

Human Physiology
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Hello, welcome everyone to another new class in human physiology. In this class, we will discuss the brain's structure and function. Remember, in the last class, we discussed the nervous system and saw how different components of the nervous system are present in our body, primarily the central nervous system and the peripheral nervous system. And as we said, in the central nervous system, the most important components are the brain and the spinal cord. So, in this class we will see what the brain is, what the different components are, and their functions. So, let us stick with it.

So, what different concepts will be covered in this class? So, mostly we will see what the brain is, and we will also discuss different parts and their functions. Then we will see different parts one by one; for example, the cerebrum, then the cerebellum, then the brain stem, the diencephalon, and the limbic system. So, all these different components we will discuss along with their different parts and functions. So, to start with what is basically the brain, the brain is the most important component of the central nervous system, right? This is the most complex organ in our body, and it weighs around 1.

4 kg. And as we said, if you remember, that overall the nervous system contains almost around 86 billion neuronal cells. These are more like the key or primary unit cells of the nervous system. The brain regulates cognitive functions, including different types of sensory cognitive processing, movement, and various vital bodily functions. The brain consumes almost 20 percent of the body's glucose.

So, can you imagine that in spite of being only 2 percent of the total mass, the brain needs such a high amount of glucose? So, basically, that is why if you remember in our endocrine classes, we said that in cases of any lack of supply of glucose to our brain, our brain can undergo a condition called hypoxia or hypoglycemia. So, basically, if there is no glucose present in the body, the brain will not get proper glucose, and that can completely shut off all its functions. So, in those cases of hypoglycemia, the brain can observe significant damage, including hypoxia, and that can lead to eventual coma or mortality. The brain is generally protected by the skull, meninges, and cerebrospinal fluid. And also in the brain, we have the blood-brain barrier.

And what is the primary role of the blood-brain barrier? Basically, this BBB or blood-brain barrier protects our brain from different invasive materials. So, it kind of tightly controls what type of elements or molecules can eventually pass from this BBB and go to the brain. So, in terms of the blood-brain barrier, we will further discuss it as we did in our glial cell class. So, in this class, let us mainly focus on the brain. So, in terms of brain structure, the first and foremost important component is the outer layer of the brain, which is like the brain membrane or meninges.

So, even before we go to the membrane, which is mostly kind of like soft tissue or tissues, we have to remember that the outer layer of the brain is basically the skull bone, right? So,

basically, you can see here that the outer layer of the bone is like this dense collagen and fibrous type of tissue, which is like skull bone. In the bone class, we already discussed that, if you remember. And then exactly below the skull bone, there are mostly three layers of meninges or brain membranes. The first layer, as you can see, which is called the dura mater, mostly has two components; it is basically a thick, tough, and inelastic outermost layer that primarily provides structural support to the brain. And it has two important layers; as you can see, one is the periosteal layer and the second is the meningeal layer.

And basically, it contains dural sinuses that drain venous blood from the brain. So, basically, this dura mater contains different dural sinuses, and its function is to drain venous blood from the brain. So, exactly below the dura mater, you can see there is another layer, or another layer of membrane or meninges, that is like the arachnoid mater. So, the arachnoid mater is mostly like a delicate membrane. So, you can see this reddish-like arachnoid mater.

It is mostly like a delicate wave-like membrane, and the subarachnoid space beneath it contains cerebrospinal fluid. So, in the subarachnoid space, the cerebrospinal fluid, or CSF, basically flows inside the meninges layer. And mostly this CSF, or cerebrospinal fluid, carries different types of nutrients. It also carries like the immune cells do. It also maintains the hydration of our brains.

So, CSF also kind of acts in terms of protection and immunity. So, CSF has a very important role, and basically, it flows inside this subarachnoid space just below the arachnoid mater. And the third layer, which is mostly a blood vessel-rich layer, is called the pia mater, which is a very thin and highly vascularized membrane that provides vascular or blood vessel support. Basically, as you know, the role of blood vessels is to carry oxygen and different other types of nutrients, including glucose. What are the different key functions of the meninges? Like the meninges, it helps in terms of providing structural support and protection to the brain.

It also kind of acts in terms of providing immune support, along with giving nutrient support. And just to kind of let you know that whenever there is any bacteria or virus, any sort of infection happens to this layer, we know there is a condition that develops in our meninges, especially in cases of kids, which can be dangerous, and that is meningitis. Then you will see a typical beautiful structure that resembles the brain's gyri and sulci. So, what are gyri or gyrus? These are basically rays with a lobe-like structure. And the sulky will be like these are shallow depressions between the lobes.

So, this is like a typical brain structure where you will see the upward lobe-like structure, which is mostly raised, called gyri. And then, in between the gyri is wherever there is this depression structure, or the gaps in between the gyri; these are called sulci. And basically the folds or these foldings of the gyri and sulci increase to help the surface area of the brain. So, what it does is that these are highly folded and help in terms of increasing the surface area of the brain, thus allowing more and more neuronal tissues to be packed inside a compact space. So, because this is highly folded, it helps create distinct packaging of the neuronal tissue in a very tight space.

And during brain development, the brain initially has a smooth surface, but slowly as it develops, it kind of folds to form the cortex and thus creates two types of distinct patterns: one is gyri and the other is sulci. Then, as we go further inside, we have to see what the different components or major regions of the brain are. So, if you remember, in the last class we said that the brain has mostly four important components. The first one is the cerebrum.

This is large. So, basically, this is like the cerebrum part, right? If you remember, this is the largest part of the brain and the most prominent part, which accounts for about 80 to 85 percent of the total brain's weight. And as you know, it is highly responsible for different types of higher levels of cognitive functions and is characterized by a folded outer layer, the cerebral cortex. And after the cerebrum, we have this small part of the brain, also known as the cerebellum, which is sometimes referred to as the small brain. So, it is basically located dorsal to the brainstem. So, as you can see, this part is the third part, which is called the brainstem.

So, just basically beside the brainstem or the dorsal part of the brainstem, we see this part, which is the cerebellum, and it helps in coordinating different types of movement. It helps in maintaining posture and balance. It also has different involvement in motor learning processes and other cognitive functions. Then the third important component is the brain stem, which is the oldest and most primitive part of the brain, and it is situated at the base of the brain, as you can see here. As you remember, we said that the brain stem is very important because it connects the cerebrum and the cerebellum with the spinal cord.

And lastly, there is another fourth component, which is the diencephalon, that is basically present inside this central core part, and it includes the thalamus and hypothalamus, which also have various sensory roles, temperature regulation roles, and hormonal regulation roles. So, this is in general like the four important components of the brain, and now one by one we will go into a little further detail, and we will see there are very specific functions for each component. So, to start with the cerebrum or the cerebral hemisphere. So, you can see this is like the whole cerebrum hemispheres. Which is kind of mostly has four distinct parts: the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe, and this is basically on the front side.

So, if we have the eyes here, right, if we have the eyes here, this part is the left part and this side, the other side, is the right side. So, basically, the cerebrum is anatomically divided into two components: one is the left side and the other side is the right side. These are also called the cerebral hemispheres, and what it does is basically help in terms of lateralization of function. So, while the hemispheres communicate extensively with each other, it has generally been seen that one side can become more dominant compared to the other in terms of particular individuals' various motor and sensory functions, as well as other language processing functions. So, generally one part is highly dominant, and it has been seen that for right-handed people, the left side is more dominant; in the case of left-handed people, the right side can be more dominant.

So, for a different type of function, including language processing, particularly speech production and comprehension. is generally kind of localized on the left side of the brain's cerebrum. So, what we are saying is that the left side of the cerebrum is mostly involved in language processing, for example, speech production and comprehension; this type of function predominantly occurs there. And on the other side, on the right side, there are also important functions; for example, spatial reasoning, facial recognition, and emotional processing. So, this type of function can happen in the right side.

So, as you can see, it has mostly four lobes: the first and foremost one, which is close to our frontal side or near the eyes, is the frontal lobe; it is mostly present in the anterior part of the brain. It also has different components or parts; for example, the primary motor cortex, which is located in the precentral gyrus area. And what it is like to be responsible for it is mostly a

kind of control over various precise voluntary movements of the skeletal muscles, right? And then the prefrontal cortex area is the second most anterior part of the frontal lobe, right? It basically controls the executive center of our brain. It also orchestrates different high levels of cognitive functions, for example, various complex behaviors such as making different types of decisions, innovating inappropriate behaviors, understanding different consequences of situations, and helping to develop a person's social behavior. And then the last part, which is like Broca's area, is mostly located on the left side of the frontal part.

So, on the left side of the frontal lobe, which has Broca's area, it is highly important for different types of motor production of speech, thus coordinating the muscles involved in articulation. So, after the frontal lobe, as you can see, the second most important part, which is just behind the frontal lobe, is the parietal lobe. So, basically, it is located posterior to the frontal lobe; it receives and processes different sensory information from the skin, for example, touch, pressure, temperature, and pain. And also, I like it different, like sensors from muscles and joints that provide different information about the body's position and movement, right? So, it has different functions; for example, it kind of provides spatial awareness and navigation. So, the parietal lobe is basically highly important in terms of understanding the spatial relations between objects and ourselves.

So, it creates a kind of 3D dimension or spatial awareness. It also helps in terms of generating attention and direction. Apart from that, it also helps in terms of language processing. For example, it contributes to the comprehension of the language, particularly the semantic and syntactic aspects working in conjunction with the temporal lobe area. Then, after the parietal lobe, we will come exactly just beneath it, where we have the temporal lobe, right? So, basically it is located inferior to the parietal lobe and also anterior to the occipital lobe.

So, right, you can see. So, basically, it is exactly located inferior to the temporal lobe but anterior to the occipital lobe. It has different kinds of components or parts, like the primary auditory cortex area, that receive and process the auditory information from the ear. So, basically, the temporal lobe helps us process and hear different sounds and noises. It also has another important part, which is the Wernicke's area. It is also crucial for language comprehension.

right, enabling us to understand different meaning of the spoken and written word. So, this part of the Wernicke's area in the temporal lobes helps our brain to understand what type of language is being spoken. It also has a very crucial component, the hippocampus, which is located pretty deep in the core area of the brain. It kind of processes the memory; it kind of develops like a long-term memory. The amygdala is also located deep within the brain and is heavily involved in processing different types of emotions, particularly fear and aggression.

Thus, it creates an emotional memory. So, this part of the temporal lobe, which is mostly situated in the deep and core part of the brain, develops, processes, and kind of generates different types of long-term memory. After the temporal lobe, as you can see, the final component of the cerebrum is the occipital lobe, right? It is mostly located in the posterior part of the brain or at the back of the head. It has primarily the visual cortex, so by the name, you can understand that it helps us to process various types of visual signals. So, as our eyes get different signals in terms of what color it is, like the edges, different types of whether it is light or dark. So, it also kind of processes differently, like a 3D kind of structure and different movement, right? So, in terms of the visual association area.

It is another component of the occipital lobe. It surrounds the primary visual cortex and interprets the visual information in such a way that it helps us to recognize various types of objects, faces, colors, and movement. So, as you can understand, the occipital lobe mostly helps us in terms of visual processing, and then all the other lobes, for example, the temporal lobe we discussed, help in terms of auditory signaling. Finally, after the cerebrum part of the brain, there is this small brain, or the little brain part, which is called the cerebellum. This mostly contains about 10 percent of the brain's total volume, but it contains almost half of the neurons.

So, you can understand that even though the size of the cerebellum is only about 10 percent of the total mass, half of the total neurons are actually present in this little brain, and that is why it is so important. These are primarily involved in terms of coordinating various types of voluntary movement. For example, they ensure different types of posture, balance, and equilibrium. Just give an example; for example, you are walking. And something comes up, and immediately you may fall over.

In that case, your little brain, or the cerebellum part, will try to create the posture and balance for you. So, they will process all these signals and ensure that you do not fall back or the fall in front you maintain your balance. So, basically, it creates a rapid kind of voluntary actions and movements. Apart from that, it also plays a very significant role in terms of various motor learning. Thus, it allows us to refine different motor skills over time.

It is also involved in coordinating eye movements, allowing for smooth tracking of the object. So, as you can see, the little brain, or the cerebellum, has various crucial roles to play. Finally, as you know from the last class, we said that in between, just in this area at the base, there is another third component called the brainstem, which basically connects the whole cerebrum and the little brain of the cerebellum with our spinal cord. It has mostly three important components: one is the midbrain, the pons, and then the medulla oblongata, right? So, what the midbrain does basically is that it is involved in different motor control, particularly eye movements. It also has a role in vision, hearing, sleep-wake cycle, and temperature regulation.

After that, it also acts as a relay station. Hence, it transmits signals between the cerebrum and the cerebellum. So, it is basically creating a bridge network that transmits the signal between the cerebrum and the cerebellum. It also involved the regulation of breathing, sleep cycles, or sleep stages. For example, it controls the REM sleep cycle and also regulates facial expressions and other sensory functions. Lastly, it has the third component of the brain stem, which is the medulla oblongata.

It controls different important centers, mostly regulating the autonomic functions. Those are highly essential for breathing, for example, breathing rate and depth. It can also control heart rate and blood pressure. Via vasoconstriction or vasodilation, different types of reflexes, such as autonomic reflexes like swallowing, coughing, sneezing, and vomiting. So, basically, the medulla oblongata is highly important for coordinating different autonomic functions of our body.

Finally, as we said, the diencephalon has two important components, and this is mostly present in the deep core area of our brain. So, you can see it is almost like in the core area or the center area of the brain, which has two important parts: one is the thalamus, which is basically the brain's sensory relay station. So, it receives different sensory information and basically relays it to the appropriate area of the cerebral cortex. So, what the thalamus does is that it receives different information from various sensory sources and then supplies that information to the

appropriate areas, such as the occipital, frontal, or temporal regions. So, basically, depending on the processing, it kind of understands where those signals need to go, and it exactly sends those signals to the right area of the brain.

And finally, you also see that there is another component, which is the hypothalamus, and the hypothalamus is also highly important not only for temperature regulation; it also has a different role as an endocrine gland. So, you remember in our endocrine class we discussed in thorough detail how the hypothalamus basically controls various precursor hormone secretions compared to the pituitary. So, whenever the hypothalamus secretes a hormone, that eventually kind of either stimulates or inhibits the pituitary gland. So, basically, the hypothalamus is one of the precursor glands of the pituitary.

Then finally, at last, like all these hippocampi, like the amygdala, then the hypothalamus, along with the olfactory bulb, all together form a system called the limbic system. This is basically like a complex network of brain structures, mostly located in the medial-like area of the cerebrum. It is basically heavily involved in terms of emotions, motivation, learning, and memory. So, in different parts of the brain, we have already discussed the hippocampus, amygdala, hypothalamus, gyrus, and olfactory bulb. This, when combined together, forms a system that is also called the limbic system.

So, hopefully you liked the brains class; we went through different parts of the brain, and we also tried to share and discuss the very specific functions of those parts. So, do you know that the brain continues to develop and mature well into your mid-20s? The prefrontal cortex, the area responsible for planning, decision-making, and impulse control, is one of the last regions of the brain to fully develop. So, that means the prefrontal cortex is the very last component that actually fully develops. This explains why some of the differences in behavior and judgment can often be seen between adults and teenagers. Activity question: imagine you are learning a new skill, such as playing a musical instrument or learning a new language.

Which areas of your brain do you think are most active during the initial stages of learning a skill? As you become more proficient, how might the activity in these brain regions change? Also, can you tell me which other brain regions might become more involved as the skill becomes more automatic or habitual? Basically, it creates a habitual memory. So, hopefully you are enjoying the class, and if you have any further questions, please drop us an email. You can also ask us questions during the live session. Hopefully you like both the nervous system and the brain class. Very soon we will meet with you for another new class of human physiology. Thank you for listening to today's class. Thank you.