Neurobiology

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Lecture 1.8: Parts of Brain

Hello everyone, welcome back to the online course on Neurobiology. In the last video, we looked at the different directions that we can use to refer to different parts of the brain. So with that in place, now we are ready to zoom into the brain and see what are the divisions or different parts in the brain and see what these parts are doing. I want to give a small disclaimer here. The next few slides may give you an impression that different parts are doing very specific functions and those functions are localized just to those parts. So just remember that this is a simplification.

In reality, each function is being carried out by more than one part of the brain that are acting in concert. So it's not completely localized. At the same time, the functions are not randomly distributed throughout the brain. So there is some localization.

It's just that the localization is not as simple as it may appear to be in the next few slides. So just keep that caveat in mind. Now with that, let's dive into it. The brain can be divided into three parts called the forebrain, the midbrain, and the hindbrain. These parts are shown in orange color here.

So forebrain is the largest part of the brain, covering a pretty large area towards the top side and front side. The midbrain is a relatively small structure here you can see in the middle. And then the hindbrain is towards the lower and posterior side, includes a few structures here. These three parts of the brain are actually segregated when the brain is forming in the embryonic stage. So the forward part of the brain at that stage is called the forebrain, and the middle part is the midbrain, and the last part is the hindbrain.

And then these parts further develop and form into these more complicated structures over time. If we zoom into the hindbrain, we can see it consists of three main structures, the cerebellum, the pons, and the medulla. So these are very primitive structures that are found in a variety of animals, and they are involved in doing a variety of functions that are involved in just the maintenance of the body. A lot of the autonomic functions that are happening involuntarily are controlled by pons and medulla, for example, breathing, or heart rate, or blood flow, or sleep

cycle, and so on. So these are highly conserved functions that are present in a variety of animals, and they are being controlled by the hindbrain.

The third part of the hindbrain is the cerebellum, the small structure here towards the back side and the ventral side of the brain. This is zoomed in here. This is what it looks like. Now this structure is involved in control of coordinated movements and maintaining balance in the body. So if you are walking or running, these neurons are being used, and there is a very high density of neurons in this area.

In fact, there are some estimates that say that the cerebellum includes more neurons than the rest of the brain combined, even though cerebellum occupies only about 10% of the volume of the brain. So this is an important area with lots of neurons involved in the movement and coordinated actions. Now let's look at the midbrain. So midbrain is the small structure here in the middle of the brain, and like pons and medulla, the midbrain is also involved in some very basic functions of the body, functions that are mostly involuntary, like visual reflexes, or hearing, or the control of sleep-wake cycle, maintaining alertness in the body, and maintaining temperature in the body. So these are basic functions that are conserved across a variety of animals, and this midbrain is also a structure that is highly conserved across animals.

And now let's look at the forebrain, which is the more interesting part of the brain because it controls voluntary movement. The forebrain also includes multiple structures. Some of the prominent structures are thalamus and hypothalamus. Thalamus is shown in blue here in the middle. It also includes basal ganglia, amygdala, hippocampus, and the cerebral cortex, this large structure which has grown the most in humans compared to other animals.

Let us look at different forebrain structures one by one. The first one is thalamus, and the thalamus again are shown in blue here. They are in the middle of the brain near the midline, and these structures are known as the relay center in the brain because all of the sensory input that is coming into the brain from various sensory organs passes through thalamus. So the information first comes to thalamus and then it goes to rest of the brain. The only exception to this is the sense of smell which comes directly from the nose to the brain without passing through thalamus, but all the other sensory information goes through thalamus.

Similarly, all the motor information goes from the brain to the thalamus and then to different parts of the body. In the forebrain, just below the thalamus is another structure called the hypothalamus. The name actually comes from it being located just below the thalamus. That is why it is called hypothalamus, and this structure shown in green here is also located close to the midbrain and it is also involved in similar autonomic functions as the midbrain and pons. So it is controlling the regulation of hunger or thirst or maintenance of temperature in the body or controlling the flight or fight mechanisms responses, committing behaviors, and so on.

Another important structure within the forebrain is called the hippocampus. This is shown in blue here. The reason it is named hippocampus has an interesting story. So if we zoom into the structure of this organ, here it is extracted out. It resembles a seahorse and the Latin name for seahorse is hippocampus.

So the scientists who observed this structure initially decided to call it hippocampus. Hippocampus is one of the most studied organs or most studied structures within the human brain or animal brain. And the reason is that it is involved in two very important functions, learning and memory and spatial navigation. So this is a drawing of hippocampus made by Ramon y Cajal more than 100 years ago in such an intricate detail. And in the last 50 or so years, scientists have spent a lot of effort in trying to understand what kinds of neurons are present in hippocampus and how they function.

In fact, in 2014, the Nobel Prize was given to these three scientists, John O'Keefe, May-Britt Moser, and Edward Moser for their discoveries related to spatial navigation. So how the brain keeps a track of different locations in its environment. And they found an important role for hippocampus in creating this spatial map within the brain. The next structure we are going to look at in the forebrain is the amygdala. These amygdala are small structures shown in green here.

They are typically described as almond shaped and they are involved in the processing of various emotions, particularly fear. So if you are afraid of something that is coming towards you, it's probably your amygdala that is being active at the time. Another important structure in the forebrain is the basal ganglia. These are two structures that are present in the two hemispheres and they are involved in the regulation of various motor functions. The basal ganglia themselves are made up of multiple substructures, which we are not going into right now.

But these are important structures that interact with the rest of the brain in determining what movement one should make. Finally, the biggest structure in the forebrain is the cerebral cortex. This whole structure on the top is involved in controlling various cognitive functions such as perception, learning, decision making, movements, and so on. So it's really an important structure. The cerebral cortex and basal ganglia together are sometimes called the cerebrum.

So cerebrum includes the cerebral cortex and the basal ganglia. Do not get confused with cerebellum, which is this area here and it is part of the hindbrain, while the cerebrum is a part of the forebrain. Now let us zoom into the cerebral cortex and see what it is made of. So the cerebral cortex is the big structure here on top of the brain. It's above the midbrain, hindbrain, over the cerebellum and it is also covering the other internal substructures of the forebrain like the thalamus or the basal ganglia.

So if you look from top, we can only see the cerebral cortex here. The cortex itself is divided into four parts or four lobes. The frontal lobe in front, the occipital lobe on the backside, the temporal lobe on the side, and parietal lobe in the center on top. These four lobes are separated by these valleys and if you look carefully, even within a lobe, you can see there are lots of these hills and valleys. So the brain seems to be tightly folded and it's forming these folds or kinks.

The parts where the brain is folding out from top so all these hills that we see they are called gyrus and the kinks or the folds that where the brain is folding inwards these regions are called sulcus. So the brain is full of gyri and sulci. Can you guess what is the purpose of having these kinds of folds in the brain or in the cortical tissue? Well the purpose is that it increases the surface area of the cortex and that allows more neurons to be packed within the same volume. Now let us look at the functional specialization of different parts or different lobes of the cerebral cortex and this is a very simplified picture and it is not complete. So please take this with a pinch of salt.

The simplest case is the occipital lobe. The information from the eyes goes to the thalamus and from the thalamus it comes to the occipital lobe near the backside of the brain and this lobe is involved in the processing of this visual information. The temporal lobes are located close to the ears so they are obviously involved in hearing but they are also involved in processing of smells and associating various sounds with other stimuli. The parietal lobe is involved in processing of speech and taste and reading and other functions and the frontal lobe is the area that is involved in processing of speech as well as processing of various cognitive functions like decision making and planning and working memory and so on. Note that there are two strips here.

So this one is called the motor cortex that is part of the frontal lobe and the somatosensory cortex which is part of the parietal lobe. These are involved in getting signals from different parts of the body in the case of somatosensory cortex and controlling different parts of the body through the motor cortex. Thank you.