Psychiatry an Overview
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Module-01
Brain and Behaviour -Approaches
Lecture-04
Electrophysiology

So we talked about the special imaging, and I will like to introduce you briefly with what do we do when we want to look at when, the question when it is happening in the brain, that is a temporal imaging.

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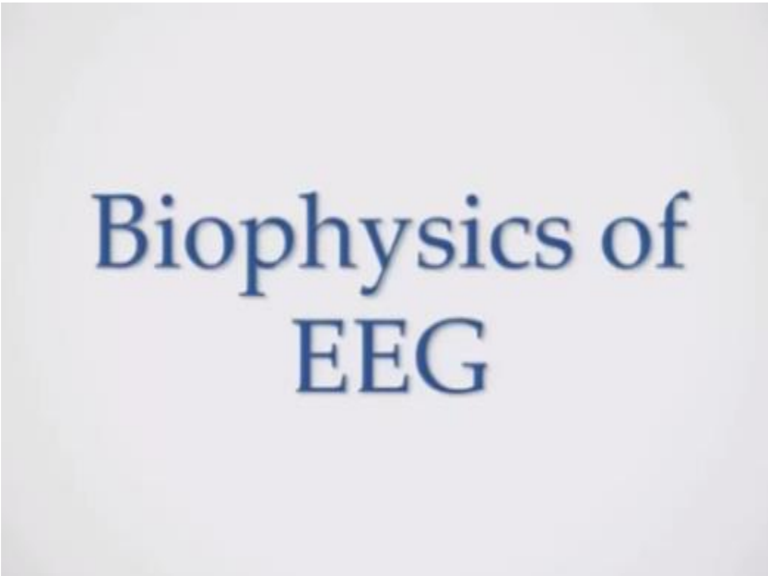

And the most common and popular tool is EEG. So as we know by now that there is a electrochemical activity in the brain, so if there is a electrochemical activity there has to be electric field by basic understanding of physics. So we know that they're all externally observable when source field is open.

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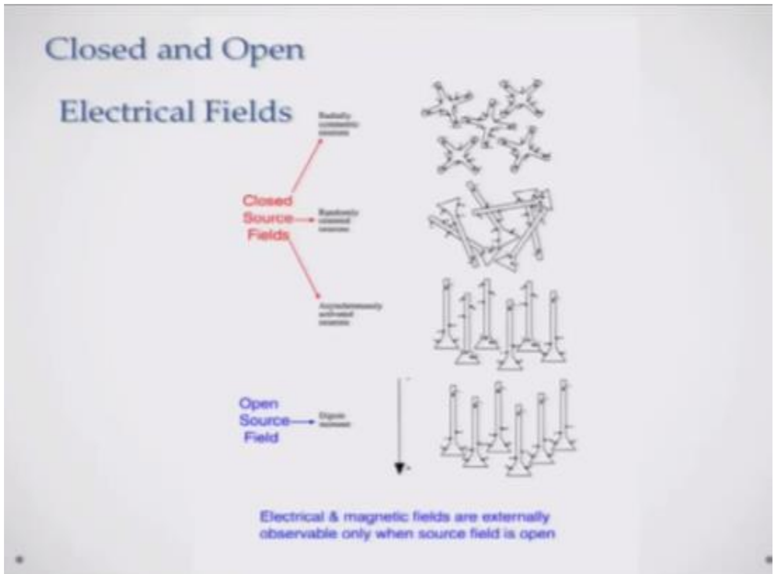

In a closed field where the electrical or magnetic activity is going on within it, there will be – it is very difficult to record. But when there is a open source field there is something called dipole which is formed between the current sources and sinks

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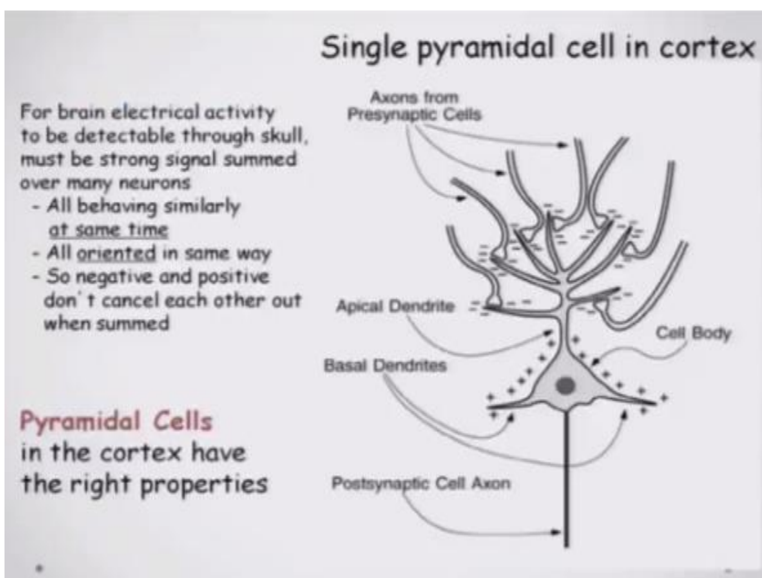

Which gives us the electrical field to record, but a sink -- though we can go and record a single cell in the cortex as we have seen when I showed you that slide on the scales we measure with a patch clamp. But for a brain electrical activity to be recorded through the skull there must be a strong signal.

So all neurons should be behaving similarly at the same time, all oriented in the same way, so that a negative and positive do not cancel out each other. So pyramidal cells in the cortex that is the layer 5 have the right properties, so what do we do again the same basic structure.

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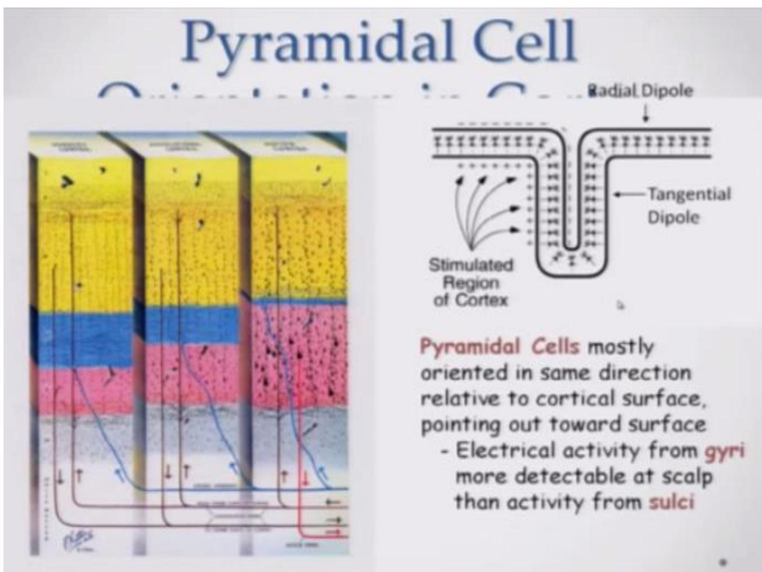

So these are the pyramidal cells, they are oriented in the same direction relative to cortical surface, pointing out towards the surface. So electrical activity from gyri that is the fold is more detectable than activity from the sulci. And these are the pyramidal cells if you look at it, sensory cortex, motor cortex.

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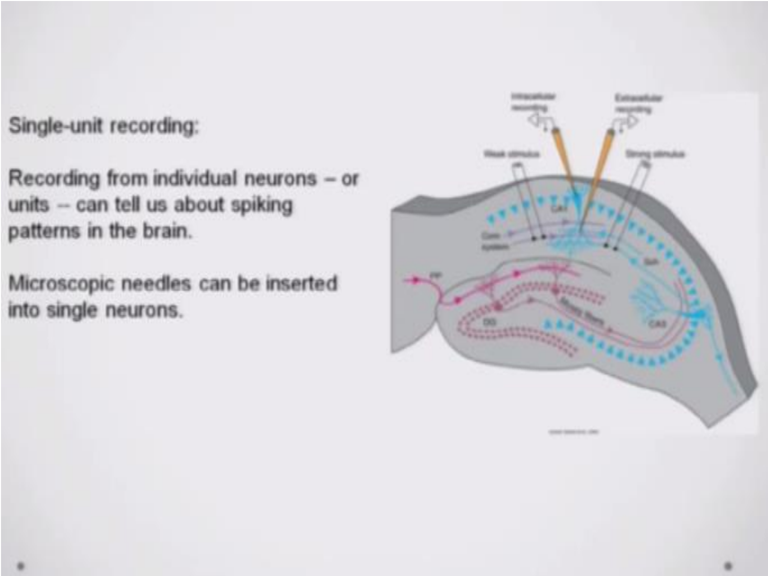

So as I said single-unit recording we have to go deep put electrode, but their intracellular single-unit recording is different from the recording we get on the EEG. And these two are different from the recording which we do in the cortex outside the single-cell, between the sample of neurons, but not from the scalp even that is qualitatively different, because that is measuring the local field potential.

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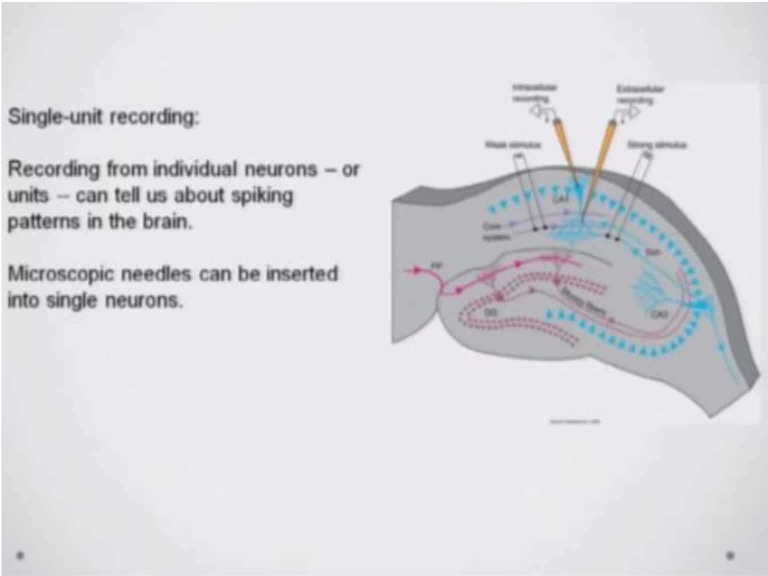

This is measuring the spiking and this may be high in amplitude, but as from a single cell and sample of neuron, it has to go through multiple layers of registers and what we get on the scalp is EEG which has a different quality.

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So we do not bother about it too much, because this is more of a research area.

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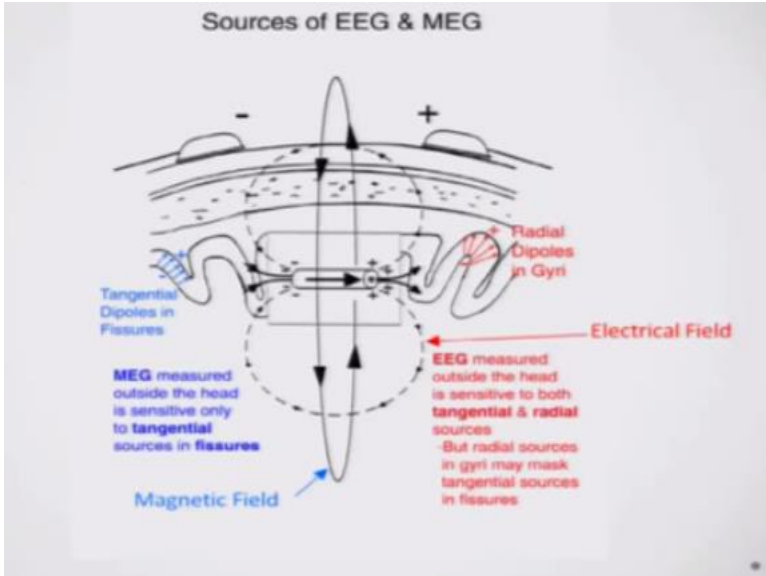

So what are the sources of EEG and MEG is the co-existing magnetic field with this electrical current called magnetoencephalography. Magnetoencephalography – so we put a scalp electrodes and measure the EEG, we've put electrodes slightly away from the scalp and measure the MEG.

But EEG measured outside the head is sensitive to both tangential and radial, so neurons which are like facing up and neurons which are doing this. EEG records both, whereas MEG if we look at Faraday's law records only the magnetic field created by tangential in the sulci. Well magnetic field goes like this, it goes like this.

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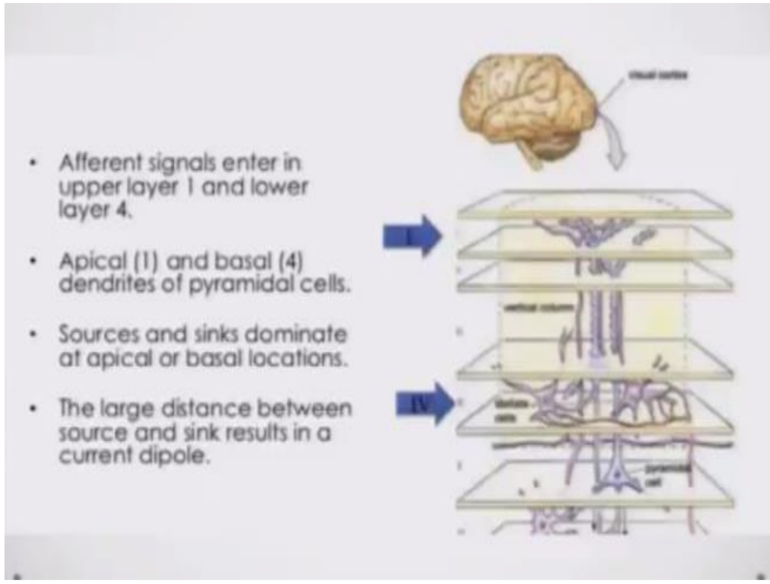

So now you go back to the sixth layers and you will know why it is important, the signals go into the first layer one, and lower layer four. Here the pyramid cells has its dendrite those antennas, and here it exits. So there is a source and the sink, the source and the sink comes from whether the external membrane is negative or positive, if it's negative in a depolarized it is a sink as compared to the fluid around it or if it is polarized it is a source.

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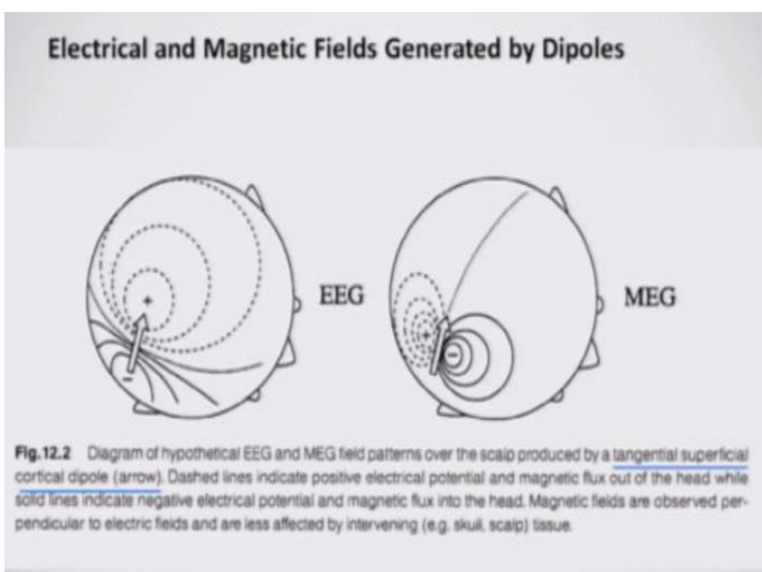

So between the sources and sinks what is formed is called a dipole. And this dipole and the difference between the electric potential and magnetic flux it is the current flow between them is the real thing.

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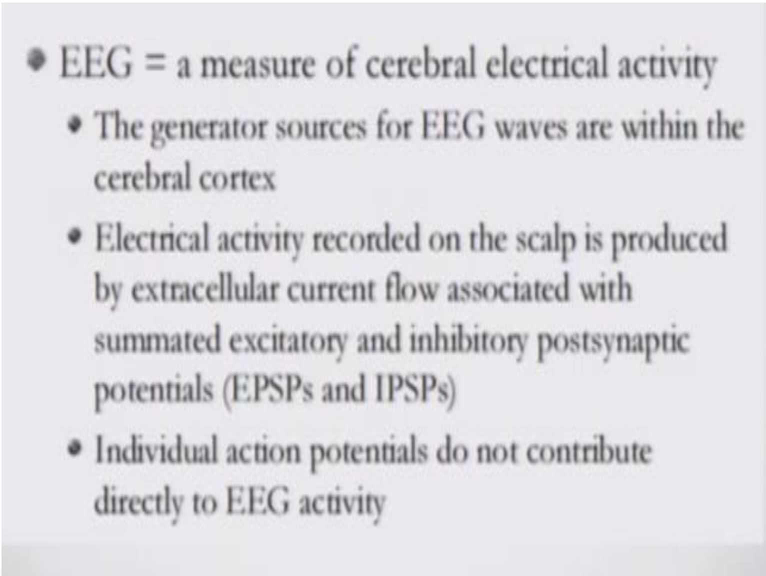

Which is caught on EEG. So EEG is a measure of cerebral electrical activity. The generator sources are within the cortex, but it is very difficult if you get some waves at the EEG it is very difficult to really go back and find out from where they are coming that is called a inverse problem, that you may get a signal on the scalp for whatever time.

But if unlike MRI which can tell you the source of activity the MRI, if MRI can tell you the source of activity but not when it is happening, because there the time duration is slow, here the time duration is faster in milliseconds. But it is difficult to localize the source.

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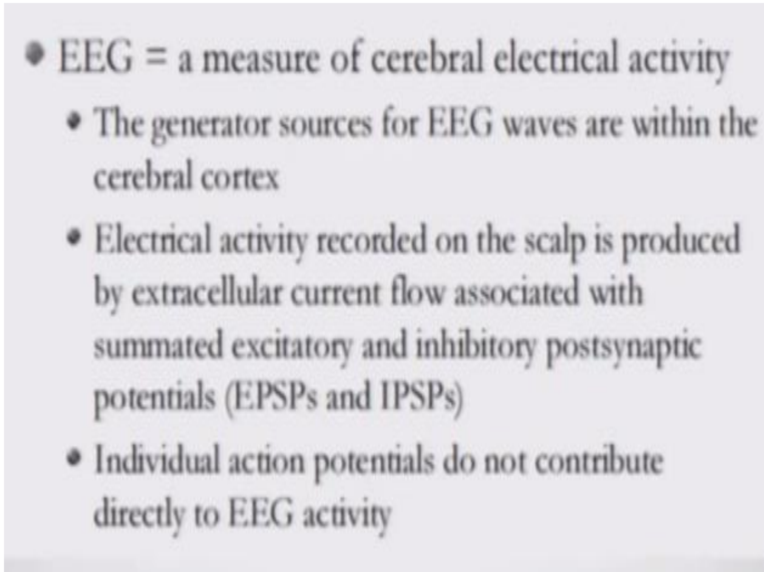

So this is recorded on the scalp by extracellular current flow with, now I remember you're EPSP and excitatory postsynaptic potential and inhibitory postsynaptic potential. But because we are recording on the scalp and the individual action potential is happening in neuron, so this does not individual neuronal activity does not contribute directly.

But when it comes to the combined cellular activity with the huge ensemble of neurons in a certain area, whether it’s inhibitory or excitatory and the summation resulting in the whole electrical dipole, that activity is recorded on the scalp.

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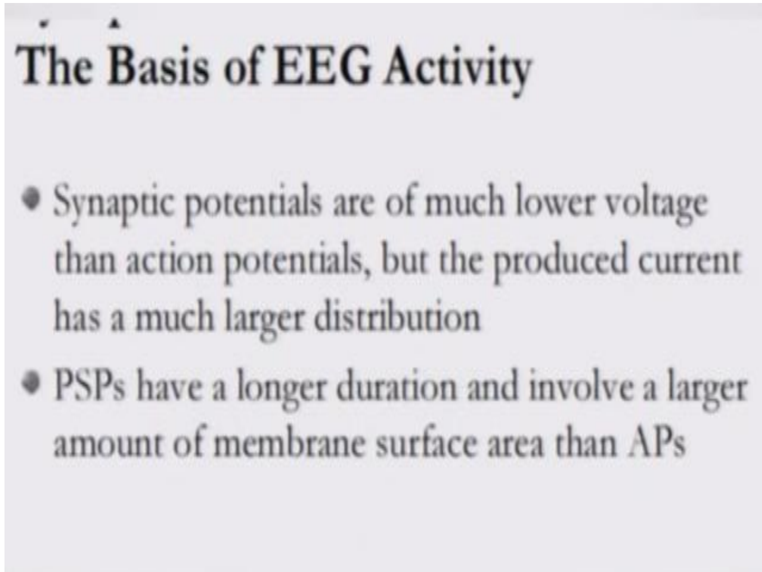

So synaptic potential are also of lower voltage, but current has a larger distribution as I said.

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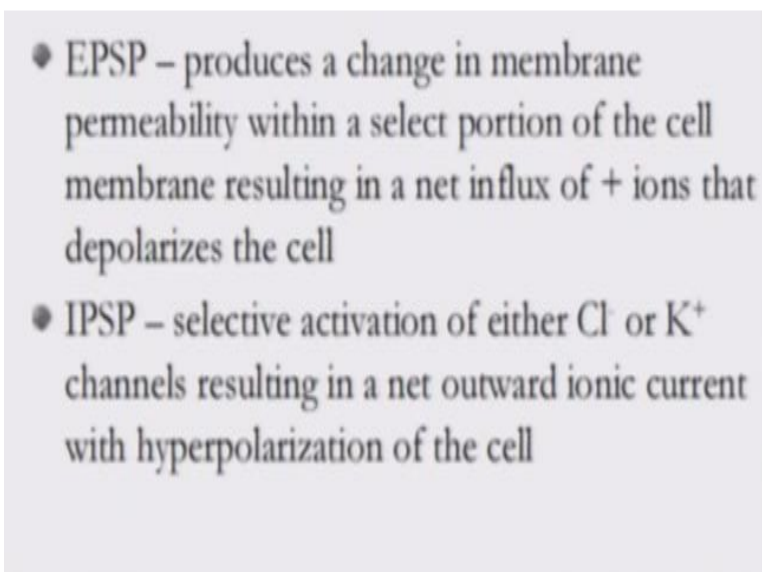

EPSP we have talked about it, there are changes in membrane permeability within the select portion of the cell resulting in a net influx of positive ions that depolarizes. So when it is excited the positivity outside the membrane changes to negative. IPSP acts on chloride or potassium resulting in a net outward ionic current with hyperpolarization so positivity increases. So all those inputs which inhibit increases the polarization, all that excites depolarizes.

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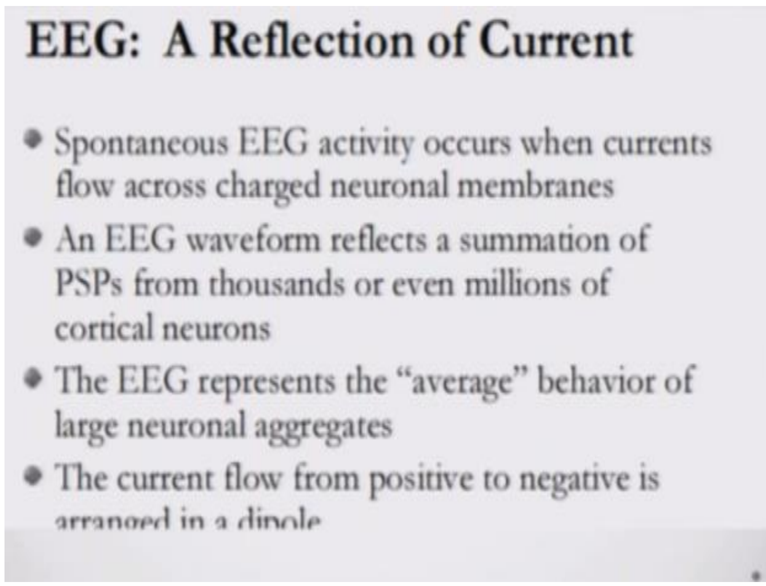

So EEG the reflection of current, current is all the time there we put electrodes it is a summation of postsynaptic potential from thousands or even millions of cortical neurons. It represents the “average” behavior of large neurons as I said.

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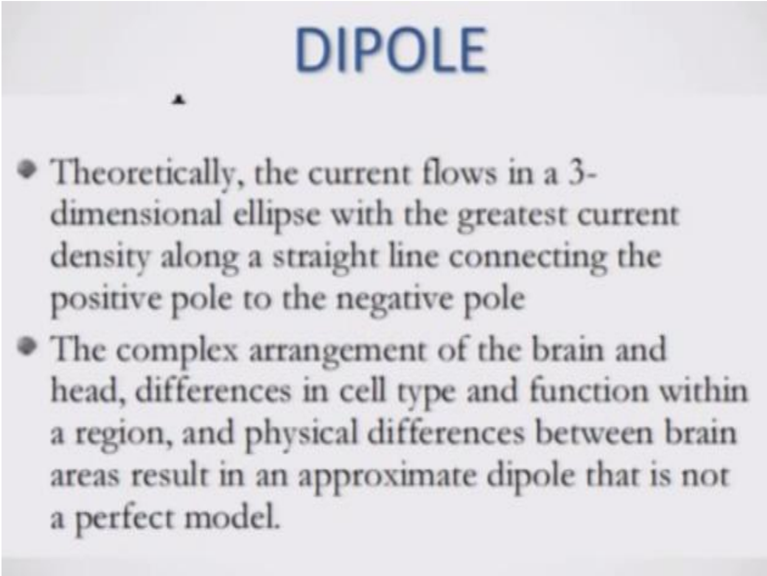

And dipole we have already talked about.

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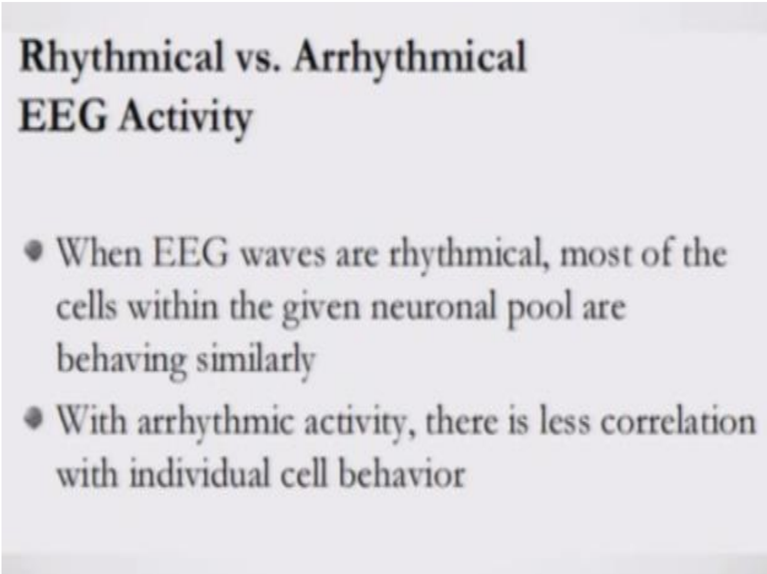

So why is EEG important, EEG tells you whether the brain is functioning rhythmically or this is arrhythmia? When EEG waves are rhythmical, most of the cells within the given pool are behaving similarly, when arrhythmic activity there is a less correlation. So brain in different areas may be firing differently and showing different area, different rhythms when it is arrhythmic activity which may be a normal resting state. It becomes suddenly rhythmical in the abnormal states also, a pyramidal cell.

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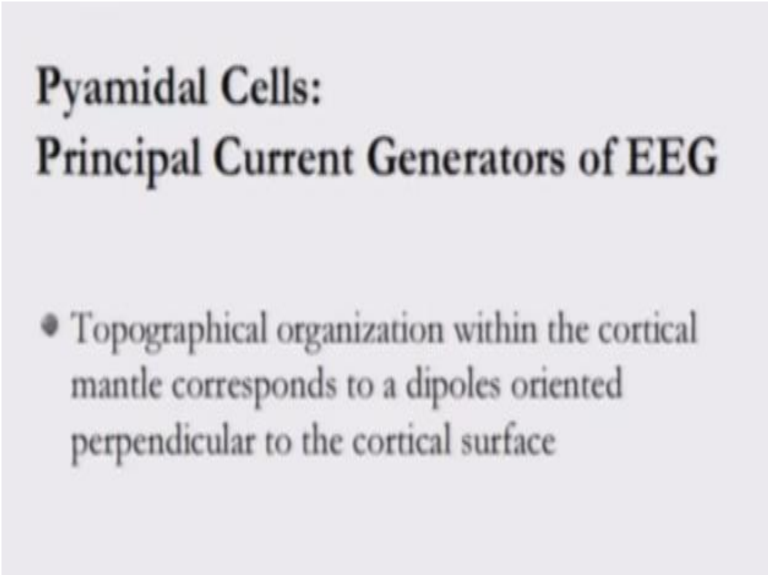

As we have talked about are the principal current generators.

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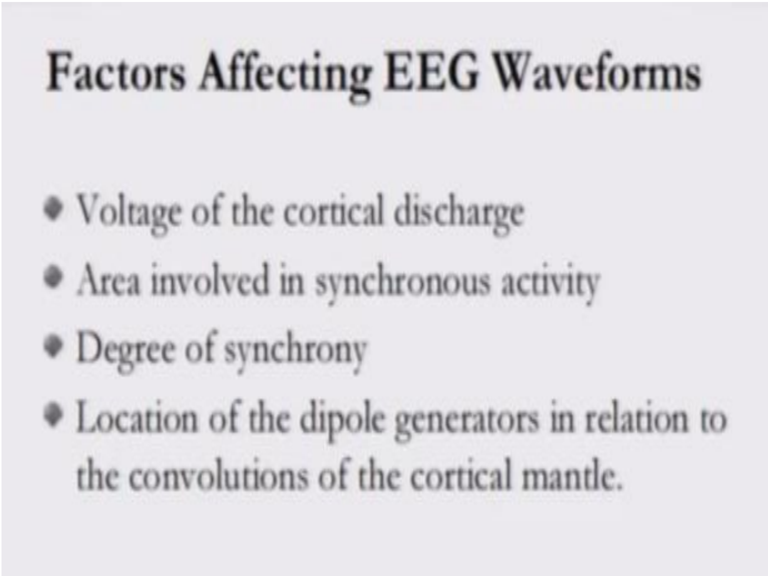

So what is important, the voltage, the area involved in synchronous activity, degree of synchrony

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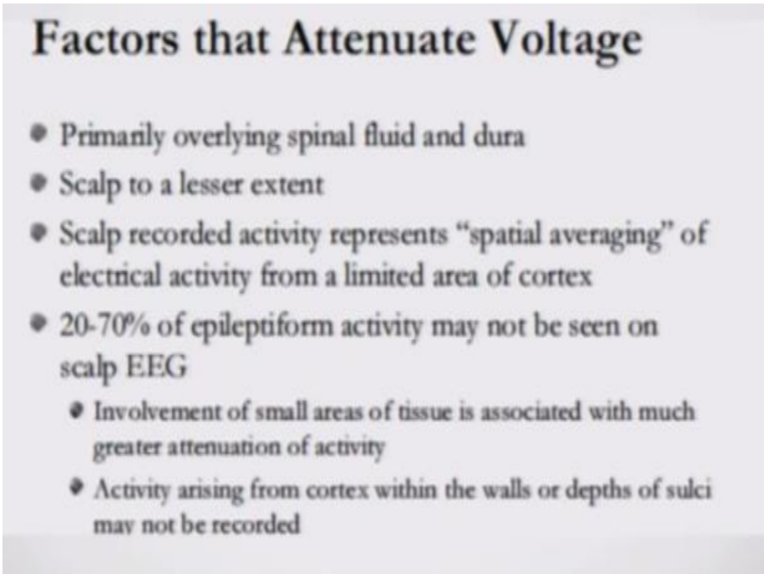

So the current has to travel from a spinal fluid and dura and a scalp, and there is a averaging of electrical activity from a limited area. The most important results of EEG which are clinically important are in epilepsy. So what do we see, in 20-70% of epileptic, epilepsy may not be seen on the scalp EEG. But sometimes when the brain gets into a synchronous firing it is normally got.

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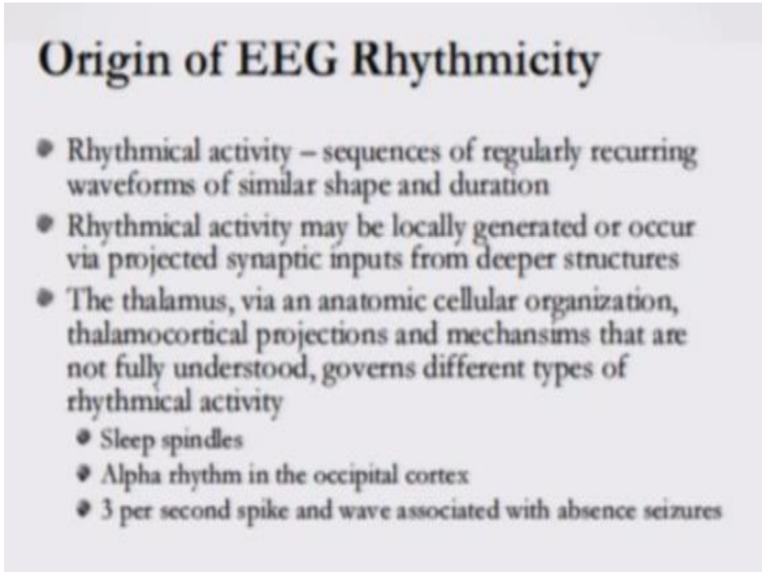

So epilepsy is where EEG is used most, so again this is the physics of it where.

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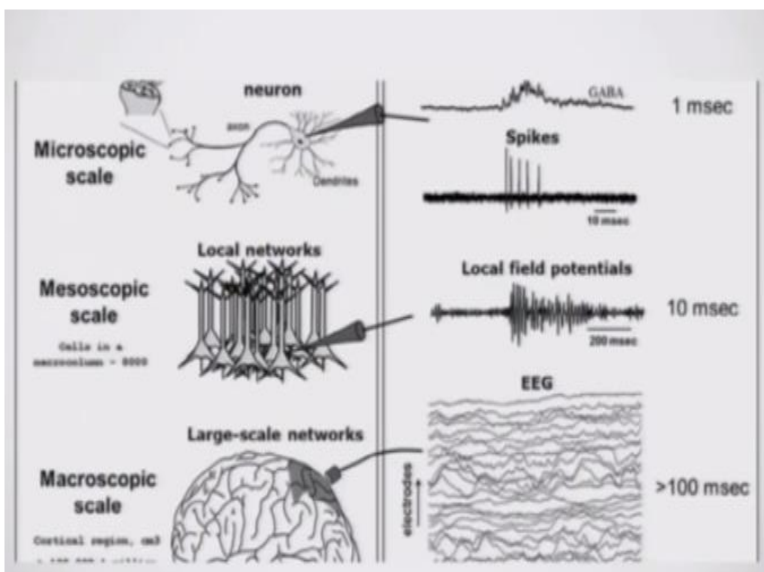

So what is the type of waves which you see is, this is again just graphically telling you, at a microscopic scale this is a neuron, mesoscopic there is a local network, cells in the micro column around 8,000, cortical regions all this micro columns form. So what do you see here is a spike.

As I said there is a qualitative difference there is a spike at micro level. The local field potential within the cortex and this is EEG one millisecond, 10 millisecond, 100 millisecond.

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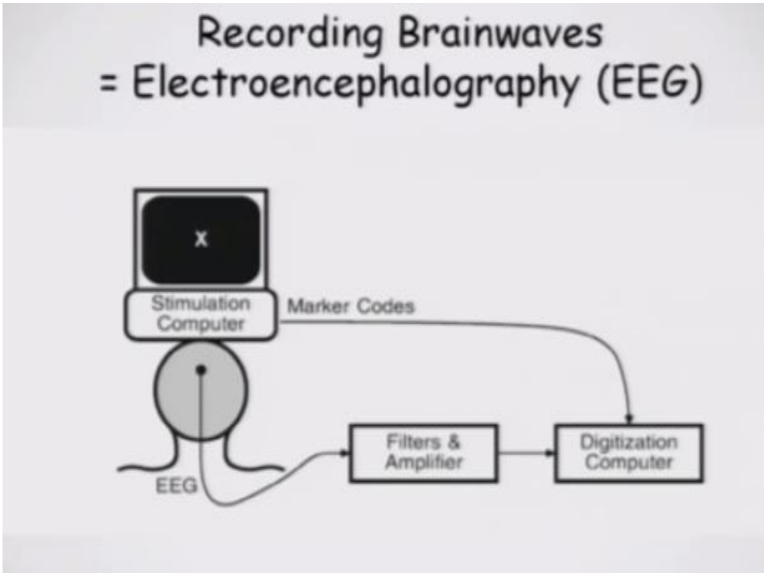

So how do you record, do you put EEG electrodes which go to the filters and amplifiers, digitize in the computer, codes and computer gives you this.

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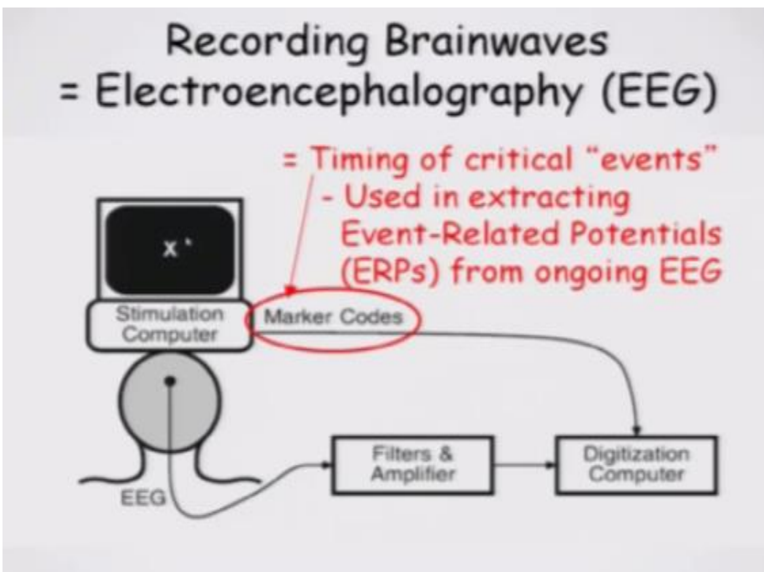

Event-Related potentials can be extracted from the ongoing EEG. Event-Related potentials are like you are recording a EEG and you give a certain stimulus after say, something called P 300. So 300 milliseconds from there is a spike positive, or an 100 after a 100 millisecond the ERPs are event-related potential by giving a stimulus.

We want to see whether that the root of the signal is functioning correctly number one, number two what is the root of the signal like for a visual stimulus or a auditory stimulus, we will just mention it later on.

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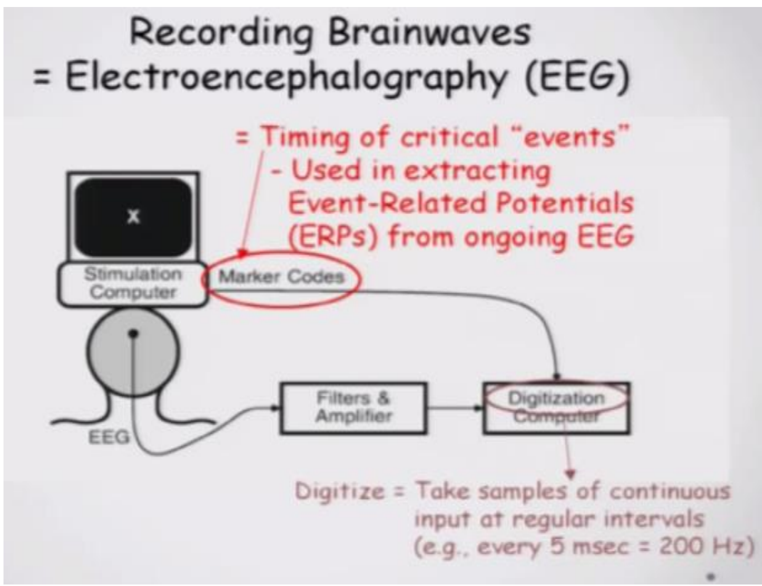

Digitization simply means you are taking sample of continuous input at regular intervals every five milliseconds 200 Hertz. So you have a certain frequency and so you take that frequency with a certain timeframe, converting like amplitude to time you are converting it to frequency versus amplitude.

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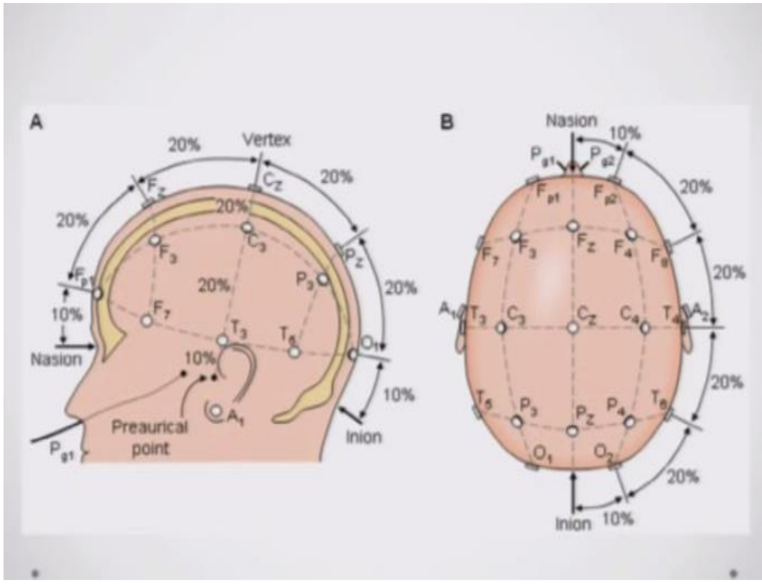

But this is how you put EEG electrodes, this is my 10-20 system, F is frontal, P is parietal, this is central, occipital. So if you take it from the midline right here, 20%, 20%, 10%, similarly 20%, 20%, 10%. This is how you put the electrodes so that you cover the -- say about 21 channel, or 32 channel.

Now we have more advanced EEG machines which use 128 or 256 geodesic channel which closely fit the head like a volume conductor. And we take the whole volume of the brain and try to cover it more closely in a dense electrode package.

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These are the caps which are just put on the head otherwise you have to put a pasting gel between the electrodes and the scalp after cleaning it thoroughly.

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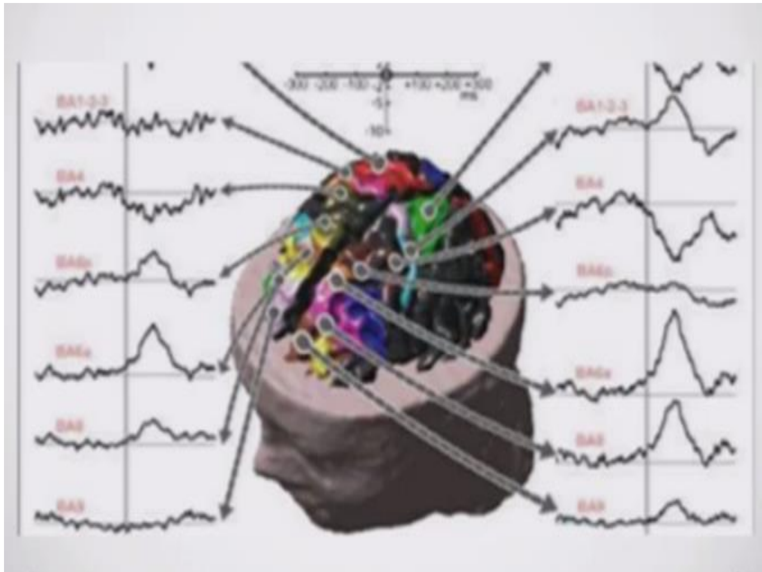

And this is the type of waves which you get from various areas of the brain.

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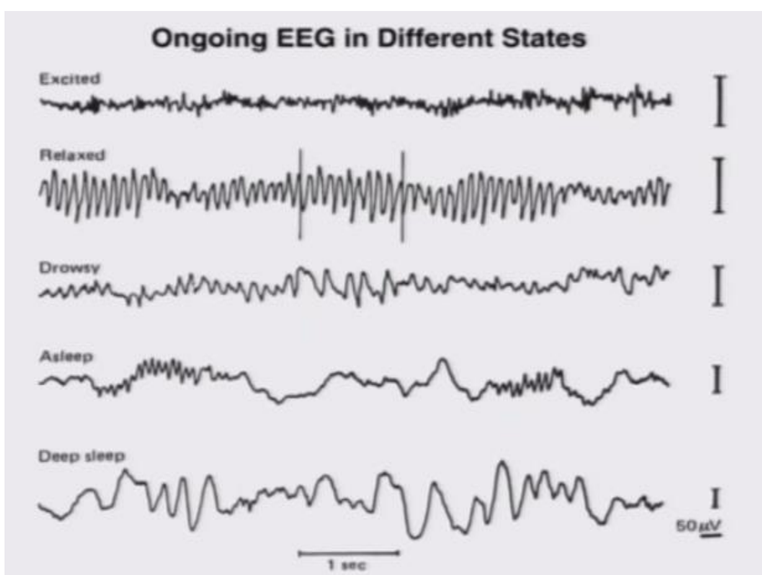

So ongoing EEG in different assist is like this, like excited state, this is the relaxed state, drowsy. So if you cannot make out when you are actually using your brain and working, so the brain waves go fast. When you are relaxed it slows down, when you are drowsy it slows down further, when you are sleeping it really slows down with a bit of activity.

And this is in deep sleep these are called oscillations. Imagine one single neuron firing action potential and sample firing together, and since so many neurons are firing differently they have a different activity in different areas, there ought to be different electrical activity. So the output is in the form of oscillations.

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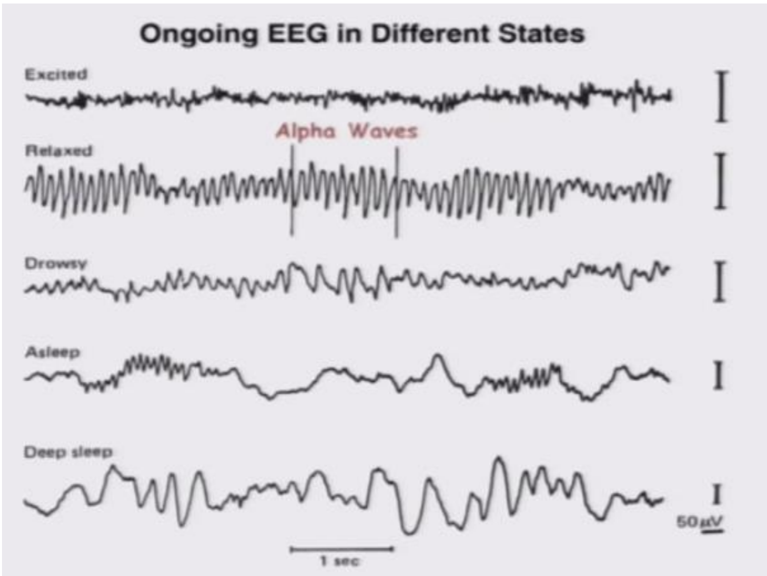

And the oscillations come.

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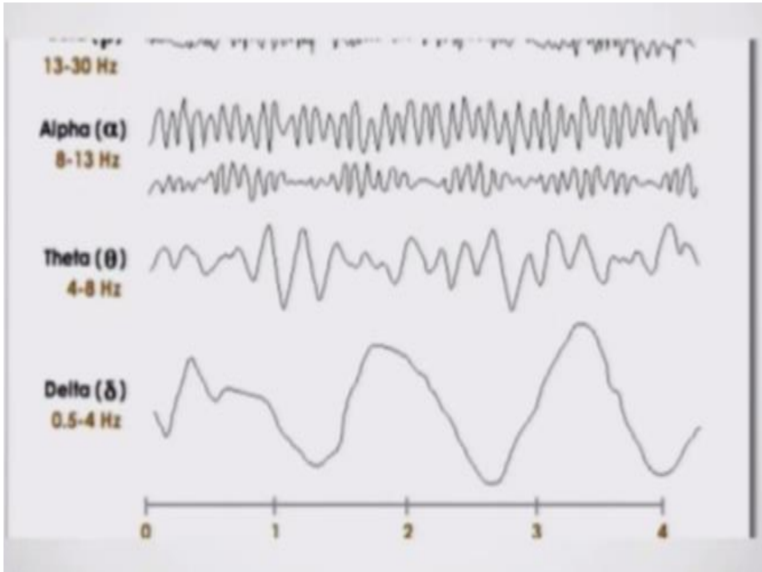

Because if there is a only excitatory signal it will keep firing, it is the inhibitory neuron from the cortex which actually create the isolation, which create oscillation by frequently inhibiting the activity of neuron, that creates this up and down and the sign waveform what you call oscillation.

So the common oscillations in the brain are alpha, which is between 8-13 hertz, theta which is 4-8 hertz, delta which is 0.5-4 hertz.

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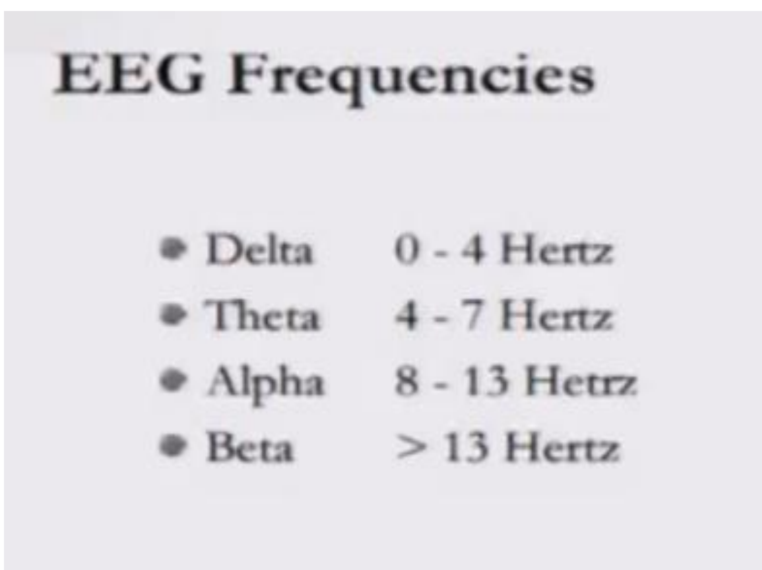

Again and beta is 13 hertz. So when your mind is excited you are given some task your mind suggests to beta. Alpha is when your eyes are closed and you are relaxed as you open your eyes alpha decreases, theta has been implicated in more memory formation and the sleep induction and delta is in the deep sleep.

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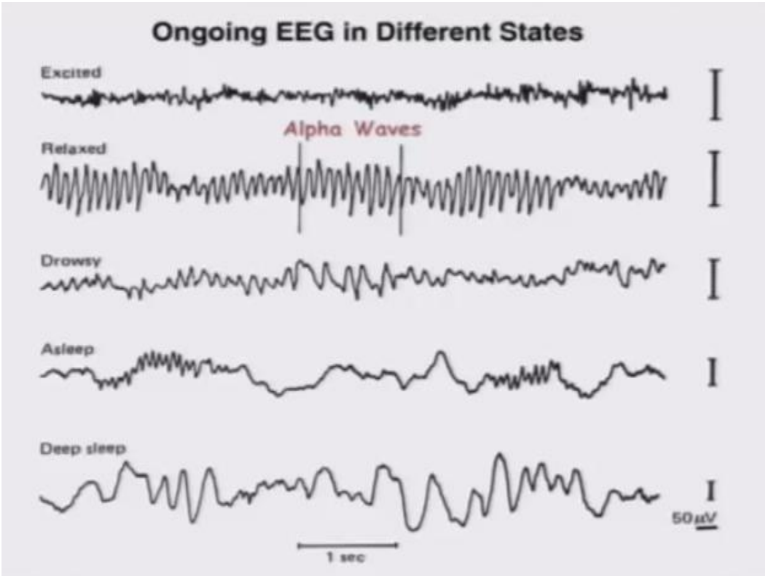

Sleep I have not talked about, but sleep is another state of mind where it does not switch off, it goes into a different arena of activity.

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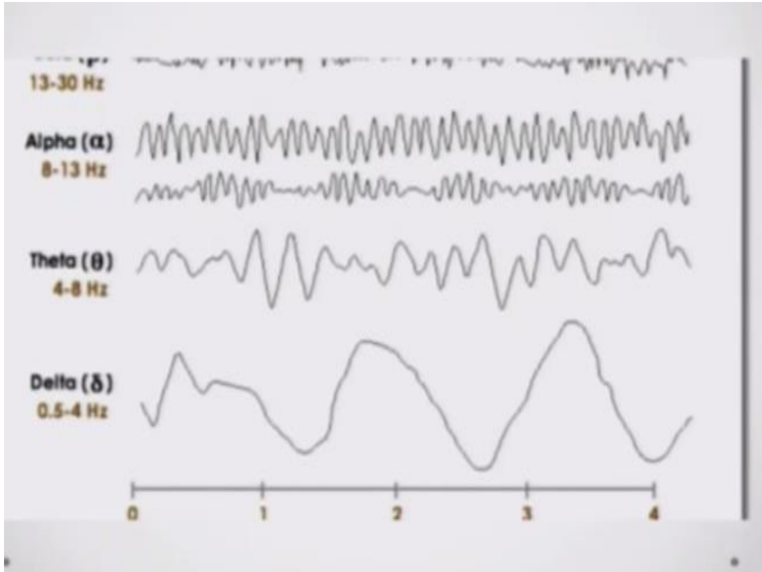

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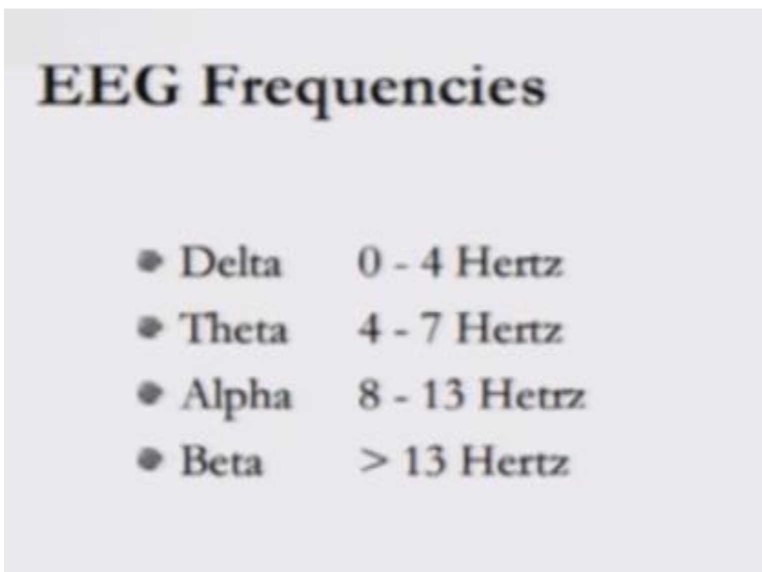

So deep sleep is a slow rhythmic activity and delta in awake state is abnormal.

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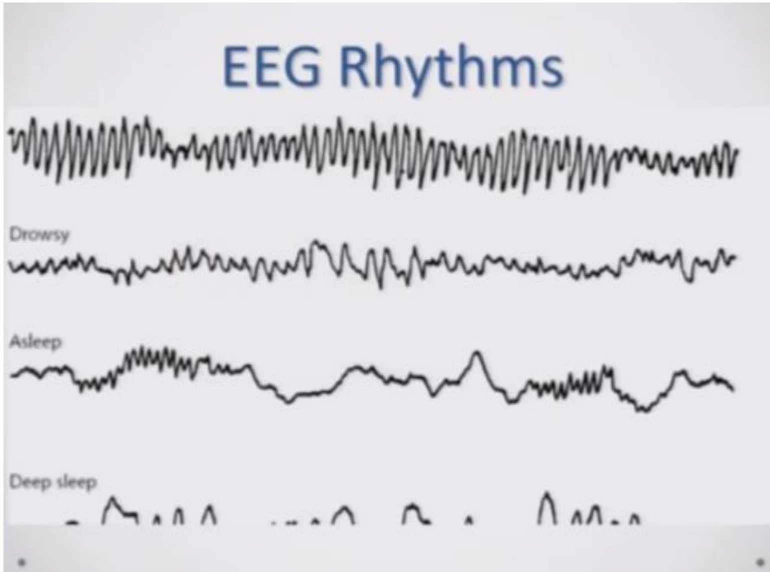

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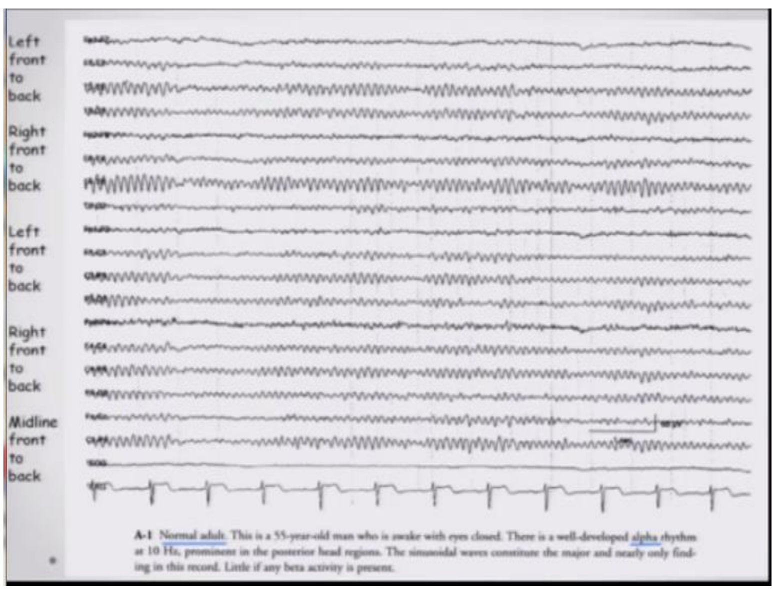

So EEG, this is like left front to back, right front to back, left front to back. These are normal EEG of an adult, these are eye blink.

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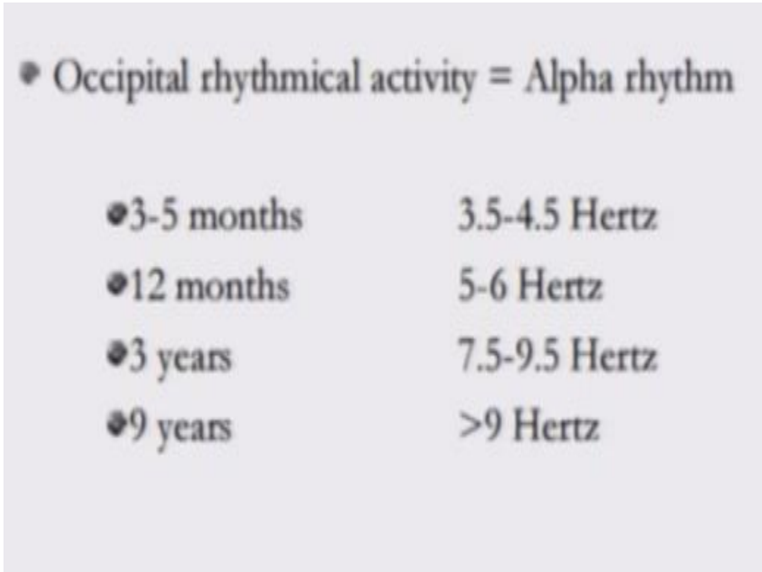

This is how it grows 3 to 5 months is slow, 12 months. So alpha normally comes by nine years of age.

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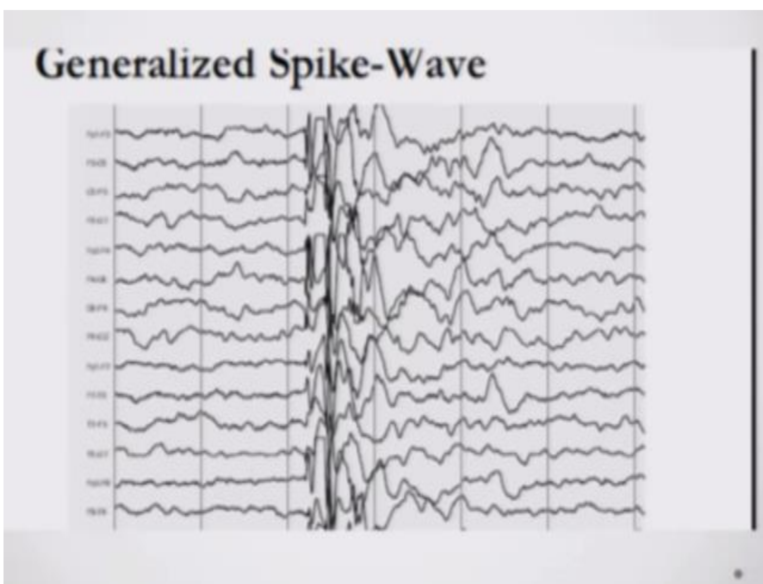

EEG is used to diagnose, this is a spike-wave, this is abnormal in a awake state.

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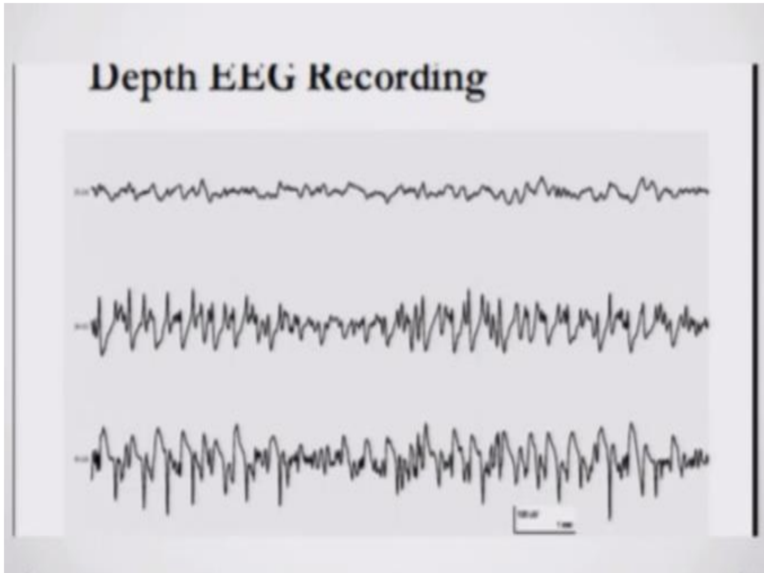

So if you go into the deep you will find a different type of recording.

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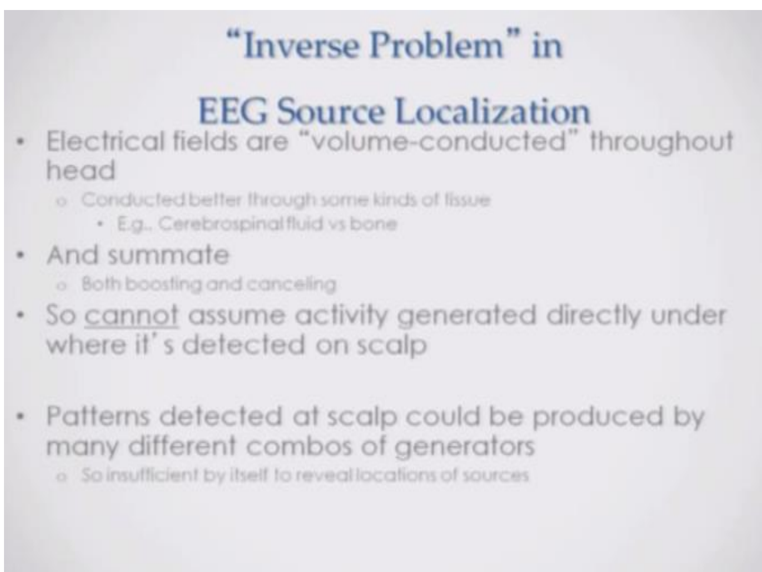

So as I said inverse problem in EEG source local it is very difficult for us to tell from the recording or from where it is coming. But EEG is very useful in catching up rhythmic activity in the brain like it appears in sleep, or it appears in epilepsy, or in abnormal encephalopathic state.

So EEG really tells you what is happening in the brain in the dynamic temporal process whereas MRI tells you where it is happening. So I guess this a good introduction and we will keep talking about EEG as and when we come to further. Thank you.