How The Brain Creates Mind
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Lecture - 06
EEG

Hello, and welcome to this first lecture of second week. If you remember last week we talked about the structure of the brain. How 10 to the power 11 neurons with a 10 to the power 15 synapses, from a huge network in the brain and how did this neurons grow under the influence of experience and external imports. How genetics and Epigenetics play amidst themselves and the brain almost talking lot of sensory input integrates and differentiate and gives your sense of identity and self. So, just to briefly revise that and I will show you these figures.

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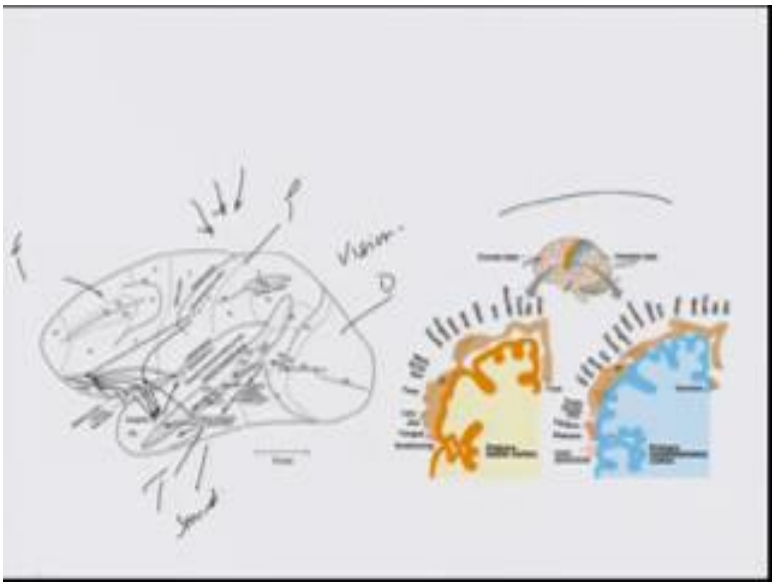

So, this is what the brain is, as we remember these are frontal lobe, these are parietal temporal or occipital, you can see it here also this is occipital, temporal, parietal, frontal. Parietal lobe receives all signals from outside; touch, pain, heat and temporal lobe essentially sound. This is for vision for and all these data which goes in through these networks, is translated, compared with whatever maps and memories are existing and it is presented to the frontal lobe where, a decision is taken whether to act on it or to think

about it and just to show you in more details. This is, there is a concept of homunculus at one point of time people used to think there is a little man sitting inside the brain who could see everything, who could see whatever is coming in, but there is no little man. So, what we called homunculus, if you a look this is somato sensory cortex, this is the representation of eye, nose, the rest of the body. So, you see the face and the hand is represented more than anything else, so actually if you just put the size and make a man he will have a very huge face, very large and big hands and rest of the body will be truncated. Even the feet will be very small.

See it is all smartness of evaluation. You can think why are feet's so small? And why are the hands so big? And why is the face so big? Think over probably because if the feet had been very broad, to make a stabilized, body standing on two feet would have been very difficult like putting in a like a center of gravity of the body, your hands have got free from when you are walking in the floor, millions of years back to a hands being free. So, you do most of the things with your hand. So, your hands have to be sensitive to lot of touch, pain, heat plus lot of external input especially for the mind goes through a face. You have seen how many senses are there? Touch it spreads over the body, but eyes ears, smell, taste everything is concentrated.

So, face naturally has to have a larger representation and that is what it is. So, these are the type of representation in the brain through which these network form maps. We will talk about these maps later on, but these map are the really memories. Now if imagine suppose, you did not have memory any system of forming memory, how do the form we will be talk about it? Then what would you compare things with every sound, every time will be new to you and you will really not know, if it is predator to it, is a good thing or it is a bad thing.

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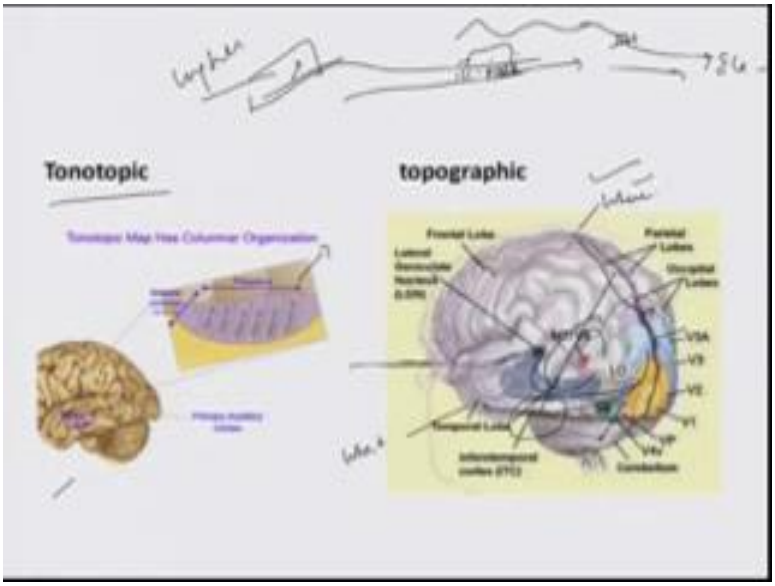

Similarly, is a Tonotopic and Topographic, as I told you last time whatever sound goes into your ear it is finally, from the beautiful membrane which is in the inside the ear which separates frequencies. As the sound comes in a pressure wave, the frequencies are separated higher, frequencies represented say this membrane is like this and it almost falls on this. So, when this memory moves, it actually infringes on this hair cells. This converts it to electric signals. So, the higher frequency are at the base line and the lower frequencies, so this structure is very tightly fixed and that is how it gives you higher frequency. This is slightly loose, but actually every time it moves it put pressure on this hair cells and this generates electric current sends it to the neuron.

Similar thing in the eye, see this is the pattern of the eye. What comes from here I will just try to trace it. It comes from here, it goes to the structure call thalamus, if you remember I talked about it where, it is a representation according to the features from left eye and right left eye, then left and then right. The signals are going from here it goes to occipital there is this layer v 3, v 2, v 1 where, depth edges movement everything is separated and from here again image is formed which is sent to deeper lobe stage, to temporal lobe. Which is if you remembered I told, what is it you are seeing? And there is another direction which goes to parietal lobe where, is it located? Now it is important.

Here, if you see in the sound frequency is separated, but signal also goes to certain areas which control movement. This whole thing is integrated somewhere in this area from here, somewhere here the whole thing is integrated and signals are sent to areas like cerebellum to frontal lobe to decide whether you want to turn your head. You will not know, whether if you do not know where it is coming from you are not turning your head. So, the signal which is coming from sound from touch, from vision is integrated and differentiated not only to realize what it is all about, but it also sent to deeper structure of brain which you will decide whether you want to most towards it or what reaction you have to give it is such a finally, balanced system.

So, we will drop these networks and how do they do for time being. If you remember I told about various levels. We are talking about the behavior the reaction from outside senses and then the whole brain and then networks trying to form a composite image of your existence, but let us leave at it that for the time being. How do they do it? Let us take few jumps down into the deeper structure. Brain is a network of electrochemical activity, is a continuous electric activity in neurons will talk about it, when we talk about electricity in brain, but the switches are chemicals and this chemicals are like, if you remember we talked about synapse I will show you what a synapse.

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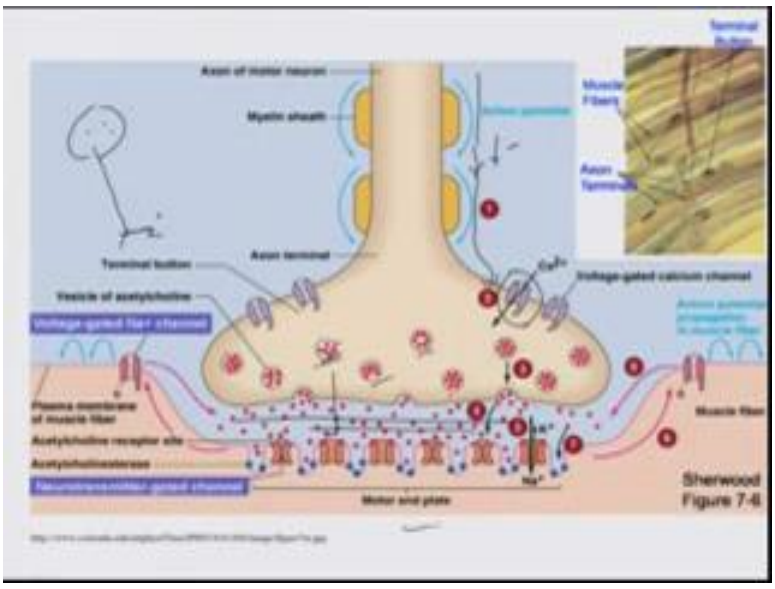

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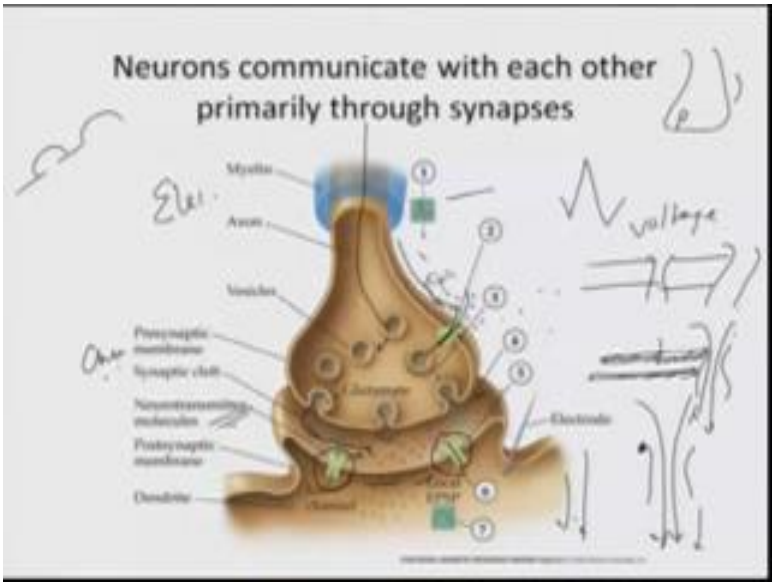

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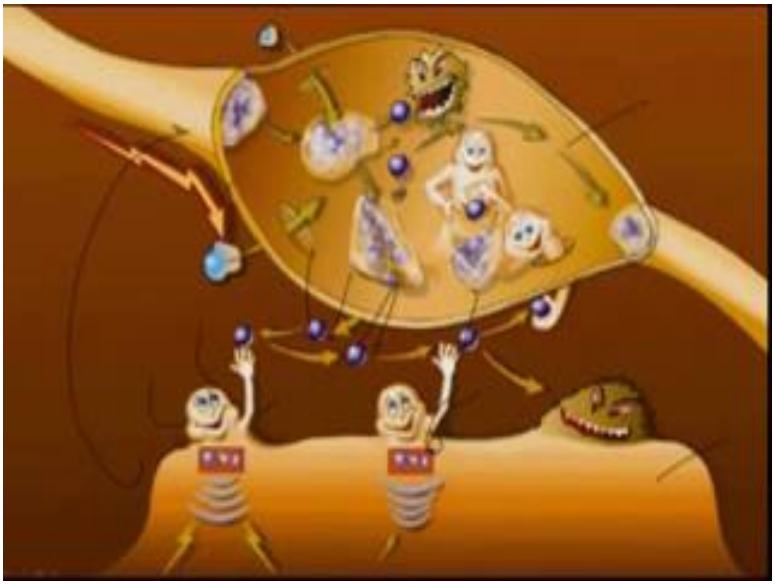

This is the synapses, this is the synapse this is the synapse. So, what is happening is that this is a neuron. If you remember, we talked about dendrites and so on, electrical signal is coming here and these are something called receptors, just to show you. There are, these are chemicals which are formed in the cell body like this is a cell body, these chemicals are found here and they come down to axon where, they come down this and

go to the dendrite. This small gaps which you see, this gap between this and this 0.5 milliseconds, but these chemicals are called neurotransmitters.

So, the electrical signal which is coming here at this synapse which is a gap between two neurons; the axon and the dendrite or here you see the motor and plate with the muscle. This gap is, electricity cannot jump. Unless you are talking about quantum tumbling and all which we are not sure about because this current you will discover as we talk is not the typical electron current which you see in metals. This is the ionic currents; it comes these and triggers the secretion of these neurotransmitters through this gap and look at it. So, you see this is electric current, you can see there is a, it is coming down here there is a calcium outside in the fluid around it, this calcium suddenly goes in as the currents comes and how does it go in? Because you see, these green structures these are called receptors.

Receptors are of two types or rather let me put it in a different way. They are channels as I told you this is a neuron, there is a channel here. These channels are of two types one which are voltage gated, this. These open up, these channels open up with a difference of sodium, potassium, chloride, calcium the voltage difference which this iron creates and then there are other channels which are like ligand gated. So, these are iron channels, this one, if you see this and then -there are channels which will open up only when a neurotransmitter combines to them, which is a ligand gated. So it is like this, these are receptors sitting here. They are waiting for this thing to come and as these neurotransmitters are secreted, these receptors catch hold of it. So, what happens? They receptors bite. The movement they bite into the proteins and these are all protein receptors, because if you look at it, it is like this is a lipid layer.

Lipid is fat simply, the lipid layer is insulated current cannot pass, but these are proteins which through this sodium potassium can transfer. Through the pressure whether this balance of presence of sodium potassium both sides or through enzymes, so movement this receptor comes and suppose it binds to one of the proteins here, it creates some mechanical distortion and the whole thing opens up. Once it opens up the sodium rushes in. By the movement it opens sodium rushes in and the movement sodium rushes in

again there is electricity which starts on the other side. So, between two electrodes these neurotransmitters jump the current.

I hope you understand it, current comes calcium goes in it binds to this, it is small things called vesicle within which this neurotransmitters are stored. They come from the cell body are stored here, once the currents comes calcium binds. So, these vesicles move towards the edge of this, there is a structure like this. Current comes the vesicles move towards the edge and suddenly they open up and as they open up this thing is secreted into what you call a synaptic cleft. This small gap, this is a small gap between the dendrite and axon, that is a (Refer Time: 13:38) and they go bind to this channels, ligand gated or and then you opens up again the sodium rushes, in another current goes down from here.

So, this is why we call it electrical chemical network. The electric activity coming from one set of neurons and passing on to the other is regulated by these chemicals. That is why it is a chemical switches. The quantity and it is very important of because whole of psychiatrists survives on this. We know how to modulate these neurotransmitters, by giving drugs. The level of these neurotransmitters decide how many receptors of and it is a dynamic process suppose, if there is suppose chemical x and it has to be present in a certain quantity in a certain area of brain, but suppose it decreases, so the number of receptors, what we call it? Let me see if I can tell you.

This is the whole area call presynaptic and this is postsynaptic. This is presynaptic and this is postsynaptic. If the number of chemicals, which has to be secreted decreases over time, then the number of receptors who wants to catch it will increase because; obviously, they have to have that certain number of neurotransmitter to keep it firing. When it gets distorted for some reason for illness and may be depression or some vitamin deficiency, then the number of chemicals which are made in the presynaptic neuron will decrease.

So, what the brain does? It increases the number of receptors. So, that even a single molecule does not go waste. Otherwise you get many receptors is less number of neuron transmitters segregated, the whole brain the postsynaptic neuron will catch it, but if it decreases the then they have the receptors have to be more right. So, plus once electrical

firing goes on, there is always feedback mechanism which goes upward, that tells that fine, the number of chemical which is coming ok, is for us. The electric activity is going fine. So, the factory can decrease the production is like a market where, you have to supply certain things. If the supply is less; obviously, you will always see the more number of people to catch it. If supply is more you will see as a less number of people because you are not seeing them. They are always there. Maybe there are 100 people and they consume 100 items which have to be delivered item suddenly. So, you never realize that everybody is getting it unless you really measure one by one. Here you cannot measure one by one because; it is in such a vast scale.

So, but if you suddenly decrease it, they say only 70. Suddenly you will see more 30 people are there, which is they will become conspicuous. Suddenly become egotistical, suddenly they become active. So, these 30 who were lying peacefully will become active and then the market will give a feedback that produce more or it will give a negative feedback, there is enough there are 120 of them you cannot use it. So, these are called positive and negative feedbacks which occur at very very neuronal level, micro level and also at very very high network level. We will talk about those networks.

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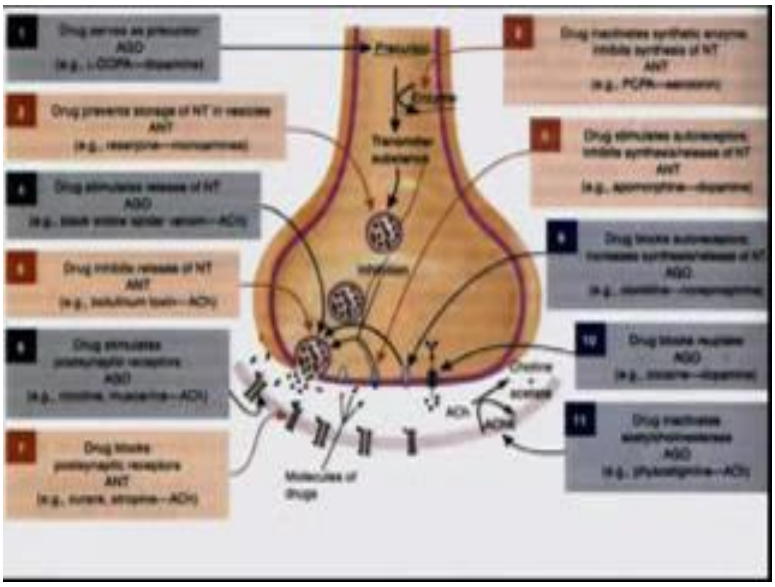

So, I just briefly try in this lecture go to and tell you what is happening actually. This is very important one concept is the feedback, neuron transmitters presynaptic, but the

other is excitatory and inhibitory. All of these chemicals do not go and trigger off electric activity. Some chemicals go and actually inhibit the activity, inhibit the activity of the postsynaptic neuron because. So, this game of excitation and inhibition is the real game in the brain, which keeps neuron firing or not firing. It is just another example to show you. So, precursor in the cell body they are enzymes, that chemicals which catalyze, transmits substance. They either this is inhibitory. So, inhibitory will send the chemical which will decrease the firing, which may actually case the channel. Some of them which are open also are closed.

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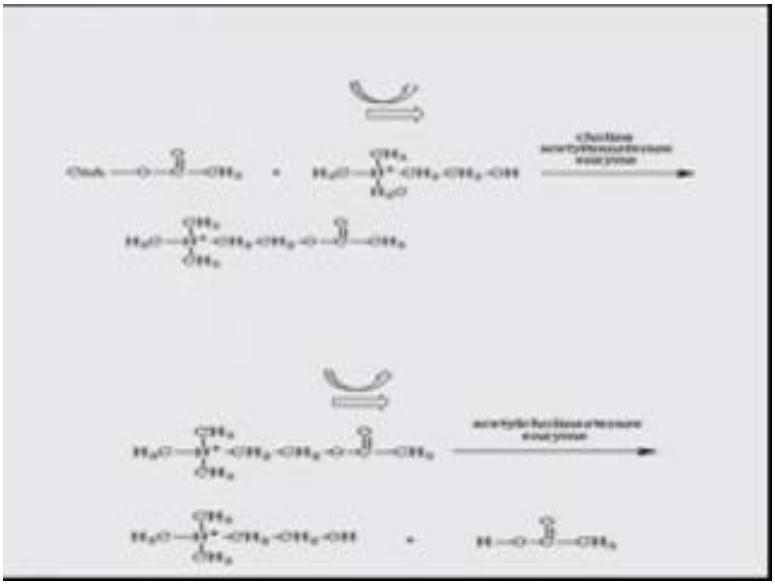

And here is the list of drugs, which you do not have to really bother about it. These are some of the all chemical reaction which are going on in the cell body.

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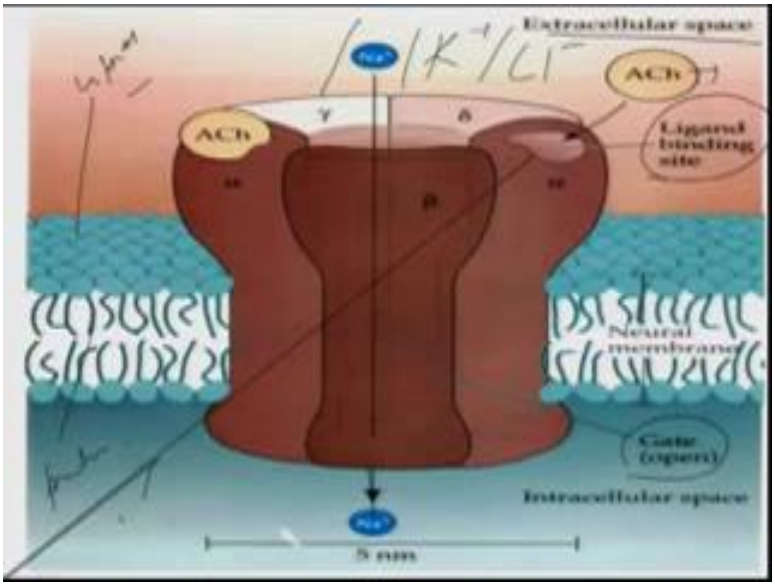

Now, this is a typical receptor. This is extra cellular space, the space outside the neuron extra ACh is one of the. So, few of the most important neurotransmitters or neuromodulators you can call them are Acetylcholine, Norepinephrine, GABA, Glassine, Glutamate, Serotonin, and Dopamine. Now you can ask me, whether each neuron has one neurotransmitters, there are areas in brain, which are very dense in certain thing like one area locus coeruleus has more noradrenaline, norepinephrine cell bodies. One area has more acetylcholine; one has more 4 or 5 of them, more dopamine. These self areas where there is dense presences of one neurotransmitters have projections of neuron all over the brain, but they are most neurons otherwise have presence of multiple neurotransmitters and there is a fire inter play which goes on between the excitatory, inhibitory. Each one of them has the receptors on the postsynaptic thing.

So, you see this acetylcholine from extracellular (Refer Time: 19:53), it goes. This is called ligand gated, ligand binding and this is a neural membrane. I told you if you remember, this is liquid which is insulated. This is protein lipid by two layers of lipid and protein. All sodium potassium from here, here see there is a balance. So, like this has 5 units and acetylcholine binds here, it changes the configuration of it as it goes and sodium start going in, gate open and sodium goes in it changes the electrical triggers, potential difference which triggers a different type of thing.

So, this is the basic mechanism at a very micro level, which is the basis of life. If this neurotransmitter business shuts off, if this movement of sodium potassium shuts down. I think that is death. We are not been able to define it, but if you see brain death this movement of sodium, of potassium, of chloride manages through these neurotransmitters. If this activity shuts off that is brain death. At a very basic and interestingly this is not a phenomena which is happening only in humans. This is a phenomena which you see in animals and may be simpler animals and may be some membrane. So, what has nature smartly evolved?

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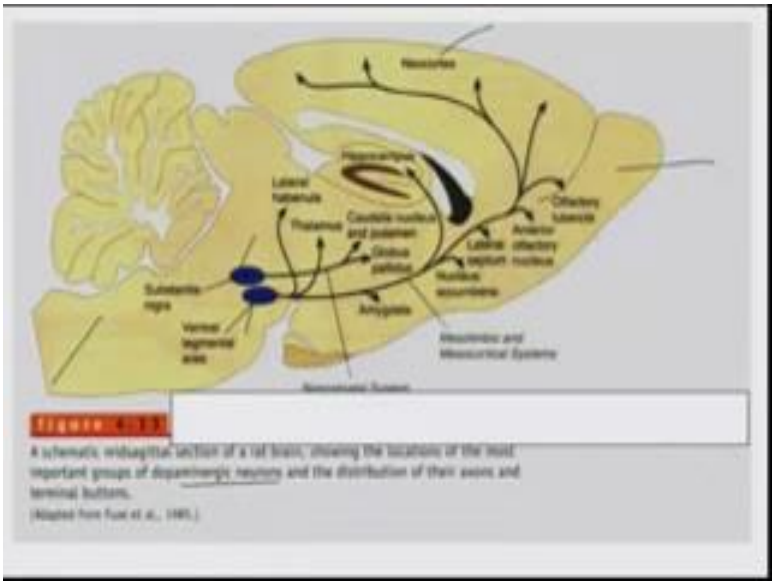

In the simplest form, if you talk of just one neuron. Each neuron has a history and, but each neuron also sacrifices its own history in the assembly of neurons; obviously, if you have to have 10 the power 11 each neuron nature has very smartly created a membrane. A membrane may differ in some, in humans this is by lipid. In other nerves system you find it like this there may be variation, but it is formed of lipid and protein. It is the partition between outside and inside with receptors which can keep changing and allowing electrolytes and irons to keep going in and out and that is essential information exchange. Energy, you require energy, brain requires almost to 20 to 30 percent of the whole glucose which body energy, requirement of body. Which is a huge number and it is a warm moist thing. It uses energy for this activity because there is a.

I will give you an example. This is a enzyme called sodium potassium ATPase. This enzyme pushes 3 sodium outside and 2 inside, keep the balance. Otherwise if you just leave it open doing nothing, a lot of potassium outside. Potassium will all go in automatically. It keeps going with some of these channels have leakage. So as potassium goes in something has to balance. Sodium is come down. So, these type of balances you just remember this because when we talked about electricity will lead to. So, these are these I said this is the dopaminergic neurons. The dopamine I told you. You see these areas, these are the areas where there is most dopamine and each of these systems they have huge projection to every regard to this neocortex to all factory, everywhere I mean it is like. You remember this substantial niagara, this is the area involved in very common this is called Parkinsons.

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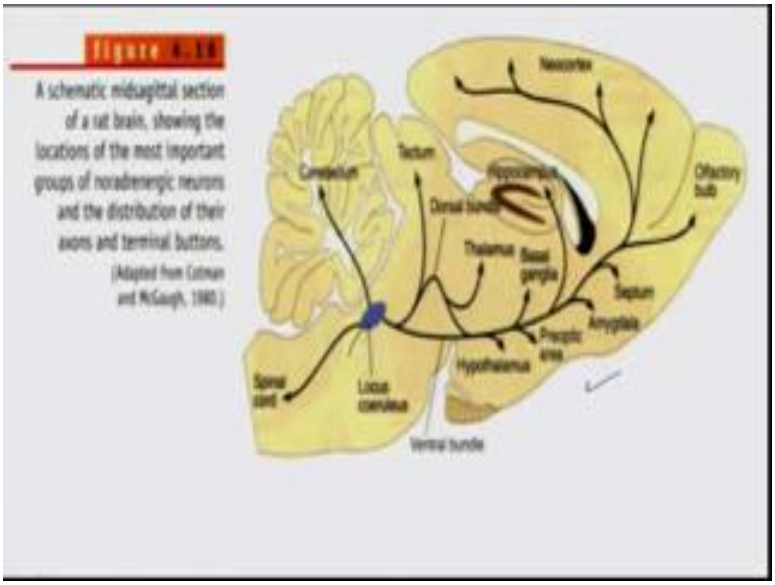

This is a noradrenergic. You see one area locus cellulose has huge projection everywhere. These are the neurons is always keep sending the same set of it and it has an importance because this system it is involved in attention noradrenergic system. Dopamine is involved in lot of things which you call the reward center of the brain. Reward means to you do something and if you feel pleasure you will keep doing it again and again. That is one of the bases of emotion also, this is called reward. If you do something and your brain does not feel pleasure, it will next time prevent you from doing it. This is also sort of emotional map or a memory or whatever you want to call it.

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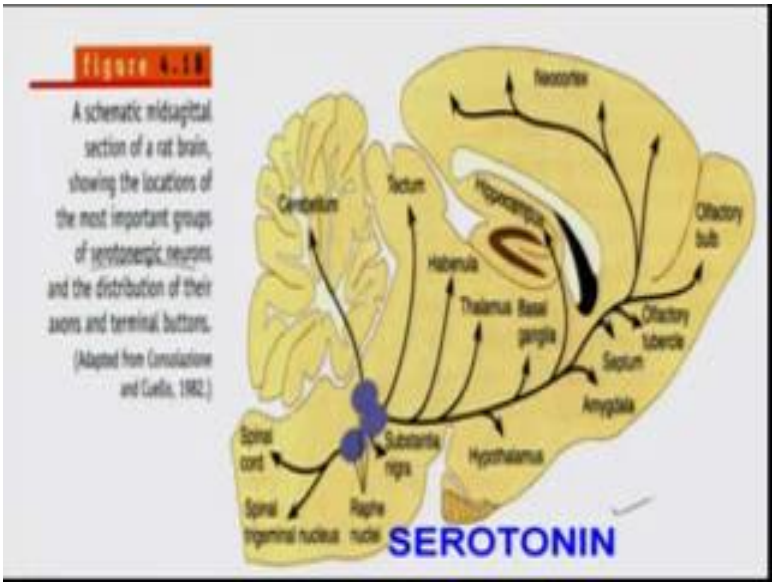

So, that is why nature has evolved in such a way that, this system will control the pressure pain, this will control the attention pain. When we will talk of sleep, we will talk more about this. Serotonergic neuron all your appetitive and repetitive behavior that you explore, you want to eat and you want to hold and you want to keep doing again and again your mood state lot depends on this thing called serotonin and these. So, you can see the commonality, the whole see the projection starting from one place from deep brain it is going to the whole thing this is also going. So, there is a fine interplay of these neurochemicals in controlling your attention, in controlling your mood stage, in controlling your reward punishment, in controlling the way you react, the way you think, the way you explore things and acetylcholine is one, which is also important for memory. You must have heard of illness called dementia and dementia is like the most the nucleus which is the most damages.

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So, this is the whole list of it. You can read it later. Hypothalamic in addition to this 5, 6 big glutamate is excitatory because when you talk of memory the and when we talk about network, the chemicals which in those network of learning and memory is glutamate. That switches the whole firing again and again to do something. Your network learns to do it certain and net certain network in the brain, you repeat it the more you do it the more your brain will keep it as a memory.

That is managed through glutamate and then this is whole host of these chemicals which are presented in gut also. So, there is a brain gut axis. So, there is a illness called irritable bowels syndrome. It is the same disturbance of serotonin here and here. Sometimes lot of IBS patient are cured with actually anti depressants, but this is the smartness of body and nature is very economical, nature if it can survive through one model you will not create another model there may be a variation to it.

So, the same chemistry when this is the heart your heart rate goes fast with the acetylcholine or nor adrenalin. So, vagus nerve which is goes from here inhibits it, but if you give chemicals which antagonize the receptors, we know there are something called agonist. There is something called antagonist. Antagonist will go and block. So, this is the whole list of thing which slides are here.

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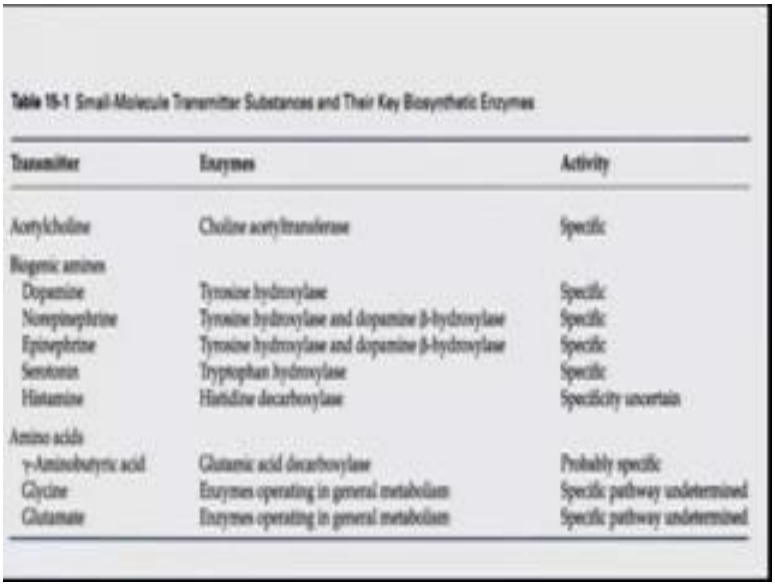

Table 18-1 Small-Molecule Transmitter Substances and Their Key Biosynthetic Enzymes

Transmitter	Enzymes	Activity
Acetylcholine	Choline acetyltransferase	Specific
Biogenic amines		
Dopamine	Tyrosine hydroxylase	Specific
Norepinephrine	Tyrosine hydroxylase and dopamine β-hydroxylase	Specific
Epinephrine	Tyrosine hydroxylase and dopamine β-hydroxylase	Specific
Serotonin	Tryptophan hydroxylase	Specific
Histamine	Histidine decarboxylase	Specificity uncertain
Amino acids		
γ-Aminobutyric acid	Glutamic acid decarboxylase	Probably specific
Glycine	Enzymes operating in general metabolism	Specific pathway undetermined
Glutamate	Enzymes operating in general metabolism	Specific pathway undetermined

And you can always go as I said. So, just to wrap it up because this was the type of (Refer Time: 27:40) which I wanted to give you about the chemistry of the brain and this is the summary which you can see.

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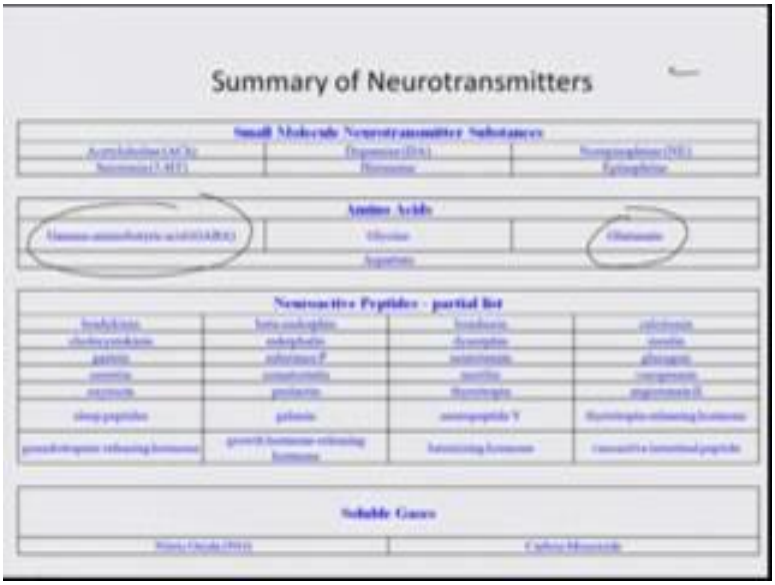

So, there are small molecule neurotransmitters. There is the amino acid, there are neuron active peptides. So, these are whole gamut of why does nature needs so many things? I think it is for fine tunings. Where if you if nature does not fine tune lot of this if you see

the glutamate here as I said it is excitatory and gamma is inhibitory. This is the interplay of this is the excitatory and inhibitory to regulate the firing, so I landed this. You can always find this type of place.

And maybe in the next lecture we will see what this all chemicals which is due. We will also talk about the electrical activity of the brain, then probably that will give you an idea of how this whole network functions and that is it.

Thank you.