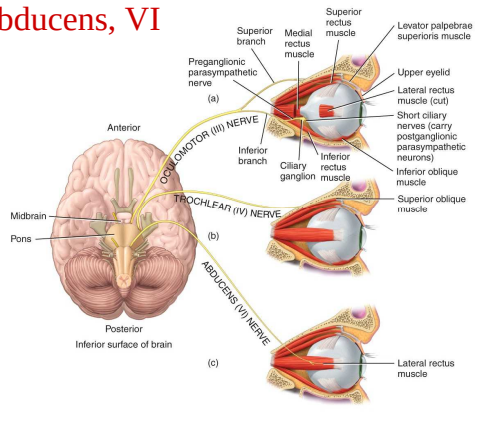
Trochlear, IV



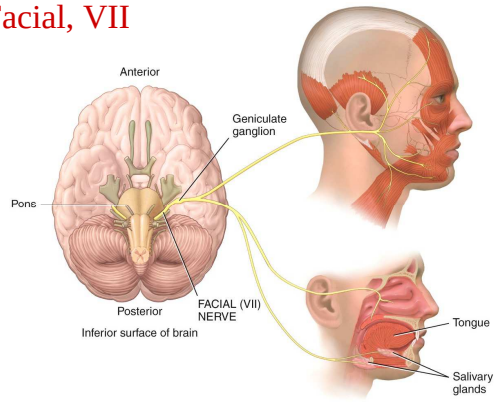
Trigeminal, V



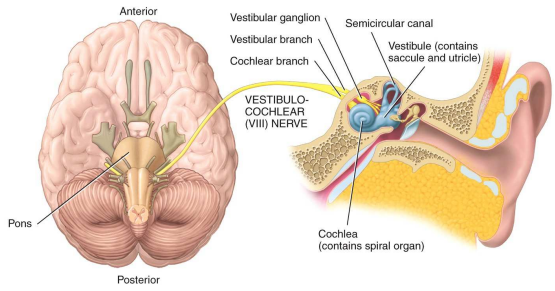
Abducens, VI



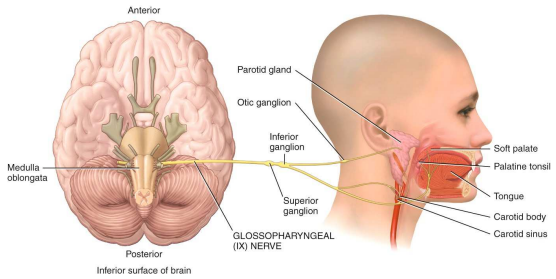
Facial, VII



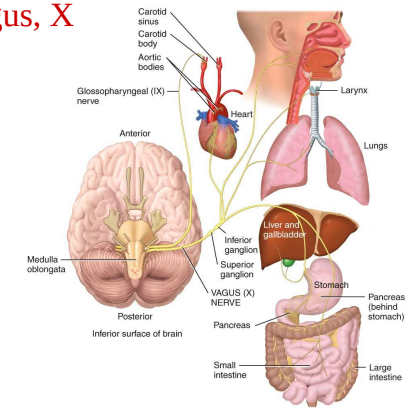
Vestibulocochlear, VIII



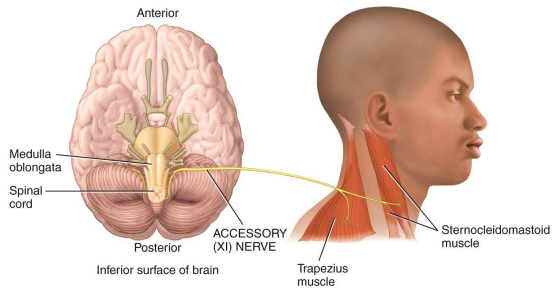
Glossopharyngeal, IX



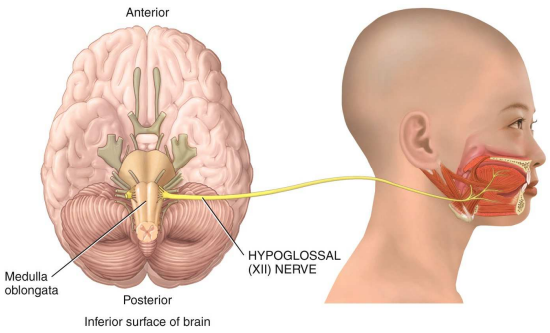
Vagus, X



Accessory, XI

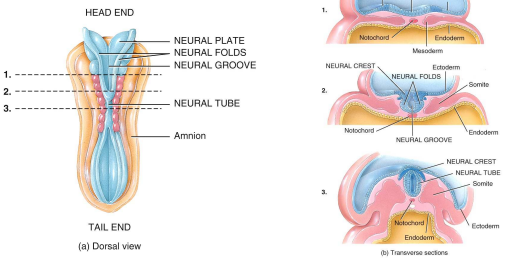


Hypoglossal, XII



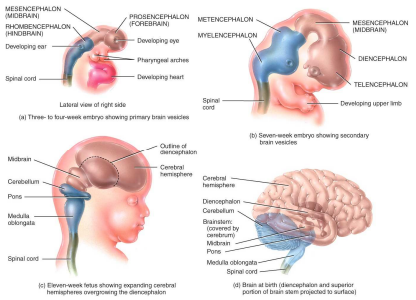
Development of the Nervous System

The development of the nervous system begins with a thickening of the ectoderm called the neural plate



Development of the Nervous System

The parts of the brain develop from secondary vesicles



Aging and the Nervous System

Aging can result in:

- Loss of neurons
- Diminished capacity for sending nerve impulses to and from the brain
- Diminished ability to process information
- Decreased conduction velocity
- Slowing of voluntary motor movements
- Increased reflex time
- Degenerative changes in vision, hearing, sight, taste, smell, touch, and balance

Disorders: Homeostatic Imbalances

- Cerebrovascular accident (stroke)
- Transient ischemic attack (TIA)
- Alzheimer's disease

End of Chapter 14