Anatomy and Physiology

Nervous System

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The Cerebrum

Cerebrum, the largest and uppermost portion of the brain.
The cerebrum consists of the cerebral hemispheres and accounts for two-thirds of the total weight of the brain.
The cerebral hemispheres consist,

- **The white matter** of an inner core of myelinated nerve fibres. Nerve fibres in the white matter primarily connect functional areas of the cerebral cortex.
- **The outer cortex of gray matter**. The gray matter of the cerebral cortex usually is divided into four lobes.

Functions:

- The cerebral cortex is responsible for integrating sensory impulses,
- It directing motor activity,
- It controls higher intellectual functions.

The gray matter of the cerebral cortex usually is divided into four lobes.

1. The frontal lobe contains control centres for motor activity and speech,
2. The parietal for somatic senses (touch and position),
3. The temporal for auditory reception and memory,
4. The occipital for visual reception.
   Sometimes the limbic lobe, involved with smell, taste, and emotions, is considered to be a fifth lobe.

- Numerous deep grooves in the cerebral cortex, called cerebral fissures, originate in the extensive folding of the brain's surface.
- The main cerebral fissures are the lateral fissure, or fissure of Sylvius, between the frontal and temporal lobes; the central fissure, or fissure of Rolando, between the frontal and parietal lobes, which separates the chief motor and sensory regions of the brain;
  the calcarine fissure on the occipital lobe, which contains the visual cortex; the parieto-occipital fissure, which separates the parietal and occipital lobes; the transverse fissure, which divides the cerebrum from the cerebellum; and the longitudinal fissure, which divides the cerebrum into two hemispheres.
- A thick band of white matter that connects the two hemispheres, called the corpus callosum, allows the integration of sensory input and functional responses from both sides of the body.
- Other cerebral structures include the hypothalamus, which controls metabolism and maintains homeostasis,
- The thalamus, a principal sensory relay centre.
- These structures surround spaces (ventricles) filled with cerebrospinal fluid, which helps to supply the brain cells with nutrients and provides the brain with shock-absorbing mechanical support.

Lobes of the brain

- The cerebral hemispheres have distinct fissures, which divide the brain into lobes. Each hemisphere has 4 lobes: frontal, temporal, parietal, and occipital.
- Each lobe may be divided, once again, into areas that serve very specific functions.

- There are very complex relationships between the lobes of the brain and between the right and left hemispheres.

Frontal lobe
Personality, behavior, emotions
Judgment, planning, problem solving
Speech: speaking and writing (Broca's area)
Body movement (motor strip)
Intelligence, concentration, self awareness

Parietal lobe
Interprets language, words
Sense of touch, pain, temperature (sensory strip)
Interprets signals from vision, hearing, motor, sensory and memory
Spatial and visual perception

Occipital lobe
Interprets vision (color, light, movement)

Temporal lobe
Understanding language (Wernicke's area)
Memory
Hearing
Sequencing and organization

Language
In general, the left hemisphere of the brain is responsible for language and speech and is called the "dominant" hemisphere. The right hemisphere plays a large part in interpreting visual information and spatial processing. In about one third of people who are left-handed, speech function may be located on the right side of the brain. Left-handed people may need special testing to determine if their speech center is on the left or right side prior to any surgery in that area.
Aphasia is a disturbance of language affecting speech production, comprehension, reading or writing, due to brain injury – most commonly from stroke or trauma. The type of aphasia depends on the brain area damaged.

Broca's area:
It lies in the left frontal lobe. If this area is damaged, one may have difficulty moving the tongue or facial muscles to produce the sounds of speech. The person can still read and understand spoken language but has difficulty in speaking and writing (i.e. forming letters and words, doesn't write within lines) – called Broca's aphasia.

Wernicke's area:
It lies in the left temporal lobe. Damage to this area causes Wernicke's aphasia. The individual may speak in long sentences that have no meaning, add unnecessary words, and even create new words. They can make speech sounds; however, they have difficulty understanding speech and are therefore unaware of their mistakes.

Cortex
The surface of the cerebrum is called the cortex. It has a folded appearance with hills and valleys. The cortex contains 16 billion neurons (the cerebellum has 70 billion = 86 billion total) that are arranged in specific layers. The nerve cell bodies color the cortex grey-brown giving it its name – gray matter. Beneath the cortex are long nerve fibers (axons) that connect brain areas to each other — called white matter.
The folding of the cortex increases the brain's surface area allowing more neurons to fit inside the skull and enabling higher functions. Each fold is called a gyrus, and each groove between folds is called a sulcus. There are names for the folds and grooves that help define specific brain regions.

Hypothalamus:
Hypothalamus is located in the floor of the third ventricle and is the master control of the autonomic system. It plays a role in controlling behaviors such as hunger, thirst, sleep, and sexual response. It also regulates body temperature, blood pressure, emotions, and secretion of hormones.
Pituitary gland: lies in a small pocket of bone at the skull base called the sella turcica. The pituitary gland is connected to the hypothalamus of the brain by the pituitary stalk. Known as the "master gland," it controls other endocrine glands in the body. It secretes hormones that control sexual development, promote bone and muscle growth, and respond to stress.
Pineal gland: is located behind the third ventricle. It helps regulate the body's internal clock and circadian rhythms by secreting melatonin. It has some role in sexual development.
Thalamus: serves as a relay station for almost all information that comes and goes to the cortex. It plays a role in pain sensation, attention, alertness and memory.
Basal ganglia: includes the caudate, putamen and globus pallidus. These nuclei work with the cerebellum to coordinate fine motions, such as fingertip movements.
Limbic system: is the center of our emotions, learning, and memory. Included in this system are the cingulate gyri, hypothalamus, amygdala (emotional reactions) and hippocampus (memory).
Memory
Memory is a complex process that includes three phases: encoding (deciding what information is important), storing, and recalling. Different areas of the brain are involved in different types of memory. Your brain has to pay attention and rehearse in order for an event to move from short-term to long-term memory – called encoding.
Short-term memory, also called working memory, occurs in the prefrontal cortex. It stores information for about one minute and its capacity is limited to about 7 items. For example, it enables you to dial a phone number someone just told you. It also intervenes during reading, to memorize the sentence you have just read, so that the next one makes sense.
Long-term memory is processed in the hippocampus of the temporal lobe and is activated when you want to memorize something for a longer time. This memory has unlimited content and duration capacity. It contains personal memories as well as facts and figures.
Skill memory is processed in the cerebellum, which relays information to the basal ganglia. It stores automatic learned memories like tying a shoe, playing an instrument, or riding a bike.
Ventricles and cerebrospinal fluid
The brain has hollow fluid-filled cavities called ventricles. Inside the ventricles is a ribbon-like structure called the choroid plexus that makes clear colorless cerebrospinal fluid (CSF). CSF flows within and around the brain and spinal cord to help cushion it from injury. This circulating fluid is constantly being absorbed and replenished.
CSF is produced inside the ventricles deep within the brain.
CSF fluid circulates inside the brain and spinal cord and then outside to the subarachnoid space.
Common sites of obstruction: 1) foramen of Monro, 2) aqueduct of Sylvius, and 3) obex.
There are two ventricles deep within the cerebral hemispheres called the lateral ventricles. They both connect with the third ventricle through a separate opening called the foramen of Monro. The third ventricle connects with the fourth ventricle through a long narrow tube called the aqueduct of Sylvius. From the fourth ventricle, CSF flows into the subarachnoid space where it bathes and cushions the brain. CSF is recycled (or absorbed) by special structures in the superior sagittal sinus called arachnoid villi.
A balance is maintained between the amount of CSF that is absorbed and the amount that is produced. A disruption or blockage in the system can cause a build up of CSF, which can

cause enlargement of the ventricles (hydrocephalus) or cause a collection of fluid in the spinal cord (syringomyelia).

Cranial nerves

The brain communicates with the body through the spinal cord and twelve pairs of cranial nerves. Ten of the twelve pairs of cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movement of the face, neck, shoulder and tongue muscles originate in the brainstem. The cranial nerves for smell and vision originate in the cerebrum. The Roman numeral, name, and main function of the twelve cranial nerves:

Number	Name	Function
I	**olfactory**	**smell**
II	**optic**	**sight**
III	**oculomotor**	**moves eye, pupil**
IV	**trochlear**	**moves eye**
V	**trigeminal**	**face sensation**
VI	**abducens**	**moves eye**
VII	**facial**	**moves face, salivate**
VIII	**vestibulocochlear**	**hearing, balance**
IX	**glossopharyngeal**	**taste, swallow**
X	**vagus**	**heart rate, digestion**
XI	**accessory**	**moves head**
XII	**hypoglossal**	**moves tongue**

Meninges

The brain and spinal cord are covered and protected by three layers of tissue called meninges. From the outermost layer inward they are: the dura mater, arachnoid mater, and pia mater.

Dura mater: is a strong, thick membrane that closely lines the inside of the skull; its two layers, the periosteal and meningeal dura, are fused and separate only to form venous sinuses. The dura creates little folds or compartments. There are two special dural folds, the falx and the tentorium. The falx separates the right and left hemispheres of the brain and the tentorium separates the cerebrum from the cerebellum.

Arachnoid mater: is a thin, web-like membrane that covers the entire brain. The arachnoid is made of elastic tissue. The space between the dura and arachnoid membranes is called the subdural space.

Pia mater: hugs the surface of the brain following its folds and grooves. The pia mater has many blood vessels that reach deep into the brain. The space between the arachnoid and pia is called the subarachnoid space. It is here where the cerebrospinal fluid bathes and cushions the brain.

Blood supply

Blood is carried to the brain by two paired arteries, the internal carotid arteries and the vertebral arteries. The internal carotid arteries supply most of the cerebrum.

The common carotid artery courses up the neck and divides into the internal and external carotid arteries. The brain's anterior circulation is fed by the internal carotid arteries (ICA) and the posterior circulation is fed by the vertebral arteries (VA). The two systems connect at the Circle of Willis (green circle).

The vertebral arteries supply the cerebellum, brainstem, and the underside of the cerebrum. After passing through the skull, the right and left vertebral arteries join together to form the basilar artery. The basilar artery and the internal carotid arteries "communicate" with each other at the base of the brain called the Circle of Willis. The communication between the

internal carotid and vertebral-basilar systems is an important safety feature of the brain. If one of the major vessels becomes blocked, it is possible for collateral blood flow to come across the Circle of Willis and prevent brain damage.

The internal carotid and vertebral-basilar systems are joined by the anterior communicating (Acom) and posterior communicating (Pcom) arteries.

The venous circulation of the brain is very different from that of the rest of the body. Usually arteries and veins run together as they supply and drain specific areas of the body. So one would think there would be a pair of vertebral veins and internal carotid veins. However, this is not the case in the brain. The major vein collectors are integrated into the dura to form venous sinuses — not to be confused with the air sinuses in the face and nasal region. The venous sinuses collect the blood from the brain and pass it to the internal jugular veins. The superior and inferior sagittal sinuses drain the cerebrum, the cavernous sinuses drains the anterior skull base. All sinuses eventually drain to the sigmoid sinuses, which exit the skull and form the jugular veins. These two jugular veins are essentially the only drainage of the brain.