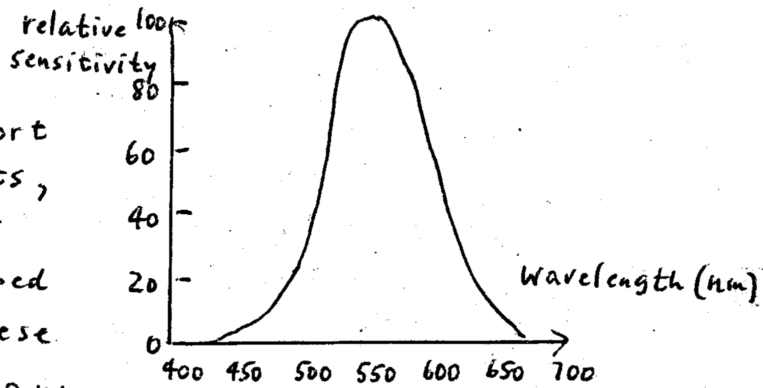
The relative sensitivity of the eye

It is interesting to ponder the extent to which we are bathed in electromagnetic radiation from various regions of the spectrum. The sun, the radiations from which dominate our environment, is the obvious source of radiations.

The visible region of the spectrum is, of course, of particular interest to us. The diagram shows the relative sensitivity of the eye of an assumed standard observer to radiations of various wavelengths. The centre of the visible region is about $5{\cdot}55 \times 10^{-7}$ m or 555 nm; light of this wavelength produces the sensation of yellow-green.



The limits of the visible spectrum are not well defined because the eye sensitivity curve approaches the axis asymptotically at both long and short wavelengths. If we take the limits, arbitrarily, as the wavelengths at which the eye sensitivity has dropped to 1% of its maximum value, these limits are about 430 nm and 690 nm, less than a factor of two in wavelength. The eye <u>can</u> detect radiation beyond these limits if it is intense enough. In many experiments in Physics one can use photographic plates or light-sensitive electronic detectors in place of the human eye.

A given stimulus does not always produce the same visual response. For example, the brightness level in a moderately well lit room appears high if one enters from a dark room, but appears relatively dim if one enters from a considerably brighter room. After a time the impression of excessive brightness or excessive dullness disappears — one's eyes have become adapted to the level of illumination. The changes in the sensitivity of the eye are to a <u>small extent</u> due to changes in the size of the pupil which is increased involuntarily by the iris in dim light. <u>By far the greater part</u> of the process of adaptation is associated with a variation in the sensitivity of the retinal receptors. The process of dark adaptation can be explained readily if it is assumed that the sensitivity of the rods depends on the magnitude of the photo-chemical effect which occurs when light falls on the visual purple (a fluid secreted by the rods and bleached by light and assumed to play the leading part in the scotopic visual process). In bright light the visual purple is quickly decomposed and, if the regeneration process is slow, the concentration is kept at such a low level that the photo-chemical effect is negligible and the rods are inactive.

On entering a dark place the relatively insensitive cones are not stimulated and the initial low concentration of visual purple causes the rods also to be insensitive. After a time, more visual purple is generated and the increased concentration gives a greater photo-chemical effect with the feeble stimulus; the visual response therefore increases. This increase in sensitivity is continued until a balance is achieved between the processes of regeneration and photo-chemical decomposition. There is, therefore, an infinite number of degrees of dark adaptation, each corresponding to different magnitudes of the stimulus.

Similarly, there are many states of adaptation corresponding to different levels of bright light when the cones alone are active. The eye becomes adapted to a decrease in stimulus in the region of photopic vision far more quickly than in scotopic vision. Whilst the photo-chemical substance in the cones is unknown, measurements of the adaptation times in relatively bright light indicate that the regeneration process is complete in a few minutes. Light adaptation is obviously caused by a reduction in concentration of the photo-chemical substances resulting from rapid decomposition and causing reduced sensitivity. It occurs much more quickly than dark adaptation. When a steady stimulus is suddenly applied to the dark-adapted eye the sensation rises to a peak and then falls to a fairly steady value within less than a fifth of a second.

In addition, when the stimulus is removed suddenly, the sensation takes a finite time to disappear. This latter persistence of vision is responsible for the effectiveness of the stroboscope and the cine film; it makes possible the removal of the flicker which would otherwise result from the repeated cessation of the stimulus. The so-called after-image which is "seen" when a stimulus is suddenly removed takes a form which varies considerably with the conditions of adaptation, and the strength and duration of the stimulus.