The Brain and Cranial Nerves

For this lecture you should consult the following diagrams on the Human Anatomy web page:

- Components of the central nervous system
- Brain: lateral view
- Brain: midsagittal view
- Some clinically relevant areas of the brain
- Brain: diencephalon and brainstem
- Brain ventricles: anterior view
- Brain ventricles: lateral and superior views
- Brain ventricles: 3D animation
- Brainstem/cranial nerves
- Anterior view
- Lateral view

The Central Nervous System

The central nervous system consists of the brain and spinal cord. In this lecture we will focus on various regions of the brain and brainstem as well as the cranial nerves, most of which arise from the brainstem. Recall that the brain is located inside the cranial vault, and the spinal cord is located within the vertebral canal.

The brain can be divided into several regions, however, for the purposes of this course we will not discuss all of these regions. We will divide the brain into the cerebrum, the cerebellum, and the brainstem.

The cerebrum is the potion of the brain that is used in thought processes and in the initiation of movement. Portions of the cerebrum play a role in emotions, etc but will not be discussed in this course. The cerebellum (which literally means "little brain") is involved in coordinating fine motor movements and in "cerebellar memory." The brainstem has many functions. Eleven of our 12 pair of cranial nerves arise from the brainstem.

A lateral view of the right side of the brain

Let us first look at a lateral view of the right side of the brain. The cerebrum is covered by many folds. The raised areas are known as gyri (gyrus singular) and the depressions are known as sulci (sulcus singular). This folding greatly increases the surface area of the brain. In the brain neuron cell bodies are located in gray matter. The gray matter is located in the outer most 1 centimeter of brain tissue (on the surface of the brain). This means the greater the surface area the more gray matter. And the more gray matter, the more neurons. Presumably the more neurons, the higher the intelligence (or at least the more complex the nervous system). Within the central nervous system we have gray matter and white matter. We have already mentioned that gray matter contains neuron cell bodies. The white matter consists of the axons and dendrites of these neurons and represents fiber tracts. There are collections of neuron cell bodies within the central nervous system that are not located along the surface. These collections of neuron cell bodies are known as nuclei. We will discuss some of the nuclei of the central nervous system and fiber tracts later in this lecture.

The cerebrum of the brain is divided into 4 (sometimes 5 lobes). These lobes are separated by various gyri. Each gyrus and sulcus on the brain has a name and a number but we will only learn a few of these names. If we look at just the cerebrum of the brain we might imagine that it looks a little like a boxing glove. The thumb of the glove is the Temporal lobe. It is separated from the frontal lobe (the front of the glove) by the lateral sulcus. On the lateral side of the brain leading down from the midline to the lateral sulcus we can see the central sulcus. The portion of the cerebrum anterior to the central sulcus is the frontal lobe. The frontal lobe is predominantly a motor lobe, that is it is used for initiating movements. The gyrus immediately anterior to the central sulcus is known as the precentral gyrus. The precentral gyrus is considered to be the primary motor cortex. Posterior to the central sulcus we will find the parietal lobe. The parietal lobe is predominantly a sensory lobe. Immediately posterior to the central sulcus is the postcentral gyrus. The postcentral gyrus is considered to be the primary sensory cortex. The parietal lobe extends posteriorly from the central sulcus to the parietooccipital notch, and inferiorly down to the level of the lateral sulcus (and an imaginary line extending posteriorly from the lateral sulcus). Posterior to the parietoocciptal sulcus we can see the occipital lobe. The occipital lobe is also a sensory lobe, but is specialized for vision. Below the posterior portion of the temporal lobe and the occipital lobe, we can see the transverse fissure, that separates the cerebellum from the cerebrum. Projecting inferiorly from the middle of the cerebrum and anteriorly to the cerebellum, we can see two portions of the brainstem, the pons and the medulla oblongata. Some texts will also talk about the insular lobe of the cerebrum. This area of the brain can be seen if we pull the temporal lobe inferiorly and look deep to it. Also note that the cerebrum is divided into right and left hemispheres which are separated by the longitudinal fissure (not visible in a lateral view).

A midsagittal view of the right side of the brain

Now let us look at a midsagittal view of the right side of the brain. In this view we did not have to cut any tissue as we passed down through the longitudinal fissure. However at the bottom of the longitudinal fissure we encounter a structure known as the corpus callosum. This structure consists of fiber tracts which connect the two hemispheres of the brain. In our diagram we will also see a large portion of the brainstem has been removed for clarification. In the midsagittal view of the brain we can only see a small portion of the central sulcus as it passed over the top of the brain. A line drawn from the central sulcus down to the corpus callosum at a slightly anterior angle, delineates the frontal lobe from the parietal lobe. Within the frontal lobe, immediately superior to the corpus callosum, we see a gyrus known as the cingulate gyrus. This gyrus is separated from the next superior gyrus by the cingulate sulcus. In a midsagittal view on the brain we see a sulcus leading inferiorly and anteriorly from the parietooccipital notch. This sulcus is known as the parietooccipital sulcus. Posterior to the sulcus we see the occipital lobe. Passing in an anterior to posterior direction within the occipital lobe we see another sulcus known as the calcarine sulcus. With the brainstem removed we have a good view of the medial aspect of the temporal lobe.

The diencephalon and brainstem

In our diagram of the diencephalon and brainstem, we can see an enlarged view of some of the structures of the brainstem, and how they relate to the surrounding cerebrum. As was stated earlier, the corpus callosum is a collection of fiber tracts that connect the two sides of the cerebrum. Fiber tracts which connect from side to side, are known as commissural fibers. The corpus callosum is the largest single collection of commissural fibers in the human body. Immediately inferior to the corpus callosum, directly on the midline of the brain, we will find a thin wall of tissue known as the septum pellucidum. This structure forms a wall, or septum, between the two lateral ventricles. On either side of midline at the top of the brainstem we will find a structure known as the thalamus. We will discuss more about the thalamus later however, at this time we will simply say that the thalamus forms the lateral wall of the third ventricle. There is a thalamus in the left side of the brain, as well as the right side of the brain. These two portions of the thalamus are connected across the midline by a structure known as the massa intermedia. This structure can be seen in a midsagittal section of the brain, because it had to be cut to produce the midsagittal section. Inferior and slightly anterior to the thalamus is a smooth area known as the hypothalamus. At the junction of the septum pellucidum and the hypothalamus there is a small area known as the anterior commisure. Hanging down below the hypothalamus we will find a small stalk known as the infundibulum. At the distal end of the infundibulum we will find the pituitary gland. The pituitary gland makes many endocrine hormones. The pituitary gland is nicknamed the master gland of the body. This nickname was applied before the true physiology of the gland was known. It is now known that the pituitary gland performs its functions mainly based on information that is sent to it from the hypothalamus. So although it is known as the master gland of the body, it receives its orders from the hypothalamus. Immediately anterior to the infundibulum we will find the optic chiasm. We will discuss the optic chiasm in greater detail when we learn about the cranial nerves, and when we discuss visual pathways. Immediately posterior to the infundibulum, on either side of midline, we will find a small round projection. Together these two projections are known as the mammillary bodies. We will see that the mammillary bodies act as relay centers in our olfactory pathways (for the sense of smell). Immediately posterior and superior to the posterior commisure we will find a structure known as the pineal body. The pineal body plays a role in controlling our "light/dark" cycles. Immediately inferior to the pineal body we will find an area known as the corpora quadrigemini. The corpora quadrigemini is comprised of two swellings on either side of midline. The upper of these two swellings are the superior calliculi, and the lower two swellings are the inferior calliculi. The structures are relay centers in the pathways for vision and hearing. The area located on the midline of the brain between the two halves of the thalamus is known as the third ventricle. Leading inferiorly from the third ventricle is a duct known as the cerebral aqueduct. This duct leads to a cavity known as the fourth ventricle. The fourth ventricle lies directly anterior to the cerebellum. In a midsagittal section of the cerebellum we can see that the cerebellum has light regions and dark regions. The light regions appear to branch like a small tree or bush. This structure is known as the arbor vitae and represents fiber tracts of the cerebellum.

Brain Ventricles

There are large cavities within the brain. These cavities are known as ventricles. The ventricles are hollow spaces that are filled with fluid known as cerebrospinal fluid. There are four ventricles found within the brain in brainstem. There are two lateral ventricles which are found in the right and left cerebral hemispheres. These ventricles drain into a midline third ventricle (already discussed) through two openings known as interventricular foramen. Fluid from the third ventricle flows through the cerebral aqueduct to the fourth ventricle. From the fourth ventricle, fluid can flow into the central canal of the spinal cord, or exit through the lateral recesses of the fourth ventricle, to enter the subarachnoid space. The cerebrospinal fluid is essential for proper functioning of the central nervous system. The brain literally floats in a very thin layer of cerebrospinal fluid. The spinal cord is also bathed in cerebrospinal fluid. It is this fluid that is withdrawn when someone undergoes a spinal tap, also known as a lumbar puncture. You should look at the various diagrams and three-dimensional animation of the ventricles of the brain so that you understand the layout of these ventricles within the brain.

The Meninges

Understand that the brain and spinal cord are covered with a series of connective tissues known as the meninges. There are three layers of meninges. From external to internal, these layers are; the dura mater, the arachnoid mater, and the pia mater. Dura mater literally means "tough mother." The arachnoid mater is a thin, wispy layer which is found just deep to, and adhered to the dura mater. The pia mater is adhered to the surface of the brain and the spinal cord. Pia mater literally means "tender mother." The cerebrospinal fluid can be found between the arachnoid mater and the pia mater. We will discuss this more in the lecture on the spinal cord.

Gray matter and white matter

Remember that the brain consists of gray matter and white matter. The gray matter represents the neuron cell bodies, and the white matter represents the fiber tracts which interconnect these neuron cell bodies. Think of this much like a telephone system in the olden days, before cordless telephones. Think of the telephones as the nerve cell bodies, and the telephone wires as the fiber tracts. Very few phones are directly connected to each other, but rather are connected to many other phones through relay stations. Your nervous system works much the same way. Most areas of the brain are connected to other areas of the brain through various relay systems. Also remember that the anterior portion of your brain, (the frontal lobe), is the motor portion of your brain, while the portion of your brain posterior to the central sulcus is the sensory portion of your brain. It is essential that you coordinate the motor portion and the sensory portion of your brain. We saw earlier that the left and right portions of our brain were connected by commissural fibers. Another type of fibers, association fibers, connect anterior/posterior within the brain. We will see in our lecture on the spinal cord that a third type of fibers, projection fibers, connect superior/inferior between the brain and spinal cord.

A few clinically relevant areas of the brain
At this time we should talk about a few clinically relevant areas of the brain. For this discussion you should look at the diagram entitled, “some clinically relevant areas of the brain.” This is a diagram of the left hemisphere of the brain. We must look at the left hemisphere of the brain for this discussion because the first area we will discuss (Broca’s area) is ONLY located in the left hemisphere. Located in the frontal lobe just superior to the tip of the temporal lobe we find a small area known as Broca’s (motor speech) area. A lesion (tumor, stroke, aneurysm, etc.) in this area would result in a patient having problems with motor speech, that is, the motions involved with speaking. This patient would badly slur the words if they could pronounce them at all. Another area related to speech deficits is Wernike’s area. This area can be found capping the posterior end of the lateral sulcus as it turns upward. A lesion in this area would result in Wernike’s aphasia. Basically the patient would speak in a “word salad.” What do I mean by a word salad? Imagine you are going to make a tossed salad for dinner. You would probably use lettuce, maybe some carrots, and some cucumbers, perhaps some pieces of ham, maybe some hard-boiled egg, etc. Now that you have all of your ingredients, would you simply take a bite of each thing out of a different bowl? You could, but that would not really be a tossed salad. In a tossed salad you have all of the ingredients you need that are tossed to provide a randomness to the salad. The same is true with a patient who has Wernike’s aphasia. The words that they wish to say are there, but they are tossed to form a randomness to what they are saying. For example, in some forms of Wernike’s aphasia, instead of saying “this pen is blue” the words may come out “blue this is pen.” All of the words that they meant to say are there, they just aren't in the order that was intended. In other, more severe forms of Wernike’s aphasia, the words that are spoken may just be random words pulled from your brain’s “library” of words.

In the upper portion of the temporal lobe immediately below the lateral sulcus, we will find two areas associated with hearing. These are the primary auditory cortex, and the auditory association cortex. A lesion in the primary auditory cortex may result in the loss of hearing. A lesion in the auditory association cortex results in the patient not being able to associate the sounds that they hear with what they really are. For example when you hear the doorbell ring you know that it is the doorbell. If you had a lesion in your auditory association cortex you may not associate the actual sound of the doorbell with a doorbell. When you hear the doorbell your brain may think that sound was a train whistle, or some other sound. Your ability to hear a sound and then associate that sound has been interfered with. You must remember that everything you think when you hear a sound had to be learned. When you were first brought home from the hospital as a baby and your neighbors came over to see you and they rang the doorbell, you as a baby did not know that that sound was a doorbell. But over the years you learned what that sound meant. The same is true of every sound that you know. A lesion in your auditory association cortex can greatly interfere with your associating a sound with the actual source of that sound.

The most posterior portion of your occipital lobe is your primary visual cortex. Immediately anterior to this area (still in the occipital lobe) is your visual association cortex. A lesion in this area interferes with your ability to associate visual information with structure. For example, I might hold up a key and ask you to identify it. You may say “that is a hat.” However if I allow you to handle the key, to feel it, you will know that it is a key, and you will know that is used for unlocking a lock.

A lesion in the cerebellum often results in unsteady motions. Because the cerebellum is responsible for coordinating fine motor movements, if there is a problem in the cerebellum our motor movements are no longer refined. If you had a lesion in the cerebellum and I ask you to touch your nose with your index finger, you would probably be able to do it, but it would be a difficult task, and it would be very clumsy for you.

These few clinical aspects were presented because many of you will have to deal with patients who have had strokes or other lesions in these areas of their brains. It is essential that you understand how to deal with these patients. They are not retarded, dumb, or stupid. They are probably very aware of their deficiencies and are probably more frustrated by these deficiencies then you are by your perceived lack of cooperation by your patients.

Cranial Nerves

There are 12 pair of cranial nerves in humans. All of these cranial nerves arise from the brainstem, with the exception of the first cranial nerve, the olfactory nerve. Cranial nerves are named in either of two ways; by their written name, or denoted by an upper-case CN, followed by the number of the nerve in roman numerals, i.e., the first cranial nerve can either be called the olfactory nerve, or it can be denoted, CN I. You must be able to provide the name and number of all of the cranial nerves on a diagram or model. In addition you must know whether the cranial nerve in question is a sensory nerve, a motor nerve, or carries both motor and sensory information.

In our diagram of the brainstem we can see that CN I (the olfactory nerve is not present) this nerve does not arise from the brainstem so is not represented in the diagram. Also note that the brainstem is divided into three regions; the mesencephalon, the pons, and the medulla oblongata. CN II (optic nerve) is present. The two optic nerves unite at the optic chiasm which then splits into left and right optic tracts that will pass to the occipital lobe of the brain. We will discuss this in greater detail in our lecture of the eye and visual pathways. Directly posterior to the optic chiasm we can see the infundibulum, the stalk for the pituitary gland. Posterior to the infundibulum we can see the mammillary bodies. Recall that the mammillary bodies are relay centers for olfaction (smell). Also arising from the mesencephalon near the junction with the pons, we will see CN III, the oculomotor nerve. As its name implies, this nerve plays a role in movement (motor) of the eye (oculo-). In an anterior view of the brainstem, we cannot see the area where CN IV, the trochlear nerve, exits the brainstem. This is because this nerve exits from the posterior side of the brainstem, and passes laterally around the brainstem to its anterior position. Look for this nerve in the lateral view of the brainstem. Arising from the lateral aspect of the pons we can see CN V, the trigeminal nerve. We will learn more about this nerve in later lectures. Exiting the anterior brainstem, at the junction of the pons and the medulla oblongata, we can find three pair of cranial nerves. Close to the midline we will see CN VI, the abducens nerve. We will cover this nerve when we lecture on the eye. At the lateral edge of the brainstem we will see CN VII, the facial nerve, and CN VIII, the vestibulocochlear nerve, sometimes referred to as the auditory nerve. We will cover these nerves in more depth with facial muscles and with the ear. The medulla oblongata is subdivided into several regions whose names we will not be responsible for. On the anterolateral medulla oblongata we see a raised area that closely resembles an olive pit. This area is known as the olive. The olive is actually a swelling caused by the underlying inferior olivary nucleus. Recall that a collection of neuron cell bodies in the CNS is called a nucleus. The amount of cell bodies in this area causes a bulging on the surface of the medulla oblongata. The olive acts as a landmark for various structures of the medulla oblongata. The region of the medulla oblongata anterior to the olive is known as the pyramids. At the lowest level of the pyramids there is a crossing of fiber tracts from one side to the other. This is known as the decussation of the pyramids. Three cranial nerves exit the brainstem posterior to the olive. From superior to inferior these are; CN IX, the glossopharyngeal nerve, CN X, the vagus nerve, and CN XI, the spinal accessory nerve, sometimes only referred to as the accessory nerve. CN XI receives some input from the first cervical nerve, hence the name spinal accessory nerve. Exiting the brainstem anterior to the olive is CN XII, the hypoglossal nerve. As its name implies this nerve supplies the area under the tongue (hypo – under, glossal – tongue).

To help remember the names of the 12 cranial nerves there are several mnemonics. One of the most common is: **O**n **O**ld **O**lympus' **T**owering **T**op, **A F**inn **A**nd **G**erman, **V**iewed **S**ome **H**ops. In addition, if you want to remember whether the nerve is sensory. motor, or both, you can use the pneumonic: **S**ome **S**ay **M**arry **M**oney **B**ut **M**y **B**rother **S**ays **B**ig **B**rains **M**atter **M**ore. Here the "S" stands for sensory, the "M" stands for motor, and the "B" stands for both (sensory and motor).

Let us put all of these together:

On (O),	Olfactory N,	CN I,	Some (S),	Sensory,
Old (O) ,	Optic N. ,	CN II,	Say (S),	Sensory,
Olympus' (O),	Oculomotor N.,	CN III,	Marry (M),	Motor,
Towering (T),	Trochlear N.,	CN IV,	Money (M),	Motor,
Top (T),	Trigeminal N.,	CN V,	But (B),	Both,
A,	Abducens N.,	CN VI,	My (M),	Motor,

Finn (F),	Facial N.,	CN VII,	Brother (B),	Both,
And (A),	Auditory N., Vestibulocochlear N.,	CN VIII,	Says (S),	Sensory,
German (G),	Glossopharyngeal N.,	CN IX,	Big (B),	Both,
Viewed (V,)	Vagus,	CN X,	Brains (B),	Both,
Some (S,)	Spinal Accessory N.,	CN XI,	Matter (M),	Motor,
Hops (H),	Hypoglossal N.,	CN XIII,	More (M),	Motor,

We will be learning more about these nerves in upcoming lectures. It is a very good idea for you to learn them now, so that you are familiar with them when they come up in future lectures.