How The Brain Creates Mind
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Lecture – 10
Dynamics-4

Hello and welcome to the last lecture of this week 2 module. I hope by now all though the lectures will telescope in to each other and we are connected. By now we have about would have called the basic idea of how the brain function. The structure and the networks and from there the behavior, structure, networks then we jumped on to the microscopic synapse and all and basic electricity. So will wind up with this week with bit more understanding of how the brain functions.

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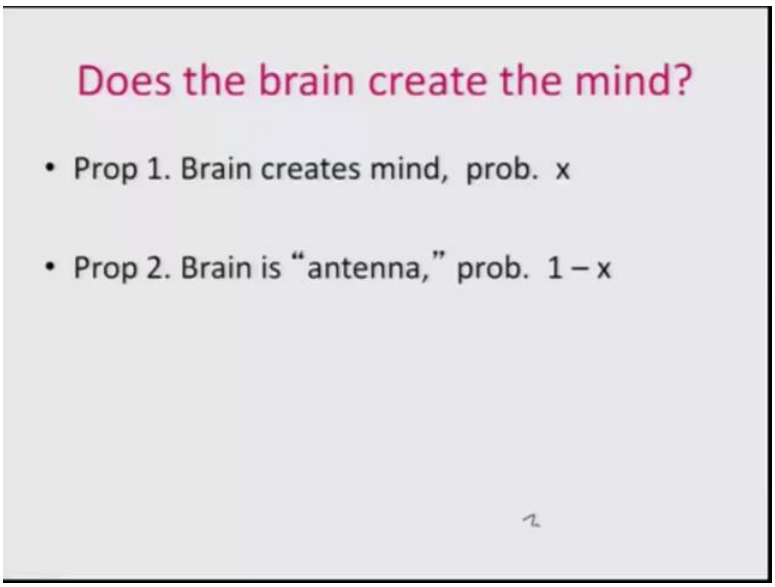

So, if we see the slide with already ask this question, there is a possibility one with the brain creates mind and the second is the brain is antenna, there has been a philosophical debate on that in the past, but if you just compare as I told in the first lecture the computer knowledge is something, but this just gross difference. The computer is must faster the units of brain is the much more then computer.

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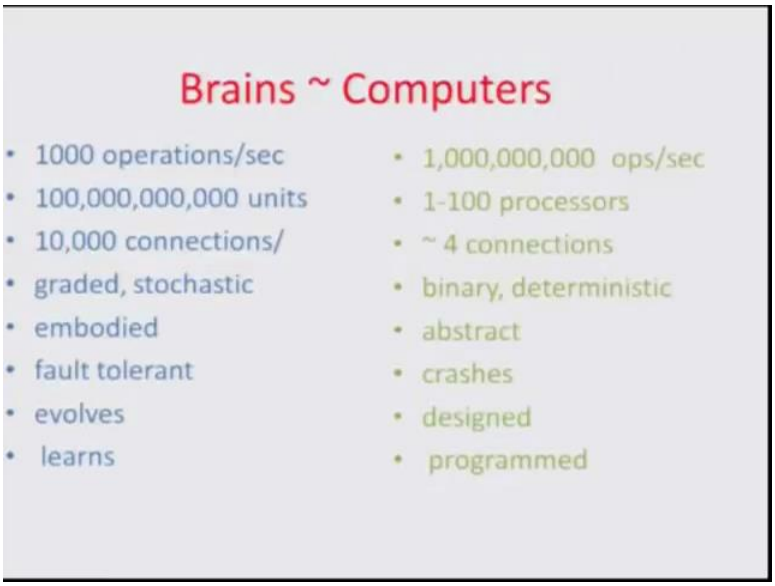

The connections are much more then the computer chips. The data which is use in computer is binary is deterministic in the sense that we have programmed it, where is the brain is lot of graded single processing happens, it is lot of is stochastic random probable process is happening there. The hardware of the computer it is some of seems to be dissociated with the software which you can load on the hardware. In the brain is like embodied these structure decides the function and function decides the structure as we talked about network and synaptic formation, brain does not crash is way with, the brain crashes all the computer of an crashes we all know how the hang up, the movement depress is one button for more than what is required brain evolves computer has to be designed for revolution.

Now, if you are believe or you can say may be god designs, god has it learns, the computer learning all though these this it as they I stopping of did machine learning, with the machine itself picks up data and formulates for the learning, with still even that learning which goes on in to computer is a program thing it is not automatically it happens. The program for learning also has to be faded. So, that that type of training, why I am talking about this because lot of this artificial intelligence and trading will talk about this towards the last lectures, has happened because of the ideas which has come from the brain research.

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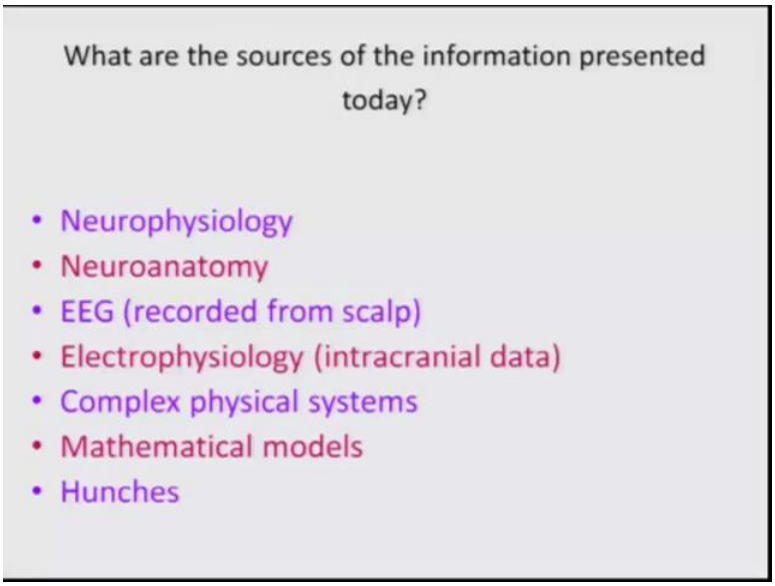

So, as we said Neurophysiology, Neuroanatomy recorded complex physical system mathematical model and over and above hunches in tuition, like one of the intuition which happened if you go back to the synapse which you remembered how does the chemical come from whether then neurotransmitter, it actually happened in the dream of auto love with that is what he claim, that we was struggling that between one synapse you one neuron which is the pre synaptic to the post synaptic. How did it go and he says that one might he saw with there is a molecule which go goes out drips and goes here and that gave him the idea of something some chemical change going on between 2 neurons and that was the discovery of a style calling.

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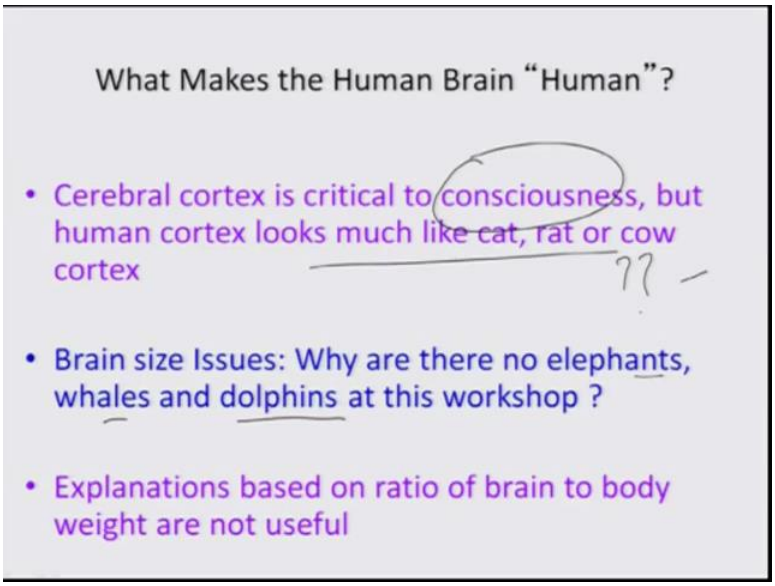

What makes the human brain human, conscious we all say conscious we talk about consciousness in different lecture. It looks much like cat rat, but we are conscious are they also conscious? Brain size, you human beings are attending elephants are not attending this mooc course they cannot log in and do an online certification. Dolphins are very intelligent, but in their own context, whales are intelligent in their own context, elephants are intelligent. So, does it make us more intelligent or it is just that our intelligence is there in our own context and they are intelligent in their own context. Ratio of brain and body we have talked about and sefalization.

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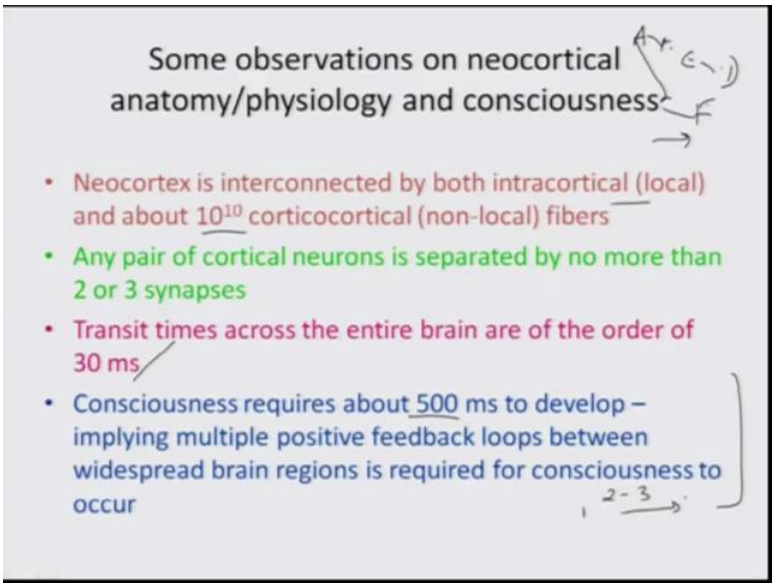

So, this is just revising, there about intra cortical within cortex neurons and this is the size any pare of cortical. So, between one neuron to the other neuron if you have to look at it, any neuron can be connected to the other neuron bit two or three synapses; that means, if you want to connect it A to said D. So, there will be 3, may be B, may be C, 1 or 2 or if you have to go F. So, may be a gets connected to something to E and F. So, all neurons will be connected to each other within the cortex with 2 or 3 synapses.

These theories come from social networking theories, where each person is connected with 6 steps to the other person, if you make a network so; obviously, what we are saying and this is the inspiration for what graph theory which tries to define neural networks. Will talk about that when comes to it. Thus it is not a linear network, because it put it linearly will keep going round and round. The transit time, I have a talked about the transit time if of the order of 300 millisecond consciousness so you do not become consciousness of conscious of anything, unless or if you us stimulus presented to you and by the term we become conscious already 200 to 500 milliseconds of passed.

This is the wonder of the brain. Whatever is happening and 200 milliseconds is unconscious. So, is a huge and to the whole debate of whether the mind of totally conscious unconscious actually neuron sense is tilting in favor of unconscious will discuss this in future lectures. So, the feedback loops which will talk about.

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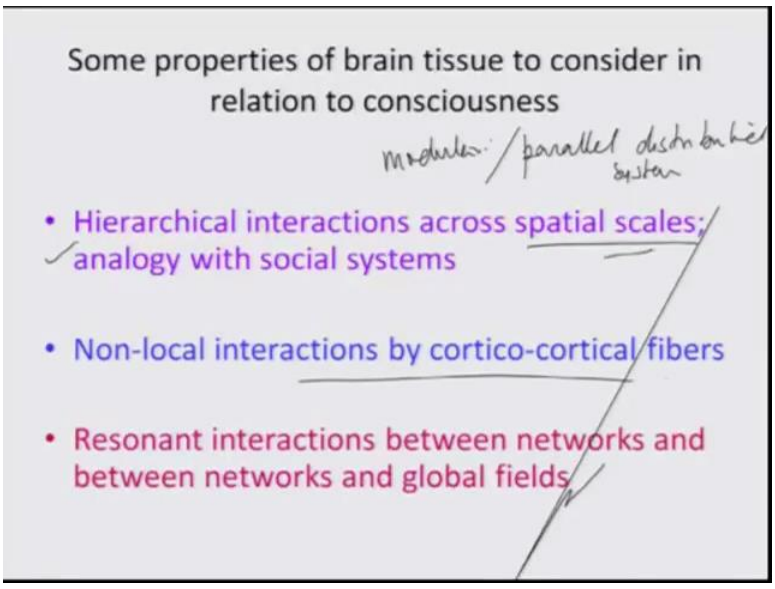

So, I should show slide we were talking about investigating on various scales. So, this is scales are natural, all though the brain is what you call up parallel distributed system and modular to it, but still there are hierarchical interactions across spatial scales. So, if a signal comes there may be few neurons which may be bringing the signal from external stimulus, but as the go inside the brain and try to present a composite image from the visual context to the thinking brain, size increases.

So, this hierarchy right from few neurons, to more neurons, to cell assemblies, to larger and various part of cortex are. So, there feedback loops, there resonant interactions just remember these words because before jumping to networks I thought it will be good for you to have just few ideas. These are simple things to understand a special skill any space and this is the type of we talked about micro columns.

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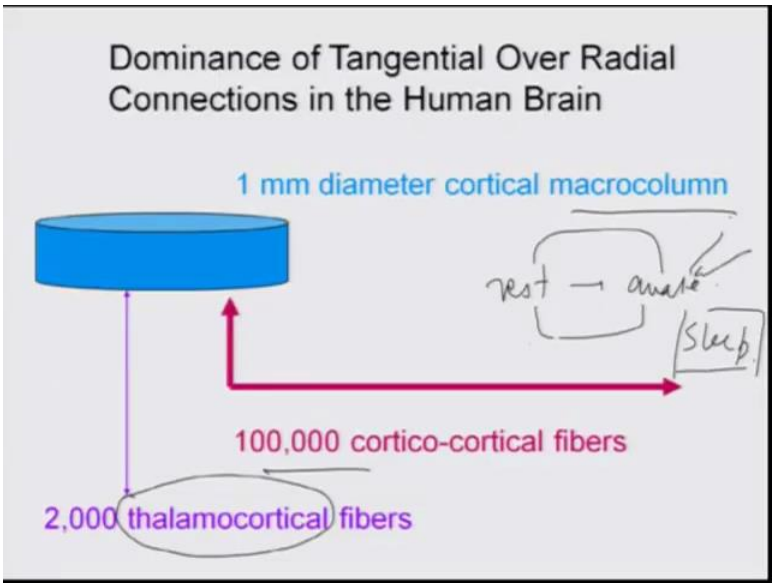

This is what I want you to pay attention to thalamocortical. Thalamus if you remember I told you the deep structure is the relay center, where all is stimulus go, all is stimulus come from it and thalamus and cortex in our reciprocal connection really control all this unifying, binding thing, that whether you feel as a self it controls consciousness, it controls your sleep way time and basically rest and awake states. Third state is sleep, sleep will comment to pitch a later. So, this is managed by thalamocortical. The activities the sensations which go in is between this thalamus and cortex.

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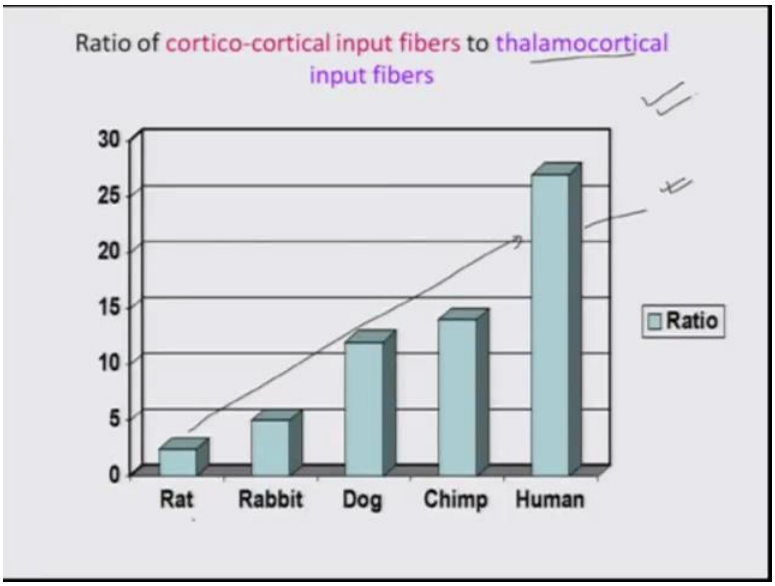

If you remember thalamic inputs go up in to layer 4 of that cortex. This a comparative thing, this is what may be making us different from other animals because they may have the same size, they may enough neurons for them to survive, but the thalamocortical connections actually increases from rat to humans. This probably differentiates, what we do and what we think and how we do it.

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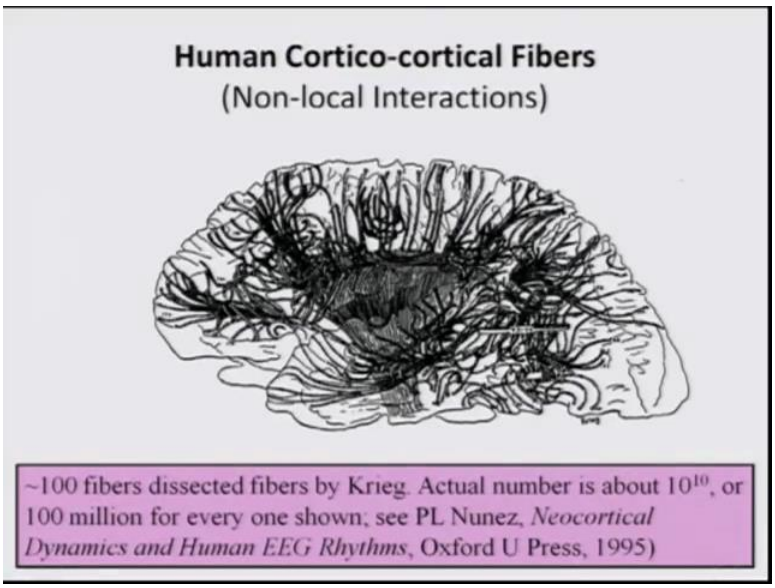

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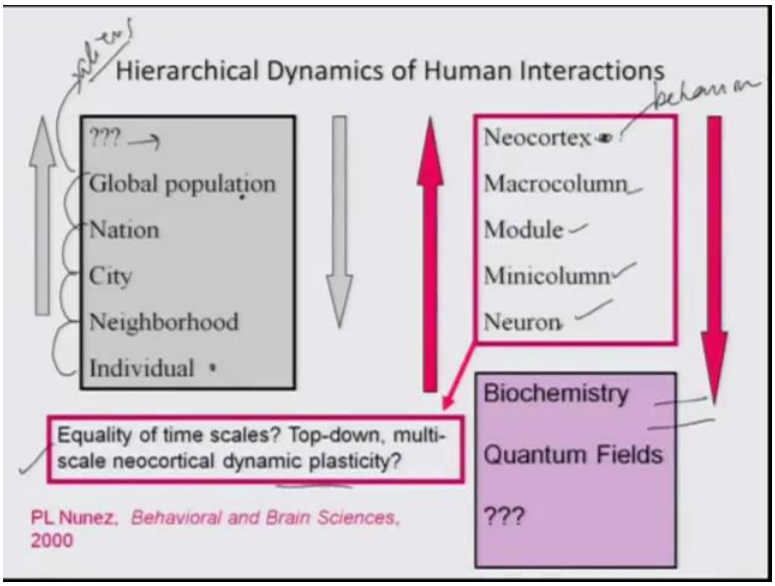

So, this is the type of network which you see. These are all networks connecting the various areas of cortex all over the brain. So, if you look at this slide this is I have showed you again and trying to revise the whole thing, is there is a hierarchical dynamics if you compare with society, like there is an individual which goes on to neighborhood, to city, to nation to global.

We do not know whether this global is going to some alliance or some other is species of animals which may be more advance then us or may be on some other planet we really do not know, it may sound has fantasy what lot of fantasies may actually later on prove on to real fact and if you think we are an experiment of nature, we may already we in a transit from going from and may be to some other species. So, this query for that unknown species, compared with how the brain works this is single thing called Neuron. Some neurons get together to many columns. So, individual's history is lost in global population. So, your own history may be very important for you, but if you look at the global population, it does not mean anything, with the larger movement of global population which defines history.

So, single structures sacrifice itself its own history for the larger history. Here module macro column, near what by the term the action happens in neocortex, a single neurons contribution is minimized because the many of them and this neocortex creates behavior. So, this is a multi scale dynamic plastic system, which keeps altering in conjunction with

external influence, biochemistry, electrical activity, whether there quantum fields or some other physics which we have yet have to discovered how quantum steps in I will tell you as it when it comes.

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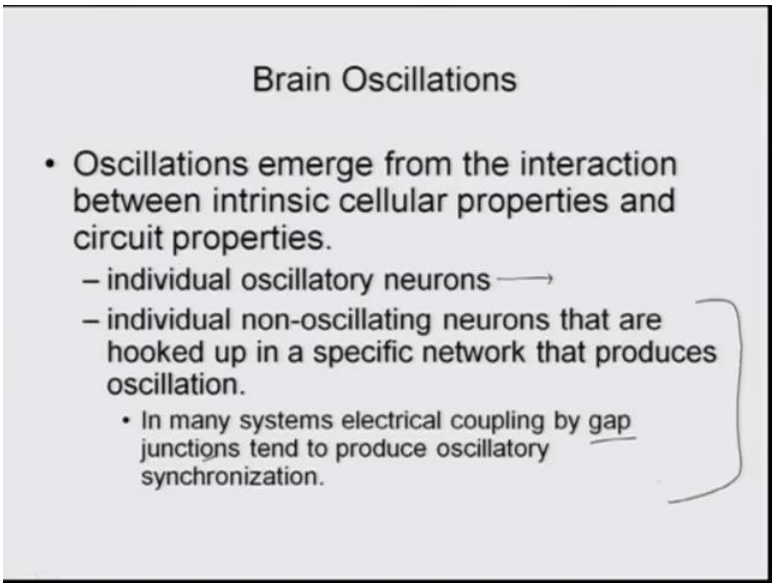

So, how is it happening? We have talked about the chemistry, but when as I said you put electron then will find; what are oscillations. Brain oscillations are very important how does information carry from one part of the brain to the other, how does change of activity alter the electrical firing. No doubt chemistry is the switch, but and that switch can regulate how it fires, but that switch is left behind when we talk of the mode of transfers, probably these oscillations of the brain are very important. They emerge from the interaction between cellular properties that is the firing between neurons and circuit properties when single neuron connects the other 2 to 10 to 100 to finally to 10 to the power 3 to 6 to 11.

So, individual neurons oscillate individual's non oscillating neurons that are hooked up in a specific network that produces oscillation. These may be very few cells if which are connected by gap junctions. Gap junction's means two neurons are attached; there is a gap this some connecting material. These problem do not oscillate, it is the sort of more DC current which is going on between them here how does oscillation happen? Oscillation is this wave. What causes? As is you remember the Pyramidal cells which are on layer 5 are the neurons in cortex which send the signal out.

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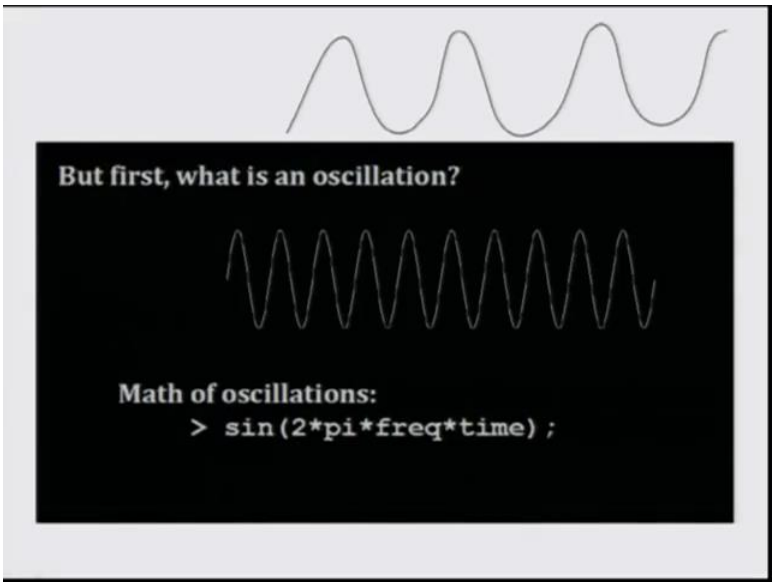

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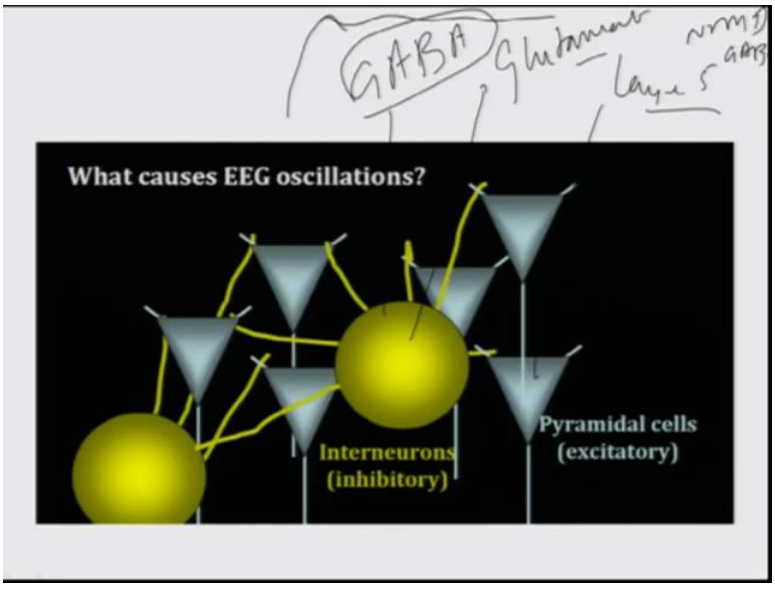

So; that means, they have to be excitatory, they will always excite whatever signal they get. So, if it is always an excitation, then whole thing will raise the like this it will never come down because already firing. So, the game is what you call this inter neurons. Between the neurons there are certain neurons which are inhibitory they inhibitory; obviously, because the chemicals which is what you call the use a chemical call Gaba.

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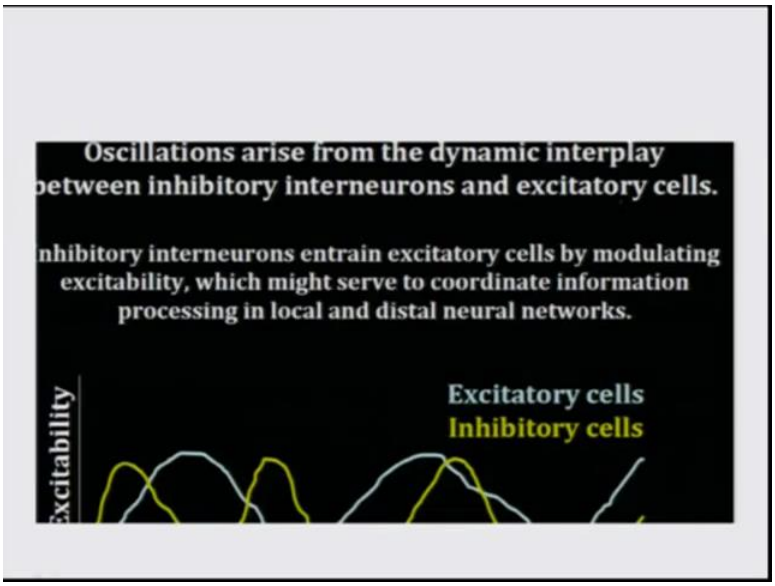

Gaba is a general inhibitory neuron. Excitatory neuron is glutamate and they have their receptors like an MDA, Gaba receptors, Gaba A, Gaba B. So, this game between Gaba and glutamate actually excites inhibitory neuron and excitatory why does it happen, is it required because if it is all excitation, how will you differentiate between these differences of information. Ultimately all this firing is about information transfer, you will not differentiate any change where the brain keeps specifying the same set of waves.

So, inhibitory neurons entrain the excitatory sense and that coordinates information because if the 2, 3 set of information coming and they all firing at the same frequency and same rate it will become very monotonous. All is survival become very very dangerous. The trick is that small differentiation and later integration of it which keeps leaving with the whole I am that is life actually if you look at it. Translate the basic electrical activity in to life this is life.

So, the interplay of innovation and excitation creates Oscillation and any signal can be expressed as sine waves with its own frequency amplitude and phase or this as oscillations present only in human beings, but you look at it, Phylogenetic preservation right, in all mammals across species there are oscillations. The frequencies cluster around is specific peaks.

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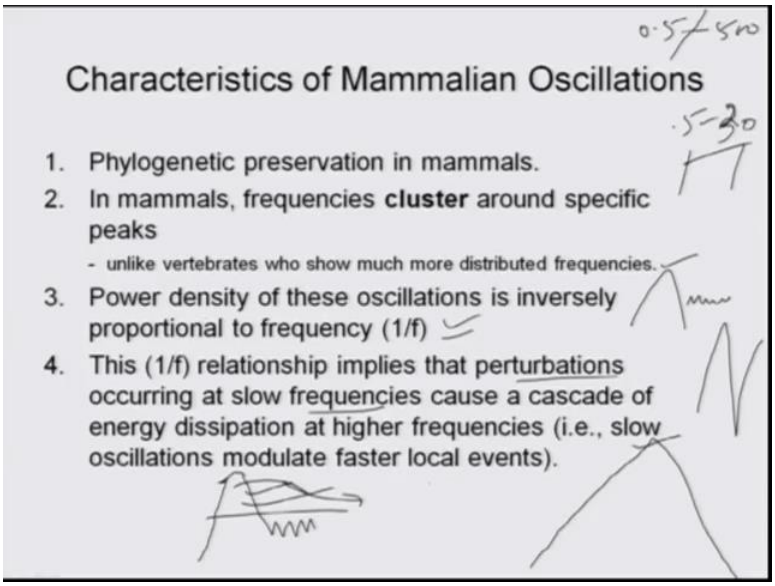

Vertebrates are more distributed, non vertebrates have less distributed. So, the range in human beings is from 0.5 to 500 on power spectrum and after doing a Fourier transformer. What we are interested on Rho EG is 0.52 say 30, that is delta 2 beta. Power density I mean the amplitude is inversely proportion to frequency it is the basic physics law. The faster it is the less time it gets to go up and down; that means, if it has to put energy and power it goes very high and it will take more time to come down to the negative state.

So, amplitude is more, waves are slow simple. This implies that the perturbations which are happening at slow frequencies cause energy dissipation at higher frequency, slow oscillations modulate faster local events, slightly hold on for minute and try to understand this. If you look at it from the point of energy and there is a firing which is going on, at higher amplitude if there is a disturbance and if it comes down to faster frequency.

So this gap, this energy which has really taken up to certain amplitude will have to dissipate somewhere. Dissipate to other neurons in a form of a single right, what you know second laugh thermo dynamics the wave entropy grows in to system, but there happens in a close system brain in that sense is not a truly close system, it is inter phase with the environment.

So, this energy dissipation, when it is transfer to the nevering neurons that will carrier signal, so that is called a Local Event; the change from higher amplitude slow frequency to lower amplitude fast frequency can be triggered by an external stimuli, but this energy which is dissipated actually it cannot go anywhere, it has to fire other neurons; that means, there will be a local disturbance there. Like if there are, I am just giving examples of there are 5 neurons which are going on a high amplitude thing and some external event happens this 5 go down to faster frequency.

So, all these energy has to be pass down to the rest of the nevering may be another 50 neurons. So, this signal which will go in there is a local event, there is local event can happen cascaded, transform information to other area, but this is how the variation of oscillation through energy changes which essentially means firing. Catches the difference in signal is local event which happens, now the 15 by fire 1500, the 15 we may fair 10 to the power 1 to their network.

So, a local and that is why how it happens like let me given example very gross example although there multiple a steps from this two actually what happens in the behavior. May be your slowly meditating, your whole brain is in a slow concentrating you know synchronize way, the brain normally de synchronize, but in normal stage you do not have a delta waves, that is abnormal because brain does not get. So, synchronize aware suppose you are memorizing something. So, you are already in 4 to 7 hertz in your which is carrying on the background of 40 hertz binding oscillation, over which your memorizing four to 7 hertz suppose and suddenly ceiling falls or the fan falls, immediately what will happen there will have to act, to act we have to get to the faster thing within the 30 millisecond to 100 millisecond period your brain will get into activity.

So, you have the frequency change which has wood have happen is from four to surgery forget memorizing at that time, it will shift to beta. Amplitude that energy will come down frequency will go fast, but lot of neurons will get activated. So, a local event which is the following externally or a sound of it triggers of this thing those set of neurons which will learning immediately you cannot keep memorizing on the fan is following on you we all know that, the panic at are the fear. So, this is the type of activity the game which goes on in the brain all the time I mean all the time tell you die. So, this is what I will told you. Brain networks oscillate and their behavior dependent. We will talk about

it. Beta is when lower activity is given to the brain mathematics may be or thinking and are you have problem solving, theta is when your memorizing in the specific areas like hippo campus will mention a hippo campus later on.

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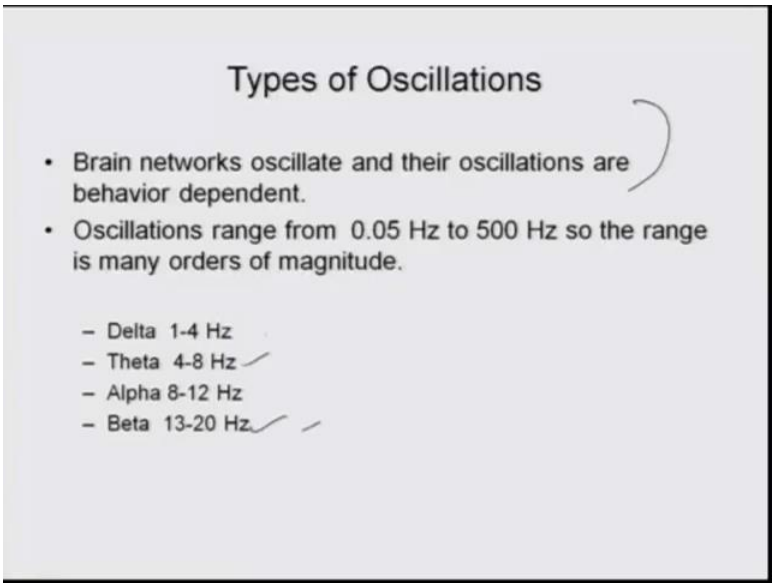

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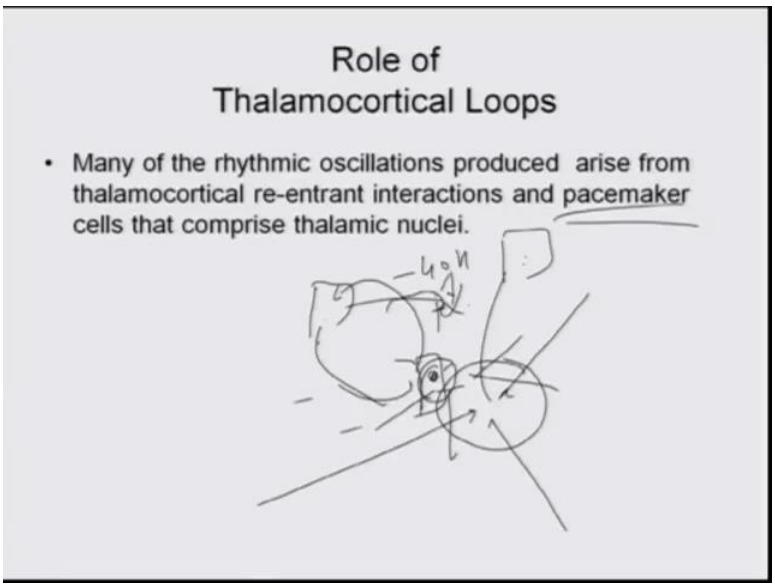

Now why I have sink thalamocortical, lot of this they arise from thalamortica re entrant re entrant simply means feedback loops, this is cortex this is thalamus, positive, negative, negative, positive. So, lot of this activity and remember thalamus, if you remember I talked about geniculate nuclei, where visual thing is coming or literacy is coming

sensory is coming, which goes to partial loop. Now you see how it is all integrated, all those informations finally, go to cortex, cortex whether you have to act on it or do whatever. This remains to be the trigger point and taking all those disturbances signals which are coming this thalamus remains the pacemaker.

So, lots of pacemakers are in thalamus, which give raise to this 40 hertz waves, alpha happens from cortex, so this interpolate. So, it is like may be if you sitting with your eye close, your brain is working at 30 in hertz or 10 hertz and suddenly some a stimulus comes and your brain is uniting all different type of stimulate to give your sense of self right from your joints to, touch to, smell to, vision to, orientation in to time any space which I have talked about parotid temporal log and suddenly we have to do some activity. So, the 13 hertz wave we switch to beta or higher depending on what activity your doing, 40 hertz may still because going in background, but this 13 hertz will be negated and that activity will increase.

Now, suppose 13 hertz is happening here, thalamus is not firing this is the predominant, but then will happens thalamus suddenly switches the whole thing. So, the whole thing in the heads becomes. This is the type of interpolate which. So, you can see this just not a Michel diagram.

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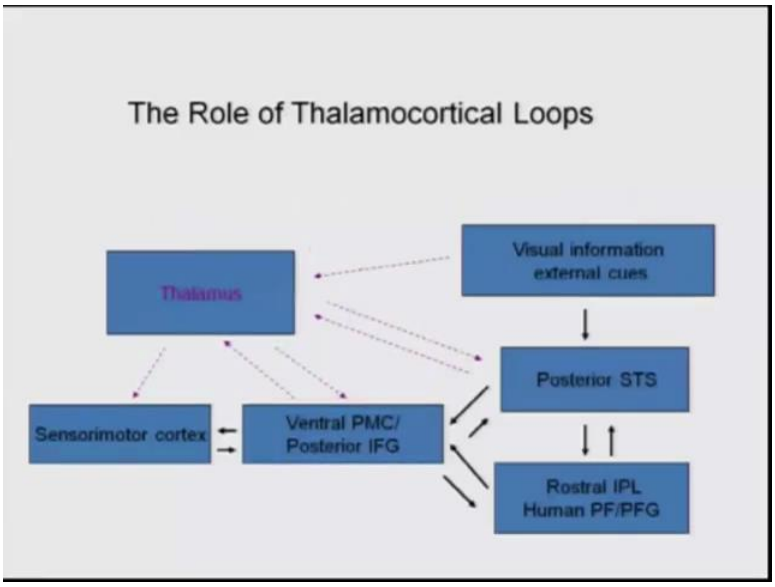

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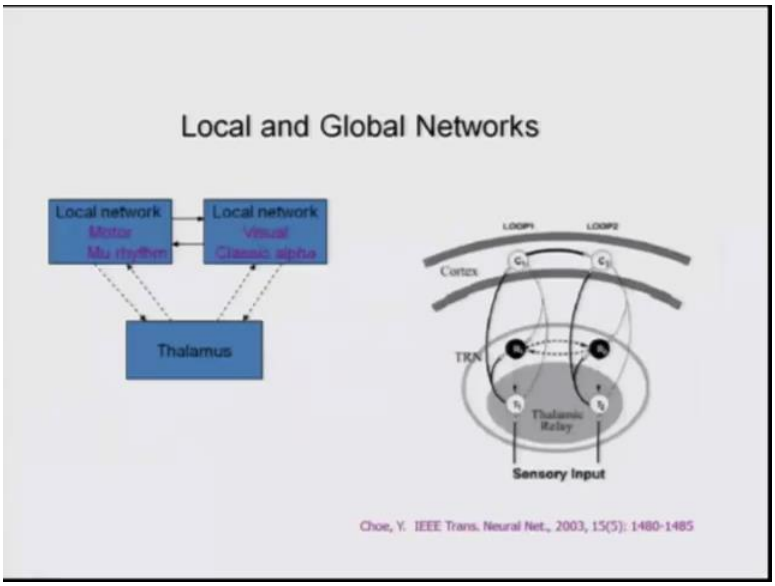

So, local there is something called Mu Rhythm. Mu Rhythm is a found in the center of the head, just before movement you are normally seat on the Rho EG. This is the type of loop which I have wanted to tell you. This is the sensory input in thalamus it goes on to protest, it goes excites this comes back to thalamus right and this has the type of reticular nucleus which you call, which keep you conscious also.

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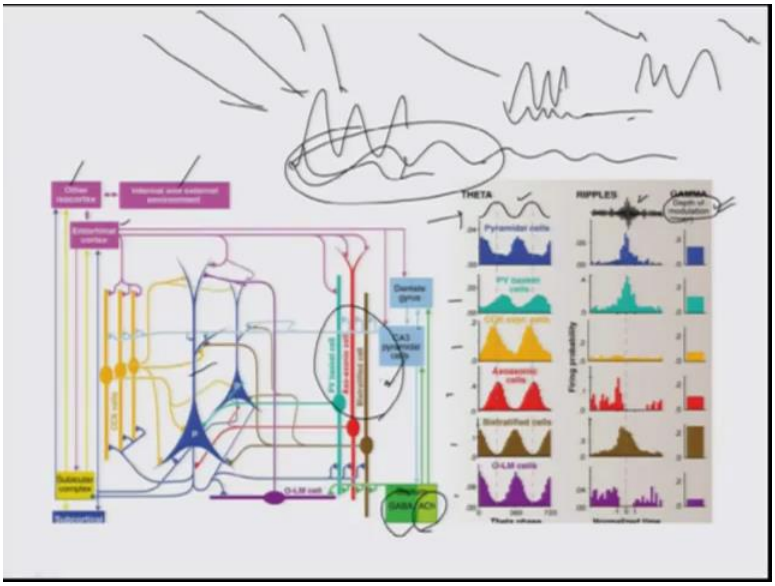

So, now betting more complicated, now see the game these are pyramidal cells, the blue once different type of cells, this has the various complex as right. This is just to show one

of the systems and this is type of just corresponding waves. So, this is the ripples, this is the theta wave, which are happening this is the actually a memory thing. See a 3 pyramidal cells are found in hippo campus, where which is the learning circuit and is stimulus goes the neurons keep firing their and that is how short term memories from there.

So, this theta wave is when we are learning and there various search pyramidal cells, basket cells, all this cells are throwing this theta wave in the learning process going on and gamma is the basic thing binding thing which has associated this formulates the depth of modulation. So, then the background of gamma, this theta waves right in experts, suppose a stimulus comes one is part second, third. So, always spikes which are coming give raise to this on the background of gamma and it is important why gamma is there because gamma I told you possible is the binding eyes oscillation. Suppose your remove the binding the oscillation whatever is stimulus us coming may be memorize, but how will get integrated.

So, get integrated it this wave is right this spikes are righting on the already existing template and they finally get integrated to form the memory because otherwise what will happen that all pieces of memory will be separate and you cannot recall the whole thing. How you will recall all things? What tell you rows you see? So, many things, but if everything of rows has gone separately and it has not been integrated with already existing background self.

Next time I talk rows you may be you will tell althorn, you will still not visualize. So, to complete that this type of network has evolved, so you see this internal external environment, ISO cortex anthorinal and these are different type of cells which are form, but the whole system goes into this forming, a style cooling and gaba. Gaba is inhibitory, as style cooling is the neuron is the chemical actually is most important for memory.

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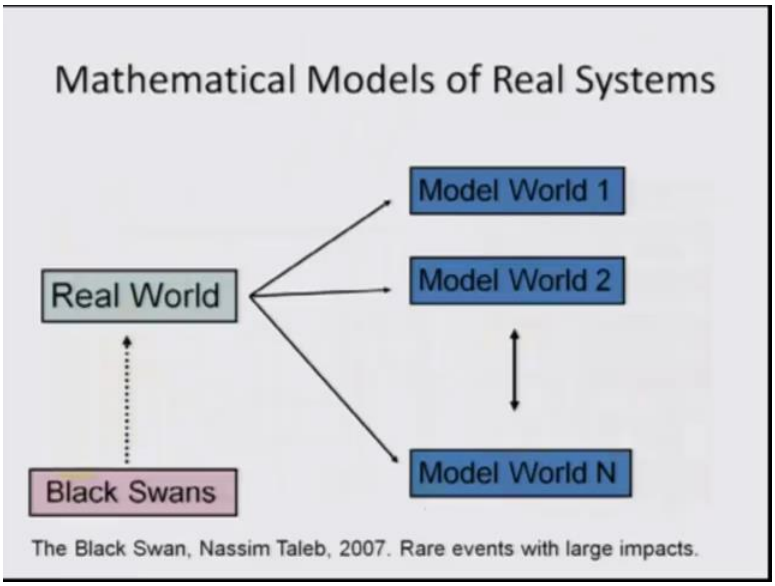

So, these are type of black swan is a theory brought out by Nassim Taleb, who says that may be if you take a general account of events happening, that may not be that me give you an idea, but it is actually the rare event and it is impact which gives you the progress of a system.

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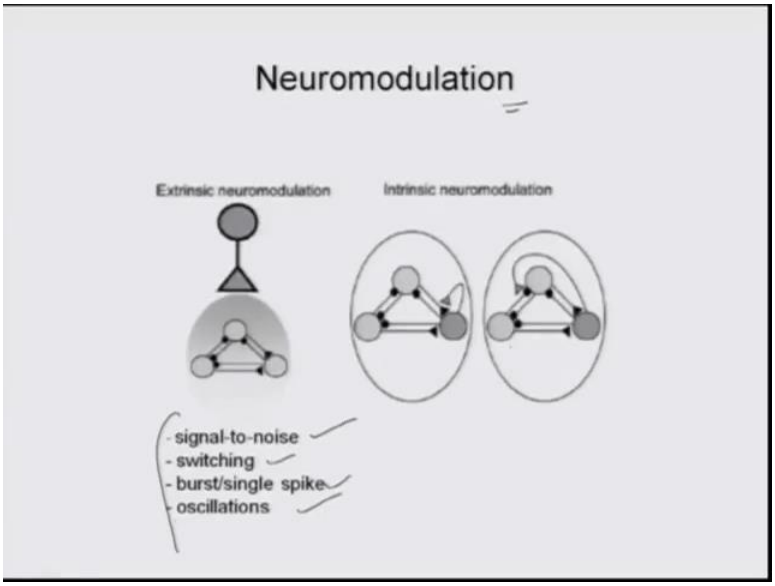

So, neuron modulation, all these firing is again has a said what are the important factors signal to noise ratio. The neuron modulators are the neuro chemicals there some intrinsic and there some extrinsic way switching between one frequencies set to other, as I said,

Burst was single spike, oscillations these are all circuit properties. Single neuron when they get in to neuron assembly they actually stat developing circuit properties the switching between tasks you can switch between frequencies.

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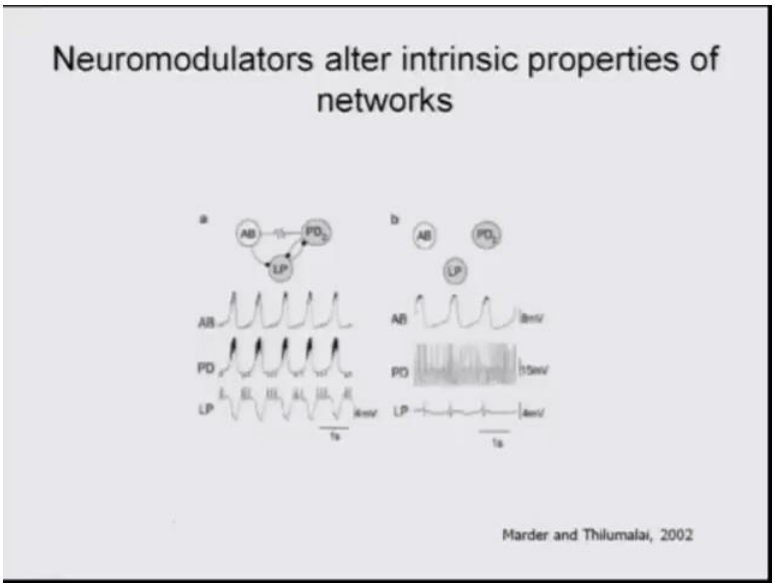

So, these modulators can alter the intrinsic property. You can see, see the type of waves in the alterations which happen with chemicals.

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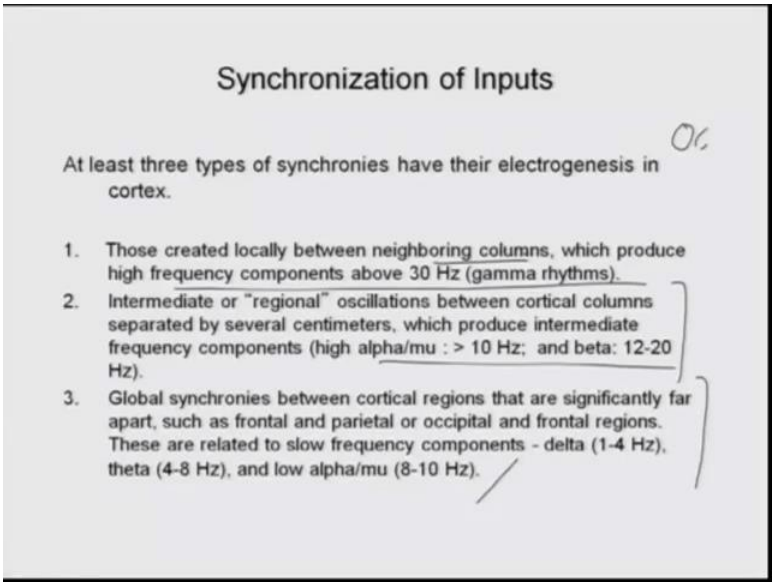

So, 3 type of stuff which happens, one which is happens in neighboring columns you remember that macro columns which produce high frequency components which was the

local disturbance of a local event, that local event change of frequency high frequency is always happens in the localized wave. Because otherwise it will not get triggered innovative it has to happen some where to start, intermediate of regional oscillations happened between larger areas, which produce alpha and beta and all that. When the activities start high frequency then it has to be spread.

But if you take the whole brain synchronization, when the whole brain is working then you get to a slow movement. So, high frequency can happened and localized area, to the underline high frequency binding thing which gives binding everything, but when the whole brain gets in to a similar type of oscillation, it is the slower frequency because they are high amplitude slow waves.

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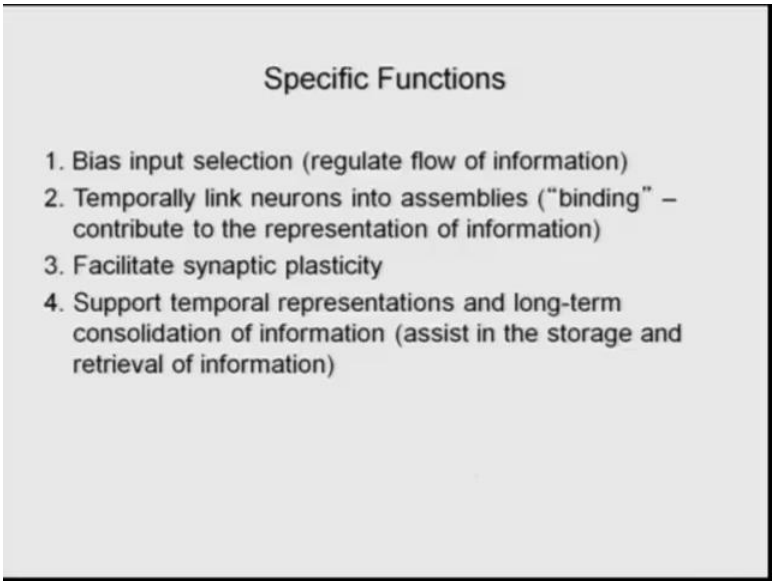

So, why is it important because input signaling, linking neurons, synaptic plasticity, temporal representation. So, we will end this and next week we will start exploring the networks.

Thank you.