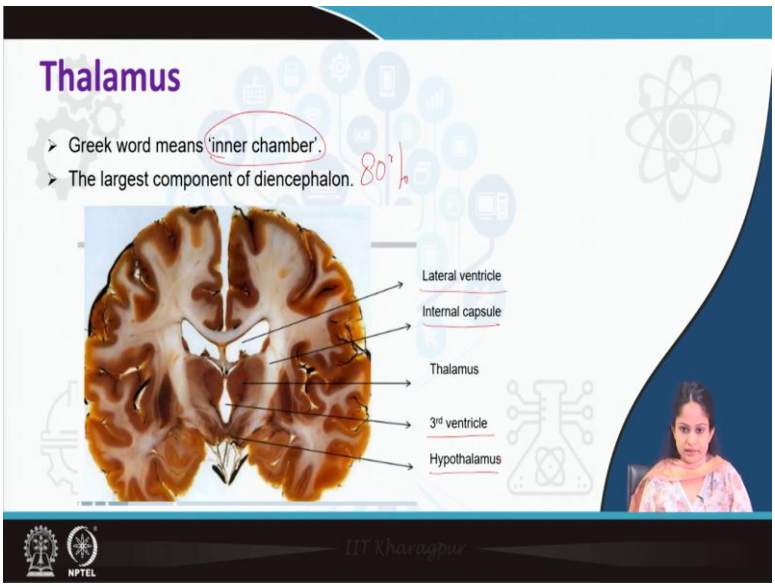
Basics of Mental Health and Clinical Psychiatry
Professor Doctor Arijita Banerjee
Doctor B. C. Roy Multi-Speciality Medical Research Centre
Indian Institute Technology Kharagpur
Lecture 04
Thalamus and Hypothalamus

Hello everyone. Today we will start our 4th lecture that is thalamus and hypothalamus.

(Refer Slide Time: 00:31)

The concepts will cover functional anatomy of thalamus and hypothalamus several nuclei which are present in the thalamus and hypothalamus. The connections of thalamus and hypothalamus functions and its applied aspects.

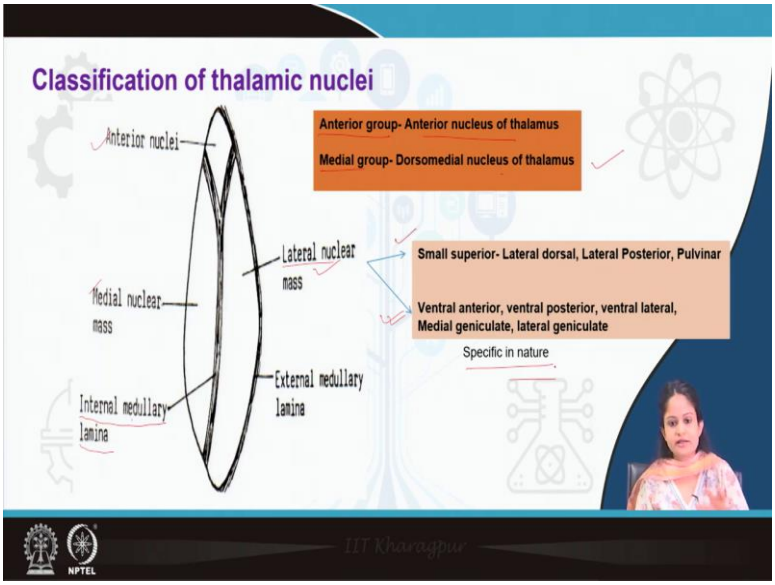
(Refer Slide Time: 00:45)



So, this thalamus word is derived from Greek word, which means inner chamber. And this thalamus forms a largest component of the diencephalon. Around 80 percent of diencephalon is formed by Thalamus, what are the other structures of diencephalon? That is AP Thalamus, hypothalamus, and sub thalamus.

So, now this is the thalamus you can see. So how it is bounded we will see the boundary of the thalamus. So, dorsally it is bounded by lateral ventricle. Literally you have the internal capsule, I had already told in previous lecture that internal capsule lies between thalamus and the basal ganglia. Then medially we have third ventricle and ventrally we have hypothalamus and sub thalamus. So, these are the boundaries you have to remember.

(Refer Slide Time: 01:36)

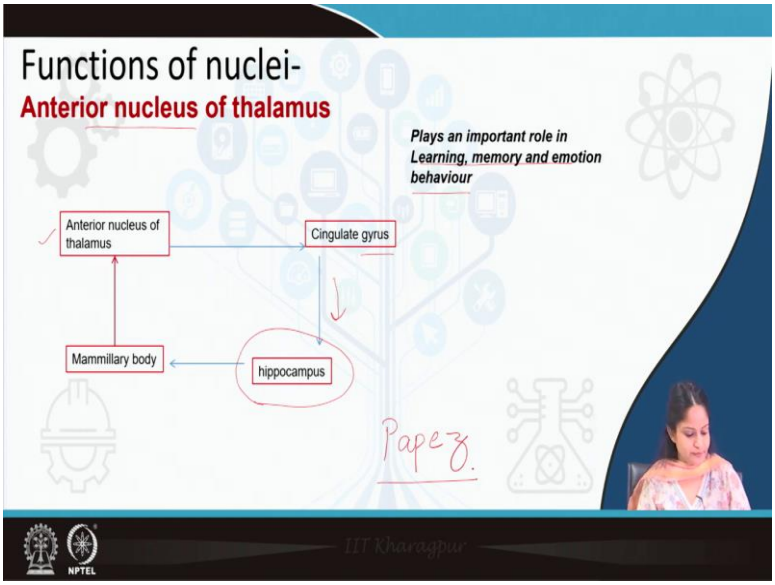


Now, how thalamic nuclei are classified? Thalamic nuclei are classified mainly based on the myelinated fibres which run in between this nuclei that is internal medullary lamina. This internal medullary lamina classifies thalami nuclei into 3 groups that is anterior nuclei, medial nuclear mass, and literal nuclear mass. Now, if you asked me whether I have to remember all the nuclei? Then no, you do not have to remember all the nuclei but at least you should remember the group of nuclei because this nucleus specific to the functions.

So anterior group of nuclei, as you can see, it is composed of anterior nucleus of Thalamus, medial group of nuclei composed of dorsomedial nucleus of thalamus, and then you have the literal nuclear mask, which is divided into superior part and inferior part. The superior part consists of littoral dorsal, lateral posterior and pulvinar nuclei, while the inferior part consists of the ventral group of nuclei that is ventral anterior, ventral posterior ventral lateral, medial

geniculate and lateral geniculate. Now, this nuclei are all specific in nature, other nuclei are all non-specific in nature.

(Refer Slide Time: 02:55)

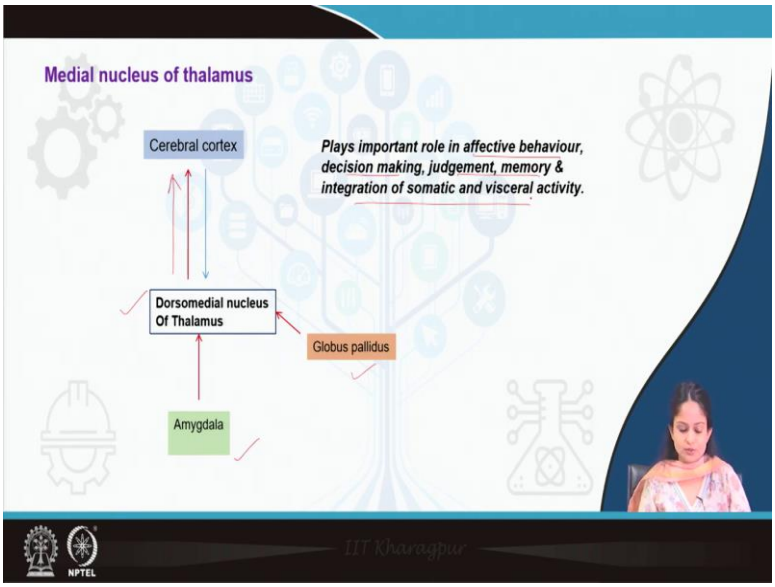


Now we will see what are the functions of this each nuclei at least the group of nucleus. So, anterior nucleus of thalamus is mainly involved in learning process. Now, it plays an important role in learning memory and emotional behaviour. Why it plays an important role. Because it is usually receiving the appearance and also the various inputs from very important structure, that is hippocampus. Hippocampus is the main structures with other structures also, it is a main site for potentiation or formation of memory.

So now it receives inputs from the mammillary body reference from the mammillary body, and it gives output to the cingulate gyrus of the cortex. This cingulate gyrus receives other information from the other areas of the cortex and sends back the information to the hippocampus. So, hippocampus is giving output to the anterior nucleus of the thalamus and it is also receiving the inputs from the other areas of the cortex thus forming this circuit. This circuit is known as papez circuit it is named by after the scientist James Papez.

So this is known as papez circuit. This we will discuss in details while we will be discussing the chapter learning and memory. Till now you should remember this circuit which is playing a main role with anterior nucleus of hypo Thalamus, which plays an important role in learning memory and emotional behaviour.

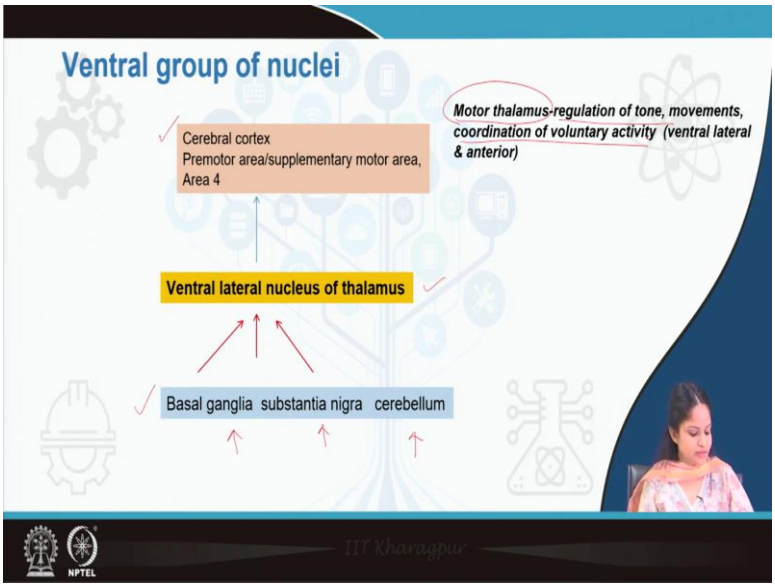
(Refer Slide Time: 04:29)



Now coming to the next nucleus that has medial nuclei. Now medial nucleus of Thalamus, which means I am talking about the dorsomedial nucleus of the thalamus. It receives inputs from prefrontal cortex, amygdala and globus pallidus. Globus pallidus is a part of basal ganglia. So, these are receiving input from globus pallidus, amygdala as well as prefrontal cortex and it also sends its efferent to the cerebral cortex.

So, it plays very important role in a affective behaviour, decision making judgement memory integration of somatic and visceral activity it plays since amygdala globus pallidus. Besides this, we have prefrontal cortex involved and this prefrontal cortex is mainly playing an important role in learning judgement making decision making. So, obviously if this gets destroyed this nucleus gets destroyed. So, there will be problems with the effective behaviour, decision making judgement memory problem. As well as it integrates the somatic and the visceral activity. So, this is dorsomedial nucleus of the thalamus.

(Refer Slide Time: 05:36)

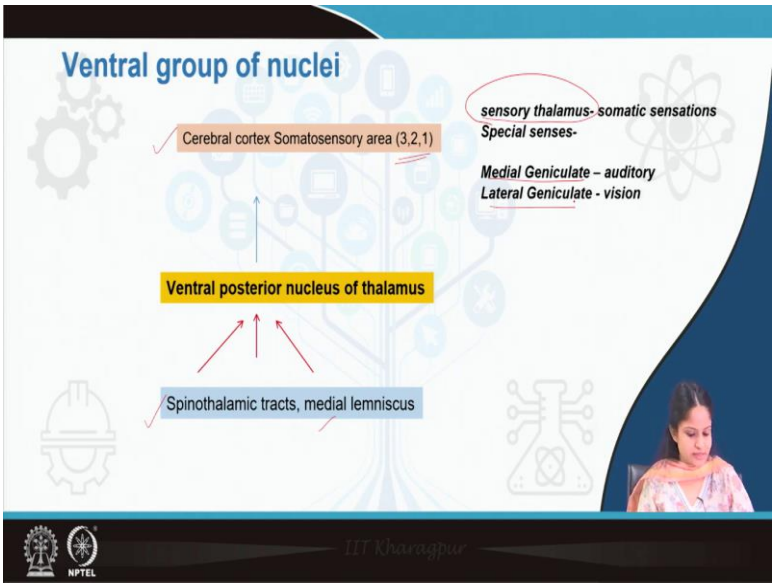


Now, coming to the ventral group of nuclei. Now ventral group of nuclei has got ventral lateral nucleus of Thalamus, ventral anterior nucleus of thalamus which is which plays almost the same functions as that of ventral lateral nucleus and ventral posterior nucleus of thalamus. You have to remember this ventral group of nuclei.

Because it is very important. Ventral lateral nucleus of thalamus mainly constitutes the motor thalamus ventral lateral as well as ventral anterior. This constitutes the motor thalamus. How? Because it is receiving all the input from the basal ganglia substantia nigra and the cerebellum, basal ganglia substantia nigra already cerebellum these structures I had already discussed in the previous lectures, it helps in the coordination of every movements.

So, ventral lateral nucleus of thalamus receives a information from these structures and it gives out the output or afferent to the cerebral cortex, mainly all the motor areas of the cerebral cortex like primary motor area, area number 4, then premotor areas supplementary motor area. Thus, this nucleus plays an important role in regulation of tone movements and voluntary activity coordination. So, this this is known as the motor Thalamus, which nuclei is the motor thalamus? Ventral lateral nucleus of thalamus.

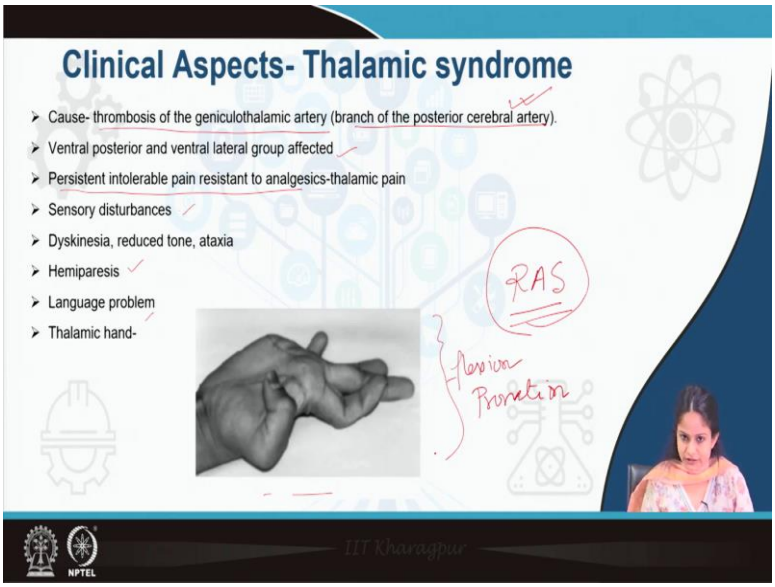
(Refer Slide Time: 07:02)



Now coming to the ventral posterior nucleus of Thalamus. Ventral posterior nucleus of thalamus mainly serves as the sensory thalamus. Why? Because it receives all the sensory inputs from the spinal thalamic tracts and medial meniscus. So, it has also got 2s parts ventral posterior medial and ventral posterior lateral. So, ventral posterior nucleus of thalamus receives the sensory inputs and it conveys this information's to the sensory somatosensory area of the cortex that is 312.

So, the sensory thalamus mainly regulates all the somatic sensations as well as the spatial sensors that is medial geniculate body, I told you my lateral geniculate body this is mainly responsible for auditory and the vision, medial is for the auditory functions and lateral for the vision. So, we have ventral group of nuclei ventral lateral, which is a motor thalamus and ventral posterior nucleus of thalamus which is sensory thalamus. So, this nuclei you have to remember in thalamus.

(Refer Slide Time: 08:08)



Now, besides this functions, which I had already discussed thalamus also plays an important role in arousal because it has got connections with the reticular activating system RAS. So, besides the motor thalamus sensory thalamus, learning memory and integration of the somatic and visceral activity it also plays a role in the arousal mechanism. Now, clinical aspects of thalamus one thalamic syndrome is very important when the posterior and the literal territory of the thalamus gets disturbed.

Now posterior and lateral territory means the ventral posterior group of nuclei will get destroyed that is the sensory thalamus and the ventral lateral group of nuclei will get destroyed that is the motor thalamus. So, the causes is mainly stroke. What happens if there is thrombosis of the geniculothalamic artery it is a branch of posterior cerebral artery. You have to remember this artery.

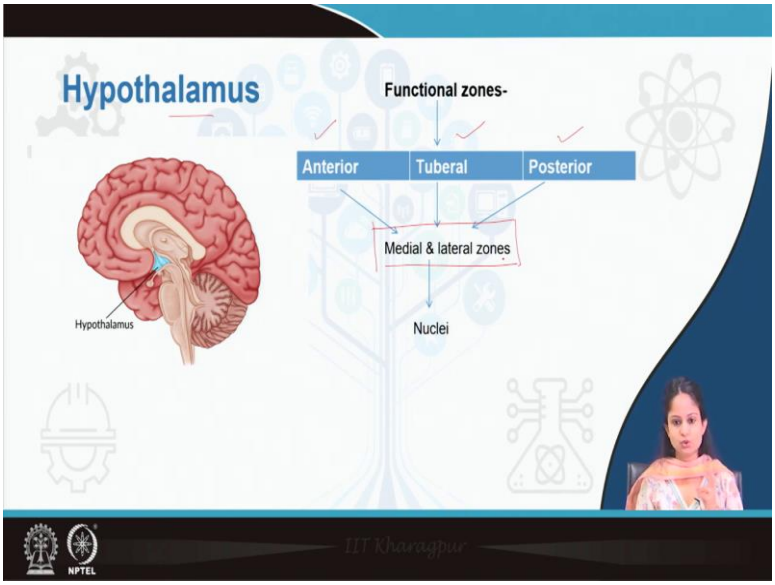
It is often asked as a short question that is posterior cerebral artery branch genicular thalamic artery this whenever there is thrombosis of this artery, the ventral posterior and the ventral lateral group of nuclei get disturbed and obviously this gets affected this will cause whatever the functions motor thalamus and sensory thalamus where having. So, this will get affected.

So there will be sensory disturbances, then there will be persistent intolerable pain, which is known as thalamic pain which is even resistant to the analgesics or the painkillers there will be intolerable pain, then as I told you, there will be sensory disturbances there will be dyskinesia reduced tone ataxia because motor disturbances, because of the motor function which is lost, hemiparesis language problem and there will be a typical posture of the hand that is thalamic hand.

Now, as you can see in the picture, what is this posture of this thalamic hand you can see there is flexion of the hand there is pronation of at the level of wrist, there is flexion there is pronation at the level of the wrist joint, then you have the extension at the inter phalangeal joints.

At the inter phalangeal joints you have extension the fingers are abducted and the thumb you can see it can be abducted or it is pushed against the palm. So, this structure is known as the dispose position this poster is known as the thalamic hand typically, feature of thalamic syndrome. So, in thalamic syndrome, the posterior lateral territory of thalamic thalamus gets disturbed and results in this dysfunctions.

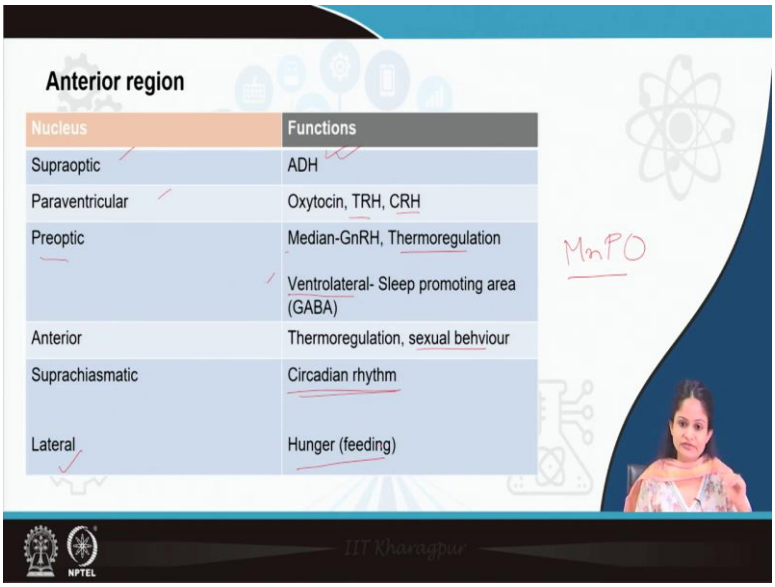
(Refer Slide Time: 10:55)



So, this must you have to remember of in case of Thalamus, Now, coming to the hypothalamus. As I told you hypothalamus means as the name suggests, anything below the thalamus, it is separated from thalamus by hypothalamic sulcus, you have to remember the 3 zones it also has got various nuclei, the functional zones if I start from anterior to posterior region It has got anterior, tuberal and posterior zones.

Now, anterior, tuberal and posterior zones is further divided into medial and lateral zones. This medial and lateral zones has further several nuclei. So, 3 zones are there, anterior tuberal and posterior. Each zone is having two zones that is medial and lateral are each having their nuclei.

(Refer Slide Time: 11:43)



So we will come to the anterior region nuclei if you see this table, you have to remember yes these are important nuclei. Supraoptic nuclei of the anterior region and paraventricular nuclei in the anterior region. These 2 nuclei secretes ADH, antidiuretic hormone and oxytocin. Now, specifically the question is asked from which nuclei both secretes antidiuretic hormone and oxytocin, but ADH is secreted maximally or in maximum amount from supraoptic nucleus and oxytocin is secreted maximally from the paraventricular nucleus.

Along with this, you have to remember the thyrotropin releasing hormone and the corticotropin releasing hormone is also secreted from the paraventricular nucleus, then a very important nucleus that is preoptic nuclei.

Now, preoptic nucleus has got 2 parts one is media and one is ventrolateral the median preoptic nuclei. We usually this is not medial, this is medial preoptic nuclei. This is mainly playing a role in gonadotropin releasing hormones mainly responsible for the reproductive behaviour and essential functions and also plays an important role in thermoregulation.

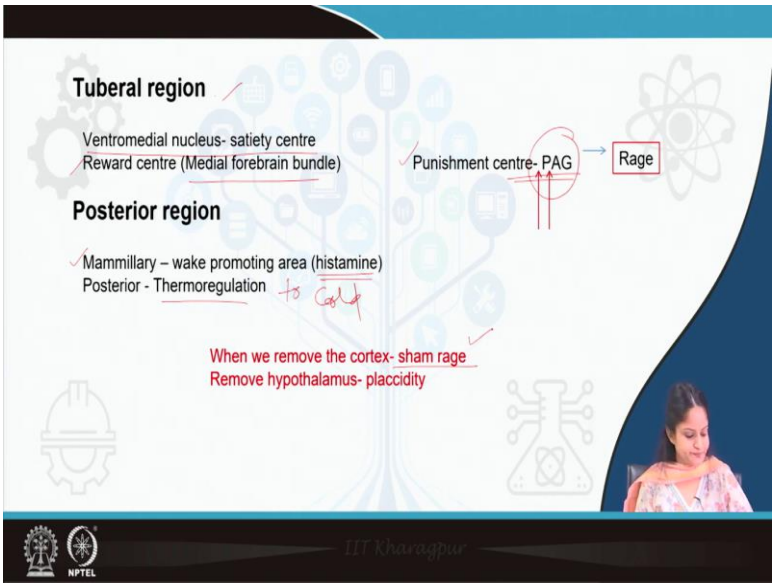
So, anterior hypothalamus, specifically median preoptic nucleus, this plays an important role in thermal regulation, when you are exposed to hot environment. Suppose I am exposed to hot environment what will be the reaction in my body I will be sweating there will be vasodilation.

So, these all features are done by the preoptic nucleus median preoptic nucleus. Now ventrolateral nucleus, this is a sleep promoting area, 2 areas you have to remember one is the sleep promoting area which induces sleep and one is the weight promoting area which

induces arousal. So, sleep promoting area is the ventral lateral nucleus, which is present in the anterior hypothalamus. Then anterior nuclei again sexual behaviour thermoregulation.

Suprachiasmatic nucleus is very important for maintaining the circadian rhythms are the biological clock in our body, then the literal hypothalamus or lateral nucleus of the hypothalamus which is present in the anterior region, it is mainly known as the feeding centre. You get hungry due to this activation of the centre, this is a lateral nucleus of the anterior region that is the hunger centre or the feeding centre.

(Refer Slide Time: 14:19)



So, when there is a feeding centre that means, there will be also a satiety centre. Satiety centre means I have taken food and I am satisfied with what I have taken I do not want to eat more. So, that is satiety centre. So, this is present in tuberal region. So, this ventromedial nucleus, this is the satiety centre tuberal region, the lateral nucleus of hypothalamus present in the anterior region that is the hunger centre or the feeding centre.

The 2 more centres you have to remember tuberal region that is reward centre and punishment centre. What is reward centre? Reward centre means whenever you get anything good. You get good marks in your exam. So, that sort of reward for you. So, you get happy. The other opposite centre is the punishment centre you feel whenever you were punished you feel sad you feel angry. So, reward centre is mainly present specifically, if the region is asked it is medial forebrain bundle and punishment centre is present in the PAG that is Periaqueductal gray region of Sylvius.

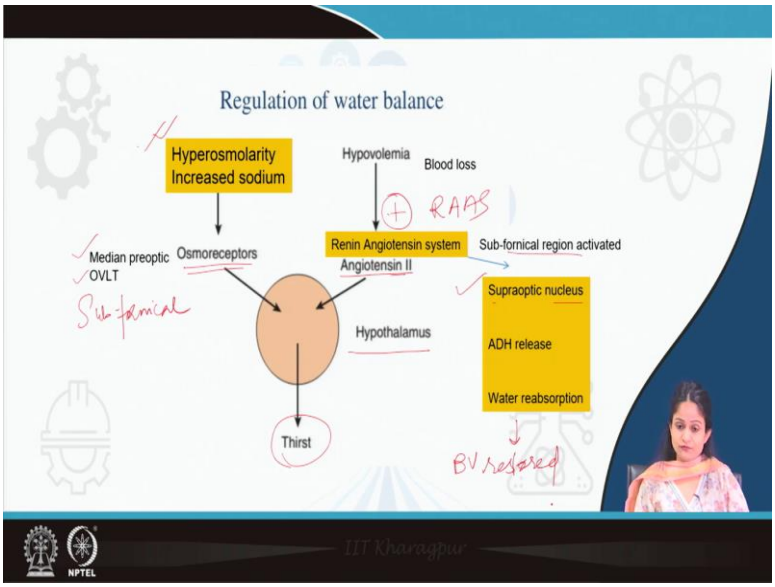
Now, these 2 region you have to remember. Coming to the posterior region of hypothalamus, posterior region of hypothalamus mammillary region I told you to region you have to remember one which induces sleep, the other which cause arousal that is a wake promoting region.

So, wake promoting region is present in the mammillary region and here the neurotransmitter histamine, they are the neurotransmitter was GABA and posterior hypothalamus is mainly responsible for thermoregulation to cold that means, whenever you are exposed to cold region you will shiver. So, this shivering occurs because of activation of this posterior hypothalamus, anterior hypothalamus median preoptic nucleus was mainly for the thermoregulation when you were exposed to hot region.

So, along with that, one important thing you have to remember is if you stimulate this punishment centre, that is periaqueductal grey region what will happen I will get angry if you are constantly stimulating this PAG region I will get angry on small things. So, this is known as rage. Now, normally in our body, this periodical grey region has to be in a submissive form. It has to be inhibited, otherwise every time I will get angry. So, normally this is kept inhibited by cortex higher functions cortex, cerebral cortex inhibits this periaqueductal grey region.

So, you do not get angry easily until unless anybody pokes you. So, whenever you remove the cerebral cortex, what will happen removal of the cerebral cortex will result in sham rage. Sham bridge means with minute and minute stimulus also you will get angry. Even if I ask your name you will get angry but if I say you hello you will get angry. So, removal of the cortex results in sham rage. And if you do not want to get any reactions from a person, no reactions at all you remove the hypothalamus. Obviously, the centres you remove, there will not be any reactions from the person that is placidity.

(Refer Slide Time: 17:33)



With this will come to the major functions of hypothalamus. The major functions first function is regulation of water balance. How blood volume is maintained in our body even after loss. So, whenever there is first condition is whenever there is hyperosmolarity whenever there is you are present walking in a desert you are thirsty. So, what happens there is hyperosmolarity that means there is increased sodium in your blood plasma. So, whenever there is increased sodium, the osmoreceptors present in our body gets activated.

Now, where are these osmoreceptors present? We have median preoptic region we have as I already told you, median preoptic nucleus we have OVLT. This is organum vasculosum lamina terminalis and you have another region that is subfornical region these are all present in front of the third ventricle. So, these 3 regions serve to be as osmoreceptors.

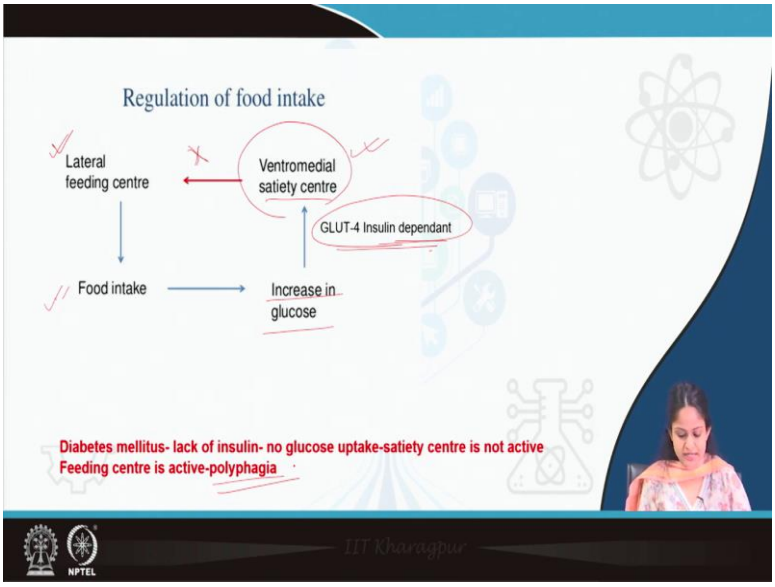
So, whenever there is increased hyperosmolarity there will be stimulation of this median preoptic OVLT osmoreceptors and it will stimulate the hypothalamus and cause drinking of water that means it will stimulate the thirst centre that is anterior hypothalamus. Now, the second feature is whenever there is heavy blood loss. Now, blood also consists of water maximum portion of the blood is water.

So, whenever there is huge blood loss in our body, say haemorrhage or road traffic accidents, what happens there is hypovolemia. Now, at that time, that is not sense that blood loss is not sensed by osmoreceptors, that time another system in our body gets activated that is renin angiotensin system or RAS renin angiotensin system or RAS this system gets activated and there is formation of angiotensin two. When this angiotensin two is formed, it will stimulate

the subcortical region which is which I already told you the osmoreceptors present in front of the third ventricle. This subcortical region will cause activation of supra optic nucleus

Now, if you remember the supraoptic nucleus present in the anterior region of the hypothalamus, this will cause secretion of antidiuretic hormone. What is the role of antidiuretic hormone? Water reserves option. So, in this way the blood volume will be restored. So, this regulation of water balance is very important you have to remember.

(Refer Slide Time: 20:11)



Coming to the next function that is regulation of food intake. Like when I will eat or when I feel hungry or whether when not to feel hungry. So, regulation of food intake is dependent on two centres which I already told you one is a feeding centre that is lateral nucleus of the hypothalamus and the other one is the satiety centre that is ventromedial nucleus of the hypothalamus, which is present in the tuberose zone of the hypothalamus. Now, if this lateral feeding centre lateral nucleus of hypothalamus or the feeding centre is always active, that means, I will always feel like eating.

So, this has to be inhibited this has to be kept inhibited, who will keep inhibited? This ventromedial nucleus or satiety centre will keep this inhibited. The satiety centre will keep the feeding centre inhibited every time and until and unless there is any other stimulus given. So, how it keeps inhibited, this keeps inhibited from the glucose level the plasma glucose level. So, whenever plasma glucose level in our body is normal or increased, it will send signals to the satiety centre with the help of GLUT 4 receptors.

Now, GLUT the glucose is transported to the brain that is a satiety centre with the help of GLUT 4 receptors, which is insulin dependent, this is very important insulin dependent that means this receptor request insulin to transport the glucose. So, this glucose will get transmitted the brain cells will sense okay there is a right amount of glucose is present. So, this person does not need to take food. So, it will inhibit the feeding centre and the person will not take food.

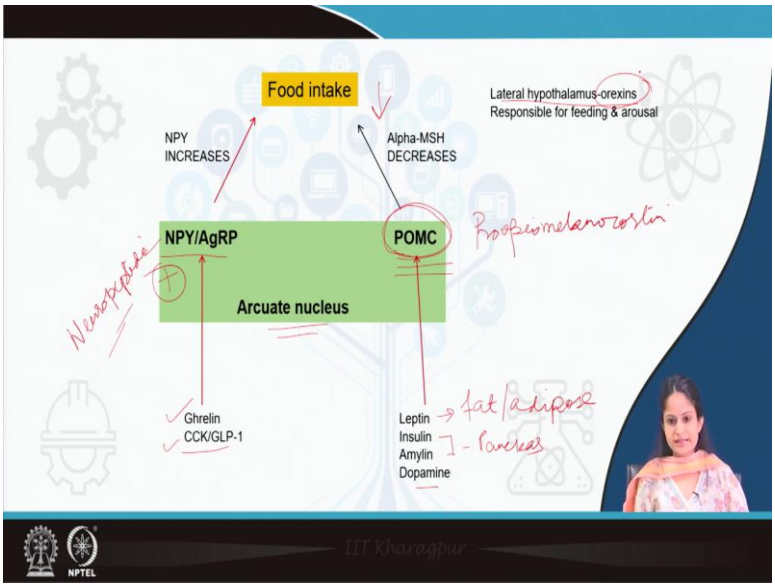
Now, what will happen if you are starving? if you are in a hunger strike or if you are starving, if your plasma glucose level will fall, when your plasma glucose level will fall, this ventromedial or satiety centre will not get any signal the brain will receive there is no glucose. So, at that time, this inhibition will get removed the lateral nucleus of the hypothalamus or the feeding centre will get activated and you will take the food and you will have the urge to take the food.

Now, what happens in case of diabetes mellitus? In case of diabetes mellitus, in case of diabetic patients, what happens the person is having huge amount of glucose in the blood plasma hyperglycemia is present, but still the person eats, why? Because in diabetes, what happens there is insulin deficiency and I told you this glucose is transported with the receptor GLUT 4, which is insulin dependent. That means, a diabetic person is not having insulin to transport this glucose.

So, in spite of having huge amount of suppose I am diabetic, my blood sugar is very much high my plasma is having huge ample amount of glucose, but still my blood brain cells mainly the satiety centre is not sensing that glucose because I am not having insulin. So, when there is no insulin, there is a deficiency of insulin, the glucose cannot be transported to the brain cells. And so, this ventromedial satiety centre inhibition is not there over feeding centre.

So, this feeding centre will remain active and the person will eat in spite of having much amount of glucose in the blood plasma. So, that is why feeding centre is active this the feature which happens in diabetic patients is polyphagia. They keep on eating intermittently, like frequent intervals of eating they usually suffer from polyphagia.

(Refer Slide Time: 24:00)



So, this is the regulation of food intake which is also governed by arcuate nucleus of hypothalamus, what is this nucleus? It is having 2 centres which balances the metabolism in our body. One is the POMC. POMC the full form is proopiomelanocortin and other portion on the other hand we have neuropeptide Y, AgRP that is a agouti-related peptide.

Even if you do not remember AgRP you should remember this is neuropeptide neuropeptide Y. So, this POMC and neuropeptide Y maintains a balance, what balance? Whenever you will stimulate this POMC region there will be decreased in the hunger, you will not be taking the food but when if you stimulate the neuropeptide Y region there we will be increasing the food intake in this way they regulate the metabolism.

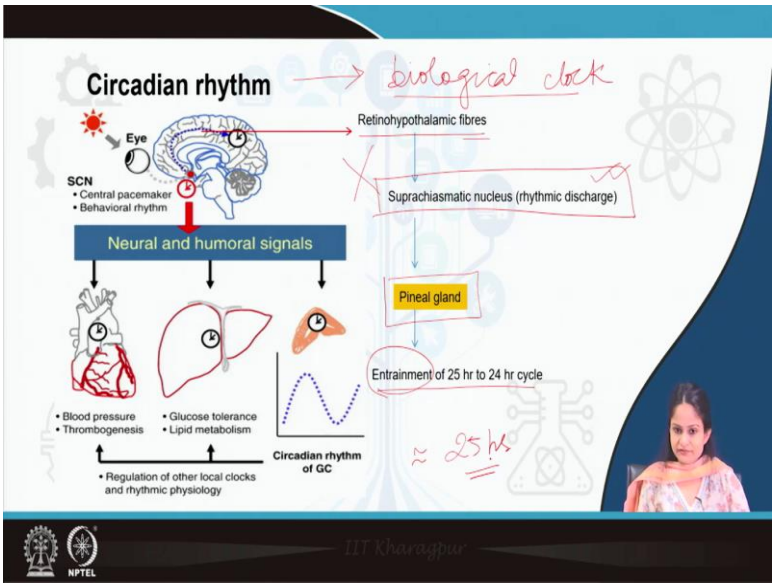
So, what are the stimulators, the hunger is decreased or POMC stimulated mainly by leptin, insulin, a myelin and dopamine. Dopamine is a neurotransmitter, insulin and a myelin, this is secreted from the pancreas and leptin is present in the fat cells or the adipose tissue. So, adipose tissue means suppose I am wearing fat, so I will having I will be having more adipose tissues.

So, the more adipose tissue means more fat cells more leptin. So, more leptin is there. So, this will cause activation of POMC and hence food increase food intake will get decreased. On the other hand, ghrelin is secreted from the stomach and these are cholecystokinin and (())(25:53), these are secreted these are the gut hormones.

So, this will stimulate the food intake this will stimulate the neuropeptide by region and cause intake of food. So, in this way, you can see there is a balance which is maintained in the food

intake. So, lateral hypothalamus along with this you should always remember there is secretion of orexins. Orexins is also responsible for the feeding behaviour as well as arousal mechanism.

(Refer Slide Time: 26:20)



Now, coming to the last portion, that is the last function of hypothalamus. This is maintaining the circadian rhythm. Now, what is circadian rhythm? Circadian rhythm is the biological clock. Biological clock means there is a 24 hour cycle which goes on in our body.

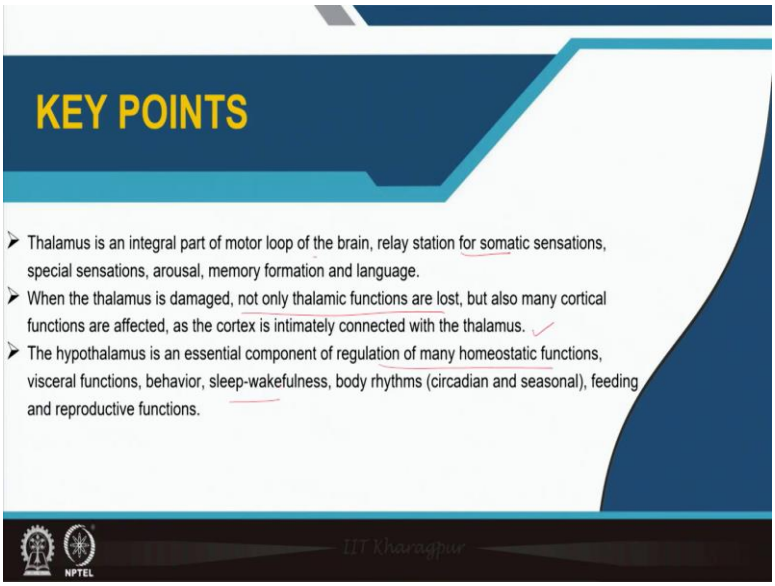
For example, if my body temperature usually gets raised at 6 pm, then the next day also during the same time 6 pm my body temperature will get raised. If you are sleeping usually around 10 pm at night, usually the next day also you will sleep around 10 pm. So similarly, this goes on the blood pressure regulations, various hormone secretions, these are all maintained by this circadian rhythms especially the sleep wake cycle.

So whenever this is hampered, you get jetlag. So the circadian rhythm is the biological clock a 24 hour cycle. So, how it is maintained? We will see the sleep cycle whenever there is light falling on the eyes, that signal is transported with the help of retinal hypothalamic fibres to the suprachiasmatic nucleus. I told you the suprachiasmatic nucleus is present in the anterior region of the hypothalamus. it (())(27:40) circadian rhythm, the suprachiasmatic nucleus has got typical phenomena of rhythmic discharge or pulsatile discharge.

So, this will cause activation of this pineal gland. This pineal gland will cause entrainment of 25-hour cycle to 24-hour cycle which means, normally in our body without the intervention of suprachiasmatic nucleus pineal gland with the help of melatonin maintains a 25-hour

cycle. It does not maintain 24-hour cycle. But that 25-hour cycle is converted to 24-hour cycle, which is known as entrainment with the help of suprachiasmatic nucleus. That means if the suprachiasmatic nucleus gets destroyed, my 24 hour cycle will become again approximately 25 hour cycle which is normal which will cause various hindrances in my daily activities. So in this way, circadian rhythm or biological clock is maintained by suprachiasmatic nucleus.

(Refer Slide Time: 28:44)



So, the key points you have to remember in thalamus and hypothalamus that thalamus plays an integral part of the motor loop of the brain released end station for the somatic sensation, special senses arousal, memory, formations and language. When thalamus is damaged, not

only thalamic functions are lost, but also the cortical functions are affected because these are all interconnected.

The cortex is intimately connected with the thalamus. And the hypothalamus forms an essential component in regulation of many homeostatic functions, visceral functions, endocrine functions, body rhythms, sleep wake cycle as well as reproductive functions. So this much you have to remember in thalamus and hypothalamus. Thank you.