Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Basic Cognitive Processes

Lecture- 16
Physiology of Visual Perception

by
Prof. Ark Verma
Department of Humanities and Social Science
Indian Institute of Technology Kanpur

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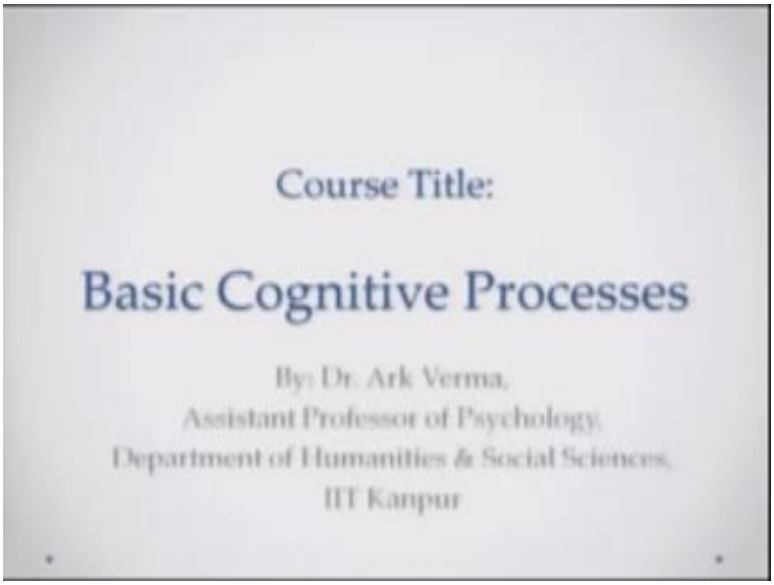

Hello and welcome to the lecture series on basic cognitive processes I am Dr. Ark Verma from IIT Kanpur.

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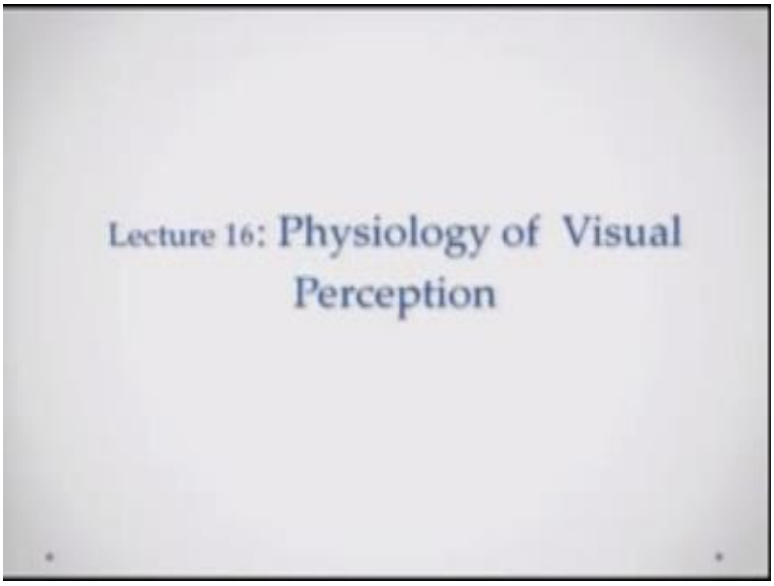

Today we will be talking about the physiology of visual perception, now you might wonder in the course on perception why am I limiting disturbers, emission perception but visual perception per see is a the most important or probably you know it is better to say the most investigated form of perception obviously you have all the senses you have you know the sight, you have hearing, you have old fashion that is the smells you have the strategy that is taste you have tactile that is related to touch.

All of these senses basically contributed to this perception but the most investigated area or something that has been most studied in cognitive psychology is this area of a visual perception okay, the eyes or so for example the most important information that probably we get out of our surroundings is through the eyes and in that sense that kind of you know skewness in the amount of research that is done in each of these areas.

Also traditionally in coastal community ecology visual perception is generally something which is given slightly more important I am not saying that I am following the convention here, but we will begin with understanding more details about visual perception in the end and if time permits we may we might talk about auditory perception and related processes as well that said we will

talk about the basic part or the first entrance into what visual perception as a process is like. So how does this really begin we will try and understand the physiology of visual perception of function or say for example how do our eyes see what really helps our eyes see and what are the very basic processes are not going to go into a lot of detail about each of these the idea is just to be you a flavor of what are the constituent processes in visual perception okay.

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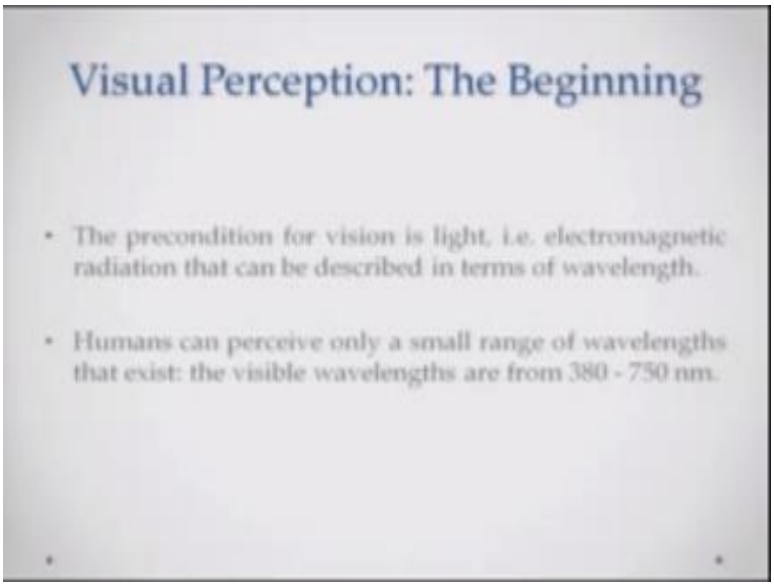

So let us begin, the beginning point or the initiating point of visual perception is basically the registering of light in your eyes okay, so the precondition for the fact that you can see anything for that matter is the presence of light if there is light you see if there is no light you do not, okay so it is kind of sort of a binary there. Now what is light, light is basically electromagnetic radiation that you know can be physically described in terms of wavelengths there is this range of wavelength which we are more sensitive to and that basically forms what is called visible light for us, okay.

Humans can perceive only a very limited range of this and a wavelength of this electromagnetic radiations and this very visible wavelength basically falls between 380 to 750 millimeters, nanometers sorry.

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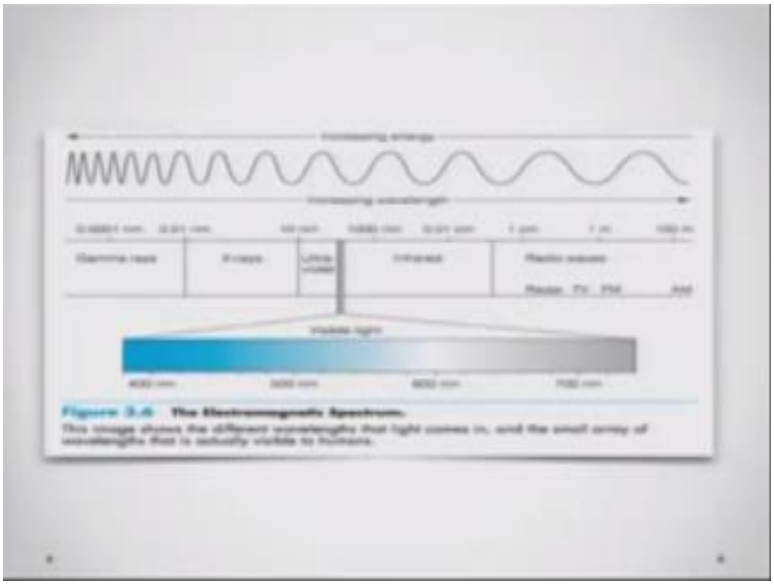

Here you can see this range of visible light, so there is this electromagnetic radiation and right from 380 nanometers to 750 nanometers is what we can actually see, so any electromagnetic radiation or the electron irradiation in this wavelength is what constitutes our you know visible spectrum.

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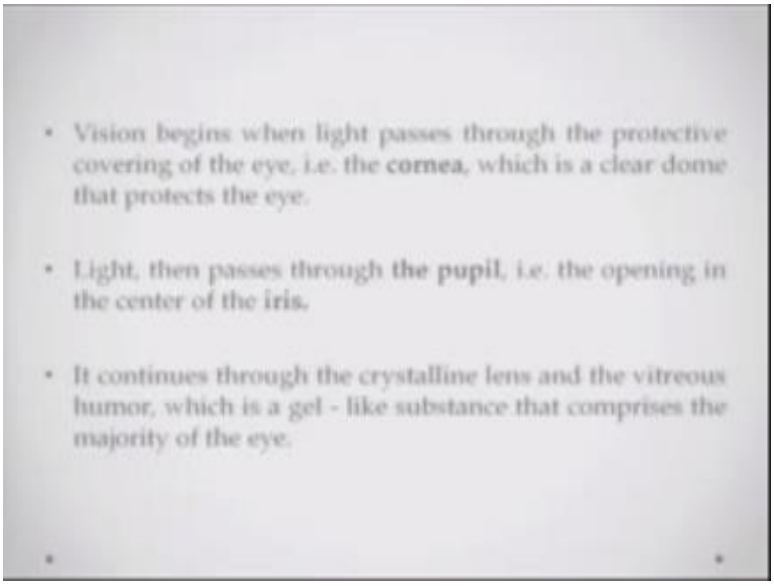

Now how does the process of vision really begin where does this you know how does light contribute to us seeing, so vision basically or our per you know sensation of anything in this world through the eyes start when light passes through this protective covering of the eye the top part of the eye which is the cornea which is a clear dome that protects the eye. We will talk about that I can actually show you the figure and come back here this is what I actually looks like.

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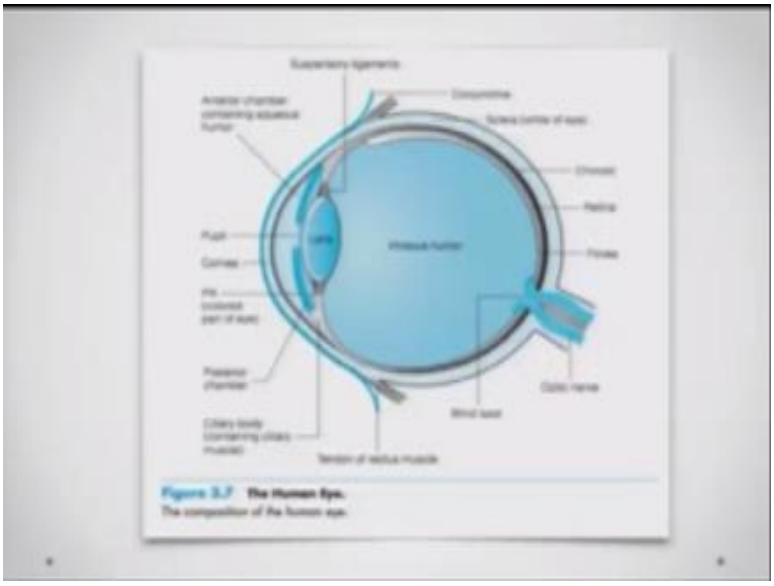

You can see there are these different parts here you can see that there is a pupil that is cornea there is the part called iris there is the posterior chain but very the lens is situated and then there is this axillary body which has those muscles the eye is filled with some substance which is called the witch's you murk's at the back you can see there is things like the retina there is the phobia and there is an exit the nerve which is called the optic nerve.

So again I am just taking names of these where different areas we talk about them in much more detail as we go ahead. Now what is so you can see what is the cornea, cornea is basically a clear dome that is protecting the eye something that is the outer layer of the eye then through this cornea the light passes through the pupil, pupil is basically the opening in the center of the iris you can again and refer to this figure here you can see that there is this pupil which is the opening you know in that thing called the iris you can see that already in the figure this one.

So light time the first of it starts through the cornea passes through the pupil which is basically the opening in the center of the iris and it continues through this crystalline lens which you saw and the vitreous humor which is a gel-like substance which is filled in the eye and then it reaches at the back.

So you see the eye starts at the cornea goes through the pupil passes through the lens passes this entire gel like which were humor and goes at the back, at the back is where the real processing of the light starts. So the light then focuses on what is called the retina you might again refer to the figure at the back there is this retina, retina is basically where the electromagnetic energy.

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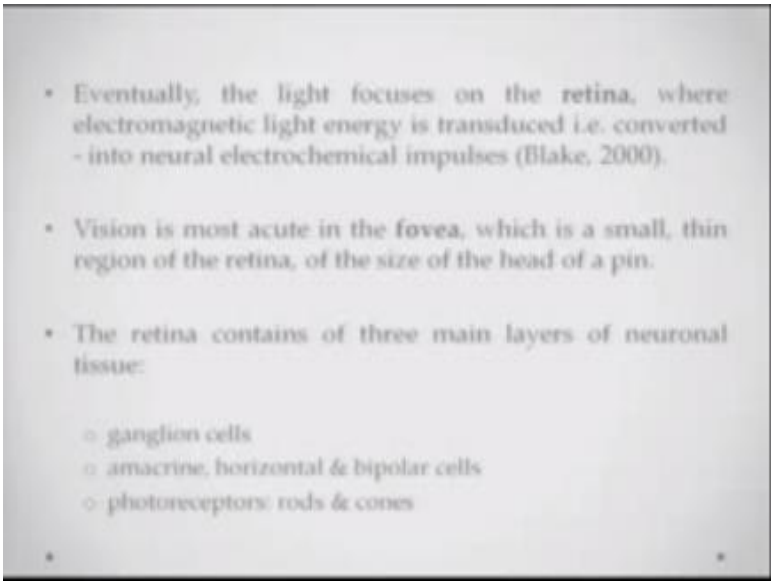

That is light is transuded that is converted into neural electrochemical impulses, if you are interested in what transduction is, any signal from the external world you might remember in the psycho physics class we have talked about it any signal from the external world any sensation needs to be converted into a signal that can be understood by the brain. So the electromagnetic radiation which is light needs to be converted into neural impulses so that the eyes or the brain more importantly can make sense of it.

So the light passes through the cornea so the pupil passes the lens and the switchers humor goes and falls back at the retina, at the retina is where this is converted into electrical impulses that is where the brain starts making sense of this. The vision is most acute at the fovea of the fovea is a

very small thing a region of the retina which is basically as the size of a pin okay, just like the size of the head of the pin okay.

The retina basically contains layers of neuronal tissue this neuronal tissue basically includes different kinds of cells, cells like the ganglion cells the amacrine cells horizontal size bipolar cells and then also photoreceptor cells called the rods and the cones we will.

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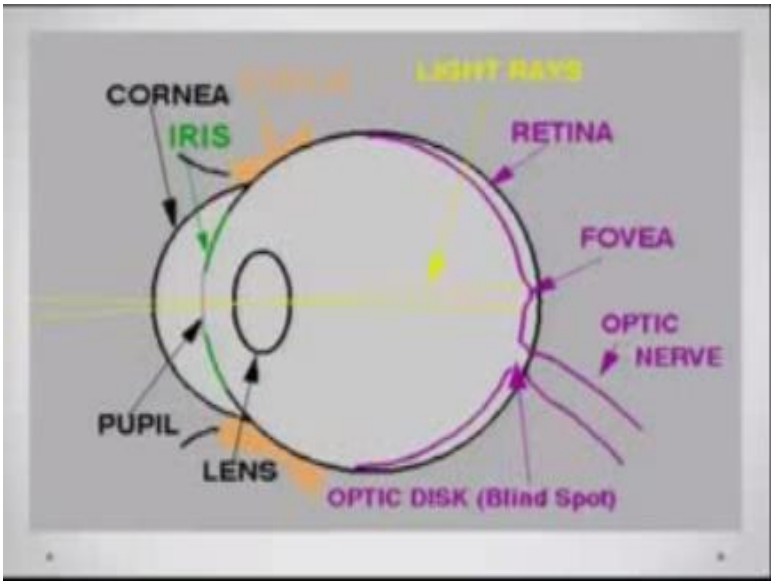

So here you can see a more clear picture of the cornea the iris you see the pupil is there, there is a retina at the back and you see that bulge just like a pin the head of the pin that is what the fovea is.

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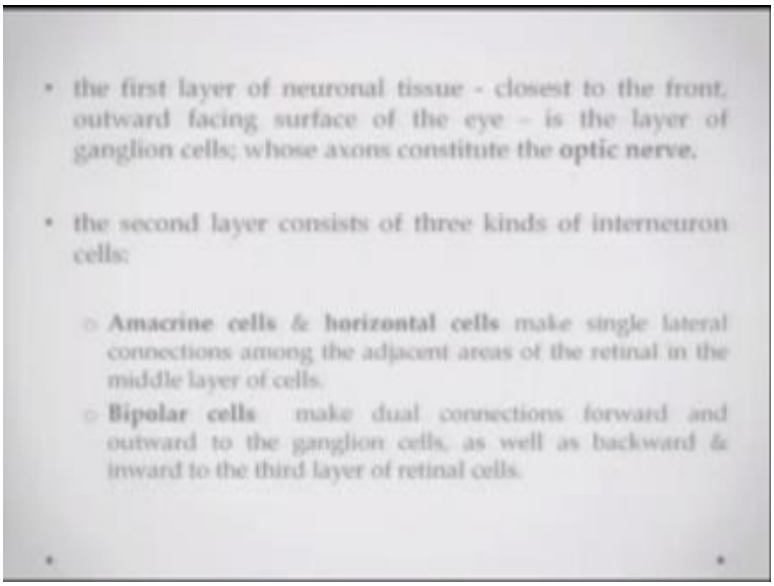

And here there is this a layering of these different kind of cells, so the first layer of the neuronal tissue at the retina is closest to the front outward facing surface of the eye. So the first layer is the layer which you know the light falls first so outward facing surface although this first layer is basically the layer of what is called the ganglion cells okay, the axons of these ganglion cells if you remember the chapter on perception the axons are actually the part which kind of protrude from the cell body the axons of these cells constitute combined together to form what is called the optic nerve.

So this is the outer facing surface of the cell the ganglion cells which form the optic nerve. I show that I show the figure to you now so you can see that see there are these ganglion cells in the layer number three.

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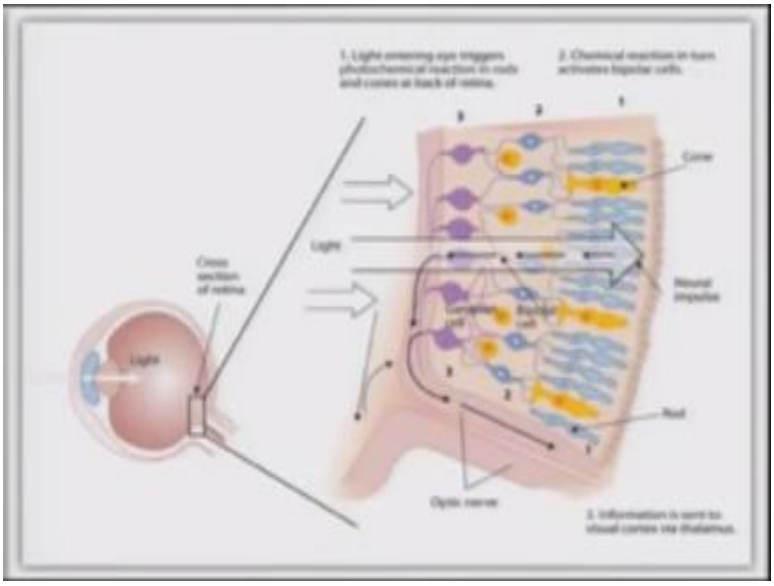

The absence of which are forming what is called the optic nerve okay, coming back in the second layer consists of three types of interneuron cells these cells are the amacrine and the horizontal cells and the bipolar cells. The amacrine cells basically make single lately connections to adjacent areas of the retina in the middle layer of the cells. The bipolar cells make dual connections they make connections forward and outward to the ganglion cells as well as backward and inward to the third layer of these retinal cells.

So we see these connections now you can see the bipolar cells being connected to the inward rods and cones and also to the ganglion cells. So they are basically connected to both inside and the outside part.

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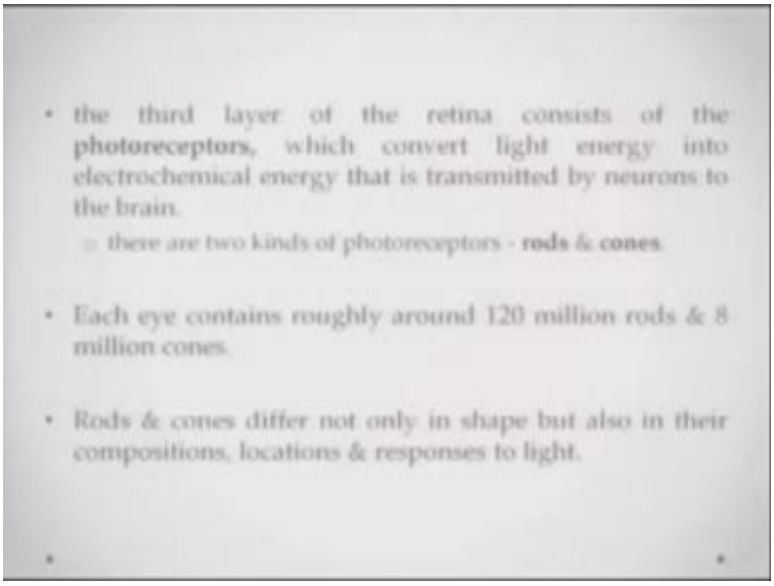

The third layer is basically the layer which consists of what are called photoreceptors as you can guess from the name these are the cells which basically convert light energy into electrical energy that is transmitted by the neurons to the brains, so this is very exactly this process of transduction is happening. There are two kinds of photoreceptor cells rods and cones each eye consists about 120 million rods and around 8 million cones both of these cells have their own specialties I will talk about them in just a moment.

Now rods and cones simply do not only different shape but they also differ in their compositions for the nature of their locations and how they respond to light. Before go further it might be helpful to see this sense again so you see that there are three layers the first layer or actually the third the layer number three is basically your ganglion cells the layer number two is your bipolar cells connected both inwards and outwards and the layer number one is basically your photoreceptors you can see the rods and cones in different shapes there.

Okay, so you can see how light is really moving lightest energy is entering the eye and it is figuring photochemical reactions in rods and cones at the back of the retina, chemical reaction to

in turn activates the bipolar cells from the bipolar cells information is going to the ganglion and from there it is going to your optic nerve and via the optic nerve it actually transmits to the brain.

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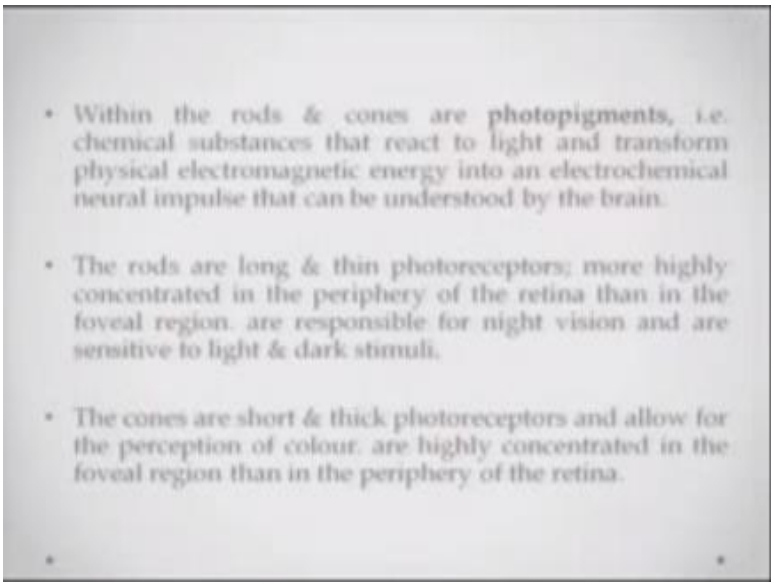

Now what are these rods and cones doing, these rods and cones basically have substances which are called photo pigments, photo pigments are chemical substances that react to light and transform physical electromagnetic energy which is light into an electrochemical neural impulse that can be understood by the brain. Now electrical chemical neural impulse we have talked about this in the physiology part where we were talking about neurons action potentials in those kind of things.

The rods are long and thin photoreceptors more highly concentrated in the periphery of the retina down in the foveal region, so what you will find they are more concentrated in the outside regions of the retina and they are basically responsible for nitrogen and are sensitive to light induction. So rods are basically which are more useful when you know there is less light in night kind of scenarios because they are basically reacting in binary to whether there is light or whether there is darkness or absence of light.

The coals are very short they are slightly thicker photoreceptors and they allow for the perception of colors okay, they are highly concentrated in the foveal region than in the periphery because this is where the light is focused more this is where the equity of understanding of a really seeing shapes and releasing colors is best, so the rods are more sensitive from the black and white the colors are more sensitive to different at the cones are more sensitive to different kinds of colors.

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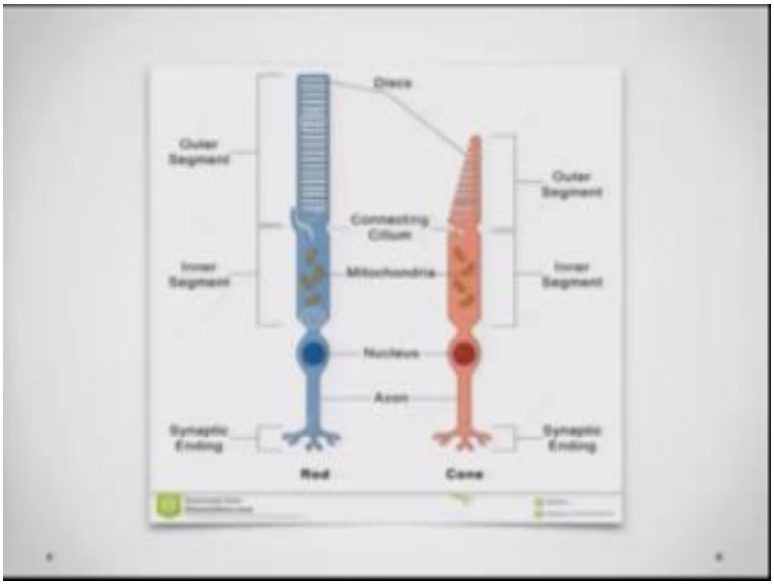

Here you can see the difference basically in rods and cones you see they are not only structurally different and they are also functionally different as we discussed already.

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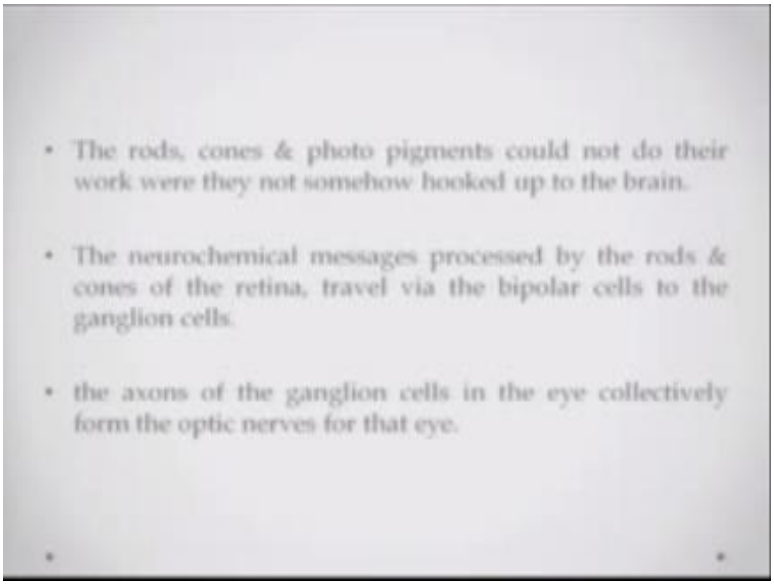

Now the rods cones and the photo pigments could actually not do their job if they were not really connected somehow to the brain so you have to talk about how all of this really connects to the brain as well. So the neutral chemical messages that are generated in this section of the eye produced by the rods and the cones travel via these bipolar cells to the ganglion cells, the axons of the ganglion cells in the eyes collectively form what is called the optic nerve for that particular eye you can see that in the figure that we talked we saw earlier. So this is how this communication is actually happening.

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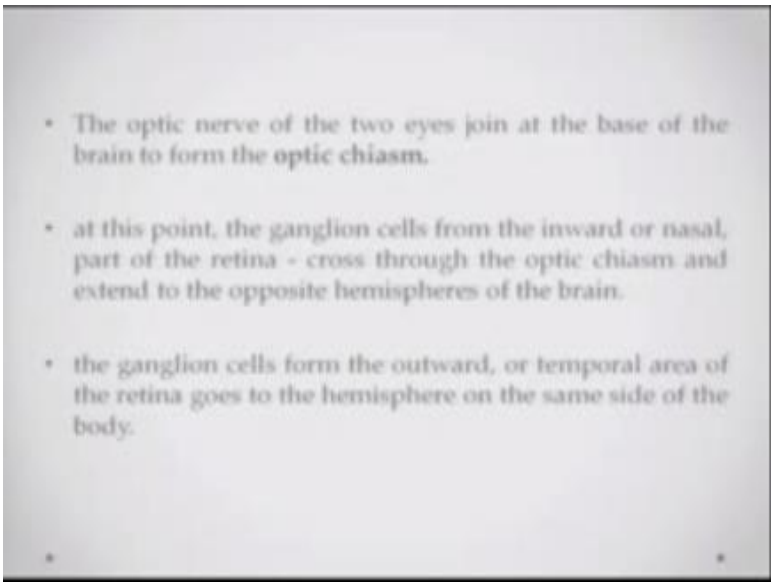

The optic nerve basically of the two is joined at the base of the brain to form something called the optic chiasm, the optic chiasm basically or at this point what happens is that the ganglion cells from the inward of the nasal part of the retina cross through the optic chiasm and extend to the opposite hemisphere of the wing. So for example I can show you show this to you through this figure you can see this figure here.

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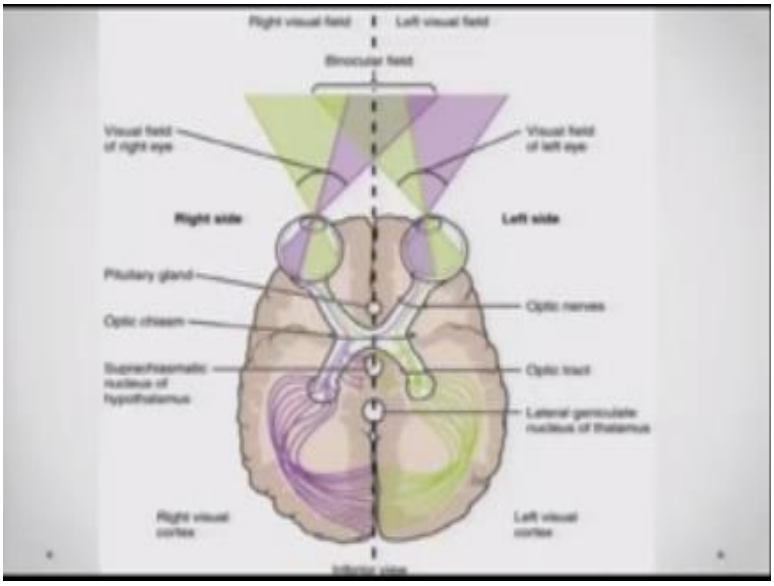

You will see that there is an inward or nasal part and there is an outward which is basically the retinal part okay, so the inward part basically is where this cross over is happening and so input from one is going to another hemisphere input from the say for example from the left eye is going to the right and say input from the right eyes is going to the left eye so this cross over point is called the optic chiasm.

Just going back so at this point at the optic eyes will the ganglion cells from the invert or the nasal part of the retina cross over through the optic chiasm an extend to the opposite hemispheres of the brain the ganglion cells from the outward or the temporal area so the inward area is called the nasal area the outward area is called the temporal area which is actually near the temples the temporal area of the retina goes to the hemisphere on the same side of the brain so this is how this crossover happens.

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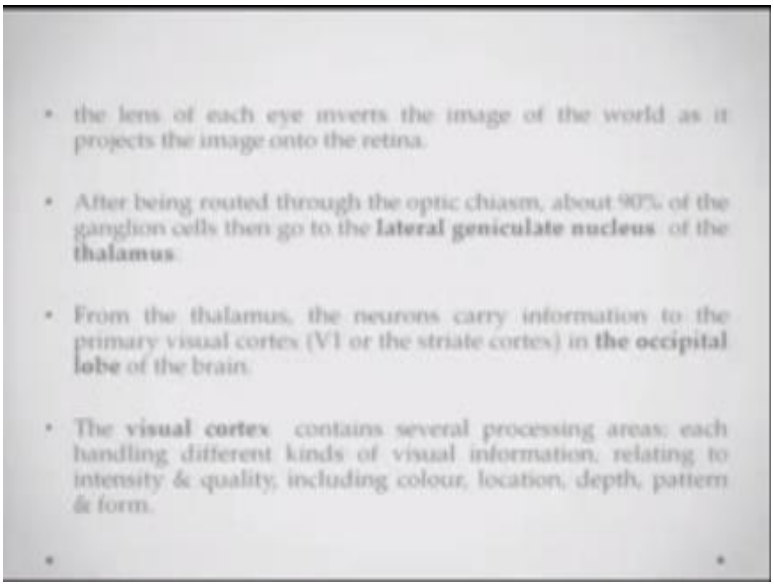

The length of each eye basically inverse the image so you might have done elementary physics in your class sixth or seventh you might have known that a particular lens kind of forms an inverted image of the world as it projects this image and the same happens to the lens design so it perform projects an inverted image to the right, after being routed through the optic chiasm about 90% of the ganglion cells then go to what is called the LGL or the lateral geniculate nucleus this is a set of nuclei in the thalamus okay.

So thalamus is the basic region of the brain where in this is going to. From the thalamus what happens is that the neurons carry information to the primary visual cortex which is the first area in the occipital cortex that kind of receives this information the primary visual cortex in the occipital lobe of the brain.

And this occipital cortex basically is where the detail processing of this information coming from these from the retina starts to happen okay, so this visual cortex or your occipital lobe it contains several processing areas each of these areas really carryout you know different kinds of analysis on the incoming visual information okay. And these areas can differ in to how they process the

intensity of light, how the process of the quality, how they process the color, the depth information, the location of something the kind of pattern there is the form that you see.

Visual perception is a really complex activity I can take an example I can say that if I am looking towards you I am actually looking at multiple levels of information I am looking at colors and looking at contours that are shapes and looking at whether it is a 2dimensional or 3 dimensional image so I am looking at depth as well and making sense of how far you are from me that is distance so I am doing and I am also say for example processing whether you are moving or not is not it.

So even though visual perception you know typically my scene rather simple, but there are so many processes happening at the same time with anything you are looking at. So if you look out and you were kind of able to figure out that you know there is our moving on the road you are actually doing a lot of these analysis over there you know you have the basic shape of the car you have the colors you have the information that is just moving you have you might get to know that you know what kind of car it is in kind of doing that kind of analysis as well, so doing these multiple levels of analysis on whatever visual information is coming to your eyes via light.

Let us have a look at this figure this is how you know this is a really a you know range so you have a by knock you know field where in both eyes are getting the input but you also have the right visual field and the left visual field okay, so right visual field is predominantly basically what the right eye is looking at left visual field if you tell me what the left are you looking at you can see here in this figure that part of the information from each of the visual field goes directly to the contralateral hemisphere, contralateral is basically the other side of optic chiasm.

You can see in this figure the information in the right visual field goes first to the left visual cortex the information the left visual field goes first to the right visual cortex I am saying first because generally these contralateral connections of these ganglion cells are supposed to be are found to be faster than the ipsilateral basically the same site connections. So this kind of also leads to really interesting or important effects we will talk about them in due course when you are actually talking about more things about visual perception.

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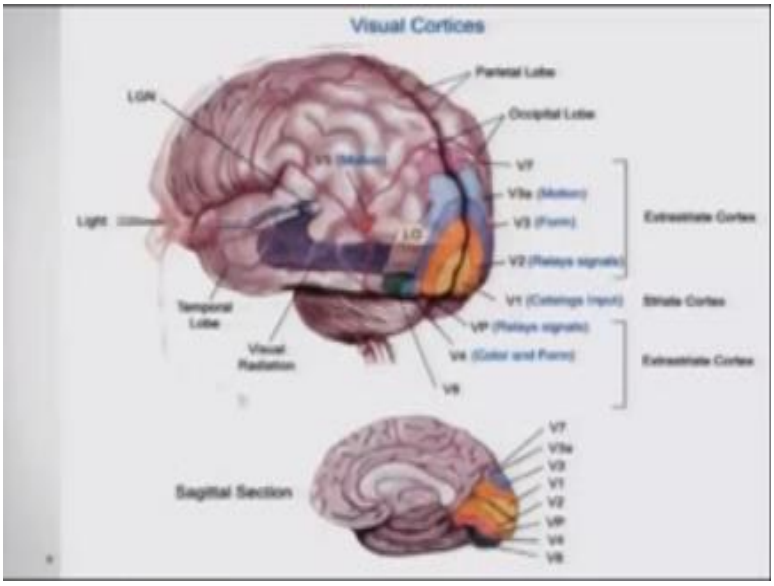

For reference here is the figure which presents what is called the visual cortices you can see that there is this lateral geniculate nucleus which is connected to the brain you can see light is entering through the eyes it is kind of you know through the optic nerve reaching this area called a lateral geniculate nucleus that is what your thalamus is about and from there the information is being related to what is called the occipital lobe which is the low which has to do with vision and you can see these so many areas here okay.

Each of these areas are referred to as V1 to V8 you can see and you can see what these what the specializations of each of these areas are. Say for example I am just feeding out for you areas from V1 basically is called the striatecortex it catalogues whatever input is coming in area of, V2 is less you know more responsible for relaying the signal to higher association areas, V3 basically a processors form V3 A processes motions so these are both areas are you know in the same place then you have areas like V5 V6 V7 V8 those kind of things.

Basically so this is how you know the processing of information starting from light till coming to the brain really happens. This is basically all about the physiology that we will be learning in this particular lecture we will go on to how these different areas in the occipital lobes perform visual

processing in the coming lectures we will talk about form perception, depth perception, constancies those many different things and how basically you make sense of a particular visual stimulus all of that in the coming lectures on perception thank you.

Acknowledgement

Ministry of Human Resources & Development

Prof. Satyaki Roy
Co – ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das
Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K.K Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
Sharwan
Hari Ram
Bhadra Rao

Puneet Kumar Bajpai

Lalty Dutta

Ajay Kanaujia

Shivendra Kumar Tiwari

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