Vision
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Resolution and sensitivity

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The physical setup of eye has some implications on the resolution and the sensitivity of what we can see.

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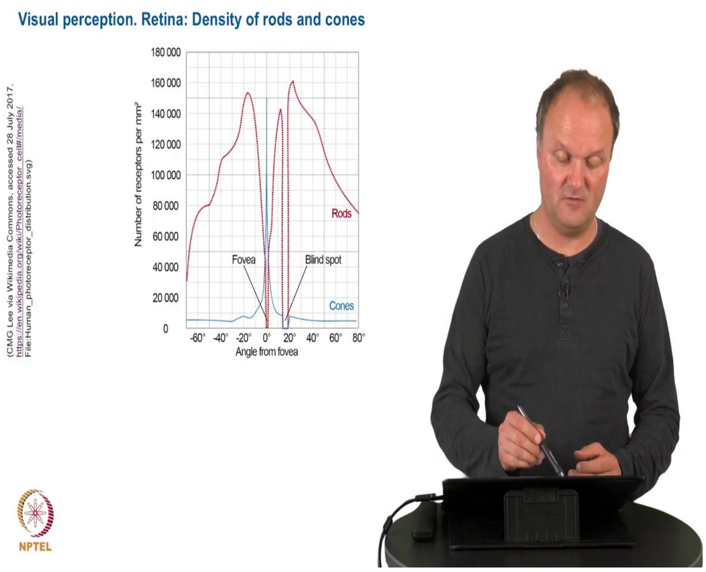

I have already explained that we have an unequal number of rods and cones. And even the distribution on the retina is different for these two types of receptors.

The rods are mostly concentrated outside the fovea whereas the cones are most concentrated inside the fovea. This can be seen in the picture behind me and has some implications especially if you want to watch something with very low light intensity.

For example stars, if you want to gaze stars then you should do that by not directly looking into the star because at the outer areas you have higher concentration of rods and these are the sensitive cells of your eye.

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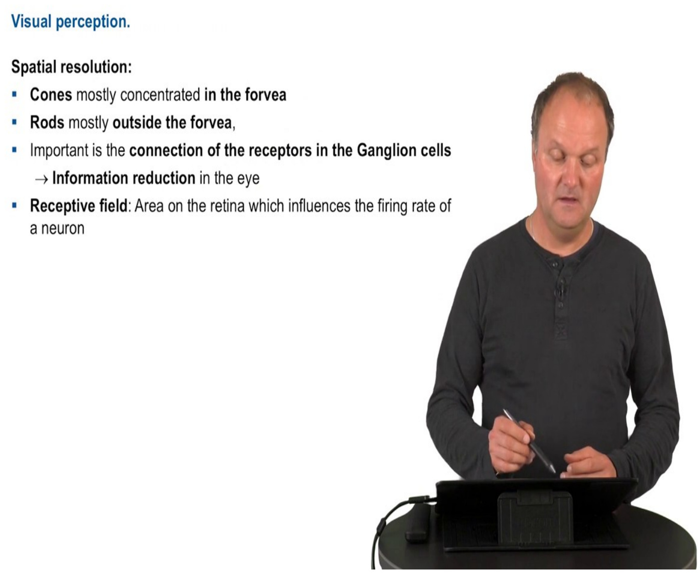

In addition to this, differences in concentration, there is also a concentration of information happening inside the eye. Actually we have more than 100 million receptors and this information needs to be somehow transported to the brain.

And in order to do so, an information reduction happens inside the eye by connecting these more than 100 million receptors to approximately only 1 point 6 million so-called ganglion cells. These ganglion cells are the ones which are processing the information and further forwarding it to the brain.

The geographical area of rods and cones which is connected to one ganglion cell is called the receptive field and this receptive field is little bit smaller for cones than it is for rods, which also leads to higher visual accuracy for the cones than for the rods.

Now

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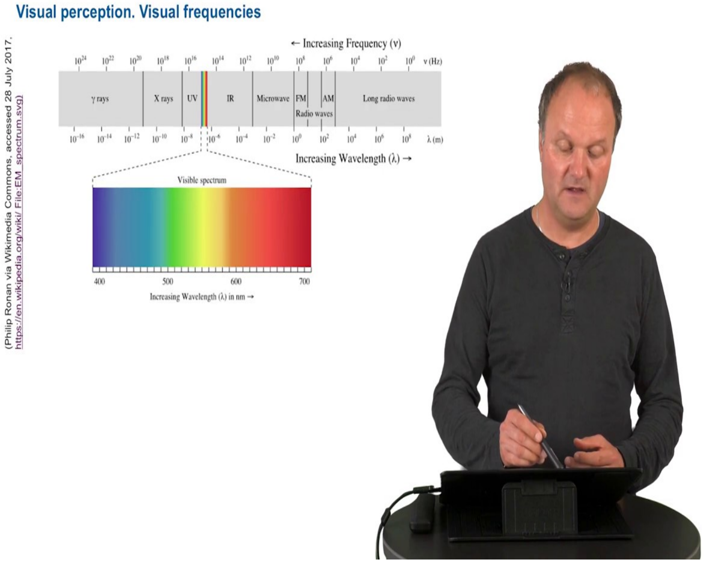

I already told you that our eye can perceive different types of colors. Actually perceptual range of light is only a very small fraction of the overall spectrum of electromechanical, electromagnetic waves as you can see behind me.

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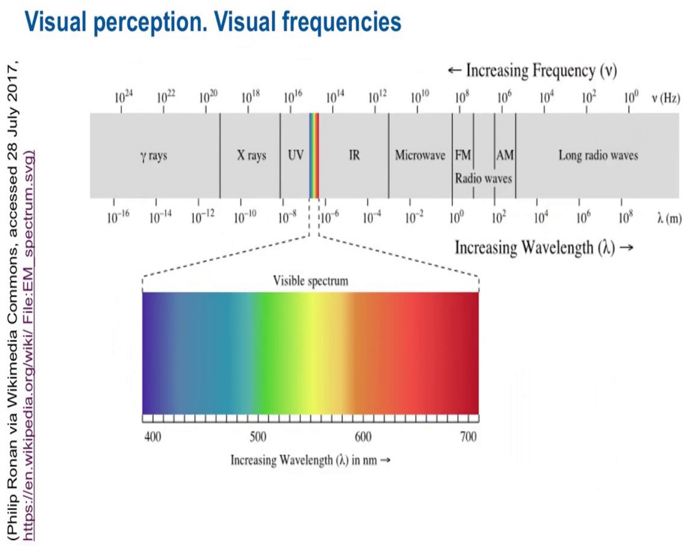

So at low wavelengths, at higher frequencies you have the so-called ultraviolet spectrum, at low, at high wavelengths or low frequencies you have the so-called infrared spectrum which then continues to microwave and so on. So the visible spectrum is just little part of approximately between 400 and 700 nanometers of wavelength.

Within this spectrum the three types or the four types of receptors

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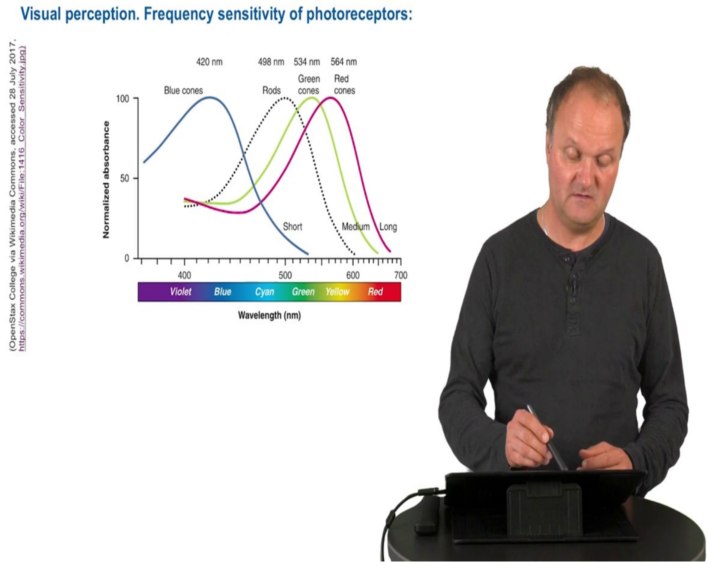

actually catch different parts of it. We can see here the sensitivity of the cones distinguishing

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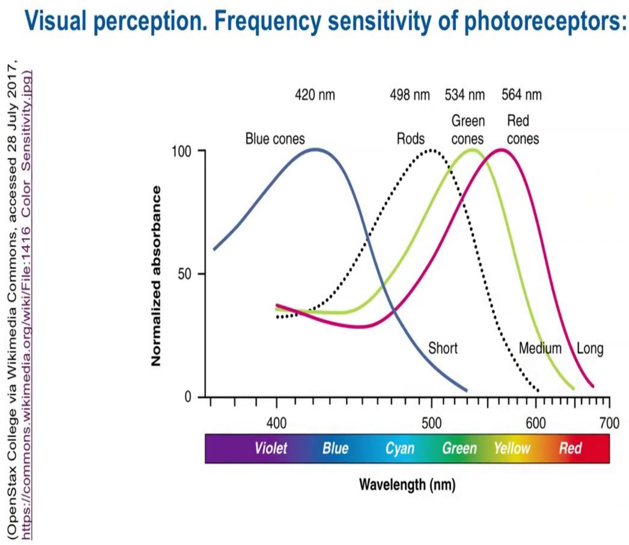

between blue cones, red cones and green cones, and the sensitivity of the rods and all of them have been normalized to the same sensitivity. We have noted that the rods actually have a high absolute sensitivity than the cones.

You see that sensitivity is not very sharp. It is relatively flat curve in each case which means that for particular light of a particular wavelength you will have number of receptors being activated, especially 3 receptors for the different colors are all activated but to a different degree.

And this combination of information which comes from these 3 types of receptors actually help you to perceive all types of colors. Now as we have only 3 types of receptors, we only need stimulation in 3 light areas in order to stimulate each of those receptor types in a particular way in order to produce all colors of the visual spectrum.

And that is why, for example your TV screen will only produce 3 types of light because it is enough to stimulate these 3 receptors with 3 types of light. And the same happens if you want to print colorful picture, then you have only 3 different colors which help you to produce all visible colors of the spectrum.

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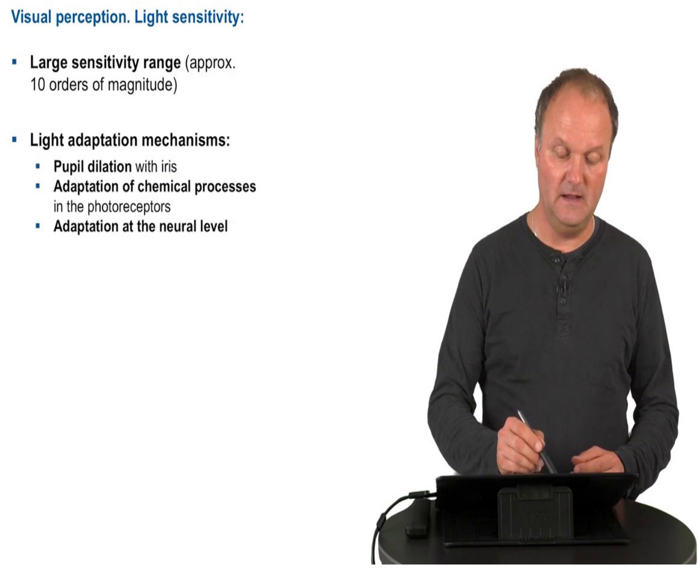

Talking about the light sensitivity, there is relatively large range of light where we are sensitive to, approximately 10 orders of magnitude can be covered by the human visual system. And in order to cope with such a wide range of different light intensities, there are different adaptation mechanisms.

One of them is actually mostly visible and sets the so-called pupil dilation that is the change of the diameter of the pupil. In the iris this is done with the help of the parts surrounding the pupil. This is done at a normal pace. It takes a few seconds and it is able to cope with approximately 34 change of light intensity.

In addition, there are chemical processes happening at the level of photoreceptors. They can cover approximately 5 to 6 orders of magnitude. But this process is relatively slow. It can take up to 1 hour in order to fully adapt.

And then there is a third process which is an adaptation at the neural level by increasing or decreasing the amount of neuron transmission. This one is less effective but it is much faster than the chemical process.