TALE - 2 Course Design and Instruction of Engineering Courses

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Lecture – 21
How Brains Learn – I

Greetings, and welcome to TALE Module 3, Unit 3. This unit is different from what we otherwise will be getting involved in this Module. This unit is related to How Brains Learn, and it is going to be in 3 units. These units present a little bit of anatomy of the brain, and identify some aspects of the brain, how they influence our teaching and learning.

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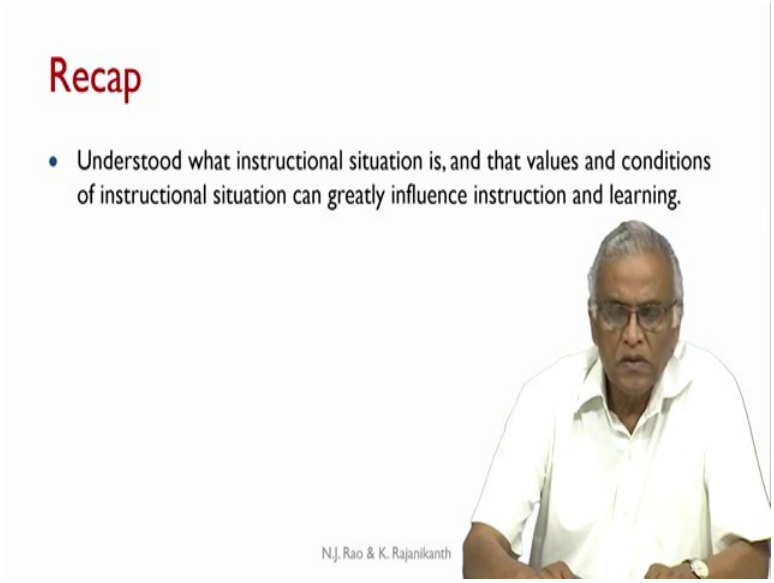

In the last unit, we understood about instructional situation, and how values and conditions of instructional situations can greatly influence instruction and learning. Practically every college has its own peculiar instructional situation. To that extent any teacher who comes to that college will have to adjust his instruction to the situation of that context.

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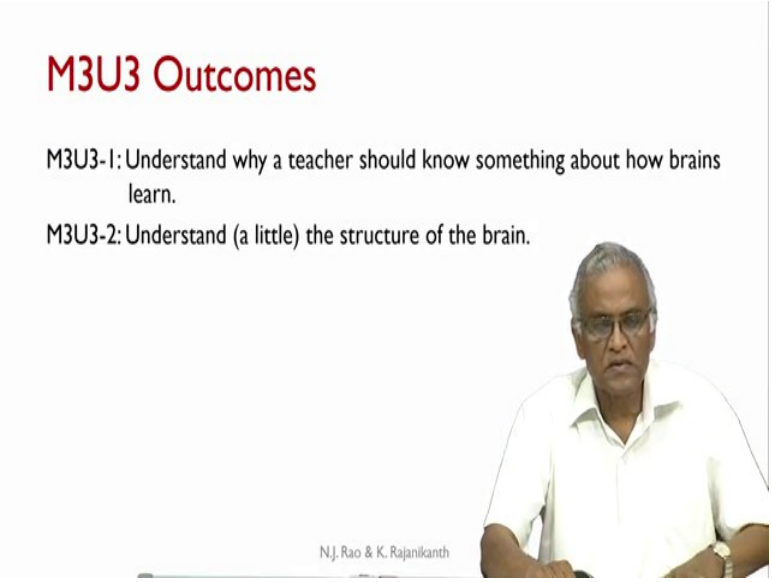

In this unit, we will spend some time in understanding why a teacher should know something about 'how brains learn?' and understand the structure of the brain.

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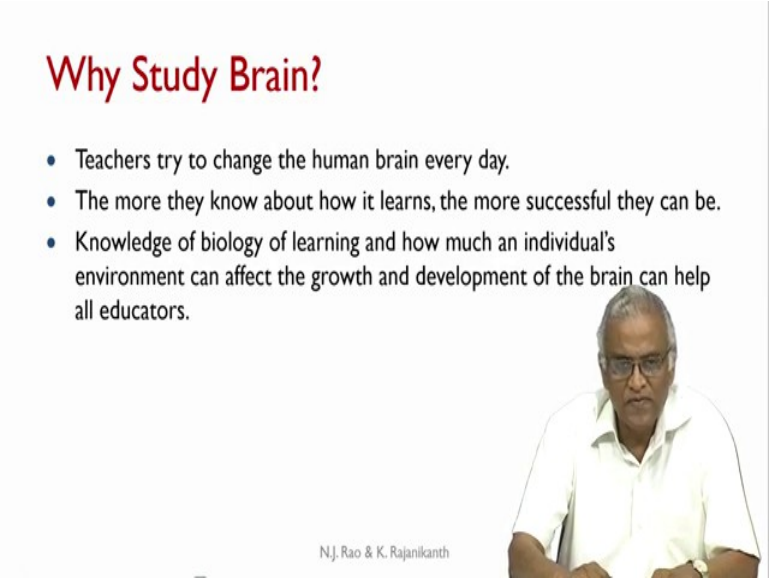

After all, what is the teacher doing every day? Every day he is trying to change the brains of his students because that is where the learning takes place. As I am trying to change the brain of my students continuously, teaching is the art of changing the brain; that is how one can interpret teaching. Obviously, teacher has very close relationship with the functioning of the brain. Because it is the brain that learns, the more teachers

know about how it learns, the more successful they can perform their job of changing the brain.

Knowledge of the biology of learning: We can say biology of learning because every time you are learning, something biologically is happening in the brain. How much an individual's environment can affect the growth and development of the brain - an understanding of that can help all educators. The more teachers are familiar with this, and they can perform their job better.

In the last several decades, there is a lot more that has been understood because thousands of researchers are working on various facets of the brain. Of course, our understanding of the brain at biological level possibly started in middle 19th century, though we have records of even doing brain surgery thousands of years ago. But we do not know the details of all that even if there is some knowledge, it is not readily accessible to us.

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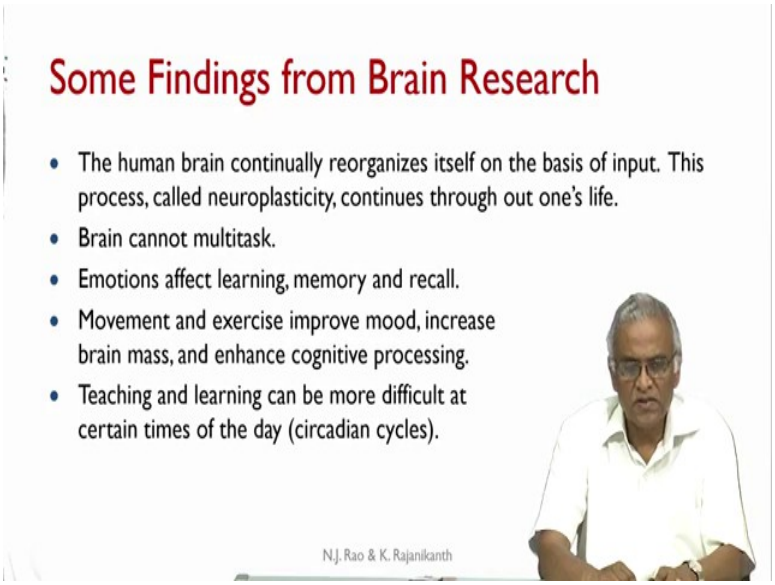

Some findings from brain research: The human brain continuously reorganizes itself based on the inputs. This process is called neuroplasticity, and it continues throughout one's life. There are computer models of the brain; that means people recognize brain as a computer. Whatever sensory input that we get, the computer processes it and gives the output, which may be translated into some action.

But, here the computer itself is continuously reorganizing itself based on the inputs. As new inputs come to us, new experiences happen to us; the brain continuously reorganizes itself. In spite of its enormous complexity, the brain cannot multitask. It cannot perform two cognitive activities at the same time. Though one may switch from one cognitive task to the other, which many youngsters feel that they can do, the brain is not designed to do two tasks at one time. What is happening is we are switching between two tasks continuously, that is, stop the work we are doing and address the other one, stop that and address the previous one, which in the end turns out to be very inefficient. So, one should not perform multiple cognitive tasks at the same time.

Emotions affect learning, memory, and recall: any emotion will affect learning and memory and recall. So, to that extent we cannot consider even a highly technical subject that one should not have an emotional aspect, everything should be neutral, and that is something that does not happen with the brain. The teacher and the students need to recognize emotions play a very dominant role in learning.

Movement and exercise: if a person exercises every day, it improves the mood, increases the brain mass and enhances cognitive processing. If you are involved in continuous exercises, you are exercising regularly then it improves your mood and can enhance your cognitive processing.

Teaching and learning can be more difficult at certain times of the day. So, there are circadian cycles in a day; there are specific periods in which you can do better compared to your work at some other time.

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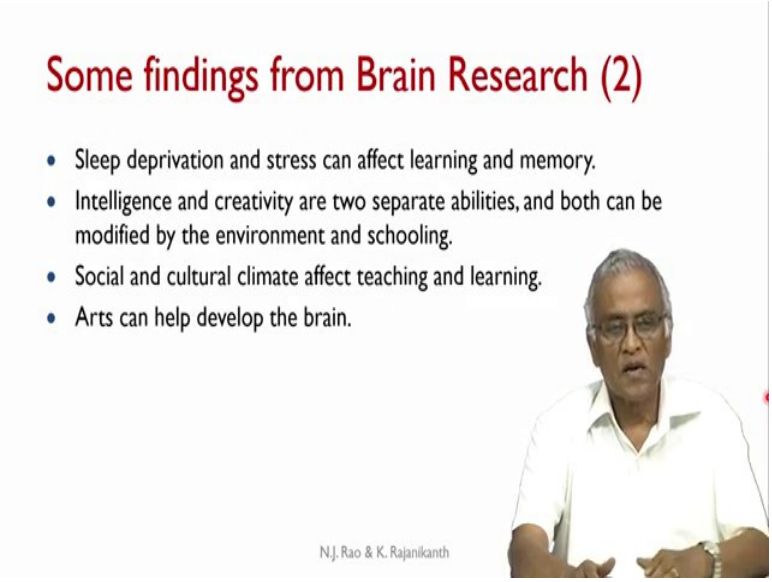

Sleep deprivation and stress can affect learning and memory. If there is sleep deprivation, obviously, you are not going to learn that very much. Intelligence and creativity are two separate abilities that should be recognized. A highly intelligent person need not be creative, highly creative person need not be that greatly intelligent, but both can be modified by the environment and schooling. That means, they are not exclusive either, they are two separate abilities, one can groom himself or herself both in the intelligence direction as well as creative direction.

Social and cultural climate affect teaching and learning: The brain has, obviously, a great deal to do with that. More importantly arts can help develop the brain. We will not be exploring these dimensions. These are presented to you like a few bits to convince you that an understanding of the brain or its functions or its structure can help the teacher.

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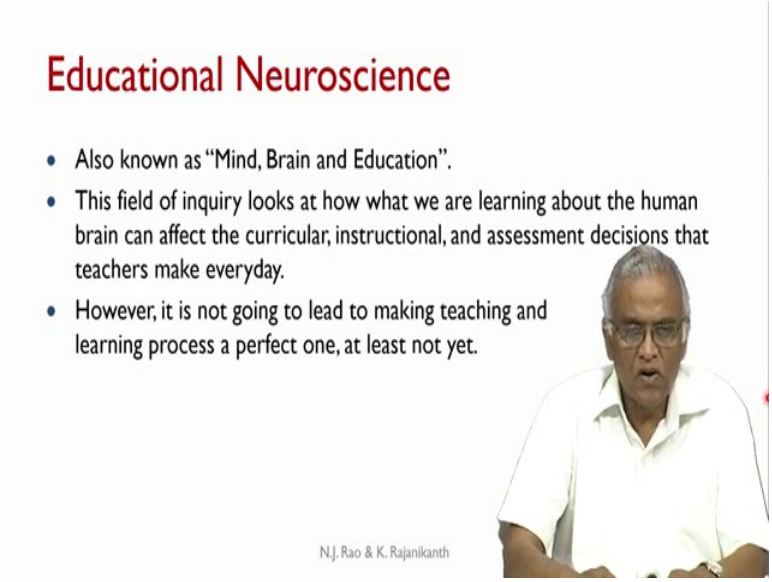

The subject is called educational neuroscience, also known as "mind, brain, and education," or changing the sequence "brain, mind, and education." This field of inquiry looks at how we are learning about the human brain can affect the curricular, instructional and assessment decisions that teachers make every day. We will see in the following unit how a little bit of understanding of the brain can help the teachers design the curriculum better.

We will look at a few of these features, but the knowledge of this educational neuroscience is undoubtedly not going to lead to making teaching and learning process perfect because we are far from fully understanding how things happen in the brain. We will be making teaching and learning processes perfect, at least not in the near future, but with whatever knowledge we have, we can make it better.

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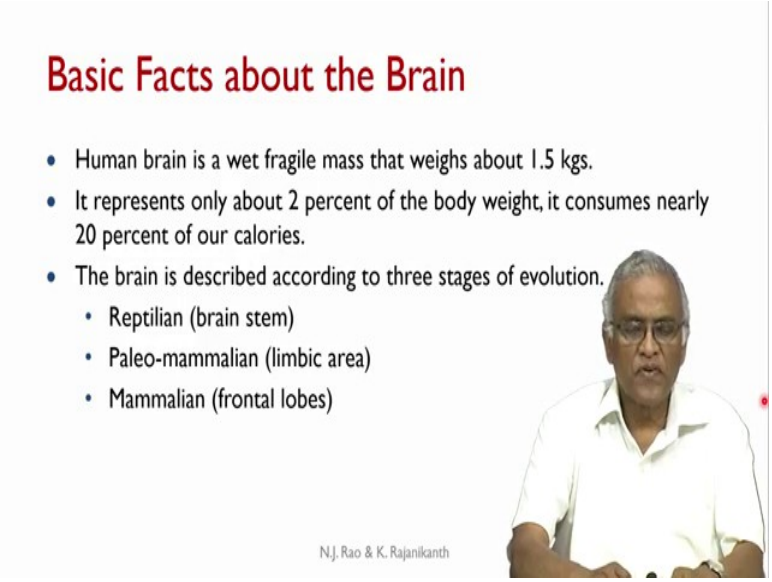

Some basic facts about the brain: The human brain is a wet fragile mass that weighs about 1.5 kg or a little less. It represents only 2% of the body weight, but it consumes nearly 20% of our calories. So, as you can see it requires lot of energy for this 2% of the bodyweight to function.

The brain can be described in several ways - one classification is according to three stages of evolution. We have a reptilian brain, now what we call brain stem, paleo mammalian brain that is limbic area, and mammalian that is frontal lobes. We will look at them in reverse order.

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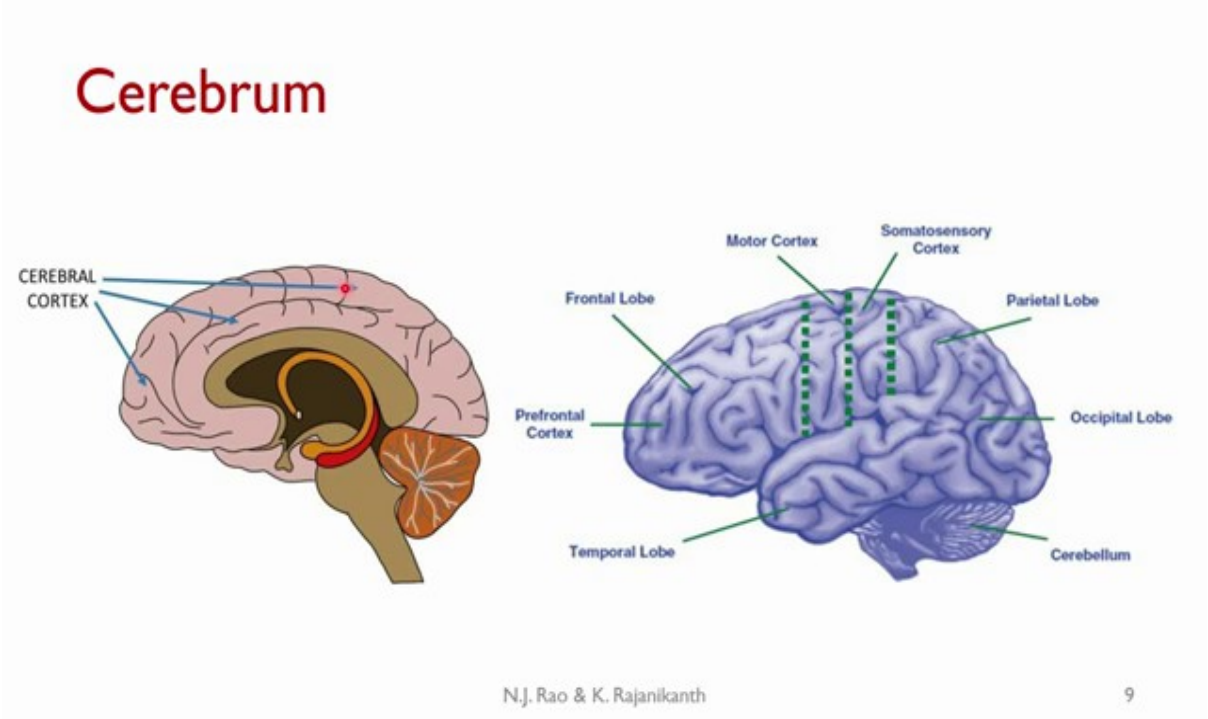

Cerebrum, as you can see this in pink color, is the cerebrum, and this is how it will look like this in the side view. There is a sulcus, and in the middle of the brain, there is a furrow which makes it look like two different hemispheres. The top view really represents us two similar-looking the hemispheres.

There are lobes in this cerebrum; frontal lobe, temporal lobe, parietal lobe, and occipital lobe. Other parts are cerebellum or small brain (as it is called) motor cortex, somatosensory cortex, limbic area, or middle brain, and at the bottom is the brainstem.

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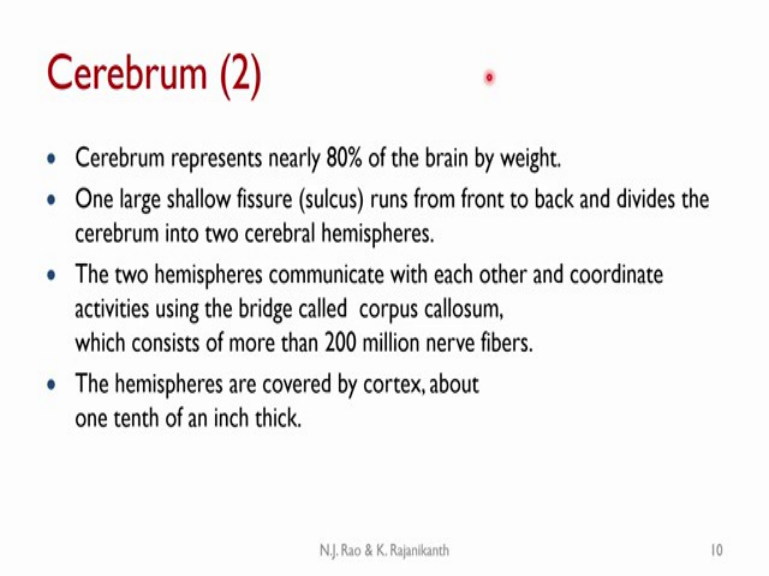

Cerebrum represents nearly 80% of the brain by weight, and one shallow of fissure runs from front to back and divides the cerebrum into two cerebral hemispheres, which are not identical in their functions, but there are several activities which are similar. The two hemispheres communicate with each other and coordinate activities using a bridge called corpus callosum.

It consists of more than 200 million nerve fibers so that the two hemispheres can act together. The hemispheres are covered by cortex (English translation - bark of a tree), which is like a bark. Cortex is nothing but the top layer of that; it is about one-tenth of an inch thick.

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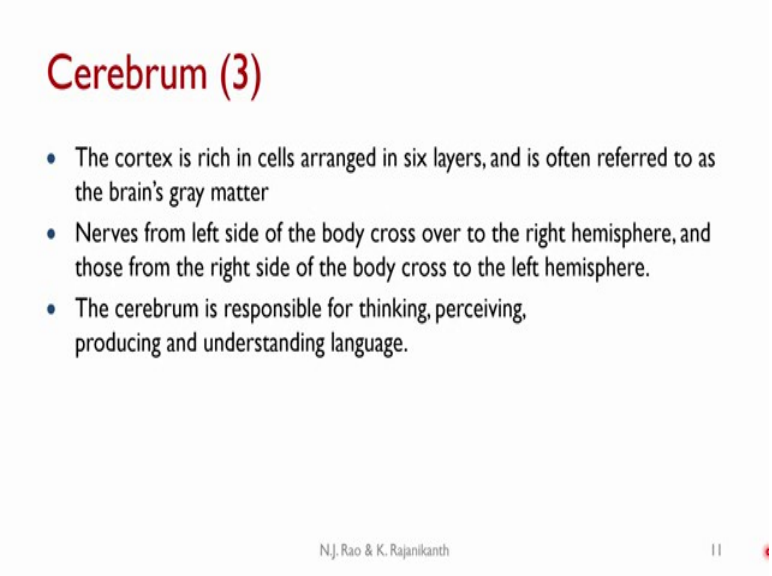

Cortex is rich in cells arranged in six layers and is often referred to as a brain's gray matter. Interestingly nerves from the left side of the body cross over to the right hemisphere, and those from the right side of the body cross over to the left hemisphere. It is still not completely known why it has evolved like that and what its purpose is. The cerebrum is responsible for thinking, perceiving, producing and understanding language; all the thinking processes take place in the cerebrum.

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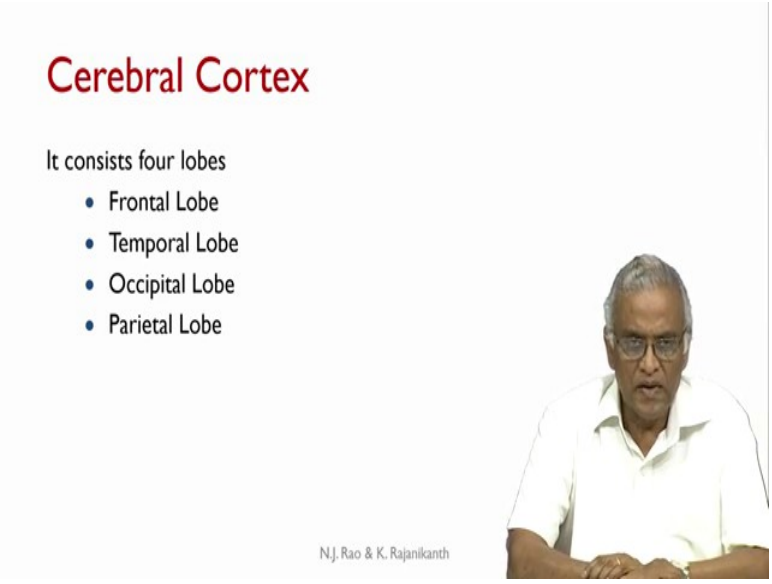

Cerebral cortex: the top layer of that consists of four lobes - frontal lobe, temporal lobe, occipital lobe and parietal lobe.

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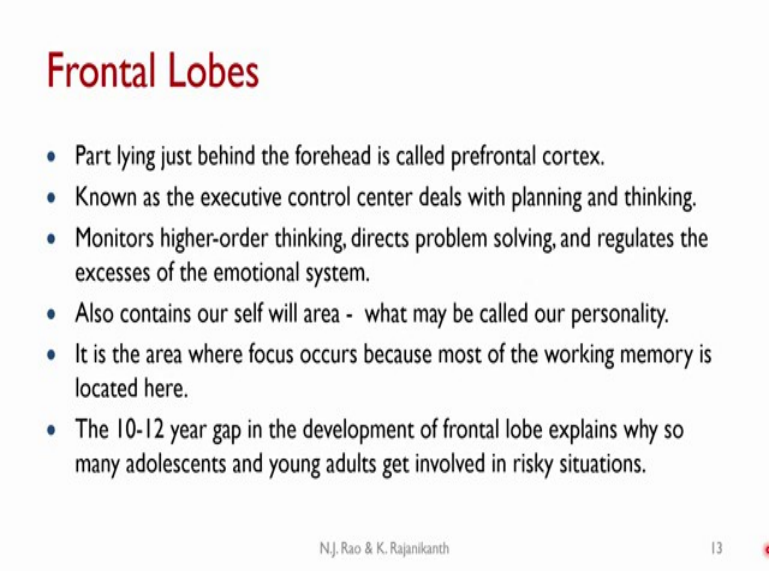

Frontal lobe: the part lying behind the forehead is called the prefrontal cortex. It is also known as the executive control center, and it deals with planning and thinking; that is an essential differentiating aspect of humans compared to the other mammals. It monitors higher-order thinking, directs problem-solving and regulates the excess of emotional system. The emotional system can be powerful, and it needs to be regulated. It also contains self-will area, which may be called our personality.

It is also the area where focus occurs because most of the working memory is located. (We will look at working memory in the later unit because memory consists of working memory and long term memory.) The interesting thing is if you look at the frontal lobe and also the midbrain or the emotional part of it; if you talk about that there is a 10 to 12-year gap between the development of frontal lobe and that of the limbic area or where the emotions are situated.

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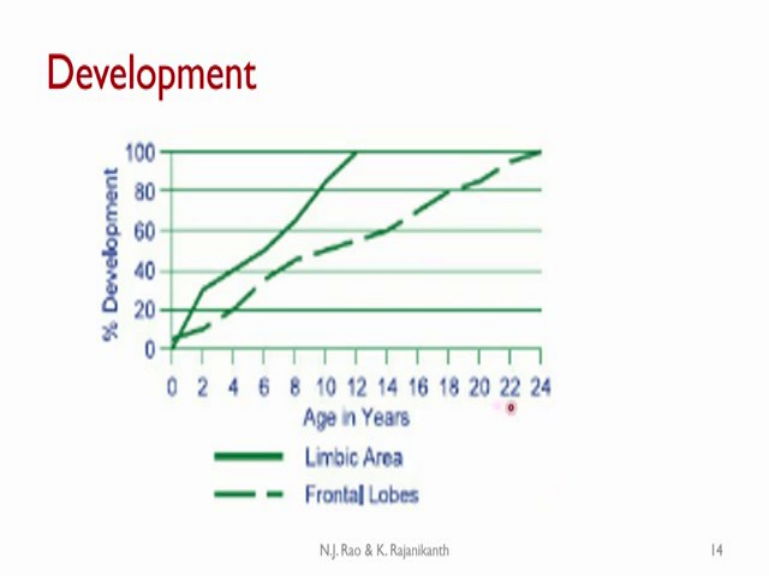

If you look at this chart - the limbic area, where the emotions are - it matures by the age of 12 that is powerful, but then the frontal lobes take a longer time to evolve, almost until the age of 24 years. The gap between the two - especially at the age of 12, is very large, this is where emotion dominates the reason. During this adolescent period where emotion can dominate the reason.

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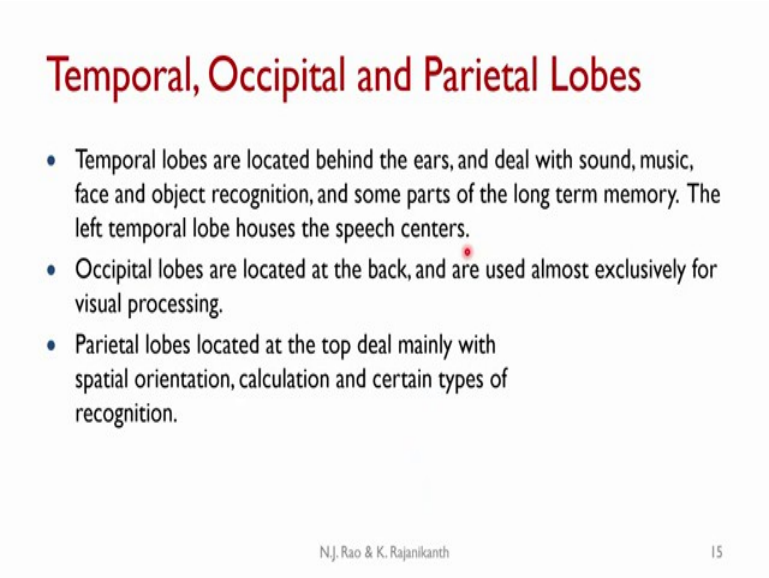

The other three lobes: temporal, occipital and parietal lobes. Temporal lobes are located behind the ears and deal with sound, music, face and object recognition and some parts

of the long-term memory, the left temporal lobe houses the speech centers. Occipital lobes are located at the back of the cerebrum and are used almost exclusively for visual processing, where all the visual processing takes place. Parietal lobes located at the top deal mainly with the spatial orientation, calculation and certain types of recognition.

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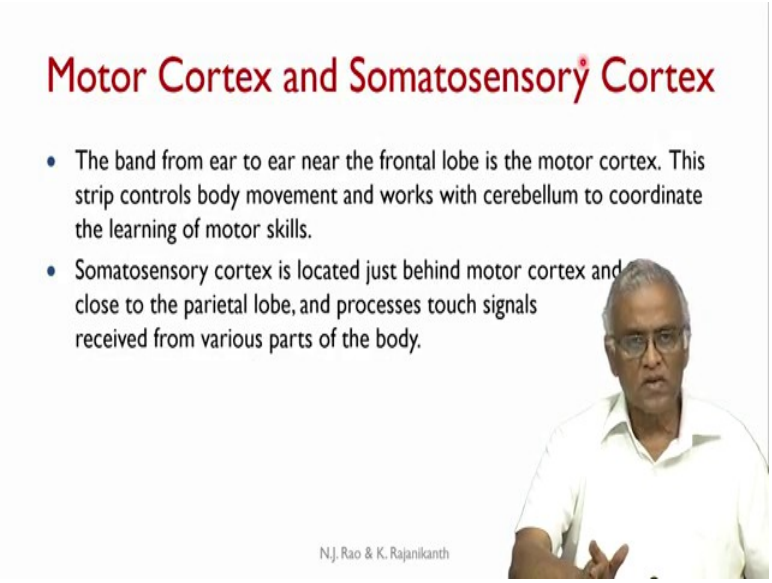

In addition to these lobes we have motor cortex and somatosensory cortex. This is where parietal lobe are the frontal lobes and are present as two bands; one is called motor cortex and the other is called somatosensory cortex. The band from ear to ear near the frontal lobe is the motor cortex, this strip controls the body movements and works with cerebellum which is the small brain that coordinates learning of motor skills.

The cerebellum and the motor cortex will have to work very closely together for any kind of skill that you develop and, that is where the mastery takes place. Somatosensory cortex is located behind motor cortex and close to the parietal lobe, and processes touch signals received from various parts of the body.

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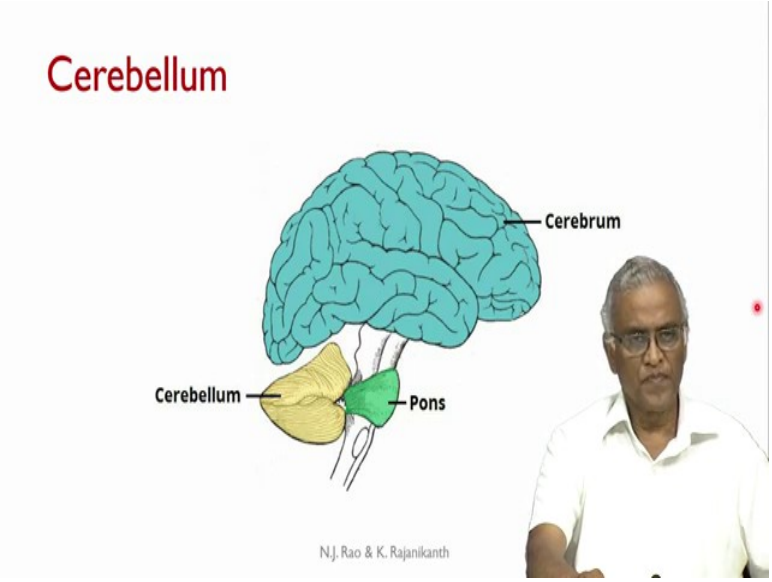

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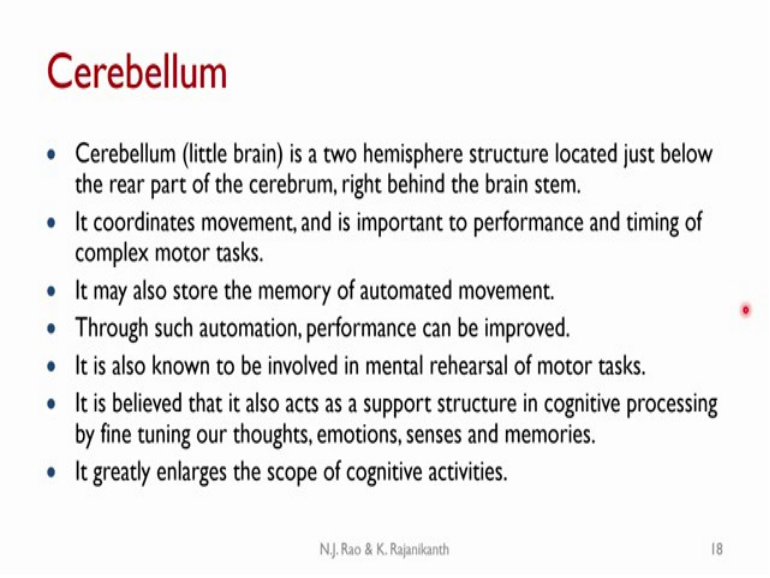

What the cerebellum do? (Literal translation of cerebellum is little brain.) Cerebellum is a two-hemisphere structure located just below the rear part of the cerebrum, right behind the brainstem. It coordinates movement and is important to performance and timing of complex motor tasks. It may also store the memory of automated movement. There are many movements in a day that we perform. After you learn a bicycle or after you would

learn to drive a car, most of the movements become automatic. It is cerebellum which is responsible for storing the memory of automated movement.

Even without any part of the cortex coming in, gets stored in the cerebellum. With such automation the performance can be improved. It is also known to be involved in mental rehearsal of motor tasks, that is when you see or you are mentally rehearsing a motor activity. This is very valuable in terms of learning of motor movements. It is also believed, it acts as a support structure in cognitive processing by fine tuning our thoughts, emotions, senses and memories. It greatly enlarges the scope of cognitive activities. As you can see practically every part of the brain is somehow involved in many of the a parietal lobe activities.

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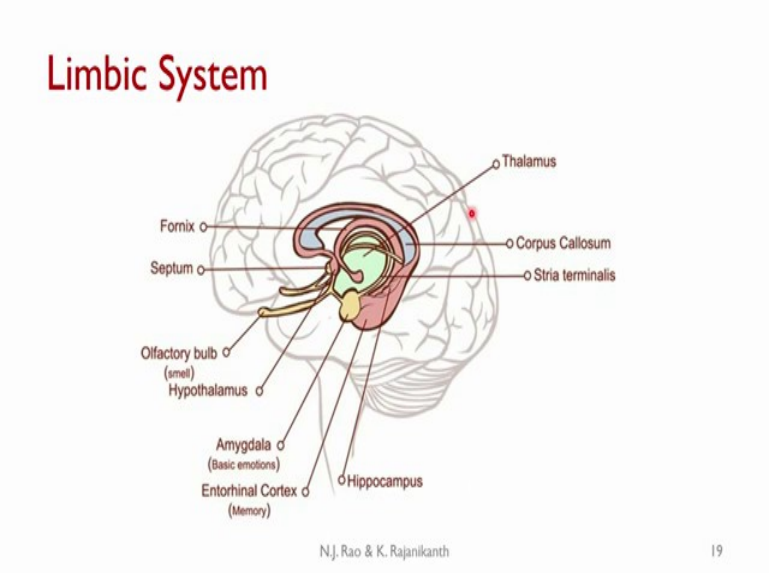

Middle brain or limbic system: It mainly consists of the thalamus. The light bluish-green part of the figure shown is thalamus. Corpus callosum is indicated in gray or bluish-grey area is the bundle of nerves that connects from two hemispheres. When we look at the limbic system, we are looking at thalamus, hypothalamus, amygdala, and hippocampus which are its four major parts. Of course, there are many other parts which will have separate names; their roles are different - we are not going to go through all of that.

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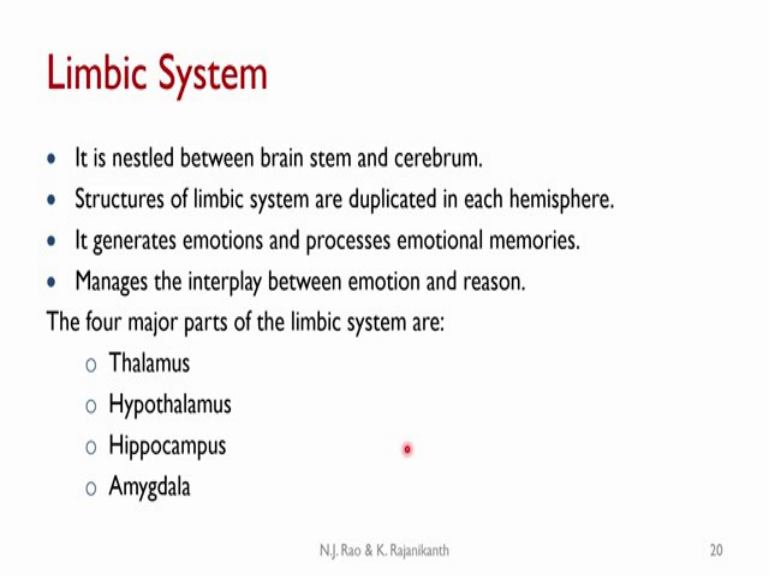

Limbic system is nestled between brainstem and cerebrum. The structures of this limbic system are duplicated in each hemisphere. It generates emotions and processes emotional memories and manages the interplay between emotion and reason. Most of the signals from all parts of the body will have to go through this limbic system. Because of that the emotions can greatly influence the cognitive process as well. The four major parts of the limbic system are thalamus, hypothalamus, hippocampus and amygdala.

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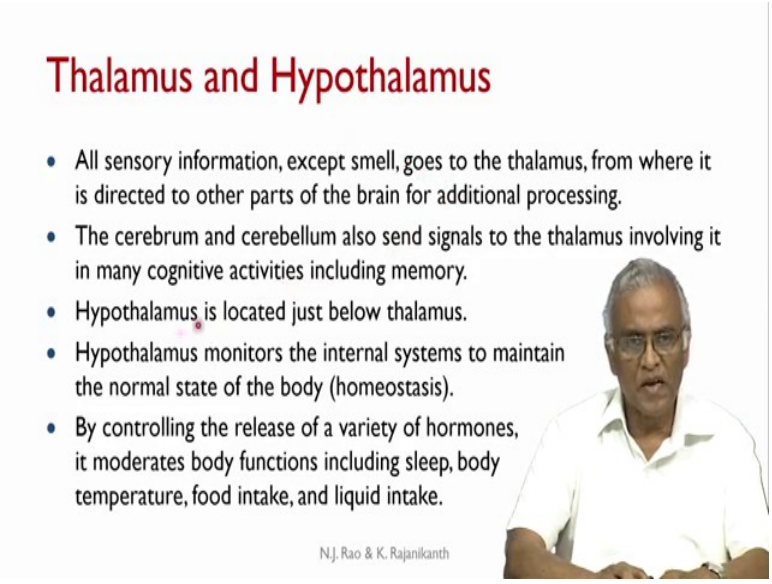

Thalamus and hypothalamus: All sensory information except smell goes to the thalamus from where it is directed to other parts of the brain for additional processing. The cerebrum and cerebellum also send signals to thalamus involving it in many cognitive activities, including memory. Hypothalamus is located just below the thalamus, and hypothalamus monitors the internal systems to maintain the normal state of the body.

That means there are several body functions that are not consciously controlled like maintaining the body temperature, the functioning of heartbeat, and all those are monitored and controlled by hypothalamus (Homeostasis - maintains whatever specified values they are supposed to be maintained.) How does it control? It controls mainly by releasing a variety of hormones. By the amount of hormones it releases, it moderates the body functions including sleep, body temperature, food intake and liquid intake. Though are nervous system is also involved, its main control is (through chemicals) by releasing hormones.

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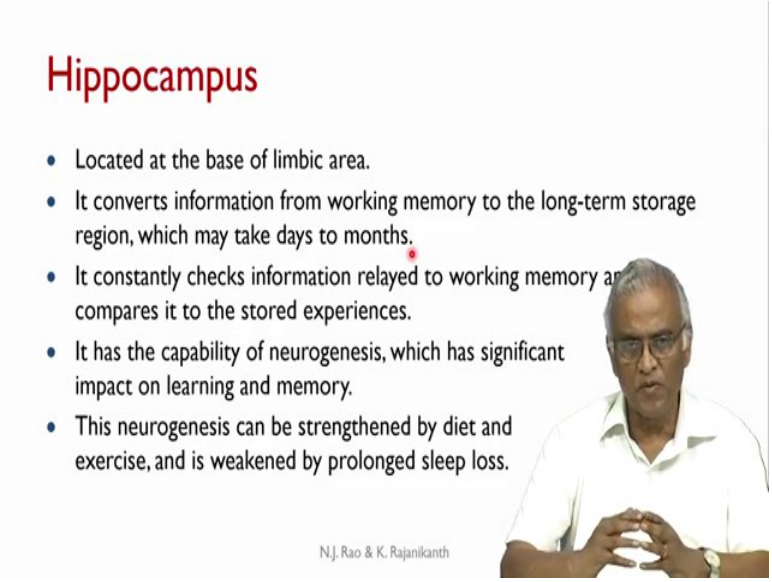

Hippocampus: Hippocampus literal translation is seahorse as it appears to one. Located at the base of the limbic area, it converts information from working memory to the long-term storage region, which may take days to months. Whatever working memory we have, temporary storage does not automatically go to the long-term storage region.

That is where our teaching comes into the picture, or the students' practices will come into picture to transfer information from working memory to the long-term storage

region. It constantly checks information related to working memory and compares it with the stored experiences. It has the capability of neurogenesis which has significant impact on learning and memory. This neurogenesis can be strengthened by diet and exercise and weakened by prolonged sleep loss. Hippocampus, as you can see, also plays an important role in terms of teaching and learning.

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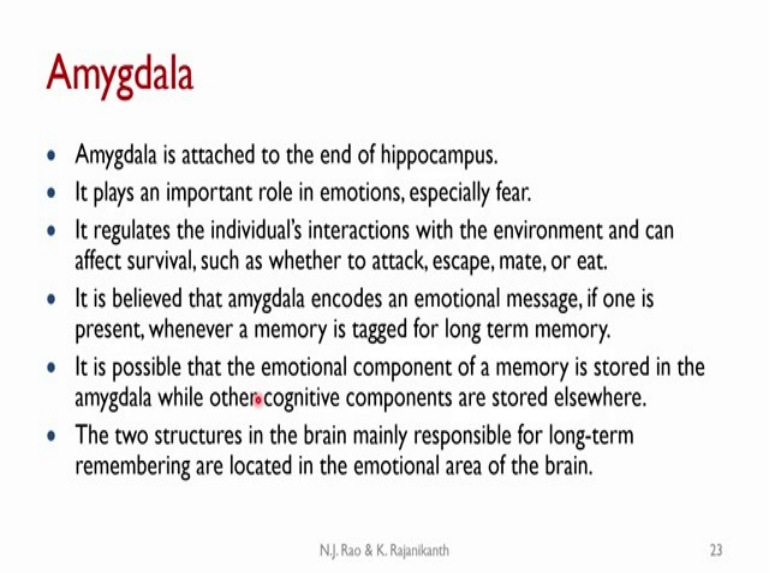

Amygdala: Literal translation is almond because it looks like an almond. Amygdala is attached to the end of the hippocampus. It plays a vital role in emotions especially fear. It regulates individual's interactions with the environment and can affect survival such as whether to attack, escape, mate or eat. Its role becomes dominant because, the time it takes to react to the external signals or signals from environment is very fast compared to the signals getting processed by the ecological part of the brain (by the various lobes.)

Through evolution, this has been possibly designed or evolved to protect humans. In the sense, if there is a danger in the environment either you need to attack or escape. So, the reactions can be strong. It is believed that an amygdala encodes an emotional message, if one is present. The memory is tagged with this emotion when it goes into long-term memory. If anything in long-term memory is tagged with an emotional message, then it can be recalled readily if it is not tagged we can still recall, but it may not be that effective.

It is possible that the emotional component of memory is stored in the amygdala, while other cognitive components are stored elsewhere. This is one thing we will see in the next unit, the same message or the same picture or an event that you have experienced; entire thing is not stored in one place in the brain. Different bits of that are stored in different parts of the brain. Somehow, they are connected to each other and if one cue comes then the entire event mentally gets recreated. But, different parts of the event are stored in different parts of the brain.

The two structures in the brain mainly responsible for long-term remembering are located in the emotional area of the brain. The amygdala and the hippocampus are responsible for long-term memory as well.

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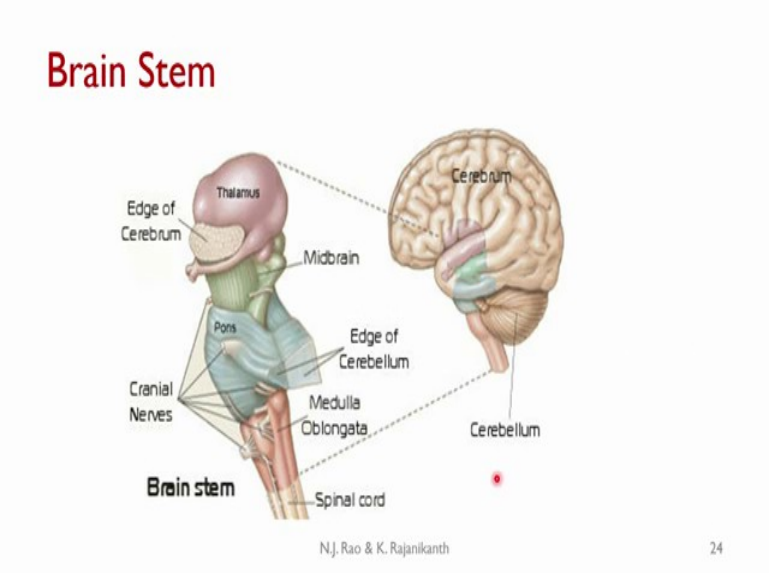

Brain stem: we are not going to look at all its details. The main part is as shown in the figure. What does it do?

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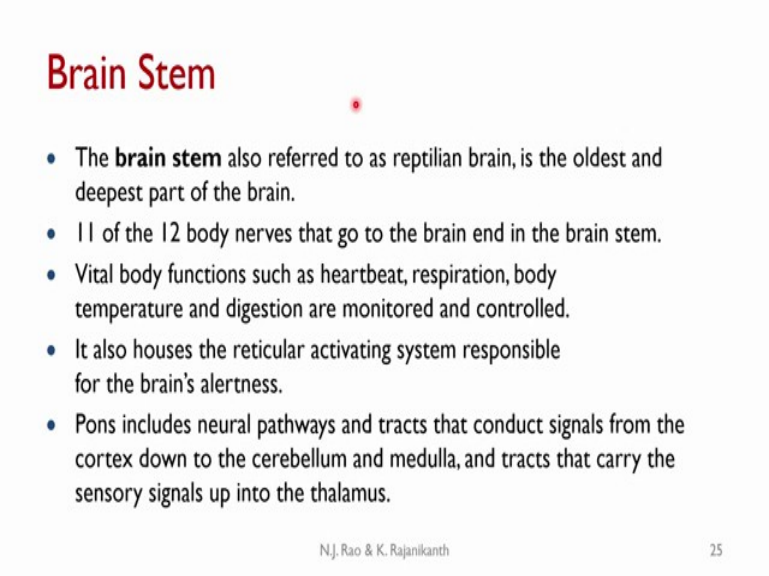

The brainstem also referred to as the reptilian brain, is the oldest and deepest part of the brain. 11 of the 12 body nerves that go to the brain end in brain stem itself. Vital body functions such as heartbeat, respiration, body temperature, and digestion are monitored and controlled right in the brainstem itself. It also houses the reticular activating system responsible for brain alertness because reactions need to be very fast if there is any danger present in the environment.

Pons includes neural pathways and tracts that conduct signals from the cortex down to the cerebellum and medulla and tracts that carry the sensory signals up into the thalamus. So, it is a kind of a junction from where the nerves from cerebrum come to medulla and cerebellum and vice versa.

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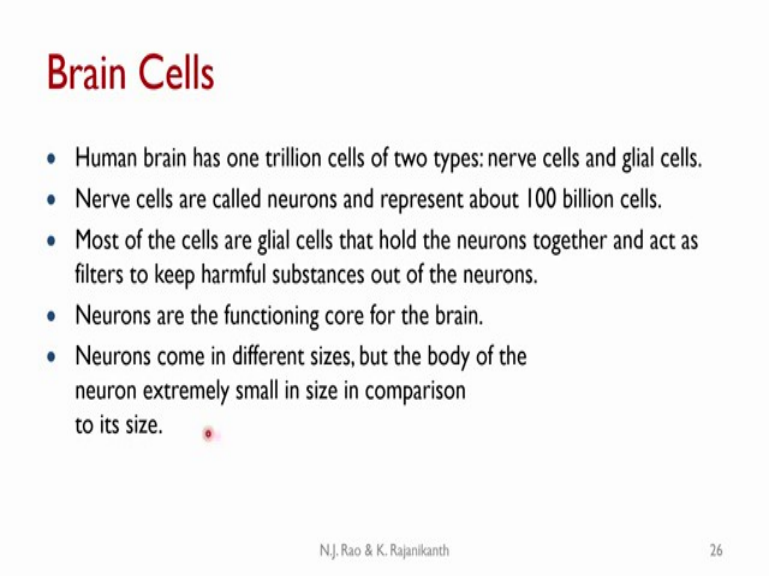

We come to the most critical part of the brain where all the work gets done – Brain Cells. The human brain has one trillion cells of two types; imagine one trillion cells. They are called nerve cells and glial cells. Nerve cells are called neurons, and there are about 100 billion neurons; that is the core of the brain, really. Most of the cells are glial cells; there are 900 billion cells; hold the neurons together and act as filters to keep and harmful substances out of the neurons and provide the required nutrition to the neurons as well.

Neurons are the functioning core of the brain. The neurons come in different sizes because some neurons can travel from all the way down the spinal cord to the leg. They can be very long, and some can be short, and there is a whole range of neurons in terms of shapes and sizes and functions and so on. But, the body of the neuron is tiny in size in comparison to its total size.

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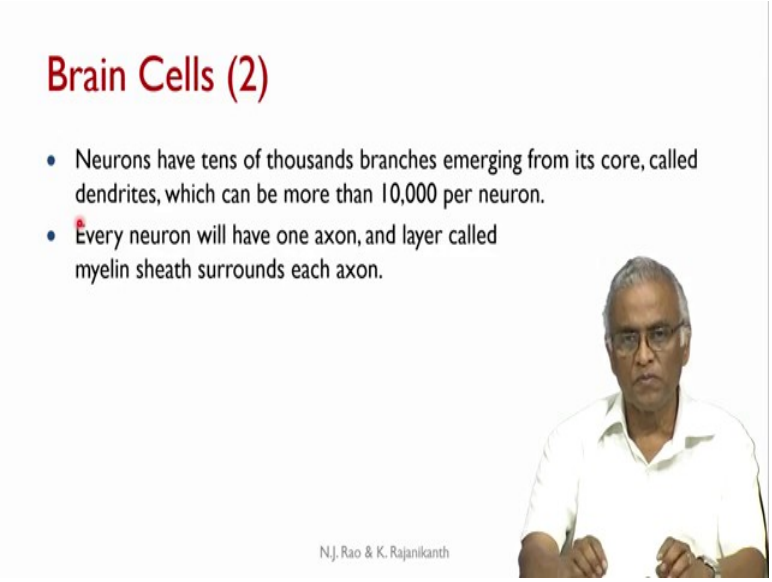

Another interesting aspect is neurons have several branches emerging from its core called dendrites which can be more than 10,000 per neuron. Every neuron will have one axon and is covered by a layer called myelin sheath surrounding the each axon.

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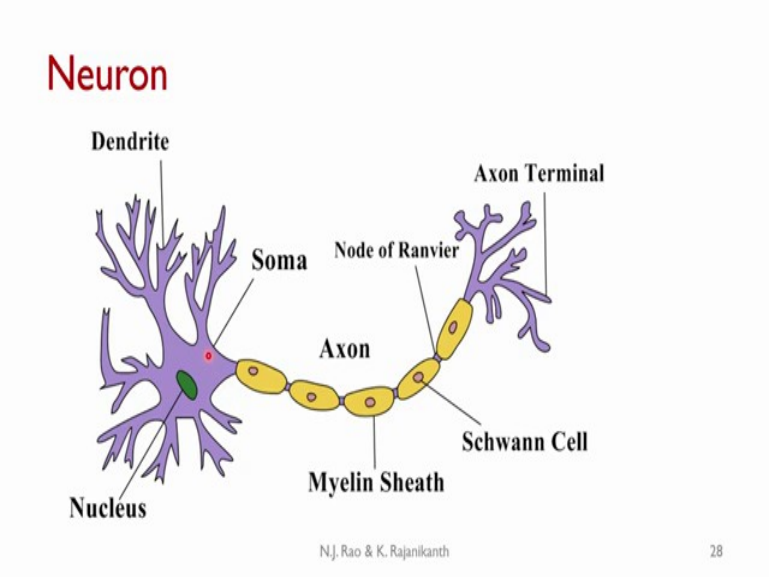

Neuron diagram: whatever be the size of the neuron the body is small as shown in the diagram. Dendrites can be up to 10,000. Axon has a sheath (yellow part - myelin sheath - comes in parts), which is more like an insulator.

The transmission of information is through electrical signals. When an electrical signal is sent along the axon, it kind of jumps from one junction to the next junction. The myelin sheath essentially makes the flow of these impulses faster, if the myelin sheath is appropriately grown.

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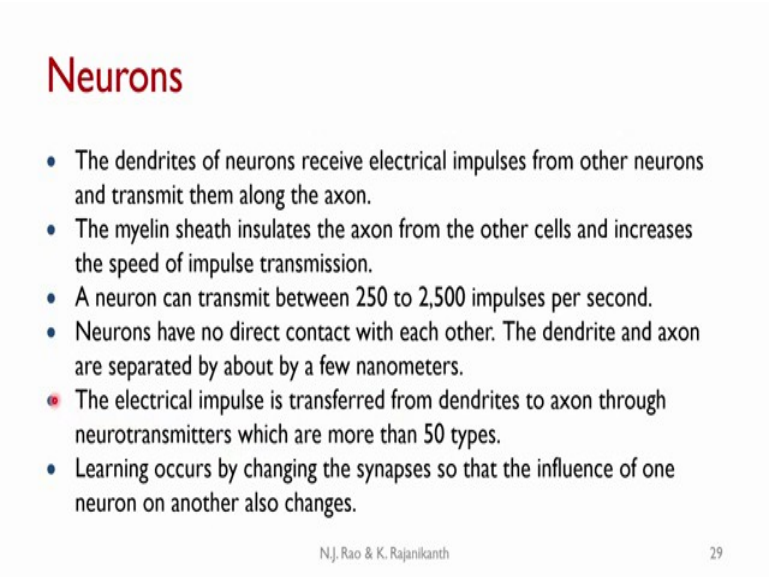

Let us look at a few more features of neurons. Dendrites of neurons receive electrical impulses from other neurons and transmit them along the axon. The myelin sheath insulates the axon from the other cells and increases the speed of impulse transmission. A neuron can transmit between 250 to 2,500 impulses per second. Neurons have no direct contact with each other. They are separated by about a few nanometers.

The electrical impulse is transferred from dendrites to axon through (not directly) neurotransmitters, and there are a large number of neurotransmitters available. Learning occurs by changing the synapses so that the influence of one neuron also changes. The learning consists of growing more dendrites and changing the behavior of the synapse (that is where the learning is.)

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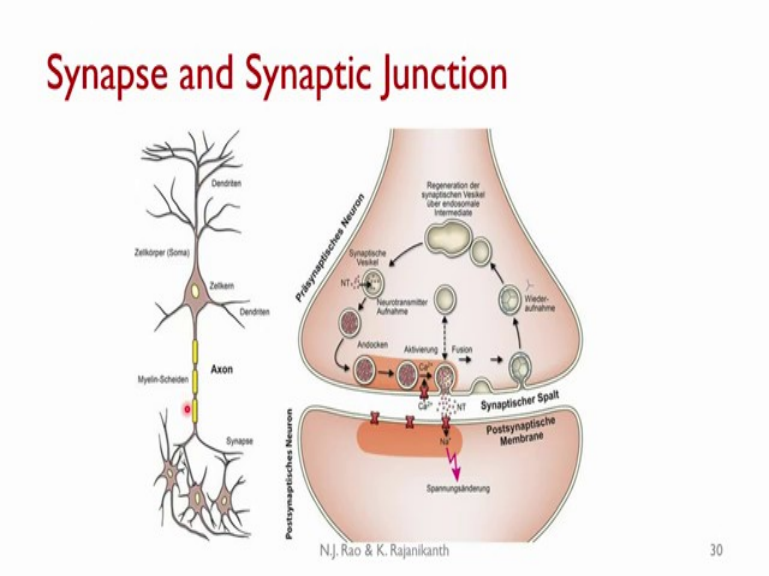

Synapse and synaptic Junction: If you look at the diagram shown, this is a neuron, and these are a whole bunch of dendrites. The dendrites of other neurons get connected to the neuron terminal and synapses are formed. This is how the synapse looks like - one is from dendrite, the other is from the neuron terminal. As you can see the neurotransmitters are released (let us not worry about this complex process, how they recycle here), and when they come in contact with neuron terminal, an electrical signal gets started and travels; that is how the synapse and synaptic junction operate.

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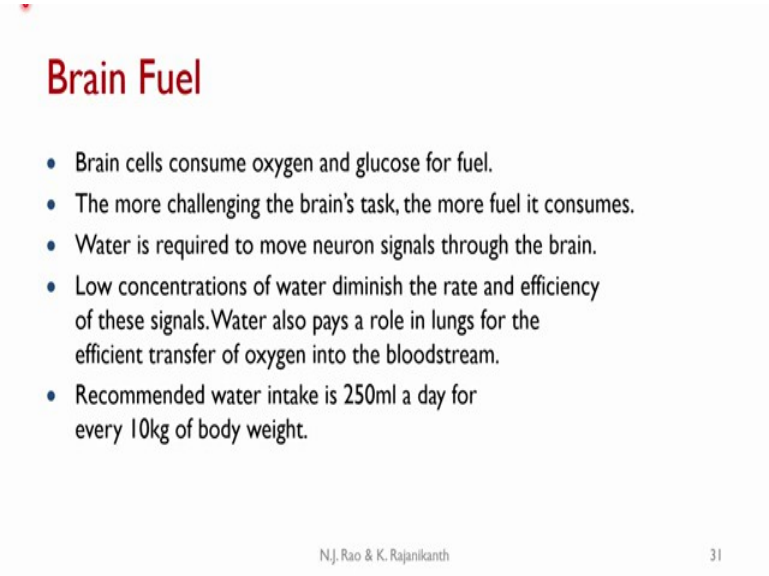

The fuel of Brain cells is oxygen and glucose. Brain cells must have plenty of oxygen and glucose available for consumption as fuel. The more challenging the brain task is, the more fuel it consumes. As you all would have experienced during your writing exam where our brain is functioning very fast, most of you would want to drink more water; that is where the oxygen comes from. Water is required to move neuron signals through the brain.

Low concentration of water diminishes the rate and efficiency of these signals, and water also plays a role in lungs for the efficient transfer of oxygen into the bloodstream. So, water plays multiple roles and helps brain to function better. According to this recommended water intake is 250 ml a day for every 10 kg of body weight, that is the minimum that you would require.

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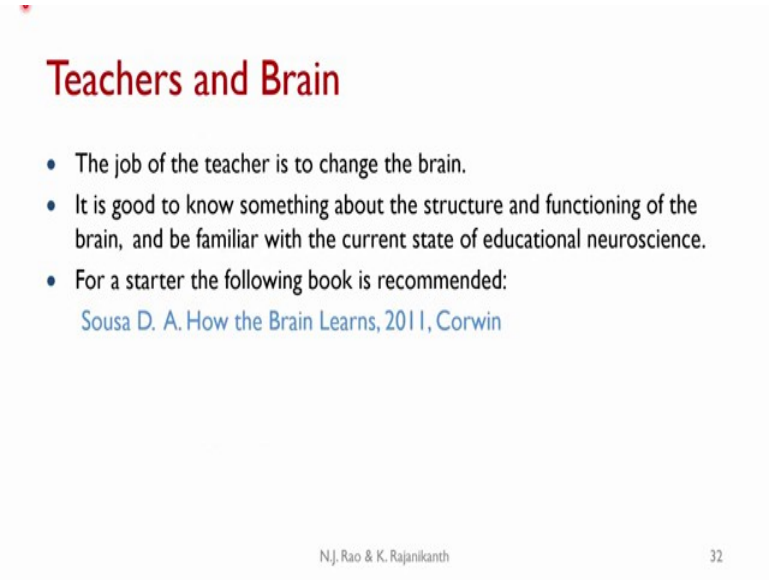

We will again talk about teachers and the brain. The job of the teacher is to change the brain. Instead of using the word teaching and learning, say his job is to change the brain. It is good to know something about the structure and functioning of what he is changing and also be familiar with the current state of educational neuroscience. One book that we will recommend for a starter that is an easily readable book by Sousa – "How the Brain Learns?"

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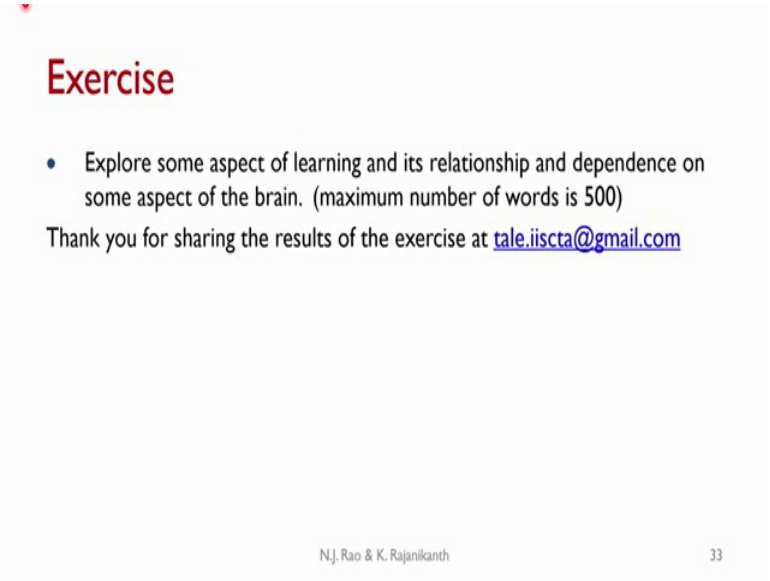

There is plenty of material on the internet; you can explore aspects of learning and their relationships and dependencies on some aspects of the brain. Maybe you can write about 500 words and would appreciate if you share the exercise at this particular email ID (tale.iiscta@gmail.com).

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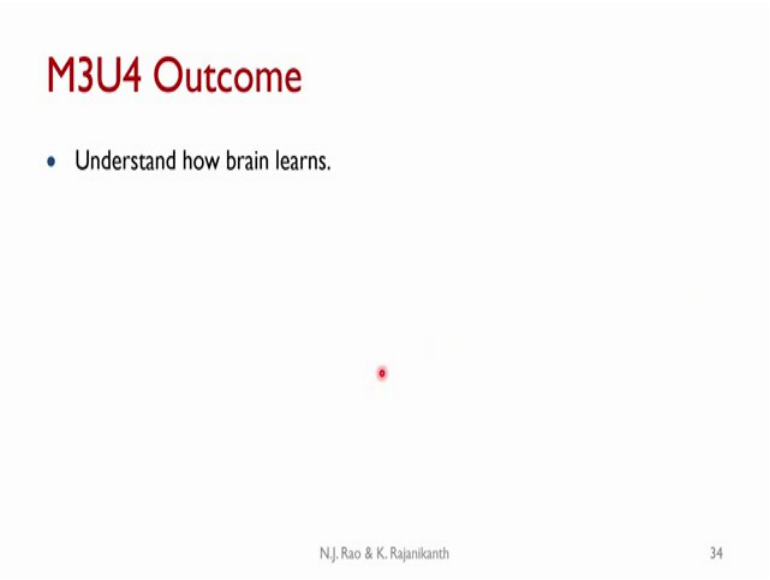

In the next unit, we will continue, not about anatomy, but assuming that we know something about it; how different activities are influenced by brain chemistry or brain structures.

Thank you very much.