Introductory Neuroscience and Neuro-Instrumentation: gross Anatomy of Brain
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Anatomical (Macroscopic) structure of the CNS

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Hello and welcome to an overview of the gross anatomy of the brain.

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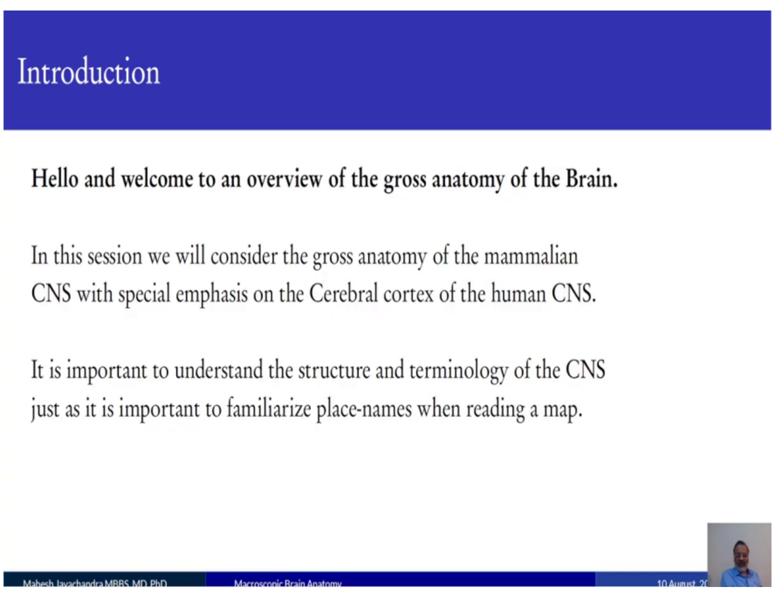

Here, we will consider the microscopic structure of the mammalian central nervous system with a special emphasis on the Cerebral cortex of the human central nervous system. It is important to understand the structure and terminology of the CNS, just as it is important to familiarize place names when reading a map of a strange country or territory, which is near to you.

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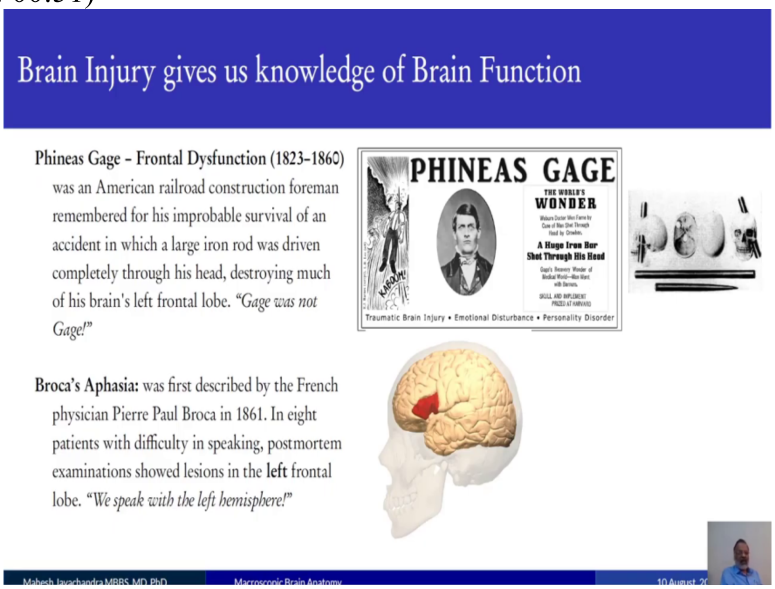

But more importantly, any dysfunction of the brain, nerve gives us knowledge, of how the brain actually works. So there are very famous cases in history. One was Phineas Gage. He was an American railroad construction foreman, and he was stamping dynamite, making, laying railway tracks. And there was an accident and the damping road exploded and went straight up into the air and completely through his head.

And it destroyed much of his brain's left frontal lobe and his behavior completely changed. He also lost his eye. If you can see the images on the extreme right, you can, his skull has been preserved. And you can see the rod going through the skull, so pretty severe damage.

However, he completely recovered. He could do his normal function, but his behavior changed. He was no longer Gage. He used to be a very serious, reserved, churchgoing man. But after his accident, he became a very coarse individual. He starts swearing, drinking, so on and so forth.

He joined the circus in the end. So this gave us the first clue formally, recorded, in history that, you could have dysfunction of this nature and leaving the rest of the brain completely intact.

And another physician who contributed to localization of brain function was Pierre Paul Broca. And in 8 patients who had difficulty in speaking, he did the postmortem of their brains after they died. And he found that there was a problem in a particular area of the brain. It was on the left side in the inferior frontal lobe, this is called the frontal lobe and below.

So he famously announced that we speak with the left hemisphere. So that is why we need to know the brain structure, because it allows us to understand brain function.

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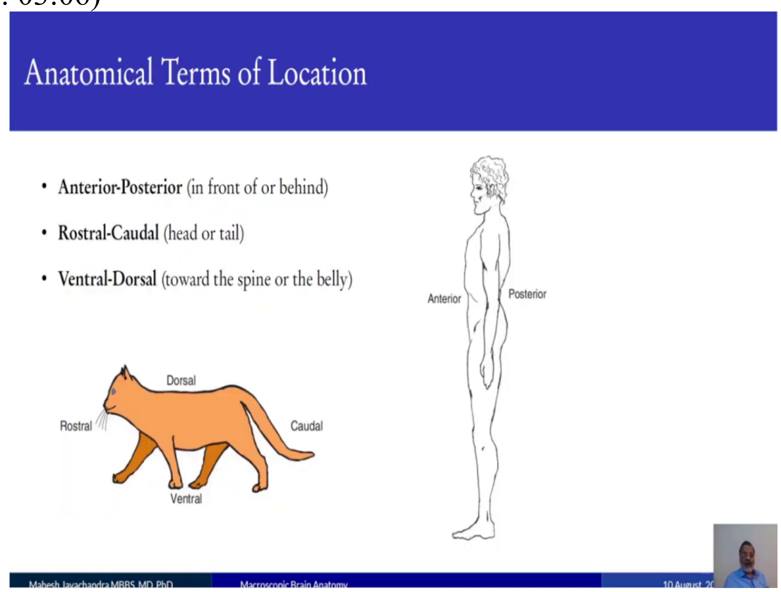

So before we get into it, just like when you read a map, you have to know north, south, east, west, how to read the legends so on and so forth. So similarly, we have some terms, most of them derived from Latin, which we use a shorthand to, communicate what exactly we are talking about.

So one set of terms anterior, which is the front of the body and posterior, which is behind. The other term is rostral, which is, towards the head and caudal, which is the tail. Also a dorsal, which is, towards the spine or ventral, towards the belly.

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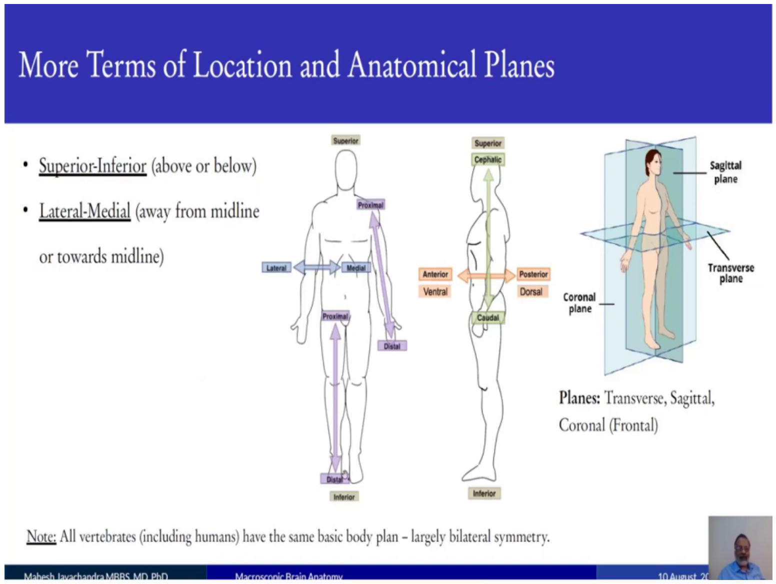

So more terms of location would be superior, which is on top or above an inferior, which is below.

Remember, all vertebrates including humans have the same basic body plan. They are largely bilaterally symmetrical. Also, you have lateral, which is away from the midline. So away from the midline or medial, which is towards the midline. And plus, you have distal, which is, like the palms or the soles of your feet, and proximal, which is your thighs or your shoulders.

So as far as planes are concerned, this is just the lateral view of the same. So you have three major kinds of planes used while describing anatomic locations. So one is the transverse plane. This is just a chopped right horizontally through the body. Then you have the sagittal plane. Imagine a sheet, a plane going right through your nose, through your forehead and write down. And then, you have the coronal plane, it will have a coron around their head, so it is going through your ears and write down. So these are the main planes and the coronal plane is also referred to as the frontal plane.

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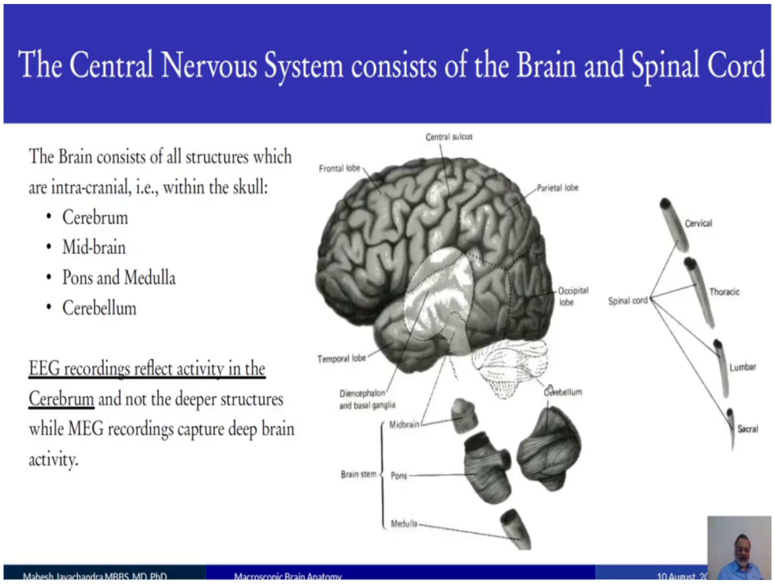

So finally, with that introduction of these terms, we will come to the central nervous system. So the central nervous system essentially consists of the brain and the spinal cord. And the brain consists of all the structures, which are intra-cranial, which is inside the skull. So you have the cerebrum, which is mostly what people think of when they think of the brain, the highly convoluted gray matter, the surface of the brain.

Then you have stuff, which you do not normally see, which is hidden inside the mid-brain. And also, you have the brainstem, which consists of structures called the pons and the medulla. And then, behind you have, the cerebellum, which is, a small brain replicating many of the morphological features you see in the cerebrum, but very different.

EEG recordings basically reflect activity from the surface, the cerebrum. So, we will not focus too much on the deeper structures of the brain, because this course is basically focused on event-related potentials, what you record from the skull, which senses the stuff on top.

You also have the spinal cord, which, is a continuation of the brainstem in the vertebral canal. And this has four different divisions, the cervical division, the thoracic division, the lumbar division, the sacral division, we will come to it later.

So as far as deeper structures are concerned, if you want to really record from them electrical activity, you have to use MEG, Magnetoencephalography, where you will record the magnetic field rather than the electrical field. But we are doing EEG, so we will be looking at stuff coming from the surface.

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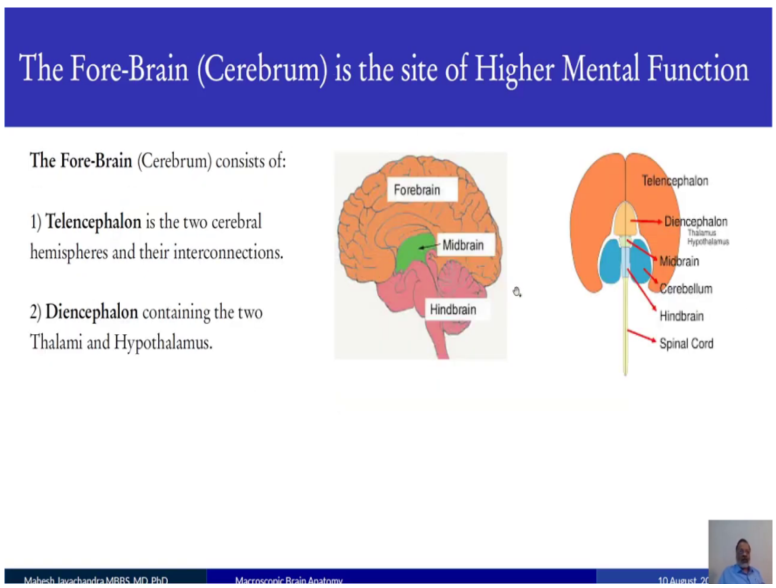

So, the fore-brain, the cerebrum, is the side of higher mental function, all our thinking, reasoning, all that stuff. And the brain can be divided in the forebrain, midbrain and hindbrain. And on this side, you see, a cross section, a coronal section, if you will, of the schematic of a mammalian brain.

So the forebrain consists of two structures, the Telencephalon, that is the 2 cerebral hemispheres and their interconnections and the Diencephalon, which is a structure within the forebrain, covered by it and consists of the Thalami, the thalamus on either side, and the Hypothalamus.

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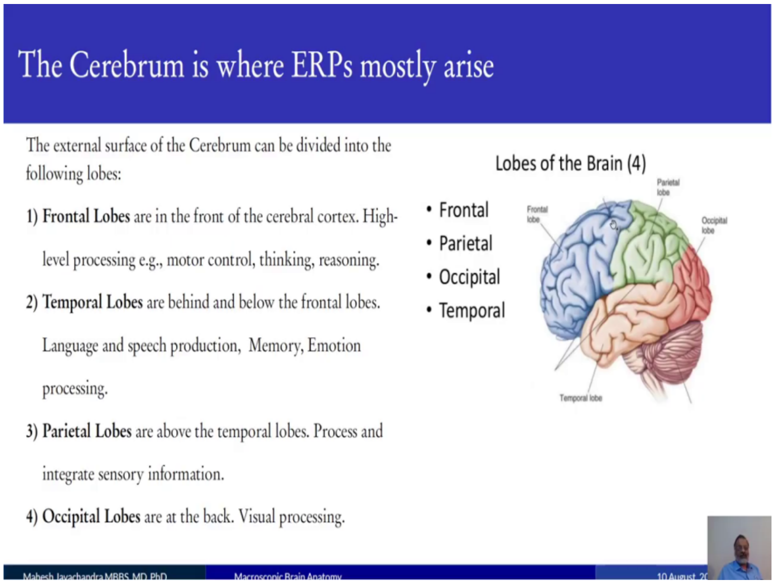

As mentioned, just now, the cerebrum is where the ERPs mostly arises. And the external surface of the cerebrum can be usefully divided into lobes poles. So you have the frontal pole or the frontal lobe, which is in front, right behind your forehead. And this is involved in high level processing, like controlling motor activities, thinking, reasoning.

The temporal lobes are below it. And they are involved in speech and language production, also memory, also emotion processing. Above the temporal lobe is the parietal lobe, but deals with interpretation of different sensory information, different modalities of touch, of sound, of vision, everything gets integrated over here, before it goes up for processing.

And finally, behind, we have the occipital lobe, which purely deals with visual processing from basic stimuli to complex stimuli like faces.

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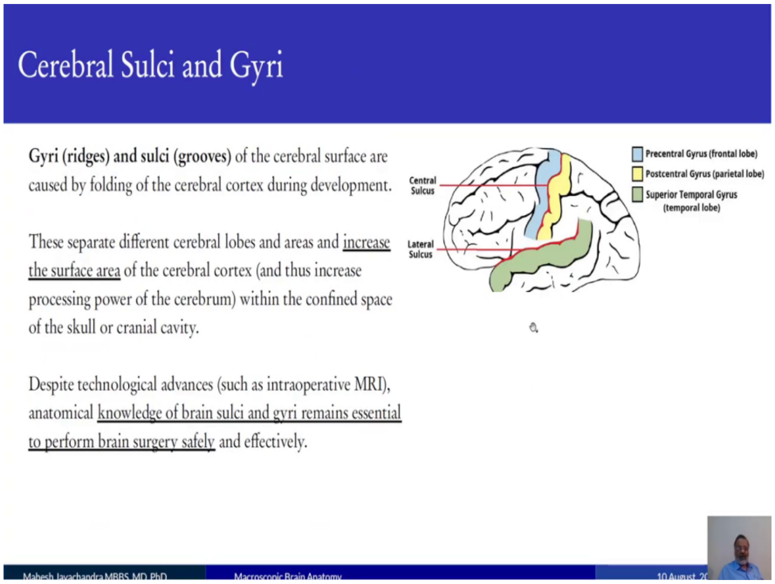

So d, as you might have noticed, there are a lot of info links, and they are called Gyri ridges and sulci, which are grooves of the cerebral cortex and this was caused during development. And the reason why, this is highly evolutionary conserved, this kind of structure, where we have enfolding Gyri and Sulci.

This increases the surface area of the cerebral cortex. And that is the processing power of the cerebrum. Even though you have a confined activity in this, I mean confined space in the skull, the skull, limits the growth of the brain. So this is one trick nature has used to increase the surface area. And it is important to have an idea of the different sulci and gyri, because even though you have, cool your techniques like intraoperative MRI, this remains essential to plan for surgery and learn anatomy.

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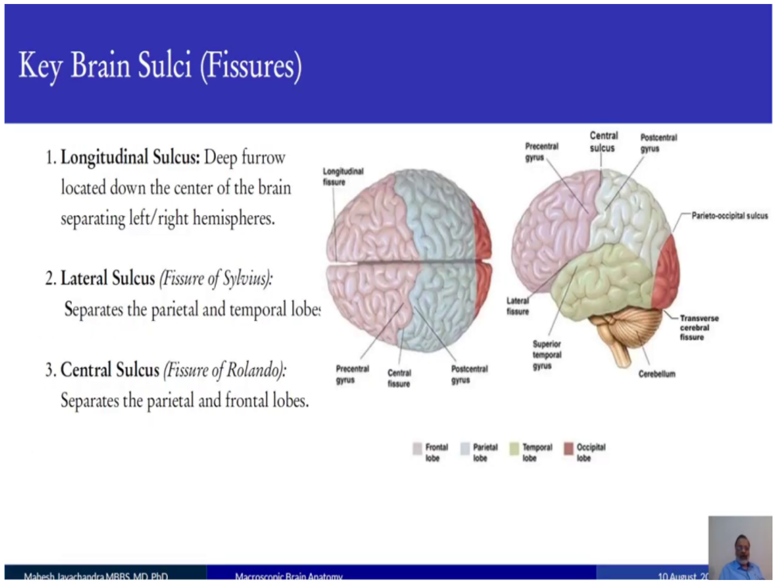

So, let us talk about the fissures of the sulci. So looking at the brain from the top, you have two hemispheres. And there is a central fissure running right through, a longitudinal fissure. So this is the longitudinal sulcus. And if you look at it from this side, this is looking at the left side of the brain. You have a lateral fissure, lateral sulcus. And this longitudinal fissure separates the 2 hemispheres. The lateral fissure was 1 on each side obviously. It separates the parietal lobe and the temporal lobe, this and this.

The central fissure separates the parietal lobe and the frontal lobe, right? And then you have a parieto-occipital sulcus, which separates the parietal lobe from the occipital lobe. These have been named after anatomists, for the lateral sulcus is also called as fissures of Sylvius and the central sulcus is called the fissure of Rolando.

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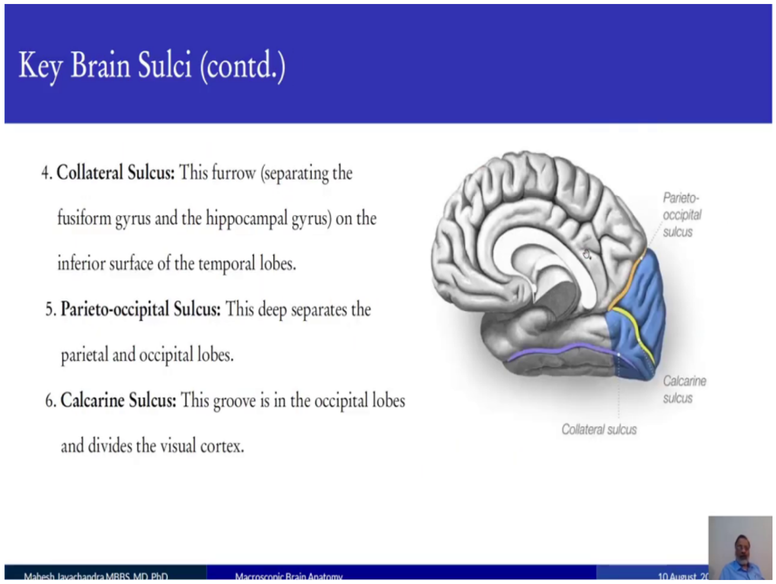

So now coming to the stuff on the medial surface of the brain. So if you took out the right hemisphere, we saw the 2 hemispheres separated by the longitudinal fissure. So what happens when you separate the 2 hemispheres and look at the inner surface of a hemisphere? So this is the inside surface of the right hemisphere. And again, you have a prominent sulci over here. So you have the collateral sulcus, which is below, which separates the fusiform gyrus from the hippocampal gyrus that is on d inferior surface of the temporal lobe. Then you have the parieto-occipital sulcus, which as it named suggests, separates the parietal lobe from the occipital lobe.

And then in the, within the visual cortex, you have a calcarine sulcus, which separates different parts of the visual cortex.

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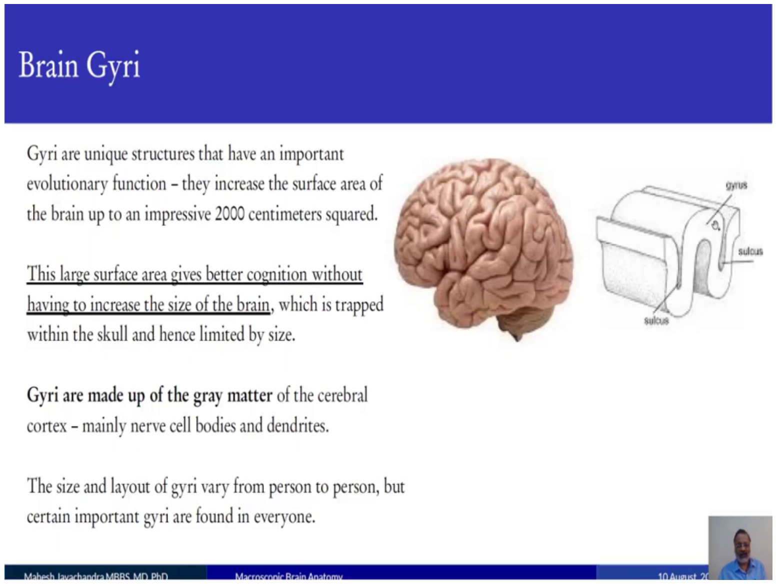

So now coming to Gyri. So this was the sulcus, what we talked about. So the enfolding and the outfolding is the gyrus. So you can think of mountains and valleys, mountain, digs, valleys. So gyri are unique structures and the evolution is very significant because they increase the surface area of the brain massively without necessarily being in prison, cranial capacity.

So even though our skulls are, of a limited capacity, you have a massive surface area because of this enfolding of cortical tissue. And as we learned in the first session, previous sessions gyri are made up of gray matter and nerve cells, bodies, dendrites, all of that structure. We will get into more detail later, but they are made up of neurons, interneurons and supporting, axons.

The size and layout of the gyri vary from person to person. No 2 brains are like, however, growth features, these, made, the macroscopic features remain constant and are useful to know.

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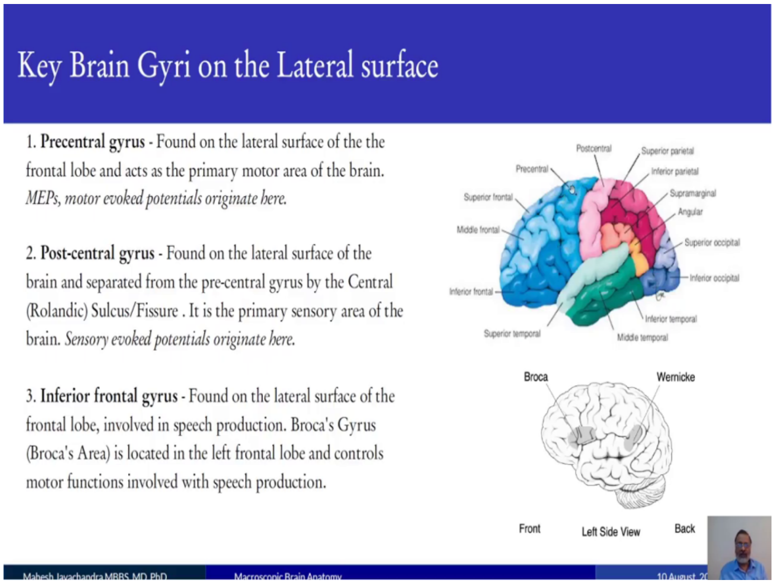

So, this is important. You have the central sulcus, as previously described. This is the area before it. So it is the precentral gyrus and this is the motor part of the brain. So all your motor activity originates, all your movements, finger movements, playing piano originates over here. Your motor evoked potentials all originated over here.

The post-central gyrus behind the central gyrus and this is sensory. So all of the sensory part of the body of the sensorium comes over here and this is where the somatosensory evoked potential originates and this is something you can record from the scalp.

Below the frontal areas is the inferior frontal gyrus, which is found on the lateral surface and it is involved in speech production, specifically an area called Broca's areas. We encountered Pierre Paul Broca, so this was the area where he found in postmortem there was a problem, and this controls motor functions to do in speech. So you are able to articulate, words because of control from here.

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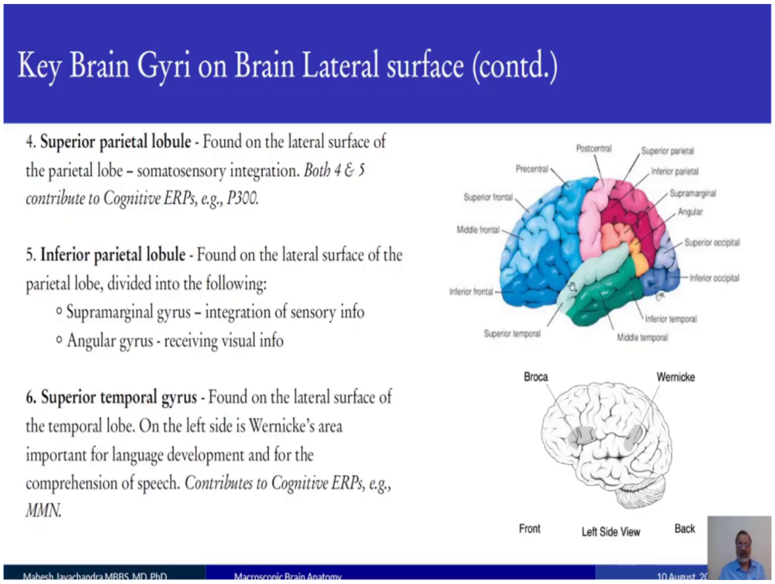

So other, gyri on the lateral surface of the brain, which is still at the lateral surface of the brain. So 1 is the superior parietal lobule and inferior parietal lobule. So these are gyri of the parietal cortex. And both these are involved in integrating sensory information. And both these contribute majorly to cognitive event-related potentials such as the P300, which we will encounter in subsequent lectures.

And the inferior parietal lobe will also integrate sensory info and the angular gyrus, which is the way it integrates visual info from the occipital cortex. So coming down, this is the superior temporal gyrus. It is on the lateral surface of the temporal lobe. This is the temporal lobe, and this is the superior temporal gyrus. So on the left side is Wernicke's area, important for speech language development.

And this also contributes to cognitive ERPs, example mismatch negativity. So, the superior temporal gyrus is found in the lateral surface of the temporal lobe. On the right is Wernicke's area, it is important for language development of the comprehension of speech.

Both, this whole area contributes majorly to auditory event related potentials, example, the mismatch negativity, which we shall encounter in subsequent sessions.

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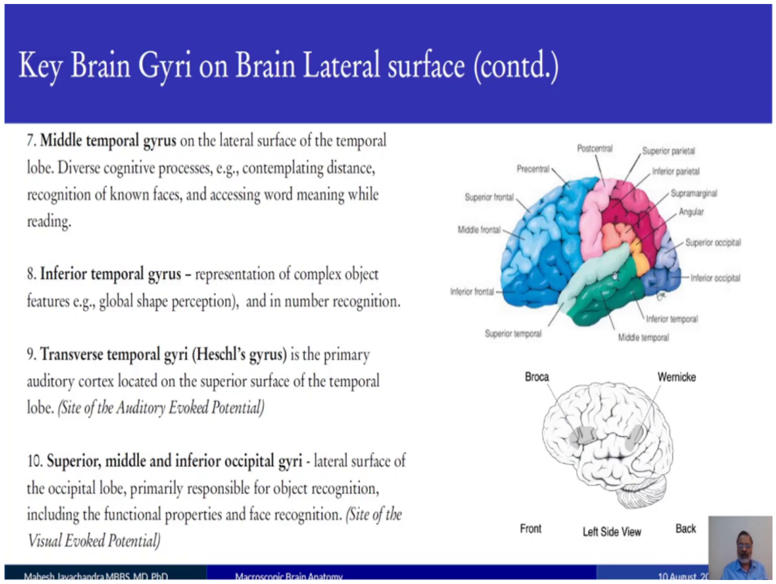

So continuing on. You have the middle temporal gyrus on the lateral surface of the temporal lobe. So you have diverse cognitive processes, such as contemplating distance, recognition of known faces, accessing word meaning when reading, all that stuff happens here. And then you have IT, inferior temporal gyrus, which represents complex object features and it is involved in global shape perception and number recognition.

Then you have the transverse temporal gyrus Heschl's gyrus over here and this is located on the superior surface of the temporal lobe. You cannot really see it here lifted it in peak there. And this is a side for generation of the auditory work potential. And you also have in the occipital area or the occipital lobe, superior, middle and inferior occipital gyri. And again, all this has to do with the visual system, like face recognition, as complex as face recognition to as simple as flashes of light. So the visual evoked potential arises from here.

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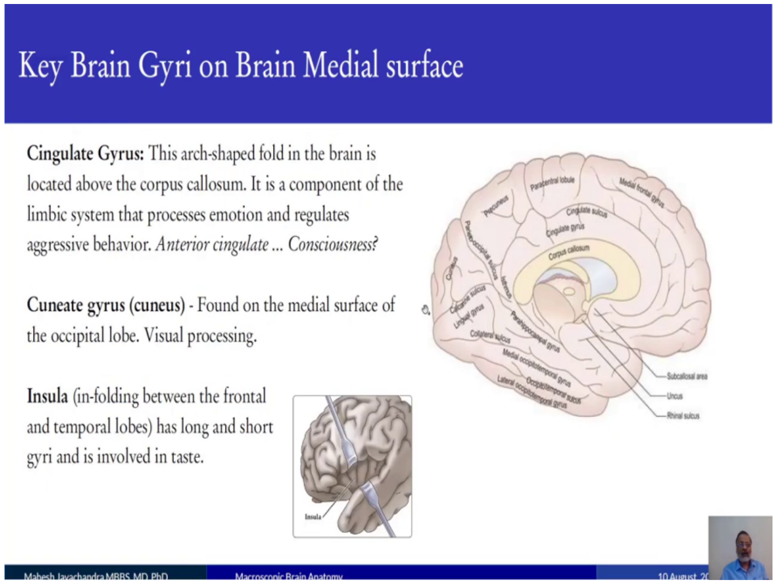

So coming to the medial surface. So, this, you cannot really record, but, from the surface of the scalp. However, it is good to know what exists. So this is, you have taken away the right hemisphere and you are looking at the inner surface of the left hemisphere. So one major gyrus over here Cingulate Gyrus, which is a component of the limbic system that promotes, processes emotion and also regulates aggressive behavior.

And some scientists have suggested with experimental data that, if there is an important place in the brain, which is a center for consciousness and intracortical correlate of consciousness as well, the anterior cingulate gyrus is a very important candidate. And then, coming to the back, the cuneate, which is, its name after its shape and it is a part of the occipital lobe and that is involved in visual processing. And finally, if you remember, the lateral surface of the brain. In fact, we should go back.

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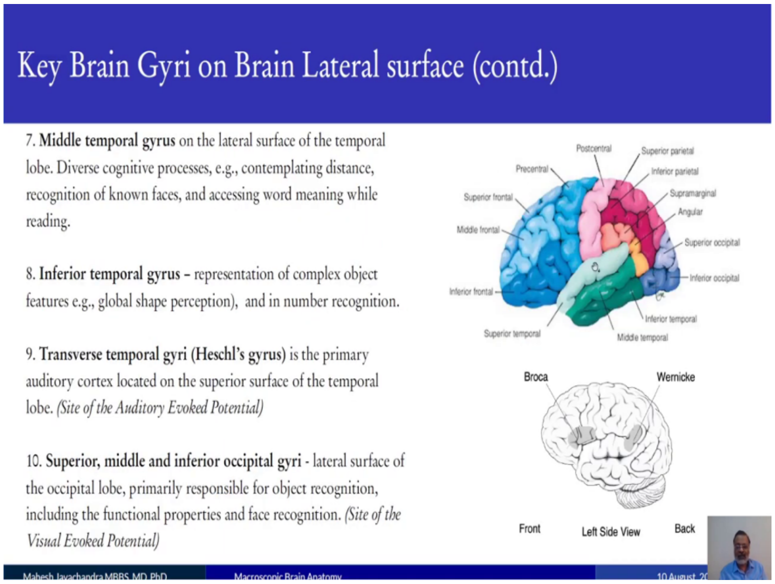

To this part, if you lift this area and, expose what is inside there is a huge enfolding. And that is called the insula. And this is concealed if you will within the temporal lobe. And it has long and short gyri. It is not as well known and studies as the outer stuff for access reasons, but it is involved in taste and aggressive behavior.

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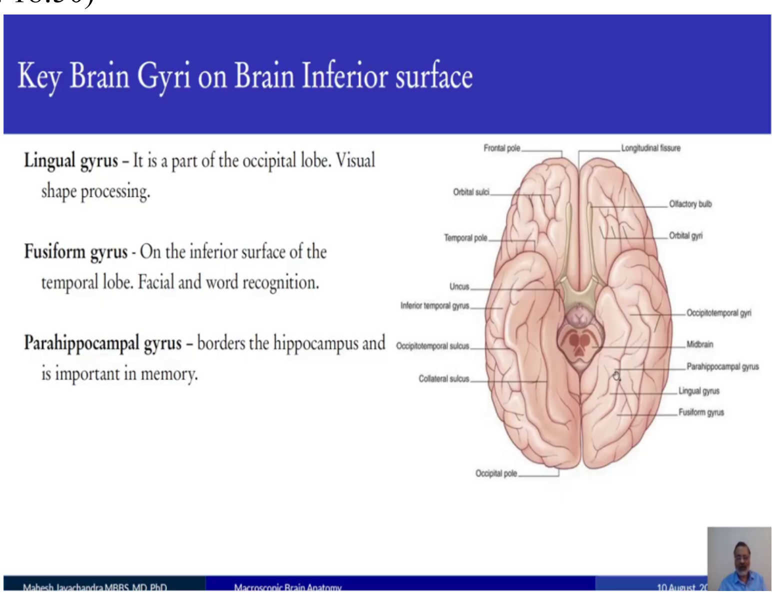

So on the inferior surface, what is below? Now, this you are not going to record at all from the scalp. However, the important, gyri over here, the lingual gyrus, it is part of the occipital lobe. And then you have the fusiform gyrus, which is next to it. And the lingual gyrus is important to visual shape processing, where the fusiform gyrus is important, involved in facial and word recognition. And then you have the Parahippocampal gyrus, which borders the Hippocampus and it is important in memory. The hippocampus is a structure inside the brain, very important for memory.

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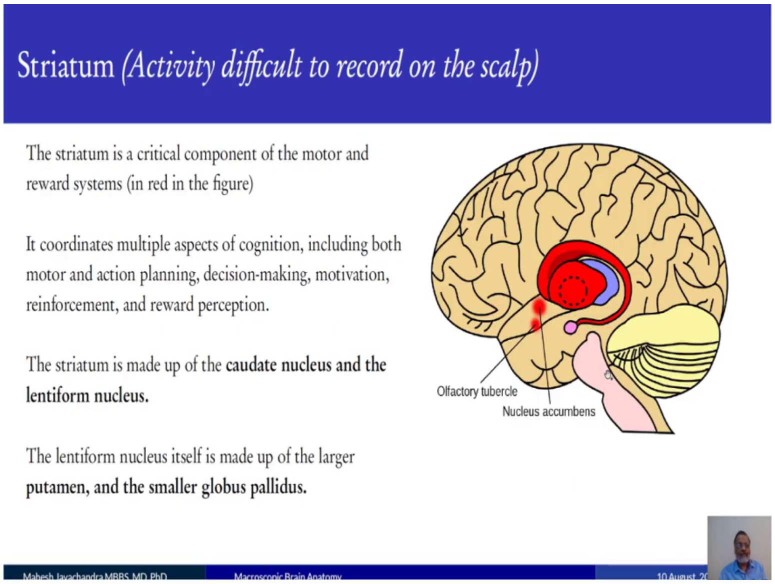

So right inside you have the structure in red, the whole thing it is called Striatum. And it is a critical component of the robot system, what makes you happy, the pleasure centers, all that is over here. And it coordinates multiple aspects of cognition, including motor and action planning, decision-making, motivation, reinforcement reward perception in all these different tasks and cognitive, in all these tasks, the striatum is involved.

The striatum can further be subdivided into the caudate nucleus and the lentiform nucleus. The lentiform nucleus intern is made up of a larger structure called the putamen and a smaller structure called the globus pallidus.

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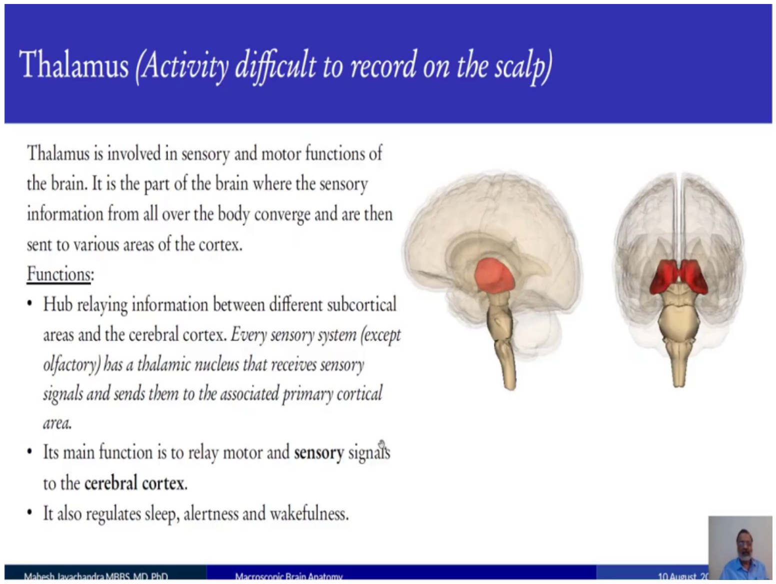

So coming to the Thalamus. Again, it is a central midline structure on both sides and its activity is difficult to record from the scalp. It is a very important structure involved in both the sensory and motor functions of the brain. And it is a part of the brain, where sensory information from all over the body converges and then sent to various parts of the cortex.

And what are its functions? It is a hub. It relays information between different sub-cortical areas in the cerebral cortex. Every sensory system, except the olfactory, the sense of smell passes through the thalamus and its main function is to relay motor and sensory signals to the cortex. It also regulates sleep alertness and wakefulness.

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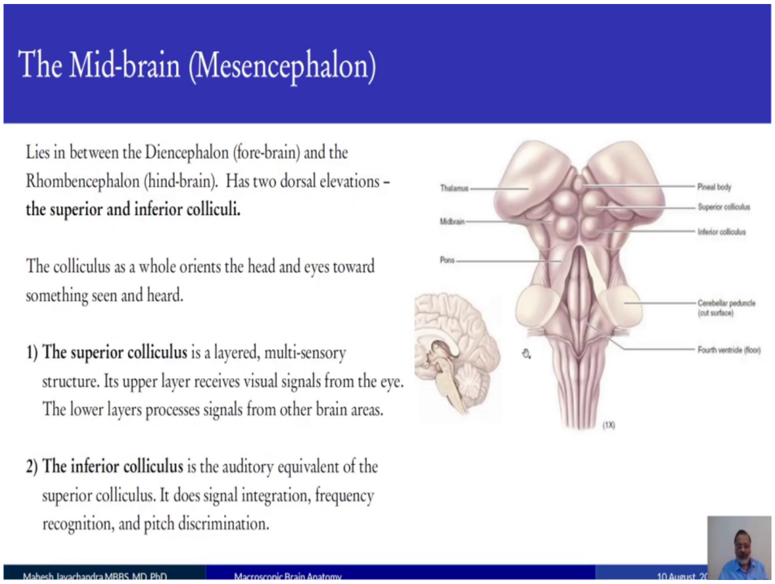

And now coming to the Mid-Brain. So if you take a cross section of the brain, this is roughly this area over here, and now you are looking at it from the dorsal surface on the back. And this lies in between the fore-brain and the hind-brain and also called the Diencephalon and the Rhombencephalon.

So it has two dorsal elevations called the colliculi, the whole thing called the colliculi. These are the superior colliculi, they are about, and these are the inferior colliculi below, remember superior and inferior.

So, it orients the head and eyes toward something seen or heard. The superior colliculus is visual. And it is a layer multi-sensory structure. It receives visual signals from the eye, but the lower layers receive signals from other brain areas. The inferior colliculus on the other hand is mainly auditory, and it does signal integration, frequency recognition, and pitch discrimination.

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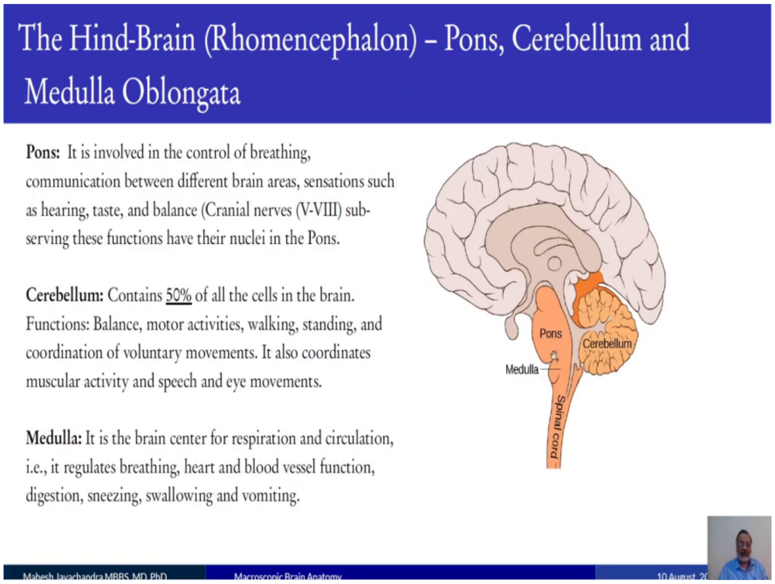

So coming to the back, the hind-brain or the Rhombencephalon. So coming to the back, the hind-brain or the Rhombencephalon, this consists of the pons, the cerebellum and the medulla oblongata. This is the pons, this is the mid-section, this is the cerebellum, and this is the medulla. And this continues as a spinal cord.

So the pons is involved in the control of breathing communication in between different brain areas and sensation such as hearing taste and balance. There are cranial nerves, which arise from the brain, which, sub, sub important functions and cranial nerves, 5 to 8 arise from the pons and their nuclei over here.

The cerebellum contains 50 percent of all the cells in the brain. And it has its own sulci and gyri structure. And it has varied functions, some of which are yet to be discovered. It is involved in balance and motor activities, walking, standing, coordinational of voluntary movements. And we know this because in neurology with patients who have strokes or problems or tumors in the cerebellum, they have profound deficits in these activities. It also coordinates muscular activity and speech and eye movements.

And then finally, the medulla, this is kind of the involuntary center, which controls respiration, circulation, regulates breathing, heart and blood vessel function, digestion, sneezing, swallowing, vomiting. All this stuff, which is not directly under motor control.

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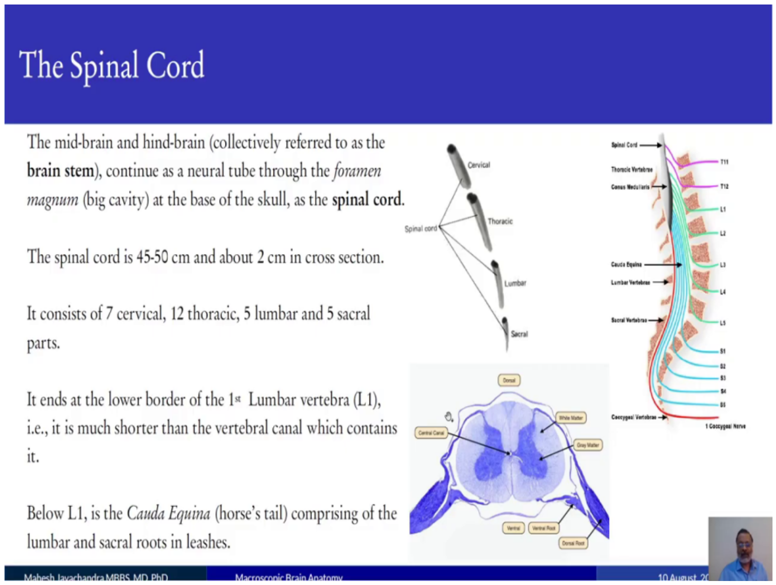

Then finally, the spinal cord. So the mid-brain and hind-brain collectively refer to as brainstem, which you saw on the previous slide. They continue through the neural, as a neural tube through the foramen magnum. It is a big cavity at the base of the skull as a spinal cord.

So the spinal cord is about 45 to 50 centimeters and 2 centimeters in cross section. And this is its cross-sectional histological structure. It consists of a cervical thoracic lumbar and sacral parts. So there are 7 cervical segments; 12 thoracic; 5 lumbar; and 5 sacral. So the spinal cord itself ends at the border of L1, lumbar 1.

So all these different vertebra, which are below the spinal cord and as much about them and it continues on as a structure called the Cauda Equina, horse's tail, consisting of lumbar and sacral roots of various nerves. The spinal cord itself ends at L1.

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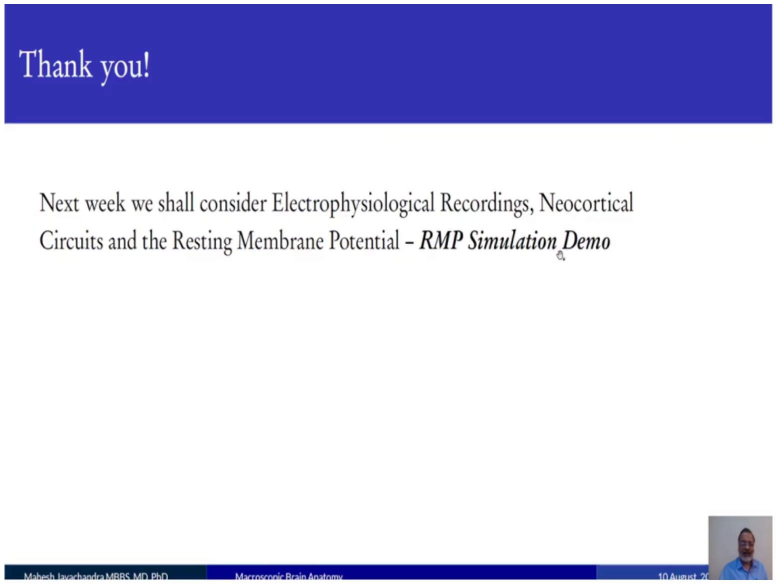

So thank you very much. This was kind of an introduction to neuroscience, the structural stuff, the terminology used, and some information about a cellular structure.

So next week, we shall get into the meet of the course, which is the electrophysiological recordings, neocortical circuits, and the resting membrane potential with an RMP Simulation Demo. Thank you very much.