Demystifying the Brain
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Lecture – 16
Memories and Holograms-Segment 02

Hi, so this is second segment of the lecture on memories and holograms in the previous segment of this lecture, we talked about memories and how you can understand them as a attractors of a network and we introduced a idea of a Hopfield network and how you can store memories using the hebbian learning hebbs rule and how you can retrieve them so and we also introduced idea of an associative memory right that that human memories are closed associate memory and are very different from index memory which we are we see in a computer.

But we never say anything about how this memories are actually stored in the brain or where they are stored in the brain and that is the subject matter of this second segment.

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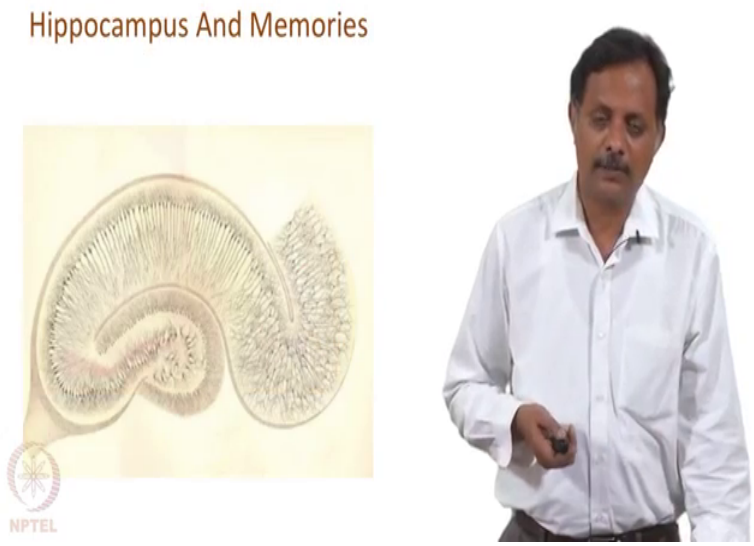

So, in this segment we will talk about hippocampus which is a very important memories related structure in the brain and how it stores memories for the short term.

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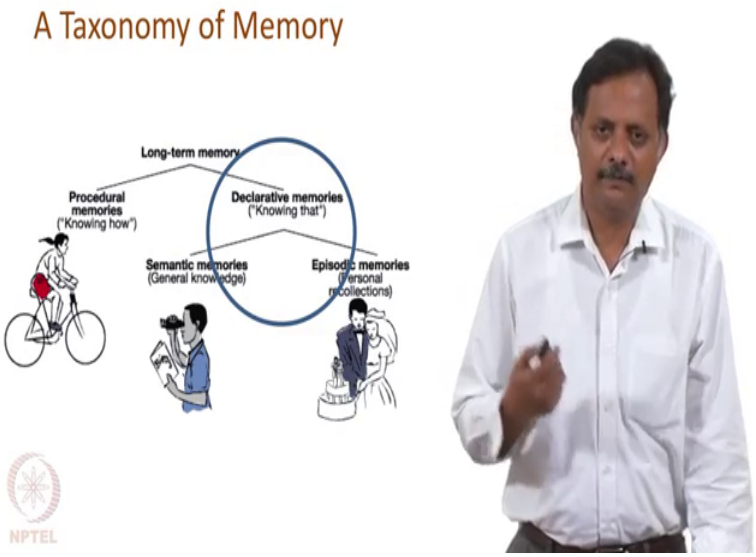

Now memory we use the term bit loosely, but there are different kinds of memories and this is a very broad taxonomy or classification of memories or long term memories into procedure memories and declarative memories, in procedural memories this memories deal with motor memories for example, cycling I mean that something you cannot explain how you do it you know we just know it is in your in it is in your [mort/ motor] motor system.

Whereas, the declarative memories are something that you know it and you can express it of an in a language in form of language and here there are two sub categories. So, there are the semantic memories these memories deal with general knowledge and episodic memories these are personal [ref/reflections] reflections or memories of events that you are experience in the past.

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So, hippocampus is a very important sub cortical structure in the brain, which is a which plays a major role in storage and consultation of memories it is called the scratch pad of memories, because this way you store information or memories for a short term after which they are you know passed on to long term stores in a cortex. So, any damage hippocampus is known to impair our ability to store and retrieve the declarative memories.

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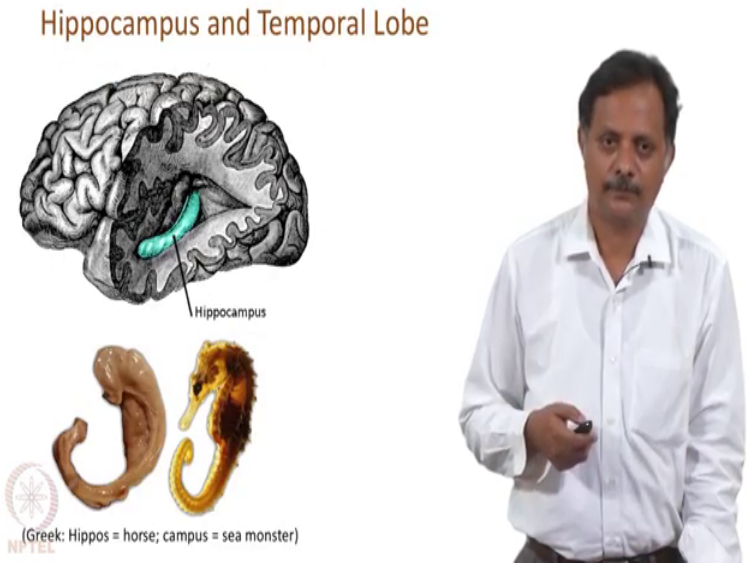

So, hippocampus looks like this it is located inside the temporal lobe and you can see that the blue region which are which denotes hippocampus and on the right you see the actual anatomical structure of hippocampus on the left and you know or on the middle and on the right extreme you see this little sea creature called the sea horse and the word hippocampus comes from the sea horse, hippos means horse and campus means sea monster because, of this appearance of this structure to sea horse and it is called it is named hippocampus.

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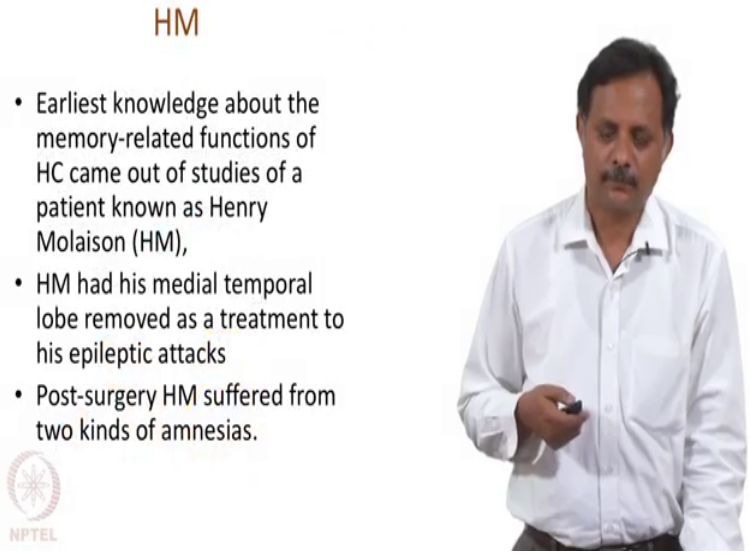

So, our earliest knowledge of the functions of hippocampus came with from the studies of a patient known as a Henry Molaison, for a very long time he this patient was report to by his initials HM.

But recently the patient passed away and you know since the and we can reveling the full name of this patient. So, HM had his medial temporal lobe removed as a treatment for his epileptic attacks as a time, when in the case of intractable epilepsy people use to remove temporal lobe because, the source of epileptic ceases or the epileptic focus used to be general located in the temporal lobe surgical are removal of this region, is saw is a generally considered as a solution for the epileptic attacks. So, is temporal lobe was removed and middle temporal [ro/lobe] lobe was removed and after that HMs of out from 2 kinds of amnesias.

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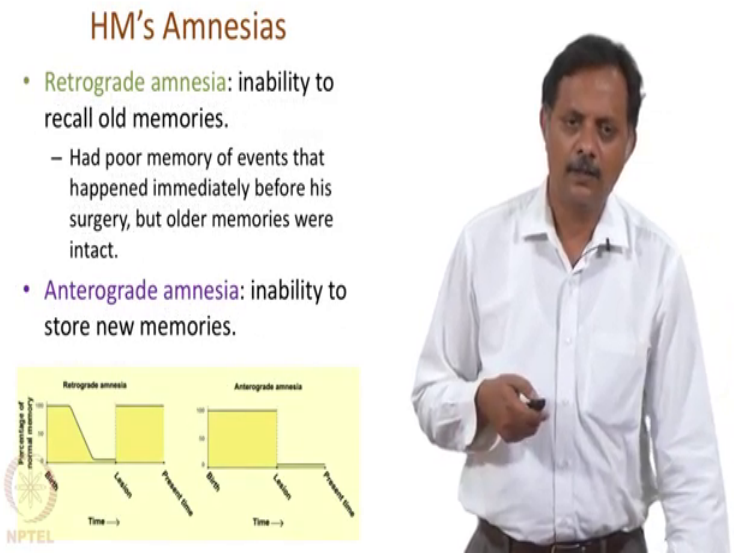

So, one of them is retrograde [am/amnesia] amnesia, which refers to inability to recall old memories. So, basically if in this picture you see the time at which are lesion or the in this case surgery has occurred and anterograde amnesia refers to memories of [me/memories] memories are tap now from the time before the [le/lesion] lesion or surgery had had happened.

So, this patient had anterograde amnesia up to a period before the surgery has happened, but memories from much long before the surgery right some of them are intact; then HM also had anterograde amnesia which refers to ability to store new memories that is after the lesion he was he is not able to store memories. So, in the picture below it is shows anterograde amnesia or you know and [ant/anterograde] anterograde amnesia, but the patient h m had both kinds of amnesia.

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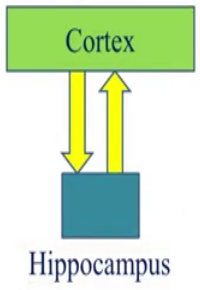
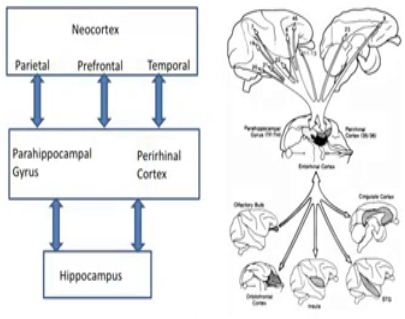


So, basically let us look at the relationship between hippocampus and cortex. So, as you have seen in the picture it is a sub cortical structure, it is located deep inside the temporal lobe and you know it is a sub cortical structure. Now how is it related with the cortex, so basically it operate very simply hippocampus is receives a extensive projections or convergent projections from the cortex and it also sends divergent projections back to the cortex.



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So, if you expand that picture little bit and put in some of the anatomical regions both on the cortical and on the cortical side and on the hippocampus site the picture looks a bit like this. So, in the neo cortex you have 3 major regions sub parietal prefrontal and

temporal and all this 3 regions and send feed forward and feedback connections to parahippocampal Gyrus and Perirhinal cortex and these two regions in turn send projections to the anterograde cortex, which is not shown in this picture and the anterograde cortex which is consider the gateway to hippocampus right; then sends projection deeper in hippocampus and to various hippocampus fields.

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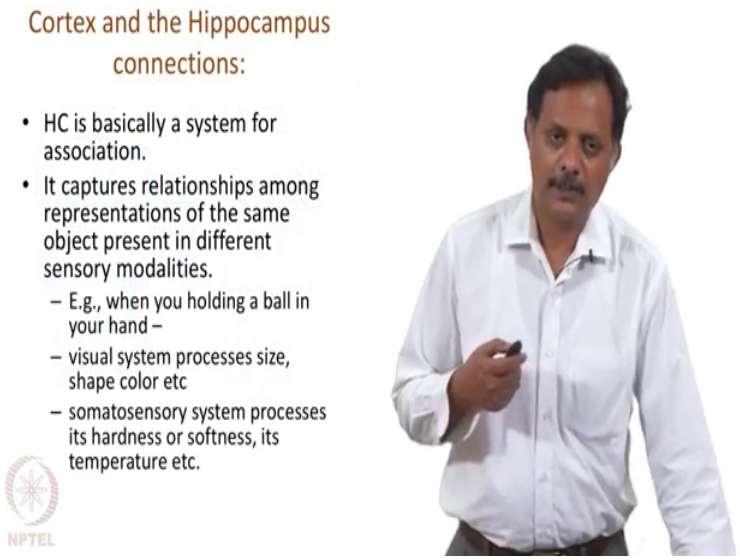

So, hippocampus is basically a system for association. So, it associates different features or different properties of an object. So, very often when you experience some object when you receive the sensory information from an object this information can be in multiple sensory modalities.

So, for example if you look at a ball if you looking at a ball which is holding in your hand right, the your visual information tells you that the object is round in shape, it is it has some kind of a color called the red and you know it feels hard or it feels soft or it is warm or hot or whatever right. So, you receive information from the object through multiple sensory modalities and all this modalities combined into a single percept of that object.

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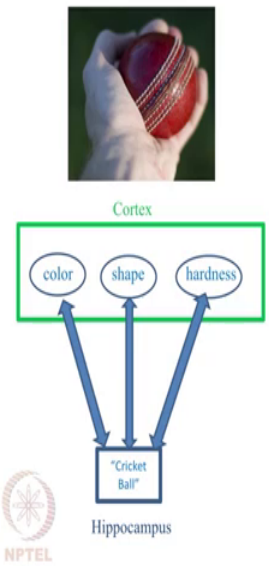

So, for example, if you are holding a cricket ball right it is a red in color and it is round in shape and it is hard right in terms of it is touch. So, all this properties are combined to create this construct or a concept called the cricket ball ok. So, the sensory properties are process in the cortex in various sensory areas of the cortex.

So, for example, color this [pol/process] process in the v 4 region of the visual cortex and shape is process in the infratemporal area of the visual cortex and hardness or the touch of it you know is probably process in the in the primary and secondary somato sensory cortex S1 and S2 SS1 and SS2.

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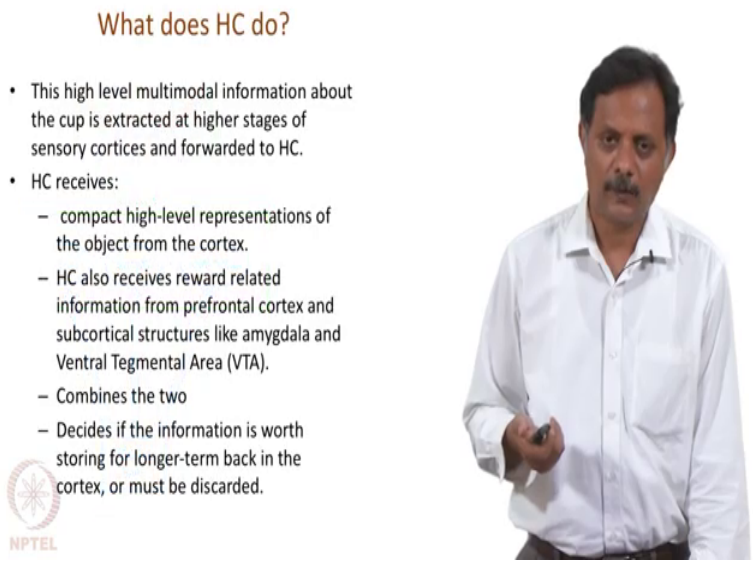

Now, these primary sensory areas project to higher you know sensory association areas in the inferior parietal and from there you know through this stages that we have just seen right, this cortical stages these areas project to the hippocampus. So, this sensory properties are represented in the cortex and they all converge to the hippocampus in the hippocampus, you code for or represent a high level abstract higher representation of the object here that is a cricket ball.

So, basically hippocampus receives a compact high level representations of the object from the cortex, it also receives reward related information from the prefrontal cortex and subcortical structures like amygdala and ventral tegmental area. So, you have seen in some of the previous lectures, that the neurons of ventral tegmental area which releases substances called dopamine right are represent reward. So, these areas and also you know prefunded cortex are they project to the hippocampus and here the hippocampus is informed about the reward associations of this of the object.

So, in hippocampus has access to reward information and also access to the sensory information from the cortex, it combines these two forms of information and decides if the information is worth storing for longer term back in the cortex or must be discarded because, 1 of things is that decides whether you store information or not is some kind of a significance or a salience of the information.

So, if otherwise as we said for example, go down the street everyday are you meet so many people or see so many things all of that may not form part of your long term memories. So, unless you find something interesting or salient or significant right, in some sense right you your brain does not decide to pass it on for memory storage.

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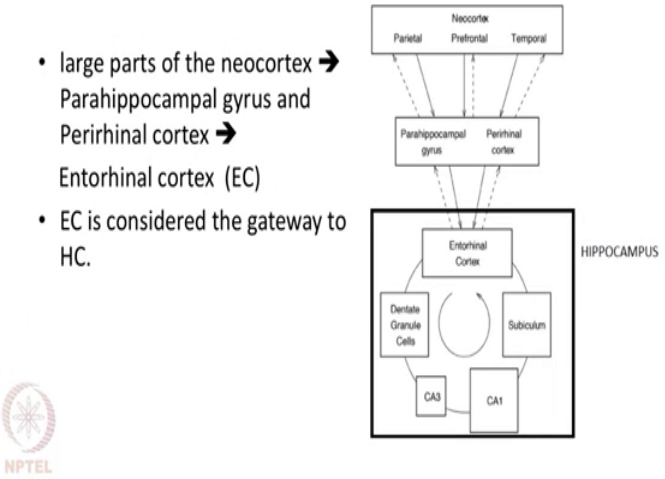

So, like I said the large parts of a neocortex are project to parahippocampal gyrus and perirhinal cortex and these two cortical areas in term project to entorhinal cortex EC and EC is considered the gateway to the to the hippocampus.

So, you can see that in this picture you can see the two cortical stages and then the input to that goes to entorhinal cortex and within the hippocampus right, you see a loop like you know architecture. So, from internal cortex you know our project to the dentate gyrus or you know which is shown here in this picture as dentate granule cells, from there you know cells project to CA3 and from CA3 the project to CA1 and CA1 that project to subiculum and subiculum projects back to entorhinal cortex. So, it form a loop of connections, the more connection within hippocampus and that you will see in a moment.

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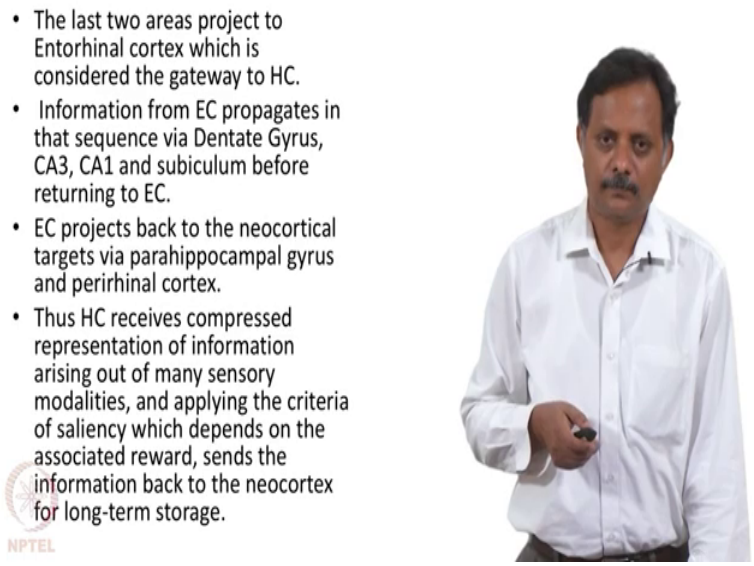

So, like I said entorhinal cortex is gate way to the hippocampus and from there you have a sequence projections from EC from HC from EC to dentate gyrus to CA3 to CA1 and subiculum before returning to EC. Now EC projects is back to the neocortical targets where the parahippocampal and perirhinal you can see that still hippocampus is receives compressed representation of the information arising from the sensory modalitiesnd combines it with the reward information and sends the information back to neocortex for long term storage.

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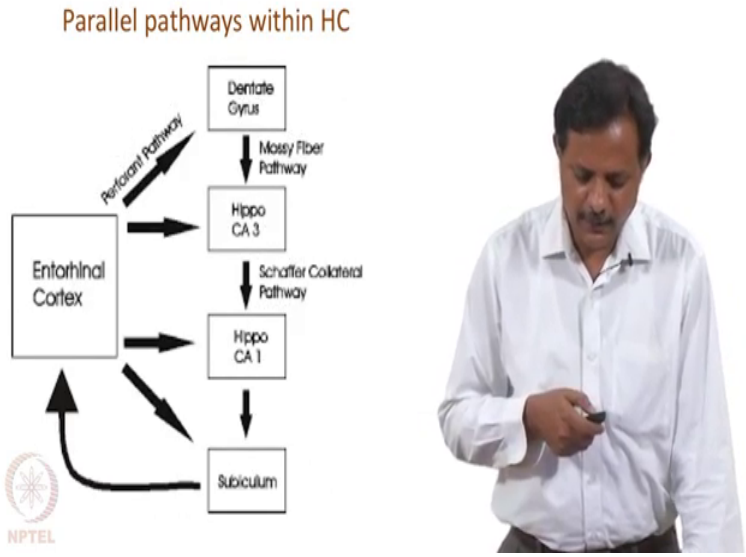

So, if you look at some of the pathways within hippocampus we this moment, we described the connections between hippocampus as a simple loop by entarhinal cortex going via all the hippocampus fields and returning back to entarhinal cortex, but actually there are more connections on that say for example, the entarhinal cortex projecting directly to dentate gyrus this projection is named perfarant pathway. Then the dentate gyrus project into CA3 right this projection is called the mossy fiber pathway then CA3 to CA1 this projection is called Schaffer collaterals and there is also a direct connection from entarhinal cortex to CA1 this called temporal enormous pathway and from CA1 to subiculum and subiculum back to entarhinal cortex.

So, you can see that within hippocampus there are several parallel fibers and so EC also projects directly to [den/dentate] dentate gyrus via the perfarant pathway and mossy fibers project from dentate gyrus to CA3 and from CA3 to CA1 you have Schaffer collaterals ok.

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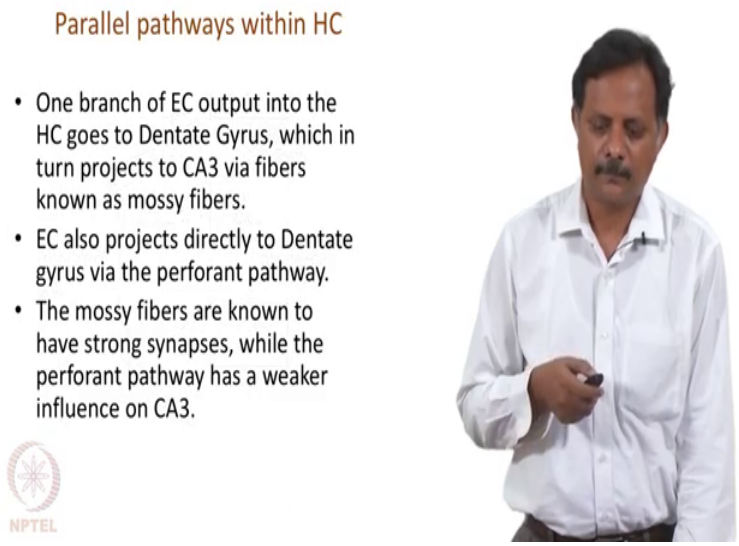

So, they all this hippocampus fields right or sub regions within hippocampus among them CA3 region has been given lot of importance and attention and that is because in terms of the microscopy architecture of connectivity within the CA3, it has some distinguishing features compare to other hippocampus fields right and CA3 has very rich internal connections or what are called recurrent connections and this property of CA3 had long lot of in lot of attention and therefore CA3 had been compare to the

[haf/hopfield] Hopfield network, because we have seen the previous segment of this lecture that what is special about Hopfield network is it is rich recurrent connections.

So, every neuron in the Hopfield network is connected to every other neuron and it is this kind of rich recurrent connections that enable this network to plays the role of an associative memory.

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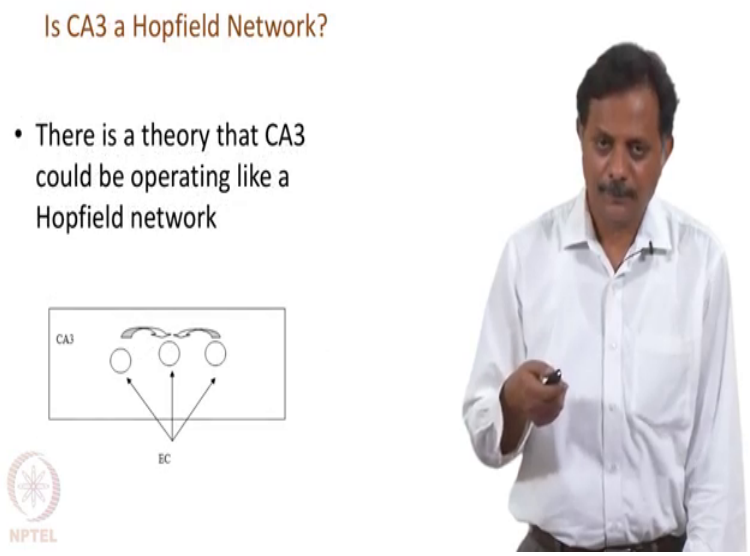

So, similarly in CA3 you have a very rich connections among the pyramidal neurons of CA3. So, therefore people have try to draw analogies between the Hopfield network an it is memory storage property and this CA3 and it is probability contribution to the memory storage properties of hippocampus.

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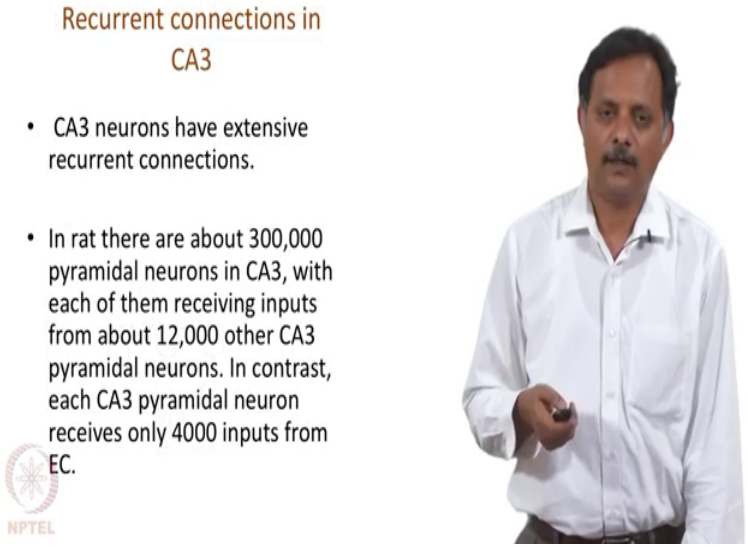

So, CA3 neurons have rich extensive recurrent connections and in for example, if you take the rat hippocampus in rat hippocampus in the CA3 field there are about 300000 pyramidal neurons and each of them receives input from about 12000 other CA3 pyramidal neurons. whereas, if you look at the inputs from CA from the EC to CA3, each of the CA pyramidal neurons receives inputs only from about 4000 EC sources, where as each of the CA3 pyramidal neurons receives input from about 12000 other CA3 pyramidal neurons; that means, there is a very rich.

So, number of connections within the CA3 is [la/lot] lot more then the number of connections from outside CA3 that is from EC to CA3.

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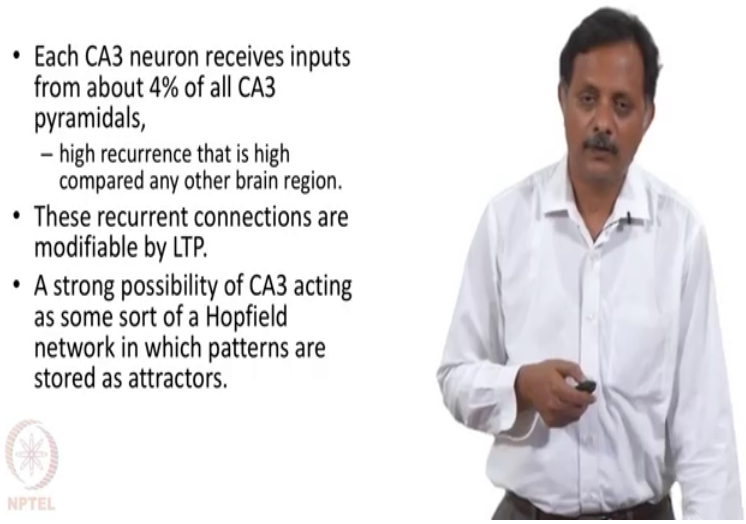

So, each CA3 neuron the pyramidal neuron receives input from about 4000 4 percent of all the CA3 parameters. So, that is a very high level of recurrence compare to any other brain region. So, in if hippocam[pus] in Hopfield network model since it is only a mathematical model and abstract model we have use 100 percent recurrence; that means, every neuron is receiving input from every other neuron, but that kind of high recurrence is at least to our knowledge does not exist in the real brain.

But even 4 percent recurrence is very high compare to any other part of the brain, you see that kind of that level of recurrence in the CA3 and also these recurrent connections are subsequently found to be modifiable by LTP. So, in the last segment of this lecture we have seen how LTP which stands for long term potentiation and LTD which stands for long term depression right these 2 mechanisms give you 1 way of activity dependent plasticity or activity dependent modification of synaptic strengths and this kinds of synapses are found in many regions particularly hippocampus.

In fact, lot of the early work on LTP LTD was done on hippocampus synapses. So, therefore, considering these features of hippocampus particularly of CA3, people have a consider the hypothesis of CA3 playing the role of some kind of a Hopfield network in which patterns can be stored as attractors.

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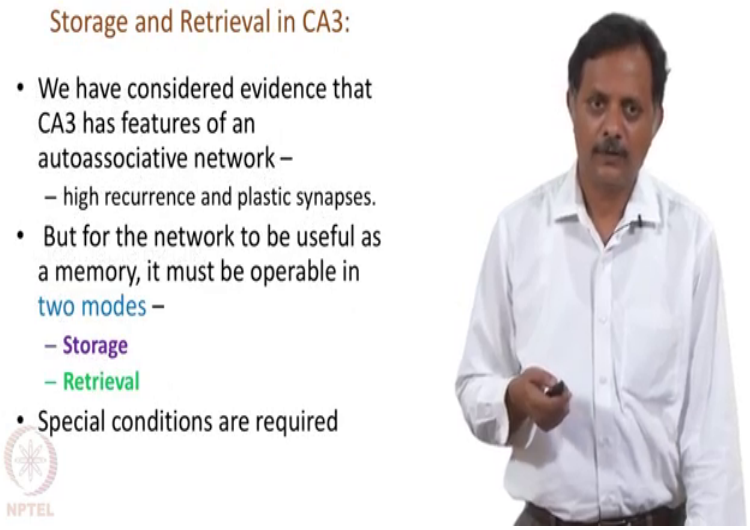

So, now if patterns have to be stored in the CA3, then the network should be and for it to be useful as a memory it must be operable in 2 modes storage and retrieval, because so you need to first figure out how to store information in it and then if you just store in it and you cannot retrieve it then it is no use. So, you need to be also able to retrieve information from this network. So, how do you do both this operations on CA3, if it is acting like a recurrent network or Hopfield network.

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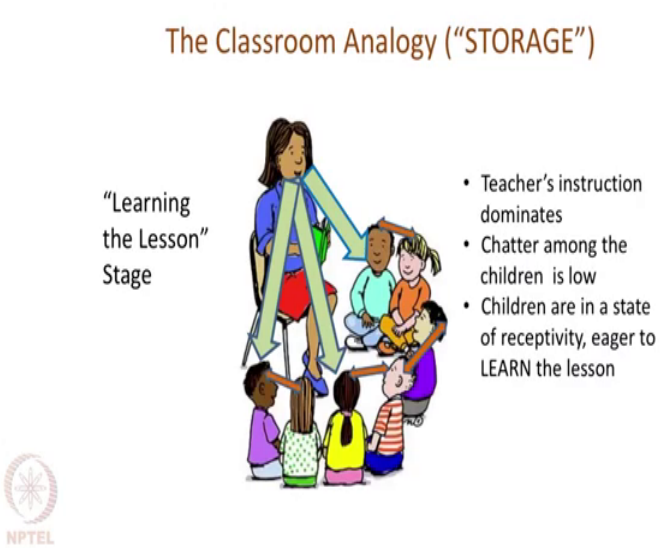

So, to explain that let us use the small analogy you know what we call the classroom analogy. So, in a classroom you can imagine that the classroom operates in you know 2 kinds of modes, first 1 called the learning the lesson stage and second 1 called call it [dic/discussing] discussing and reproducing the lesson stage. So, learning the lesson stage the teacher gives out her lesson and the students listen to the teacher and receive all that and you know and learn the lesson.

So, during this stage the teacher's instruction dominates. So, only person who is talking during this stage is the teacher and then all the students sit quietly and listen to the teacher and there is not much chatter among the stu[dents] children because, the chatter among themselves that will distract them from receiving what is receiving from the teacher.

So, children are in the state of receptivity and eager to learn the lesson. So, they are kind of open and then kind of the brains are in a position to receive it and then store it in inside them. So, this is the first stage first mode the learning the lesson stage or learning the lesson mode.

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So, in the second mode so the children have learned the lesson and now they are ask by teacher to reproduce and then express what they have learnt in the previous stage. So, we call this that we discussing and reproducing the lesson stage. So, in this stage the teacher does not say much you know the teachers instructions is low and they conversation

among the children's are children are high because, in this stage you know you would imagine that since they are very small children give a single child does not know everything that a teacher has taught. So, they have to talk among themselves discuss among themselves, share whatever knowledge they have gained and then as a group they express what they have learnt.

So, in this stage the conversation among the teachers are high and the children do not learn a thing because, now they are only recalling what they have already learned then they do not learn anything new. So, the brains are not in a stage of kind of plasticity or they are plastic in this current mode.

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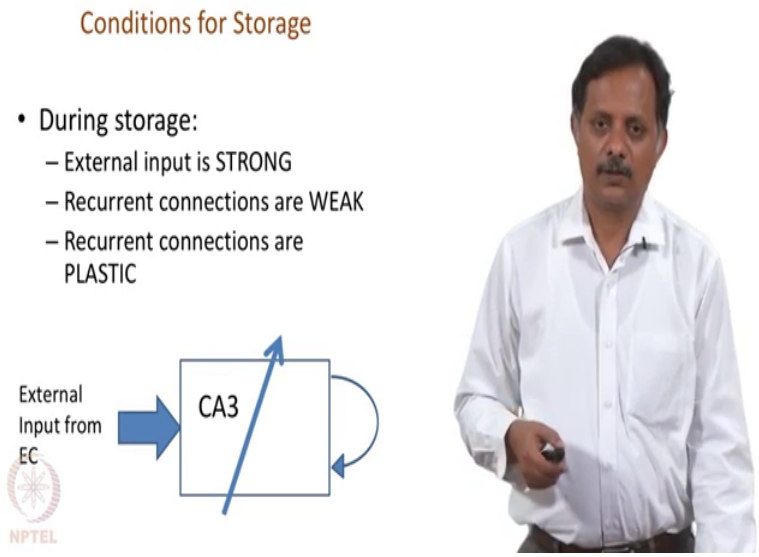

So, we have two modes here 1 is storage mode, where teacher the children are all receiving information and not talking much among themselves and the they have been kind of plastics state. So, that they can register or store what they have learnt and then the second stage they are not receiving much from the teacher, but they are receiving more at that interacting more with other children and the brains are not in a plastic stage and they are not learning anything new, they are only reproducing what they have learnt earlier.

So, these are two modes in which this little group or this task can operate ok. So, if you take this analogy and apply it to the operation of CA3 neurons and what is it look like.

So, during storage the external input so because CA3 they receiving information from you know higher parts of the brain; for example, you know the higher cortical sensory cortical areas project all the way to the EC or internal cortex and then which projects to CA3 ok.

So, this is external input and that during storage the influence of the external input on CA3 neurons is strong and during this stage the influence of the recurrent connection should be weak because, a given neuron should be influenced more by information coming from the from outside right and not been influence too much by what the other neurons are you know saying to it, because the current connections strengths which the neurons have right represent old information and then that should not kind of distracted neurons from receiving the new information which is coming from outside ok.

So, then so; that means, the external input should be strong and more influential and the recurrent connections among the pyramidal neurons of CA3 there should be weak. third thing that you require in this for storage to occur efficiently, is that the recurrent connection that is the connections among the pyramidals of CA3 must be plast[icity] there in a change must be in a state of plasticity.

So, they should be more easily modifiable by the ongoing activity within CA3. So, in the in the figure shown below you can see that the external input coming from a EC and that is represented by thick arrow. So, therefore that is very influential it is able to imprint itself on to the pyramidal neurons of CA3 and then the thin arrow which cuts across CA3 to represents modifiability or adaptation of CA3 that if that basically denotes at the recurrent connections of plastic and then the loop kind of the arrow that bends backwards and returns back to CA3. It represents that the CA3 neurons have a very strong recurrent connections because, the loop angle represents the fact that there are recurrent connection within CA3.

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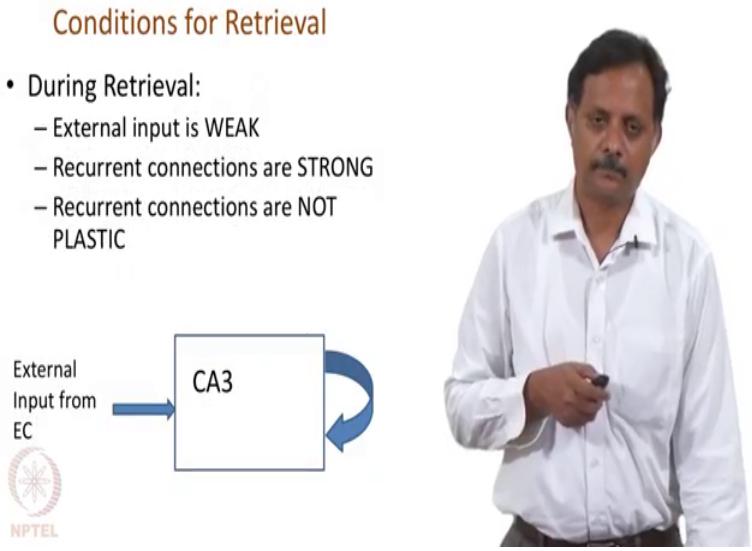

Now, for retrieval to occur you need to have kind of opposite conditions to be met. So, during retrieval the external input should be weak. So, you see that the external input from EC to CA3 right, it is represent by [thi/thin] thin arrow in this case; that means, external input in this case should not be very influential it should not be influence this CA3 activity too much and in this case the loop which represents the recurrent connections among CA3 neurons this recurrent connection should be much more influential.

So, recurrent connection so are strong in this case and third thing recurrent connection are strong, but not plastic they are not modifiable but they are strong. So, this is the kind of these are the kinds of conditions that must be met. So, for retrieval here it is storage and here it is all retrieval.

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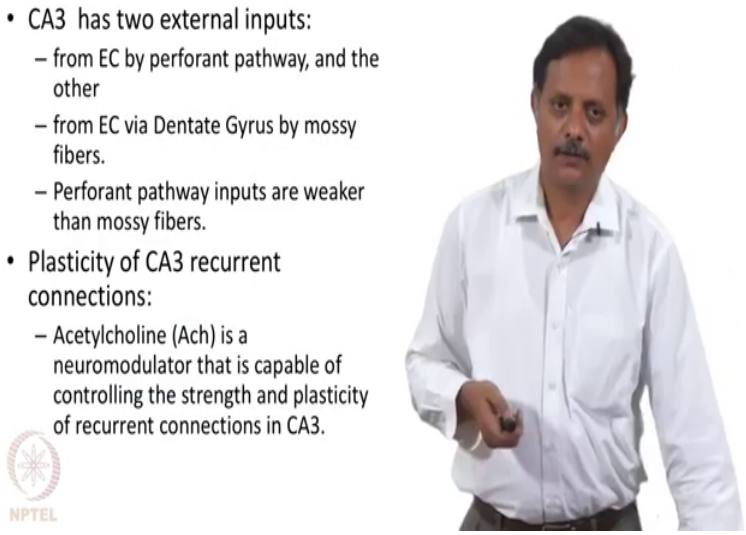

So, now CA3 has to a external inputs from EC via perforant pathway and other 1 is from EC via dentrate gyrus by [momo/mossy] mossy fibers. Now perforant pathway inputs are weaker than mossy fibers, if you come to plasticity of CA3 recurrent connections ;say acetylcholine a chemical which is also a neuro modulator is capable of controlling the strength and plasticity of recurrent connections in CA3.

So, basically what we need is some way of changing the strength of a external inputs making it stronger making it weak, some way of changing the strength of the recurrent connection making it stronger making it weak and some way of controlling the plasticity of the recurrent connections ok. So, we see that all there are mechanism each achieving each of them you know in place within CA3.

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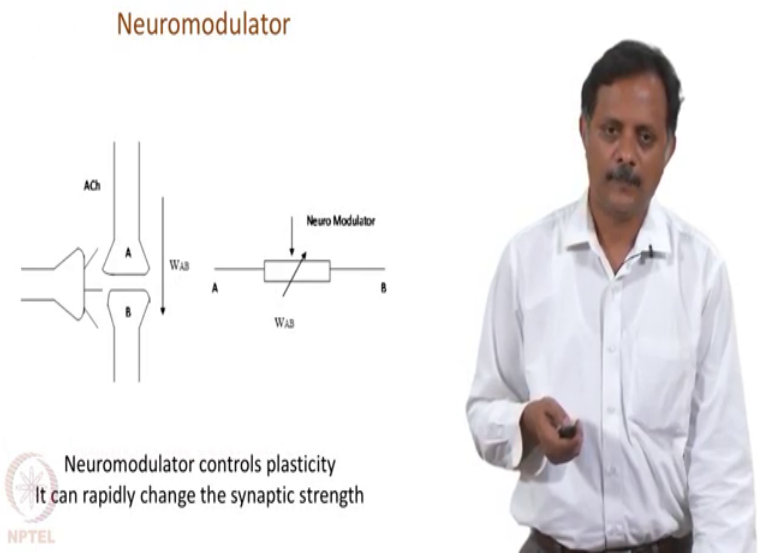

So, we just said that acetylcholine is a neuro modulator, now mathematically neuro modulator is also is a chemical it is similar to neurotransmitter, but it is different in a in important sense; a neurotransmitters basically is a messenger that carries a signal from the pre synaptic side to the post synaptic side and the amount of neurotransmitter release or number of receptor on the post synaptic side, all this together define some kind of a kind of an abstract quantity called the synaptic strength.

Now what a neuro modulator does a neuro modulator are actually is released on to a synapse right, where you have a you know existing neurotransmitters like glutamate or gaba a fast acting neurotransmitter. now the release of a neuro modulator near a synapse on to a synapse modulate the strength of the synapse and can make it transiently stronger or weaker.

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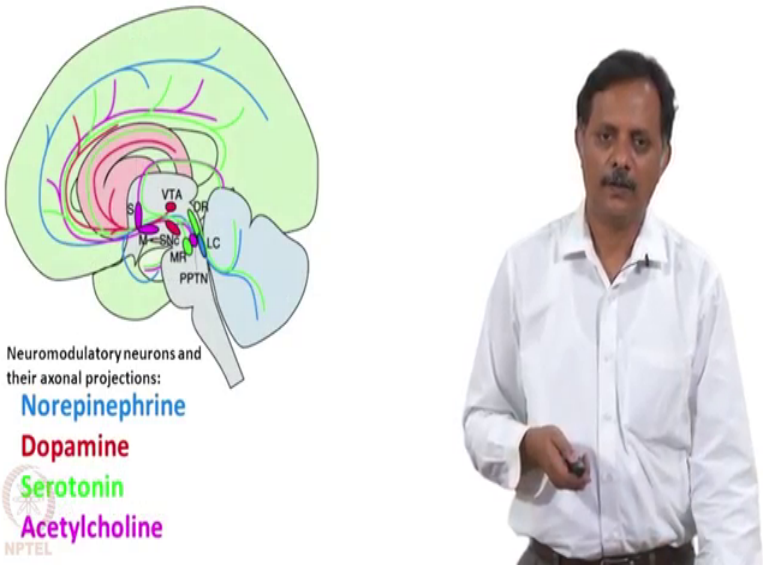

So, in an anatomically speaking neuro modulator substance; there are four important neuro modulators ah; these are Norepinephrine dopamine serotonin and acetylcholine and the memory research the fourth 1 which is acetylcholine generally plays a much more prominent role.

So, all the all 4 do contribute to memory operations acetylcholine is generally discussed more in the context of memory research and these substances are released by small classes of neurons located you know generally in the mid brain and you know in say in sub cortical areas and this clusters also project to all of this clusters are small, each having probably a few 100 thousand neurons right, these neurons project to widely distributed targets both in the cortex and in sub cortical structures ok.

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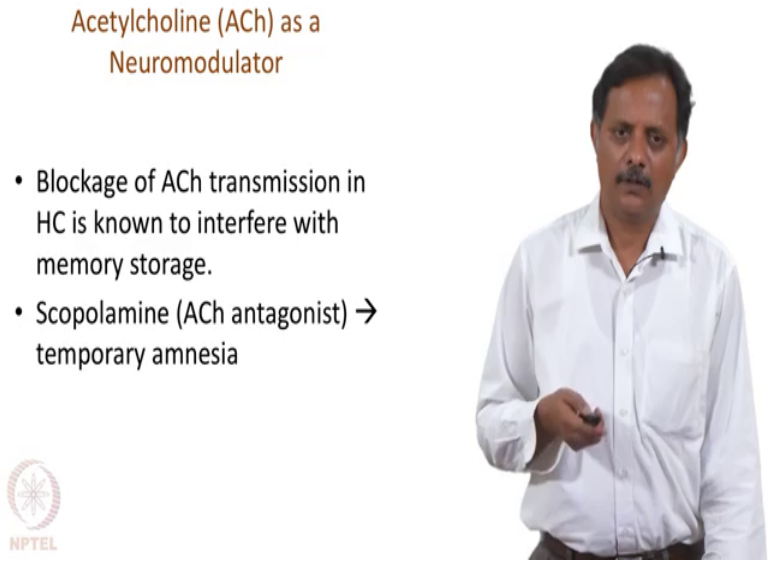

So, for example, and like I said ACH is a neuro modulator and blockage of ACH transmission to a hippocampus right is known interfere with memory storage. So, so ACH is the is it release it released into hippocampus and ACH neurons project both hippocampus that is are that is there sub cortical target and they also project to the cortex and so blockage of ACH is known to interfere with memory storage in hippocampus and also application of drug likes scopolamine which is a an ACH and antagonist, that means it blocks a action of a acetylcholine it is known to produce or induce a temporary amnesia.

So, it will pro[duce] because it blocks a ACH, it also blocks plasticity of the connections within hippocampus it induces a temporary amnesia or memory loss.

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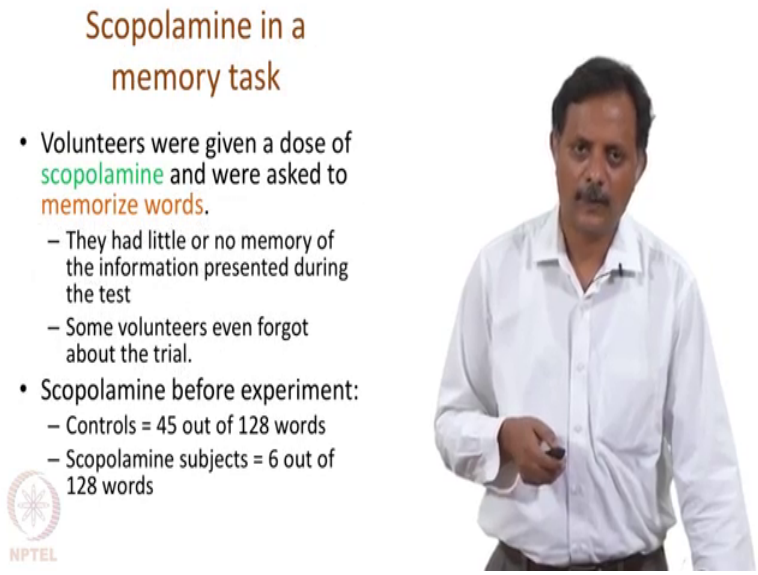

So, scopolamine was administered in a memory task and they found very interesting you know results. So, in this task a bunch of volunteers were given a dose of scopolamine and were asked to memorize words and the and some volunteers were given just a placebo and so the 2 groups were given a bunch of words to memorize, the group that was given scopolamine had little or no memory of the information presented during the test and some volunteer even forgot about the trail.

So, the memory loss induce was so profound that the even forgot that they had a test at the time and scopolamine was given before the experiment right. So, they controls subjects remembered about 45 out of 128 words; whereas, scopolamine subjects because of the action of scopolamine it is a antagonist action of scopolamine acetylcholine, these subjects were able to memorize only 6 out of 128 words ok.

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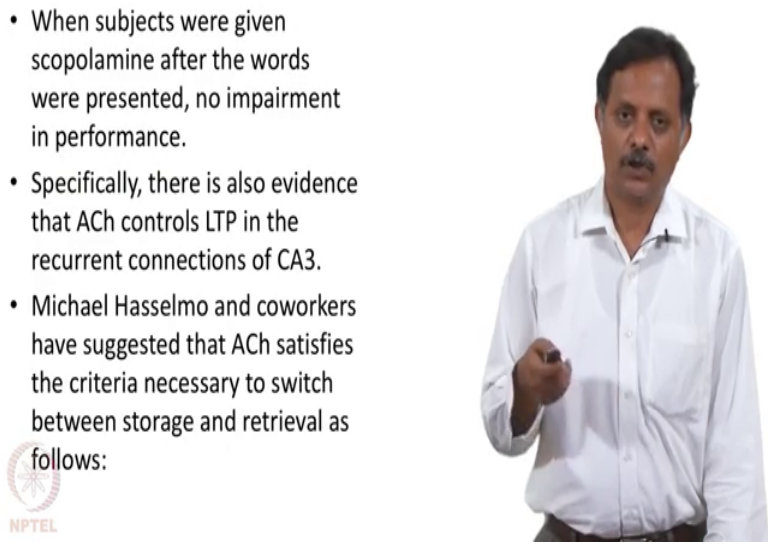

But when the scopolamine was given after the words were presented; that means, they have this subjects are already learned the words and then they have taken scopolamine right, then there is no [imp/impairment] impairment in performance. So, only even it is given before the task right it was able to influence natively the performance.

So, they also evidence from electro physiology that ACH controls LTP in recurrent connections of CA3. So, seeing all this experimental evidence; Michel Hasselmo and Coworkers have suggested that ACH satisfies the criteria necessary to switch between storage and retrieval and that you start workout as follows.

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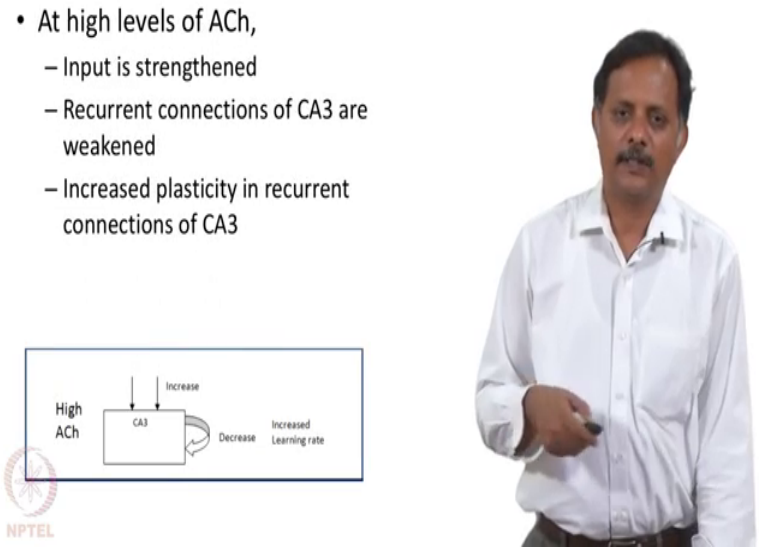

So, it high levels of ACH or acetylcholine the input is strengthened the recurrent connections of CA3 are weakened and there is increased plasticity in recurrent connections of CA3 and at low levels of ACH the input is weakened, the recurrent connections of CA3 are strengthened and there is decrease plasticity in recurrent connections of CA3.

So; that means, at high levels of ACH the CA3 is operating in the storage mode because, it matches all the conditions that we have ask for right for storage to occur and at low levels of scopolamine of acetylcholine right, we achieve the conditions that are necessary for retrieval mode ok.

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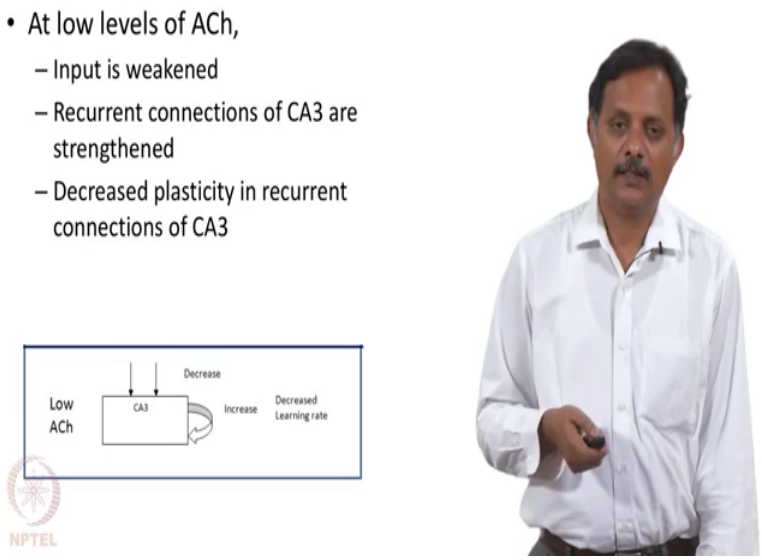

So, how do you say that now how do you say that at low levels of high levels of ACH there input is strengthened and recurrent connections are weakened and at low levels of ACH input is weakened and recurrent connections of CA3 are strengthened and how do you say all this ok.

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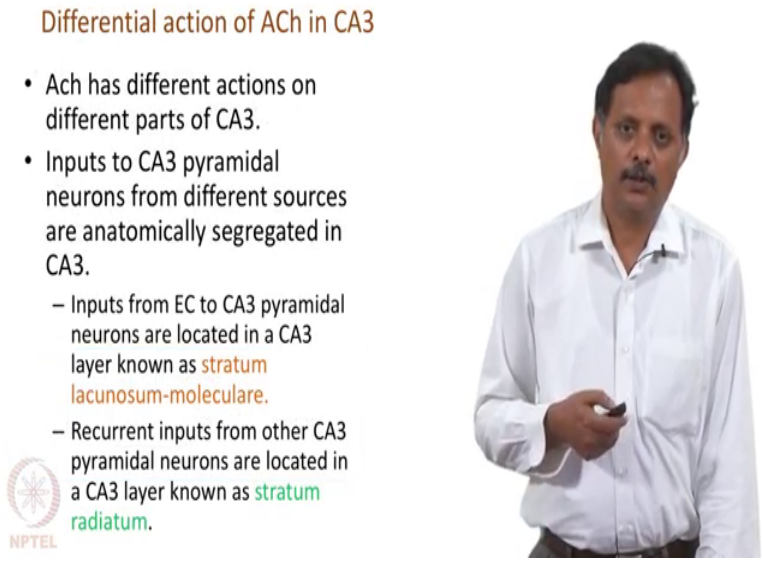

So, it turns out that ACH has different actions on different parts of CA3, so now within CA3 if you look at the microscopic connectivity of neurons within the CA3 right. Input to the CA3 pyramidal neurons from different sources are anatomically segregated in

CA3. So, for example a given CA3 pyramidal neuron receives inputs from other CA3 pyramidal neurons these are the recurrent connections within CA3 and it also receives inputs from the EC these are the external inputs to the pyramidal neurons of CA3.

So, now inputs from EC to CA3 pyramidal neurons are located in a CA3 layer. So, there are different layers within CA3 and external inputs to CA3 are located this synapses are located in a given the CA3 layer called the stratum lacunosum molecular, then the recurrent inputs from other CA3 pyramidal neurons are these are located in a different layer different CA3 layer these are known as the stratum Radiatum.

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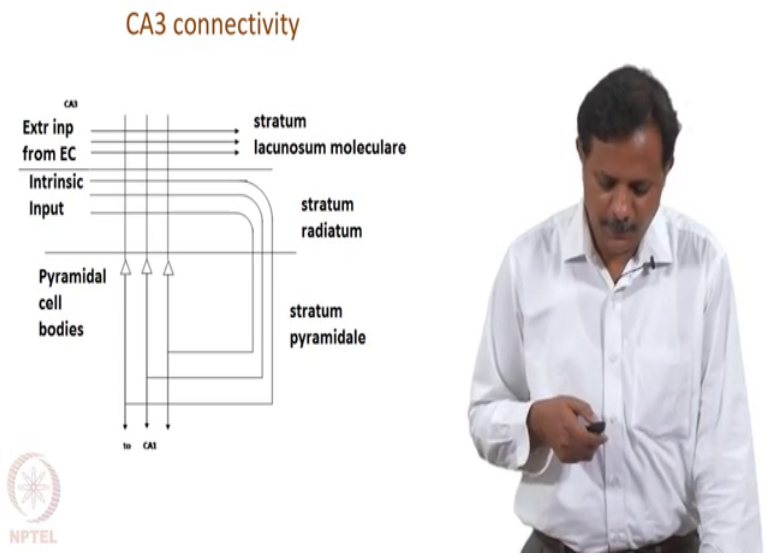

So, if you look at this picture you can see, so how this different connections are you know segregated. So, AC at the top the external input from EC making connections with the dentrates of you know CA3 pyramidal neurons and these synapses are located inside the layer stratum lacunosum molecular and whereas, the intrinsic inputs that is a inputs of the pyramidal neurons among themselves right.

You see them in the this middle layer right from intrinsic synapses themselves and that layer is called the stratum radiatum and then the cell bodies of the pyramidal neurons are located in a third layer which is called the stratum pyramidal.

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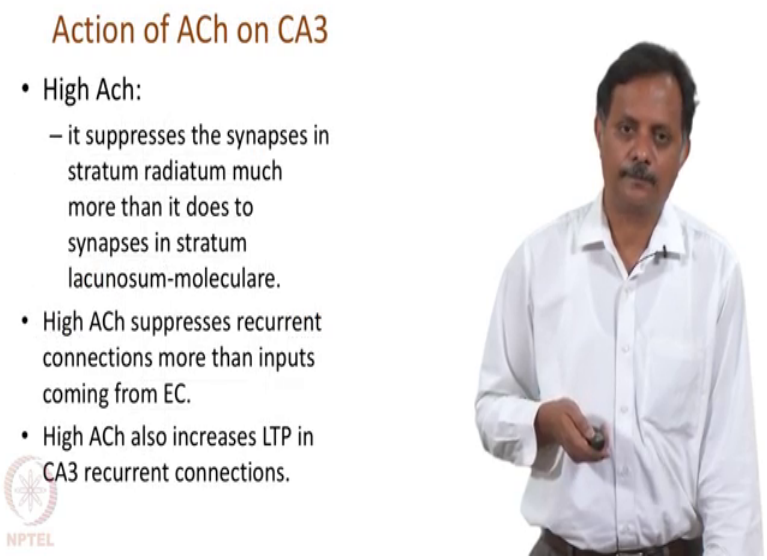

Now, it turns out that when you increase acetylcholine levels in CA3, it suppresses synapses in stratum radiatum much more than it does to synapses in stratum lacunosum molecular. So, that means, it suppresses synapses in of the recurrent connections lot more than it is suppresses the synapses of the external inputs so and also high ACH also increases LTP in CA3 recurrent connections. So, basically that means, that it is at high ACH you are able to achieve the conditions necessary for memories storage in CA3.

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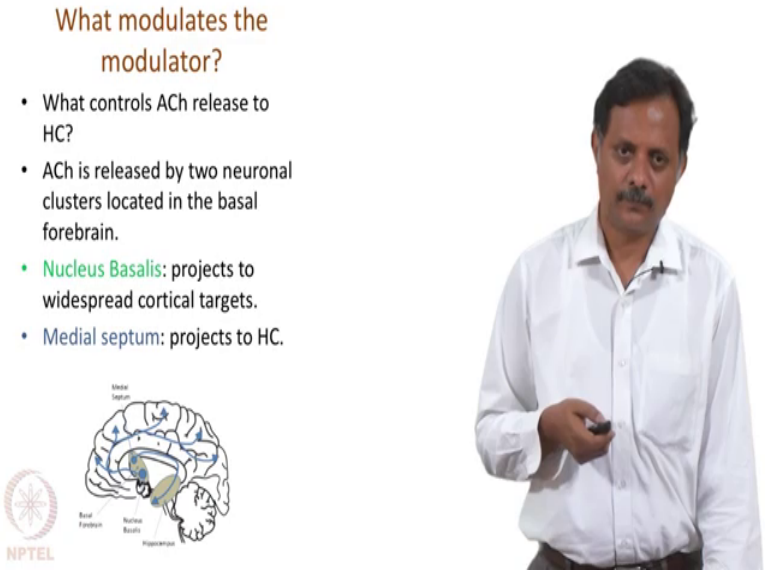

Now, ok. So, we said that ACH is a neuro modulator and you know increases ACH can to hippocampal complex or a hippocampus right can increase memories storage in CA3. But what decides or what controls ACH release to hippocampus or to say to CA3. So, ACH releases by two neuron clusters because, we said there are this neuro modulators are released by small clusters of neurons located in the mid brain and you know other sub particle areas.

So, ACH particularly release by neu[ronal] two neuronal clusters located in the basal forebrain, these are these are nucleus basalis which projects to widespread cortical targets you know that is show in this simple cartoon figure here and another cluster is medial septum which projects to hippocampus.

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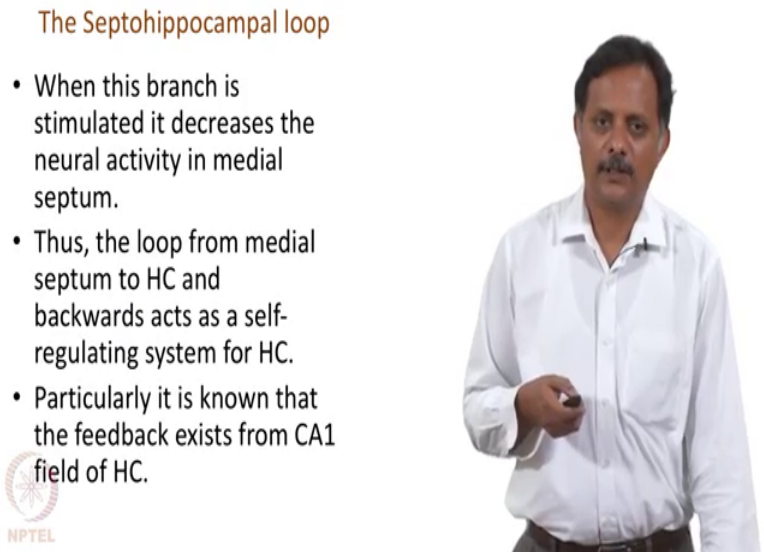

So, this loop between so actually the medial septum projects to hippocampus and hippocampus projects back to the medial septum and that is called the Septohippocampal loop and when the branch from hippocampus to medial septum is activated right. It is it is suppresses neural activity in medial septum and therefore, the loop from medial septum to hippocampus and backwards act as a self regulating system for hippocampus and so it is known that there is a feedback from CA1 field of hippocampus back to medial septum.

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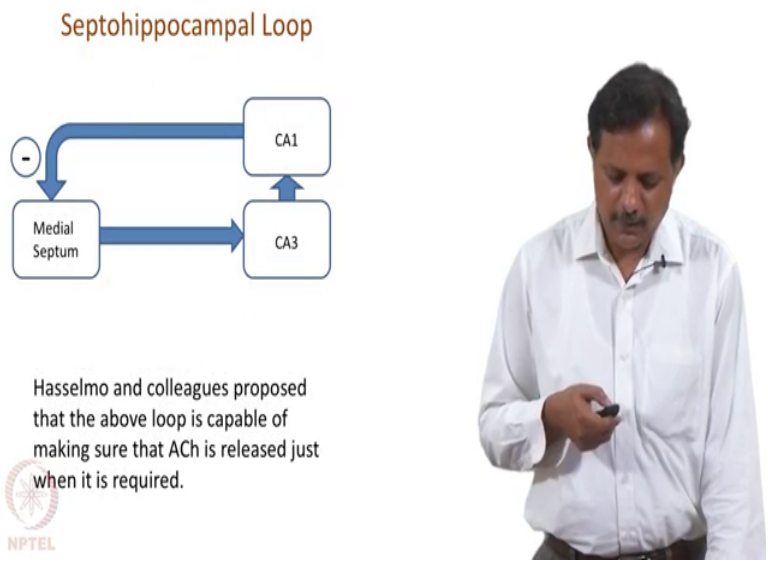

So, you see that the medial septum projects to CA3 and CA3 projects to CA1 and CA1 sends feedback to medial septum and the effect of CA1 and medial septum is inhibitory. So, hasselmo and colleagues are proposed that the above loop is capable of making sure, that ACH is released just when it is required and how do that work ah?

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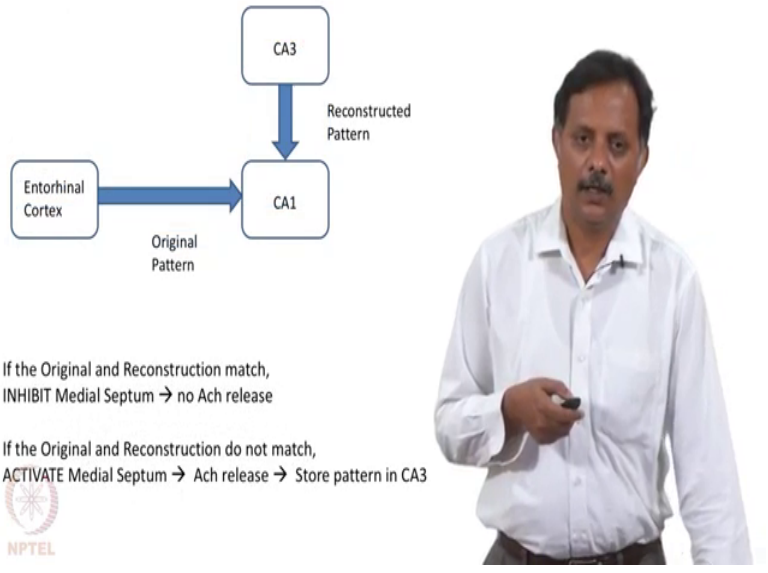

Basically the idea is. So, CA1 is thought to be playing in the role of a comparator. So, we have been arguing all long in this you know segment, that CA3 is like some kind some kind of Hopfield network and it stores memories in the recurrent connections of CA3 and

so what this CA1 receives from CA3 is the representation of these stored memory within CA3. Whereas, CA1 also receives direct input from internal cortex, so this is the temporal enormous pathway right and that is the direct representation of the of the same pattern. So, CA1 is thought to compare the direct copy of the pattern from internal cortex and the reconstructed pattern right of this stored version in CA3.

Now the hypothesis is that if the original from the EC and the reconstruction from CA3 match right, then CA1 makes it is comparison and inhabitants medial system and that suppresses or blocks release of a ACH from medial from medial septum. Whereas, if the original reconstruction do not match, so the original from the EC and there is reconstruction from CA3.

If they do not match then CA1 sends feedback to medial septum which activates medial septum and therefore, the cause release of ACH that release is released into CA3 as you can see in this picture. So, basically CA1 says the 2 patterns are not matching and therefore, medial septum release ACH to CA3 and therefore, that induces plasticity in CA3 and therefore, the pattern is stored in CA3 ok.

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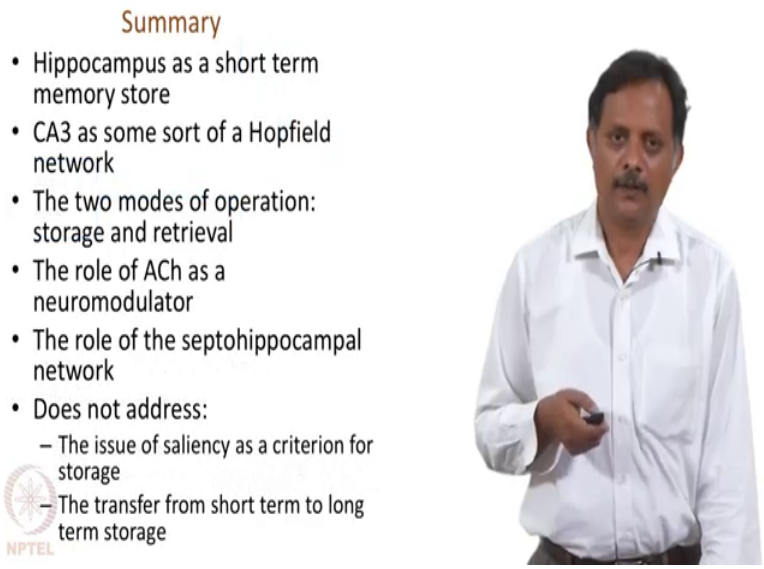

So, that kind of completes the story what the story says is you know how or and what kind conditions by what cellular and neuro chemical mechanisms are memory stored in hippocampus.

So, basically what it says is the key ideas of ideas of this theory, is that the CA3 is functioning like a some kind of a Hopfield network and it operates in 2 modes storage and retrieval and ACH plays the role of neuro modulator which is the CA3 region between 2 modes or storage and retrieval and the Septohippocampal network or the loop plays the role of some kind of a regulator and what this loop does is if this stored pattern in CA3 under direct copy from EC.

If these two patterns match then there is no release of ACH into CA3 because, the pattern is already stored. But when these two patterns do not match; that means, the pattern at is receiving is a new 1 or something that is not memorized. So, therefore that causes releases of ACH to CA3 and therefore CA3 then are you know stores the pattern in itself.

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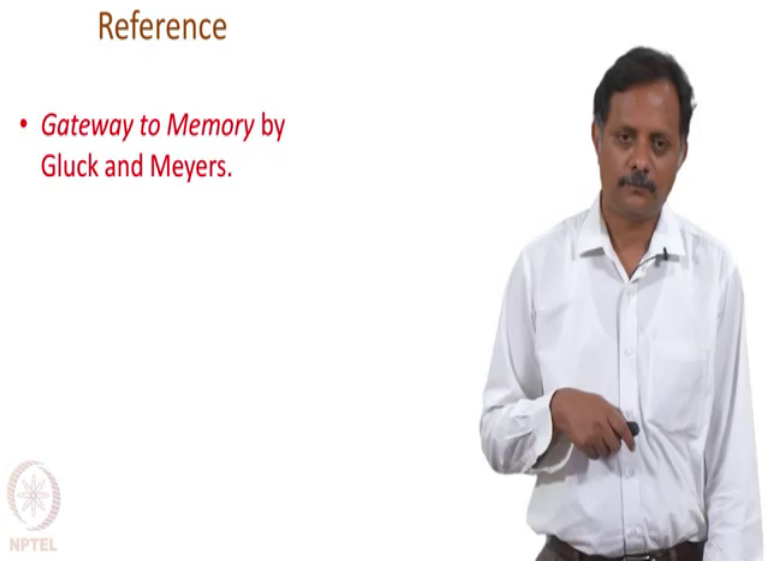

It is a very interesting theory and actually a got most of the material that I discuss in the segment from this reference, it is book called the gateway to memory by you know Gluck and Meyers.

But thing is this theory has certain shortcomings it is does not it is a question of salience as a criterion for storage, because in the early part of the this segment we mentioned that 1 of the key features key determining criteria, for storage of memory is the reward or salience associated with the memory right. Only when we find that the pattern is important for us right we this store the pattern and that kind of a important such that salience is very often represented by dopamine signals which represents reward.

So, like I said VTA has projections to hippocampus, but this current theory does not address exactly how that works and also it is also it is interesting theory and, but it is not fully tested it is its not fully realize and detailed computational models. So, that you know you can really verify all this ideas in a detailed quantitative model, also this theory does not tell you how it only tells you how information stored in the hippocampus, but it does not tell you in what form in exactly how this information is passed on to the long term stores in the cortex ok.

In this regard I just want to mention that in my lab we have been working on a alternative theory of a hippocampus and memory storage in a hippocampus. So, where we explain how what is stored in the hippocampus and what exactly is pass on to the long term cortex and by what mechanisms and our theory is based on reinforcement learning.

So, which is a very important form of learning and I mentioned it before, the learning that happens in basil in area or is driven by basil in area can be explained very effectively by reinforcement learning or conscious from the reinforcement learning.

So, on the similar lines we are trying to develop a theory of hippocampal function where, the memory storage and retrieval are memory consolidation are transfer of memory from hippocampus to long term cortical stores, all these processes can be explained very effectively by using ideas from reinforcement learning. But unfortunately whenever theory is alternative preliminary stage and hopefully in by next year; we are hoping that this three will be will worked out and you know we publish.

Thank a lot.