Croydon Astronomical Society

Eyes on the Universe

by

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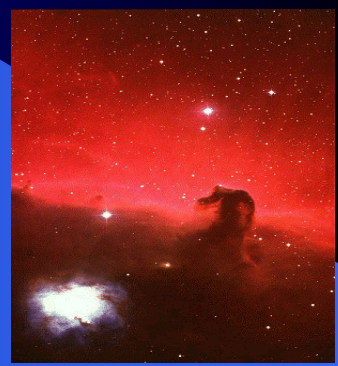
Engineer at Work - Astronomer at Play !



Light Intensity

- Astronomical Magnitudes are logarithmic
- { Minus } One magnitude is 2.521 times brighter.
- 5 magnitudes is 100 times brighter / dimmer
- The logarithmic scale reflects the operation of the eye

- **Typical Levels**
- **Sun = - 26.7**
- **Full Moon = - 12.5**
- **Venus = - 4.3**
- **Sirius = - 1.4**
- **Limit of Vision = + 6.5 ???**
- **Binocular Limit = + 10**
- **Pluto = + 15**
- **Large Telescope Photographic Limit = + 25**
- **Dimmest object imaged ≈ +29 ?**

Exit Pupil

- Telescopes & Binoculars have an exit pupil.
- This is calculated from the Diameter of the Objective (mm) divided by the magnification.
- For 7 x 50 Binoculars = 50 / 7 = 7.14 mm
- For 500 mm Telescope at 50 magnification = 10 mm
- For telescopes this determines the minimum useful magnification.

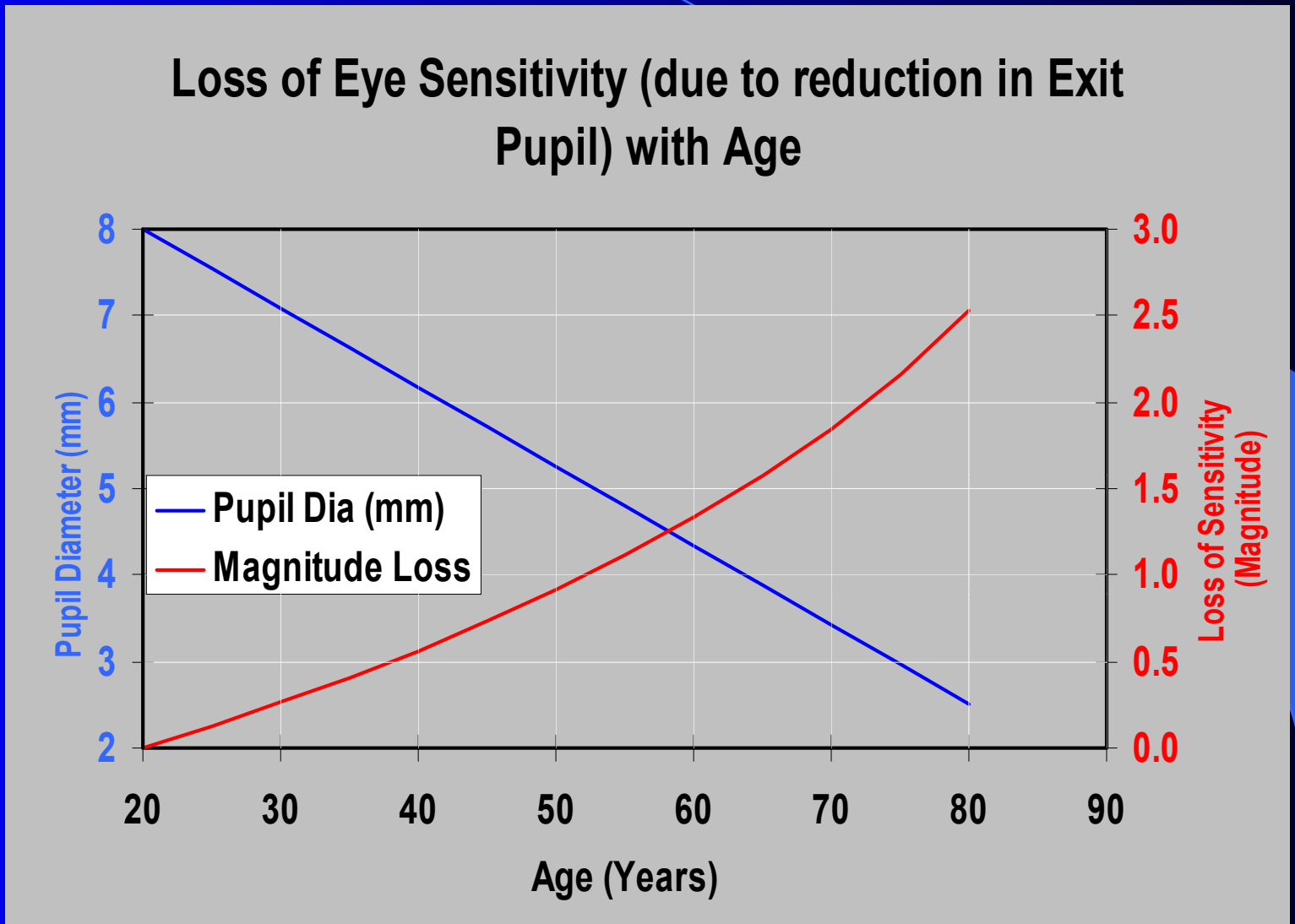
How the eye works

- It is very similar to a camera
  - At the front is a lens
  - The pupil adjusts the eyes sensitivity to light – much as the diaphragm does in a camera
  - The image is formed on the retina which is at the back of the eye – where the film would be in a camera
  - The ‘image’ is sent to the brain along the optic nerve – the brain does the clever bit !

Reduction in size of Eye's Pupil

- As we get older the maximum size that our pupil will open becomes smaller
- Buying a Telescope or Binoculars with a larger exit pupil than this is of no benefit
- The lens on the eye also yellows & loses more light as it gets older
- The following graph shows how the maximum size of the pupil falls with age & how many magnitudes loss this causes

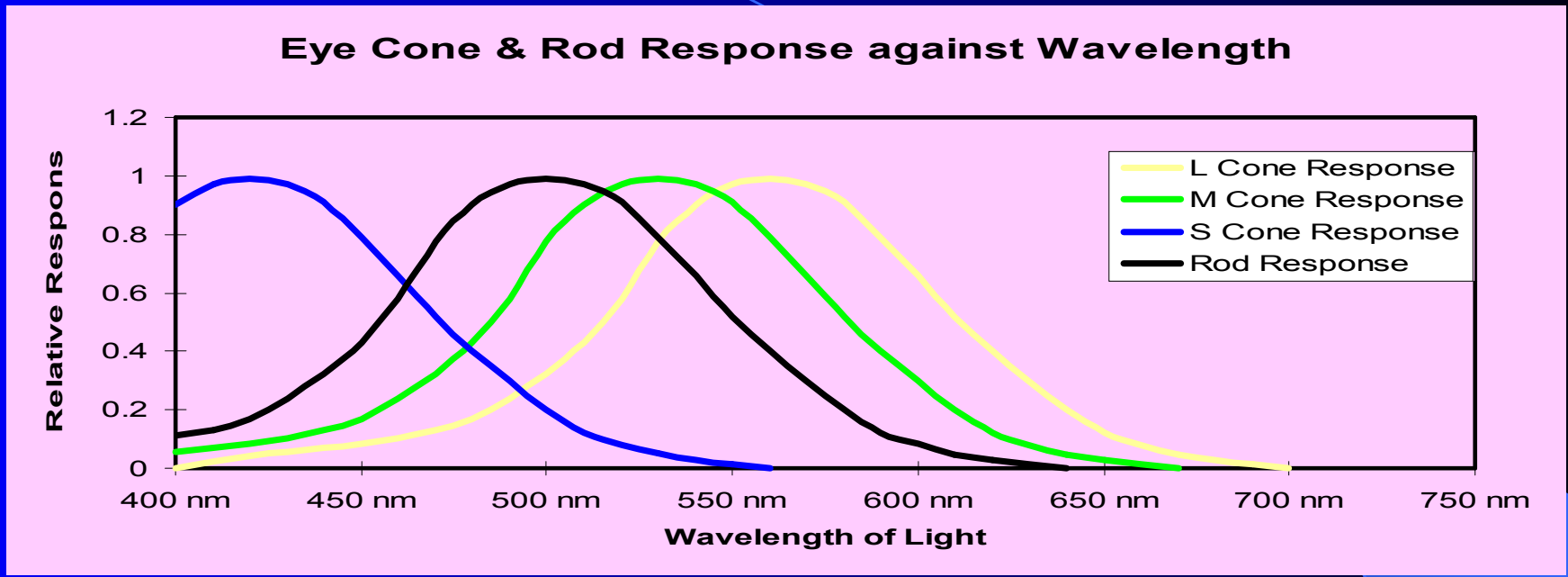
Reduction in size of Eye's Pupil



How the eye detects an image

- The retina at the back of the eye detects the image.
- There are two types of receptors in the retina.
- Cones for detailed vision in high light levels.
- Rods for low light levels but low resolution (they are not colour sensitive) .
- The Cones used for colour vision are subdivided into 3 types with different colour responses

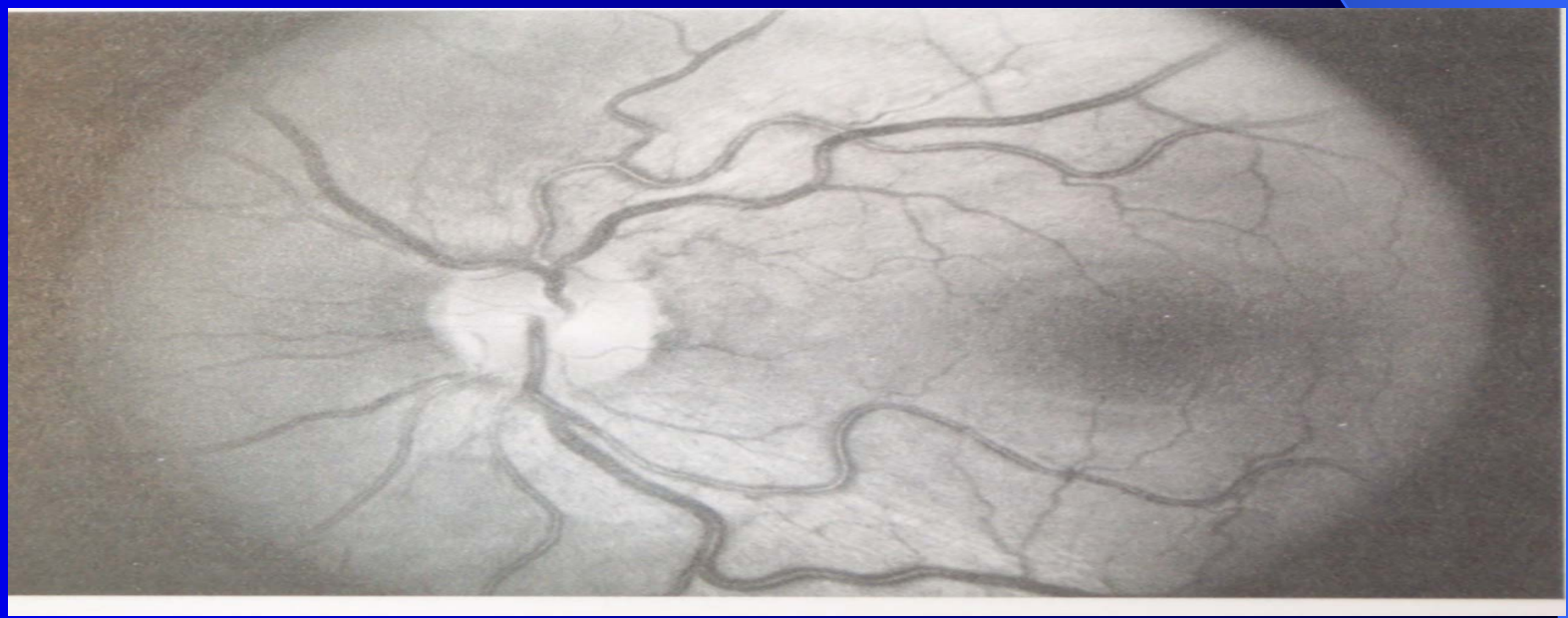
Spectral Response



- As the eye has a logarithmic response the performance particularly in the red region is better then may be suggested by this graph
- **L Peak = 564 nm (Yellow Green)**
- **M Peak = 534 nm (Green)**
- **S Peak = 420 nm (Blue)**
- **Rod Peak = 498 nm (Blue Green)**

Distribution of Cones & Rods

- **Cones are in Centre**
- **Rods are around periphery**
- **Fovea is the highest resolution around One to Two Degrees (A thumbnail at arms length)**
- **Where the Optic nerve joins the retina there is a blind spot**



Resolution of the Retina

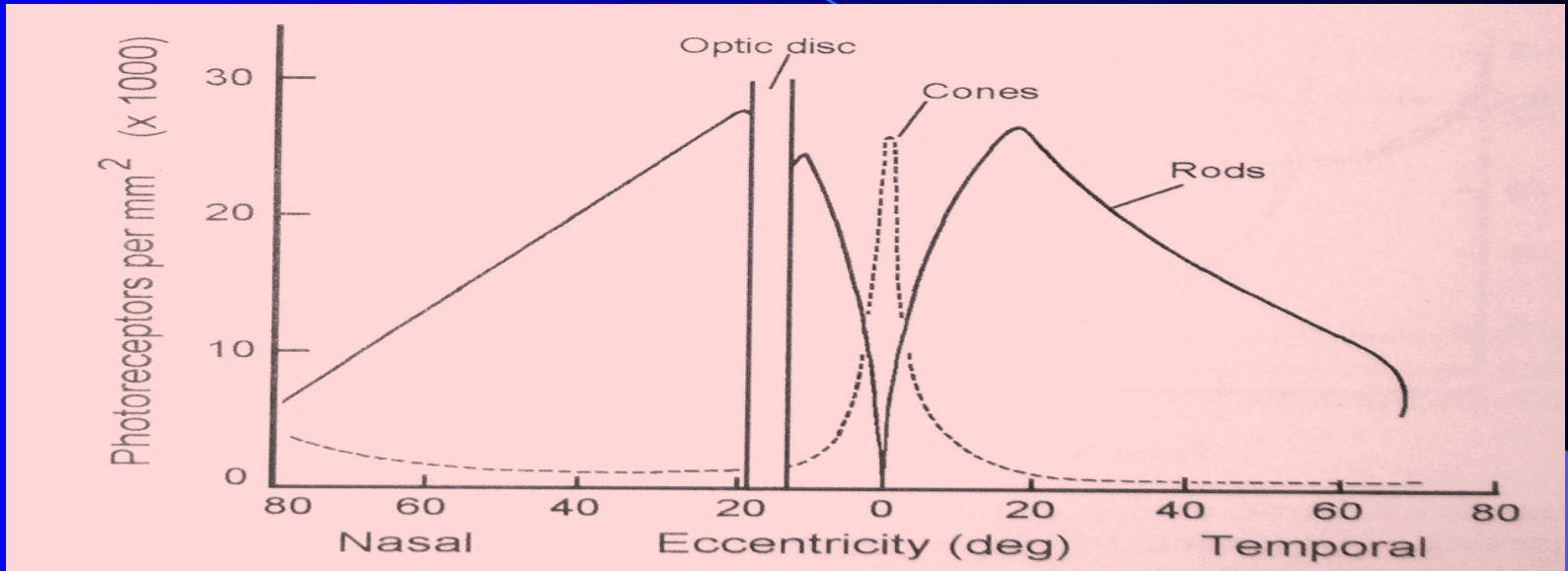
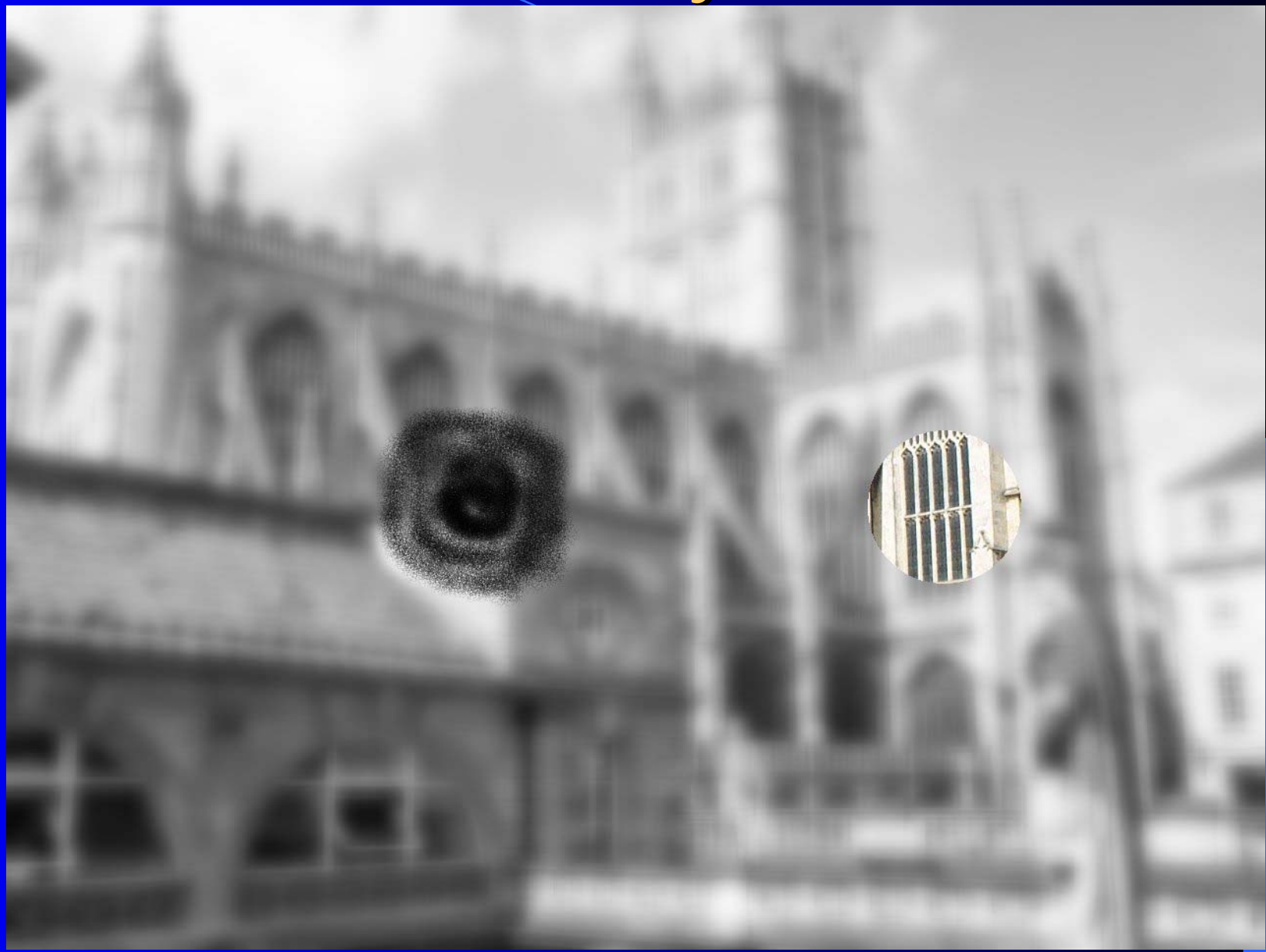


Figure 6.12. Distribution of rods and cones along a horizontal lin

- **The optic disk is where the optic nerve connects**
- **The rods work in groups (like binning a CCD) – this is part of the motion detection system so the resolution of the rods is lower than shown in this diagram**

What the eye sees



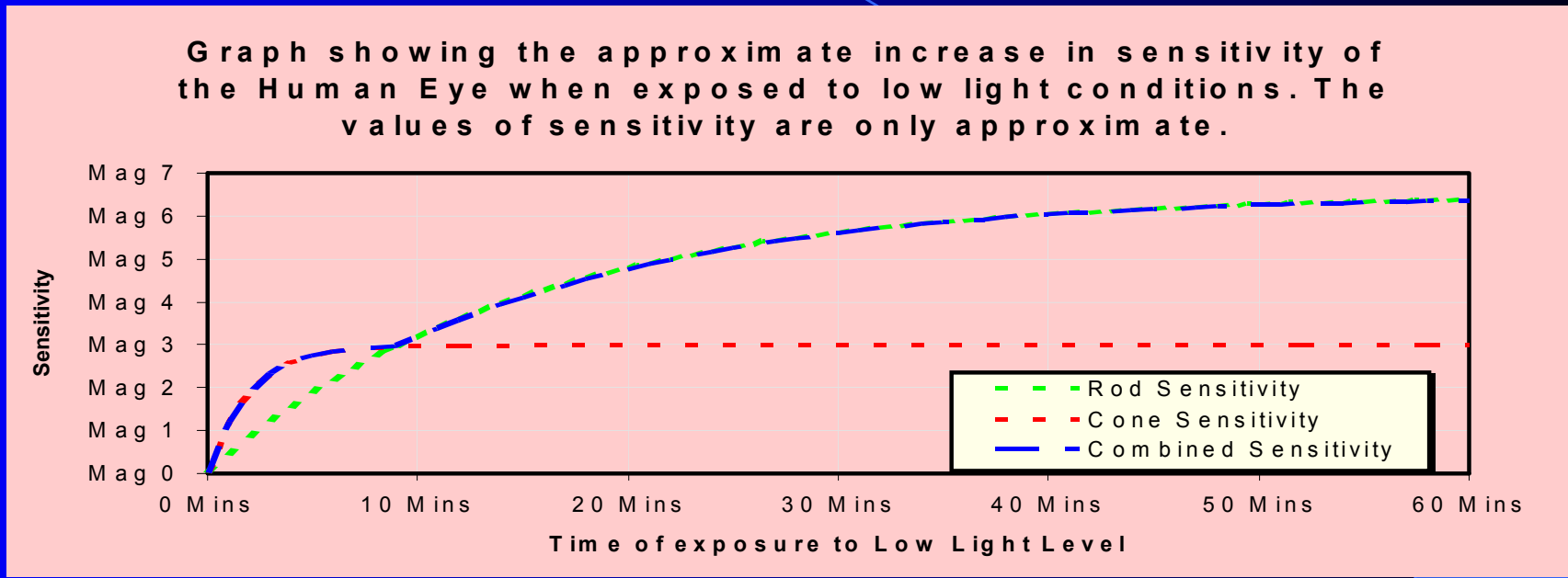
What the brain sees

Dark Adaptation

Three Stage Process

- 1- The pupil opens gives about 3 magnitudes in 2-3 seconds.
- 2 - The Cones adapt to the low light level.
- 3 - The Rods adapt to the low light level.
- The Cones & Rods adapt at different rates as shown on the next graph.

Adaptation Response Time

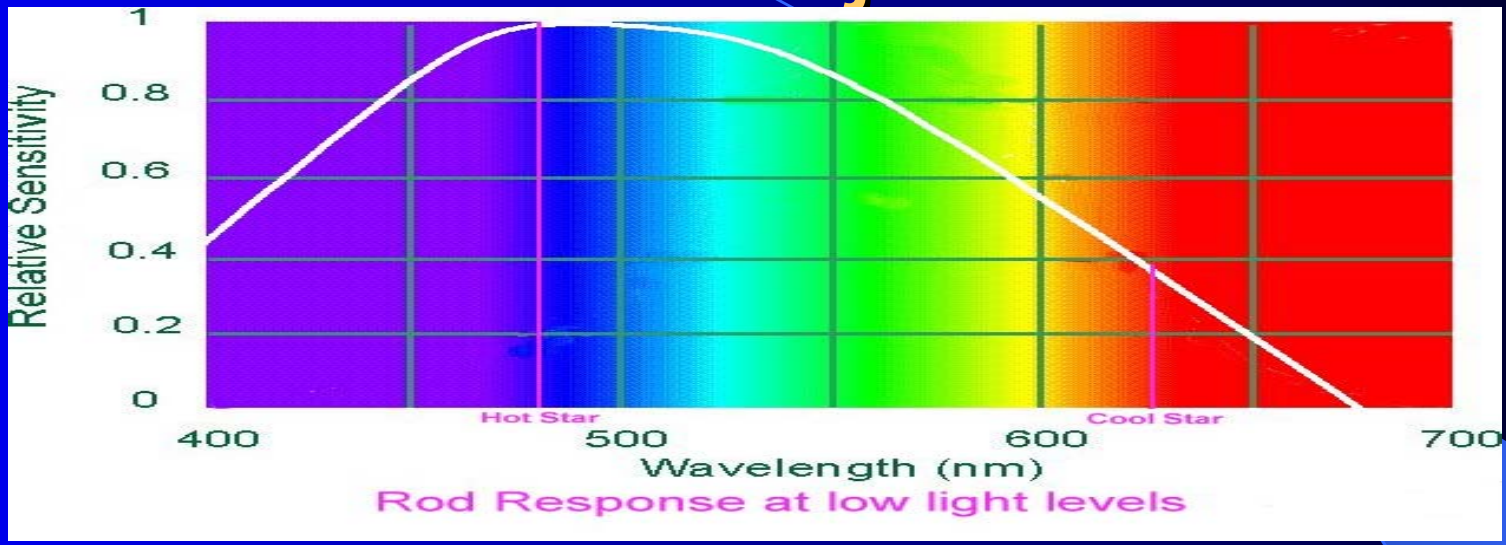


- The Blue Dashed Line shows the combined response.
- The point where the Rods become more sensitive is known as the ‘Rod - Cone Break’.

Averted Vision

- The centre of the Eye has no rods so does not work at low light intensities.
- To see dim objects you need to use the periphery of the eye - this is averted vision
- However the blind spot stops the use of one side.
- Best response is opposite the Blind Spot (Temporal Side)
- Above & Below are quite good

The Purkinje Effect



- Dim stars only activate the rods
- A red star will appear dimmer than a blue star even if they are the same intensity due to the response curve shown above
- This causes errors in visual estimates of star brightness
- It is known as the Purkinje effect

Summary

- Wait 30 - 50 minutes before looking for dim objects.
- Use low levels of deep red light to look at charts – this does not effect the dark adaptation of the rods.
- Use averted vision
- Beware of the blind spot
- Don’t expect to see colour in dim objects.
- Rod vision has low resolution so you will not see detail.
- The larger the image the better provided that it is above the detection threshold.

and Finally

- Lack of Oxygen reduces the sensitivity of the retina – if you observe from a mountain take your oxygen !
- ☹ Alcohol also reduces the sensitivity to light ☹