The Human Brain: Anatomy, Functions, and Injury
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Brain Anatomy Menu

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  The Medulla Oblongata
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Skull Anatomy

The skull is a rounded layer of bone designed to protect the brain from penetrating injuries.

Blood Vessels of the Skull
Rough Interior of Skull

Anatomy Menu
Main Menu
The base of the skull is rough, with many bony protuberances. These ridges can result in injury to the temporal lobe of the brain during rapid acceleration.
The brain requires a rich blood supply, and the space between the skull and cerebrum contains many blood vessels. These blood vessels can be ruptured during trauma, resulting in bleeding.

Groove for middle meningeal artery
Arteries of the Brain

The human brain requires a constant supply of oxygen. A lack of oxygen of just a few minutes results in irreversible damage to the brain.
The Neuron

Dendrites: Collects information from other neurons.

Cell Body

Axon: Transmits information to other neurons.
The Meninges

The meninges are layers of tissue that separate the skull and the brain.
External Brain Structures

Cerebrum

Cerebellum

Cerebral Hemisphere

Brainstem
The largest portion of the brain is the cerebrum. It consists of two hemispheres that are connected together at the corpus callosum.

The cerebrum is often divided into five lobes that are responsible for different brain functions.
The cerebrum’s surface—the neocortex—is convoluted into hundreds of folds.

The neocortex is where all the higher brain functions take place.
The cerebral cortex is a thin layer of cells about 1.5 to 4 mm thick.

The cortex provides the connections and pathways for the highest cognitive functions, such as language and abstract thinking.

The cerebral cortex contains about 25 billion neurons, more than 62,000 miles of axons, and 300,000,000,000,000 synapses.
Frontal Lobe

The frontal lobe is the area of the brain responsible for higher cognitive functions.

These include:

- Problem solving
- Spontaneity
- Memory
- Language
- Motivation
- Judgment
- Impulse control
- Social and sexual behavior.
Temporal Lobe

The temporal lobe plays a role in emotions, and is also responsible for smelling, tasting, perception, memory, understanding music, aggressiveness, and sexual behavior.

The temporal lobe also contains the language area of the brain.
The parietal lobe plays a role in our sensations of touch, smell, and taste. It also processes sensory and spatial awareness, and is a key component in eye-hand co-ordination and arm movement.

The parietal lobe also contains a specialized area called Wernicke’s area that is responsible for matching written words with the sound of spoken speech.
The occipital lobe is at the rear of the brain and controls **vision** and recognition.
Precentral gyrus
Central sulcus
Postcentral gyrus
Temporal lobe
Occipital lobe
Lateral sulcus, sylvian fissure
Lateral view of brain

- Parietal lobe
- Frontal lobe
- Occipital lobe
- Lateral sulcus
- Temporal lobe
- Cerebellum
Superior view of brain

- Central sulcus
- Precentral gyrus
- Postcentral gyrus
- Longitudinal fissure
Ventral view of brain

- Olfactory bulb
- Optic nerve chiasma
- 3rd nerve, oculomotor
- 4th, trochlear nerve
- 5th, trigeminal nerve
- 6th, abducent nerve
- 7th, facial nerve
- 8th, cochlear-vestibular
- 9th, Glossopharyngeal nerve
- 10th, vagus nerve
- 11th, Spinal accessory n
- 12th, hypoglossal nerve
The limbic lobe is located deep in the brain, and makes up the limbic system.
The Limbic System

The limbic system is the area of the brain that regulates emotion and memory. It directly connects the lower and higher brain functions.

A. Cingulate gyrus  
B. Fornix  
C. Anterior thalamic nuclei  
D. Hypothalamus  
E. Amygdaloid nucleus  
F. Hippocampus
Cerebellum

The cerebellum is connected to the brainstem, and is the center for body movement and balance.
Thalamus

Thalamus means “inner room” in Greek, as it sits deep in the brain at the top of the brainstem.

The thalamus is called the gateway to the cerebral cortex, as nearly all sensory inputs pass through it to the higher levels of the brain.
The hypothalamus sits under the thalamus at the top of the brainstem. Although the hypothalamus is small, it controls many critical bodily functions:

- Controls autonomic nervous system
- Center for emotional response and behavior
- Regulates body temperature
- Regulates food intake
- Regulates water balance and thirst
- Controls sleep-wake cycles
- Controls endocrine system

The hypothalamus is shaded blue. The pituitary gland extends from the hypothalamus.
The Medulla Oblongata

The medulla oblongata merges seamlessly with the spinal cord and creates the base of the **brainstem**.

The medulla is primarily a control center for vital involuntary reflexes such as swallowing, vomiting, sneezing, coughing, and regulation of cardiovascular and respiratory activity.

The medulla is also the origin of many **cranial nerves**.
The Pons

The pons is the rounded brainstem region between the midbrain and the medulla oblongata. In fact, pons means “bridge” in Latin.

The main function of the pons is to connect the cerebellum to the rest of the brain and to modify the respiratory output of the medulla.

The pons is the origin of several cranial nerves.
The Ventricles

The ventricles are a complex series of spaces and tunnels through the center of the brain.

The ventricles secrete cerebrospinal fluid, which suspends the brain in the skull.

The ventricles also provide a route for chemical messengers that are widely distributed through the central nervous system.
Cerebrospinal fluid is a colorless liquid that bathes the brain and spine. It is formed within the ventricles of the brain, and it circulates throughout the central nervous system.

Cerebrospinal fluid fills the ventricles and meninges, allowing the brain to “float” within the skull.
The Brainstem

The brainstem is the most primitive part of the brain and controls the basic functions of life: breathing, heart rate, swallowing, reflexes to sight or sound, sweating, blood pressure, sleep, and balance.

The brainstem can be divided into three major sections.

Detailed brainstem anatomy.
Brainstem Components

More Information:
- Medulla
- Thalamus
- Pons

Anatomy Menu
Main Menu
Brainstem Divisions

- Midbrain
- Pons
- Medulla Oblongata
The Cranial Nerves

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

The brain is a complex and delicate organ, and one that is vulnerable to injury from a variety of different traumas. These include:

- Frontal Lobe Injury
- Occipital Lobe Injury
- Temporal Lobe Injury
- Side Impact Injury
- Coup/Contre-coup Injury
- Diffuse Axonal Injury
- Epidural Hematoma
- Subdural Hematoma
Frontal Lobe Injury

The **frontal lobe** of the brain can be injured from direct impact on the front of the head.

During impact, the brain tissue is accelerated forward into the bony skull. This can cause bruising of the brain tissue and tearing of blood vessels.

Frontal lobe injuries can cause changes in personality, as well as many different kinds of disturbances in cognition and memory.
Occipital lobe injuries occur from blows to the back of the head. This can cause bruising of the brain tissue and tearing of blood vessels. These injuries can result in vision problems or even blindness.
Temporal Lobe Injury

The temporal lobe of the brain is vulnerable to injury from impacts of the front of the head.

The temporal lobe lies upon the bony ridges of the inside of the skull, and rapid acceleration can cause the brain tissue to smash into the bone, causing tissue damage or bleeding.
Side Impact Injury

Injuries to the right or left side of the brain can occur from injuries to the side of the head.

Injuries to this part of the brain can result in language or speech difficulties, and sensory or motor problems.
Coup/Contre-coup Injury

A French phrase that describes bruises that occur at two sites in the brain.

When the head is struck, the impact causes the brain to bump the opposite side of the skull. Damage occurs at the area of impact and on the opposite side of the brain.
Diffuse Axonal Injury

Brain injury does not require a direct head impact. During rapid acceleration of the head, some parts of the brain can move separately from other parts. This type of motion creates shear forces that can destroy axons necessary for brain functioning.

These shear forces can stretch the **nerve bundles** of the brain.

More on diffuse axonal injury.
Diffuse Axonal Injury

The brain is a complex network of interconnections. Critical nerve tracts can be sheared and stressed during an acceleration-type of injury.

Diffuse axonal injury is a very serious injury, as it directly impacts the major pathways of the brain.
An epidural hematoma is a blood clot that forms between the skull and the top lining of the brain (dura).

This blood clot can cause fast changes in the pressure inside the brain.

When the brain tissue is compressed, it can quickly result in compromised blood flow and neuron damage.
A subdural hematoma is a blood clot that forms between the dura and the brain tissue.

The clot may cause increased pressure and may need to be removed surgically.

When the brain tissue is compressed, it can quickly result in compromised blood flow and tissue damage.
Brain Functions

- Vision
- Taste
- Cognition
- Emotion
- Speech
- Language
- Hearing
- Motor Cortex
- Sensory Cortex
- Autonomic Functions

Main Menu
Vision

The visual cortex resides in the **occipital lobe** of the brain.

Sensory impulses travel from the eyes via the **optic nerve** to the visual cortex.

Damage to the visual cortex can result in blindness.
Taste

The gustatory complex (green circle) is the part of the sensory cortex (purple area) that is responsible for taste.
Cognition

The prefrontal cortex is involved with intellect, complex learning, and personality.

Injuries to the front lobe can cause mental and personality changes.
Emotions are an extremely complex brain function. The emotional core of the brain is the **limbic system**. This is where senses and awareness are first processed in the brain.

Mood and personality are mediated through the **prefrontal cortex**. This part of the brain is the center of higher cognitive and emotional functions.
Broca’s area is where we formulate speech and the area of the brain that sends motor instructions to the motor cortex. Injury to Broca’s area can cause difficulty in speaking. The individual may know what words he or she wishes to speak, but will be unable to do so.
Wernicke’s area is a specialized portion of the parietal lobe that recognizes and understands written and spoken language. Wernicke’s area surrounds the auditory association area. Damage to this part of the brain can result in someone hearing speech, but not understanding it.
Hearing

There are two auditory areas of the brain:

• The primary auditory area (brown circle) is what detects sounds that are transmitted from the ear. It is located in the sensory cortex.

• The auditory association area (purple circle) is the part of the brain that is used to recognize the sounds as speech, music, or noise.
Motor Cortex

The motor portion of the cerebrum is illustrated here. The light red area is the premotor cortex, which is responsible for repetitive motions of learned motor skills. The dark red area is the primary motor area, and is responsible for control of skeletal muscles.

Different areas of the brain are associated with different parts of the body.

Injury to the motor cortex can result in motor disturbance in the associated body part.

Functions Menu
Main Menu
Sensory Cortex

The sensory portion of the cerebrum is illustrated here.

Different areas of the brain are associated with different parts of the body, as can be seen below.

Injury to the sensory cortex can result in sensory disturbance in the associated body part.
The brainstem controls the basic functions of life. Damage to these areas of the brain are usually fatal:

• The pons plays a critical role in respiration.

• The medulla oblongata is responsible for respiration and cardiovascular functions.
Bibliography

The following are excellent resources and were the basis of the anatomical and functional components of this presentation:

