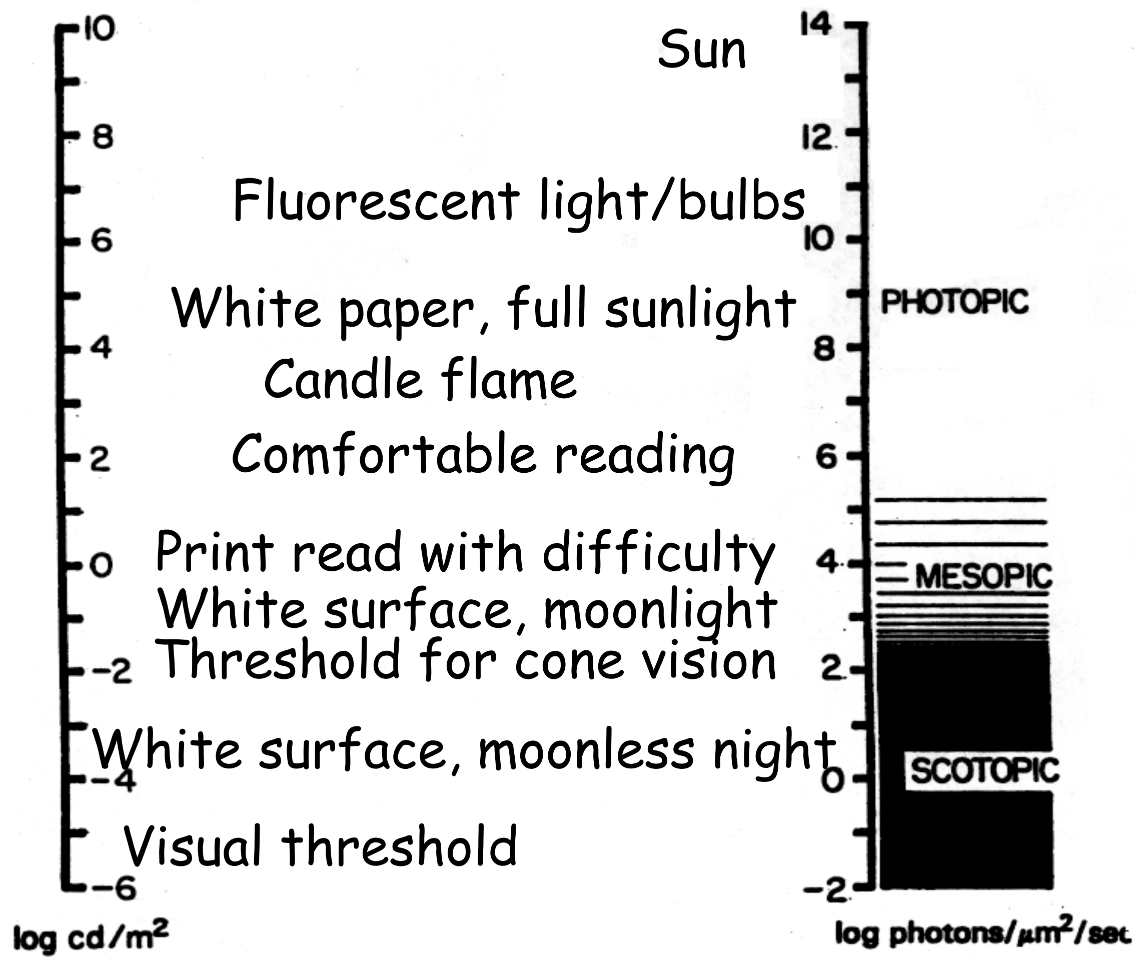
# Light and dark adaptation

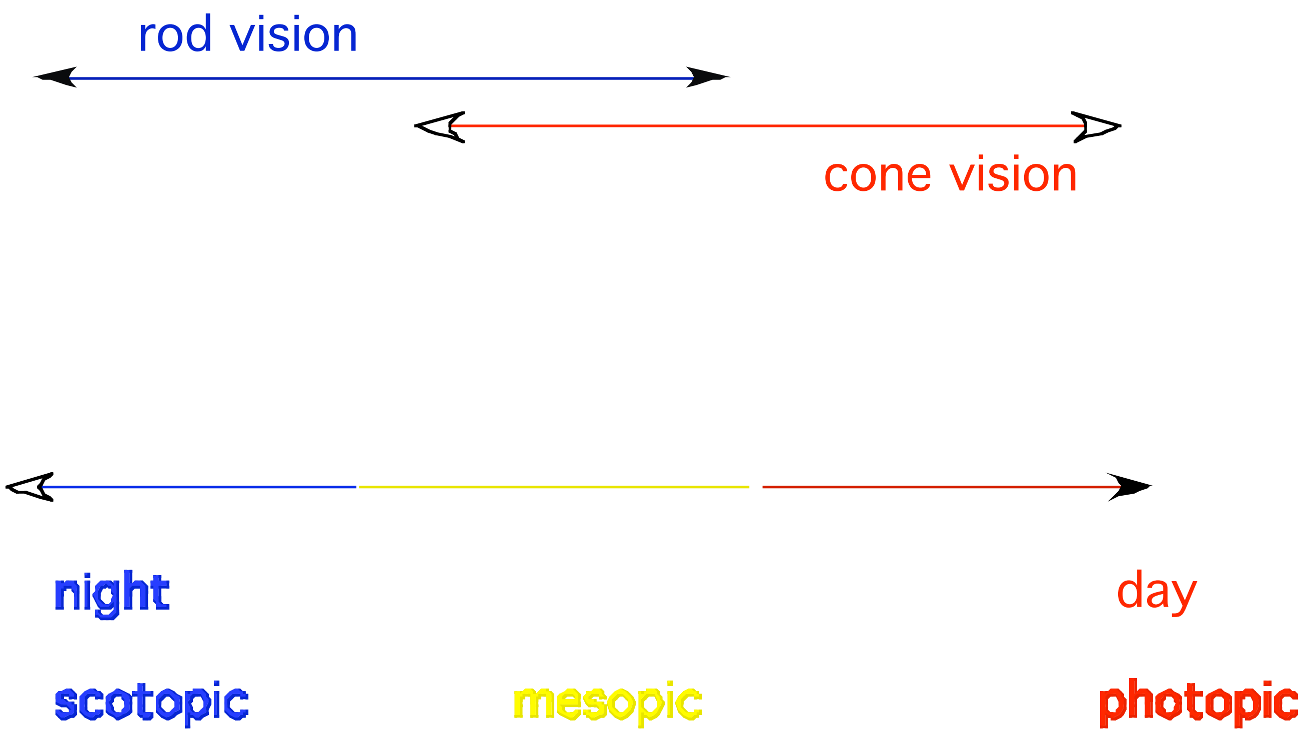
- The range of light levels over which we can see
- Why do we need adaptation?
- The design problem
- Role of pupil changes
- The duplex retina: four comparisons of rod-based and cone-based vision
- Dark adaptation and pigment bleaching
- Light adaptation:
  - Weber's Law
  - The response of visual neurons

# Luminance and retinal illumination



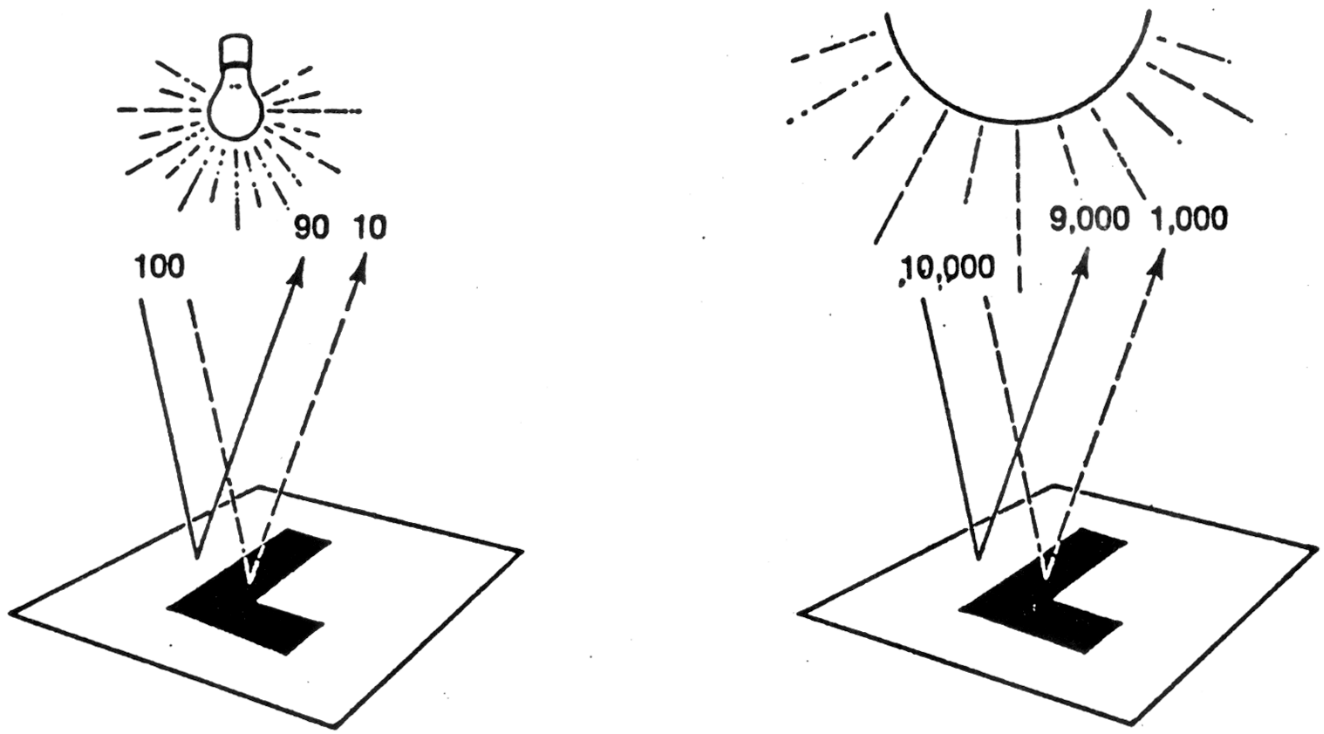

The range of luminances (left) and retinal illumination (right) found in the natural world

# Rod and cone operating ranges



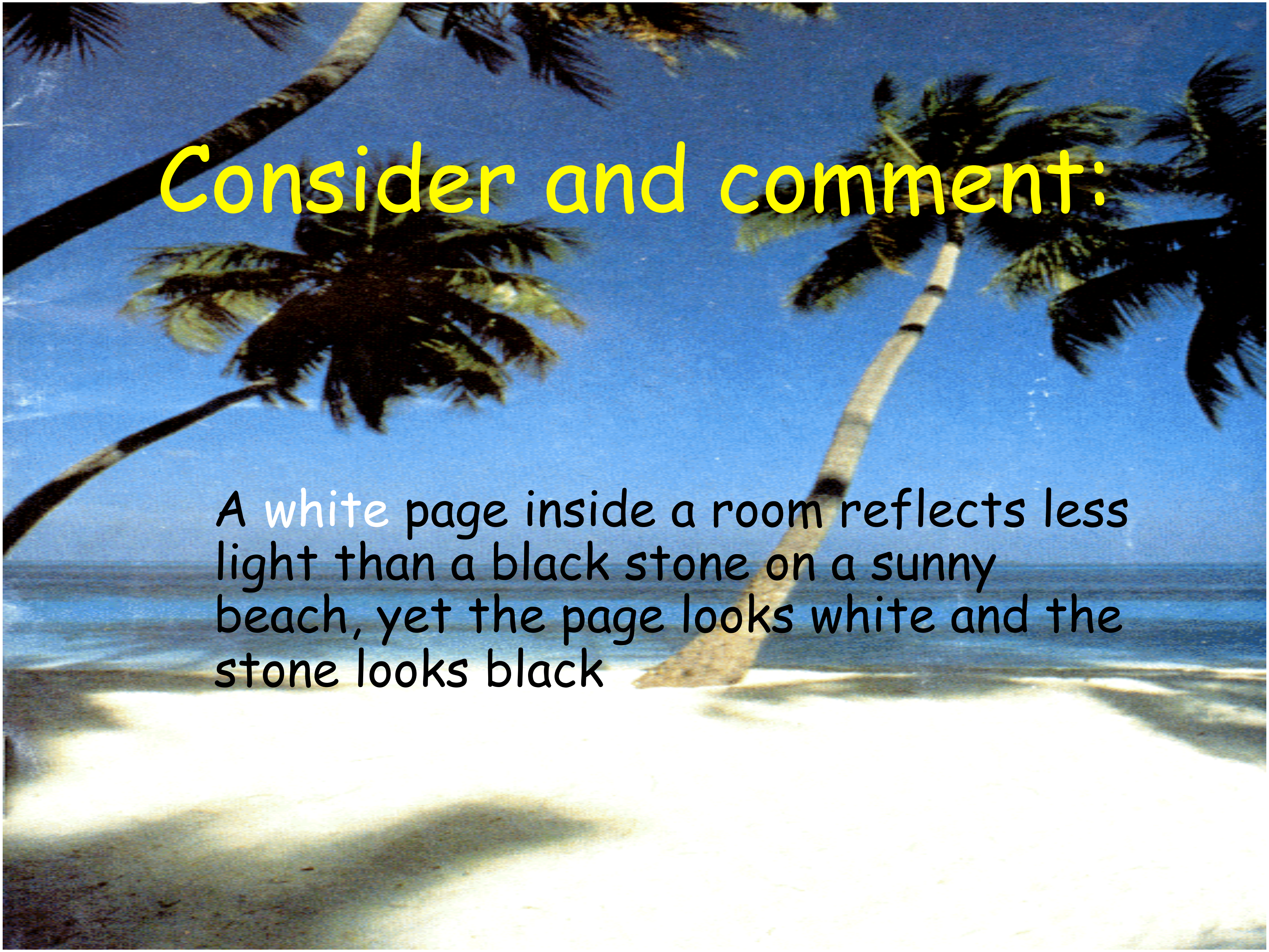

LUMINANCE RANGE

# Light reflected from a surface under low and high illumination

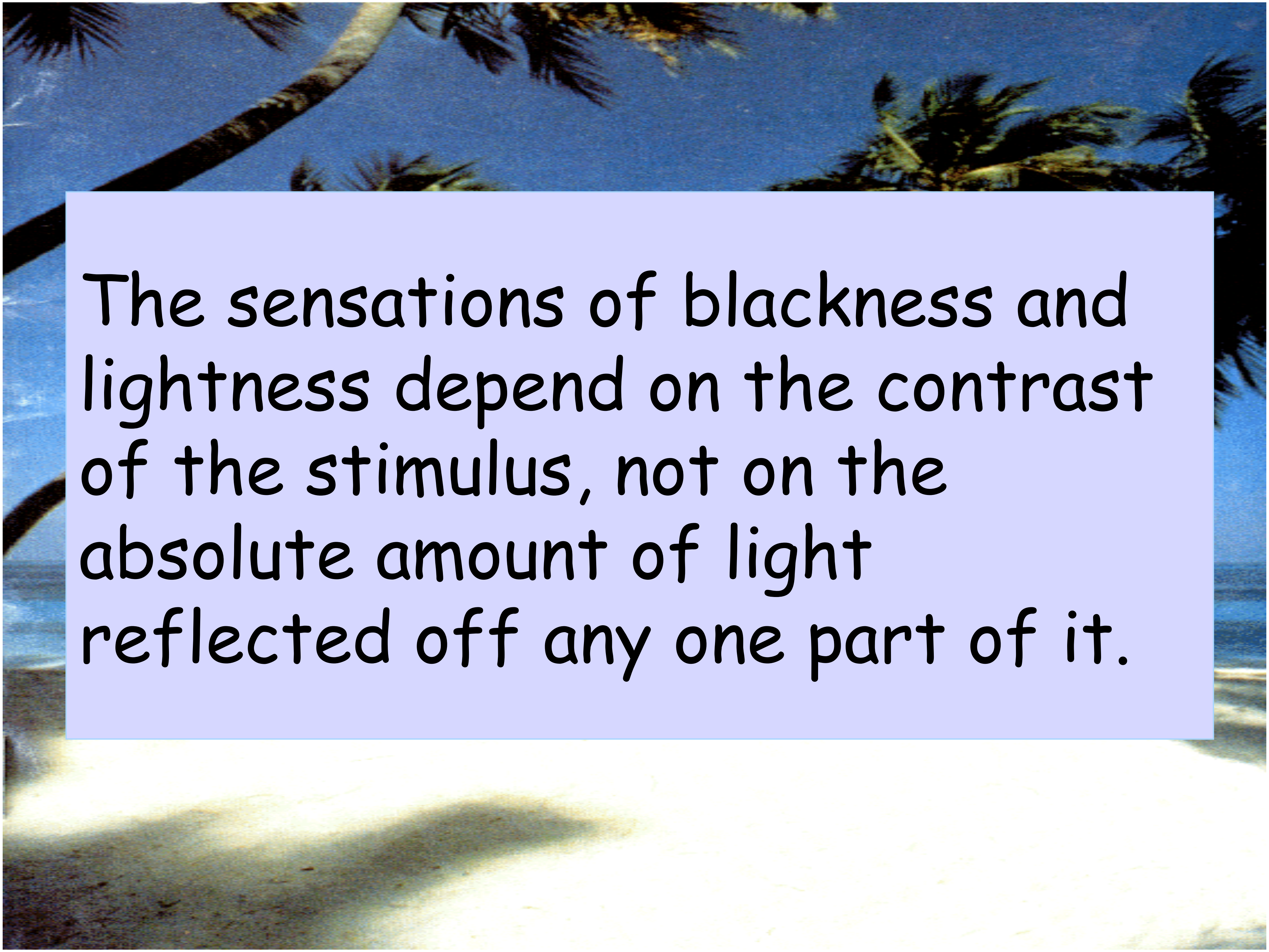



(a) (b)

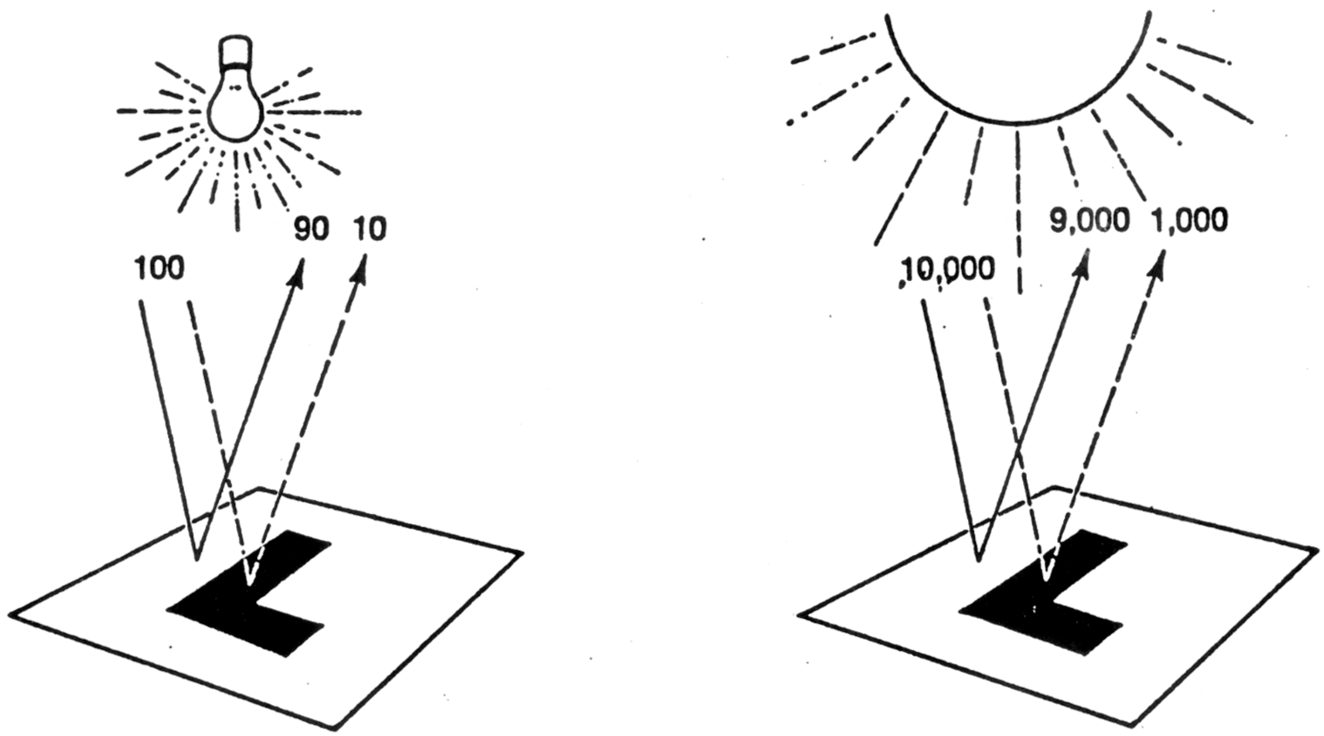
The ratio of light intensities reflected from the white surround and the black letter is 9:1 under both low and high illuminations.



Consider and comment:
A white page inside a room reflects less light than a black stone on a sunny beach, yet the page looks white and the stone looks black



The sensations of blackness and lightness depend on the contrast of the stimulus, not on the absolute amount of light reflected off any one part of it.



(a) (b)

Luminance difference between 'L' and background =

80 units 8000 units

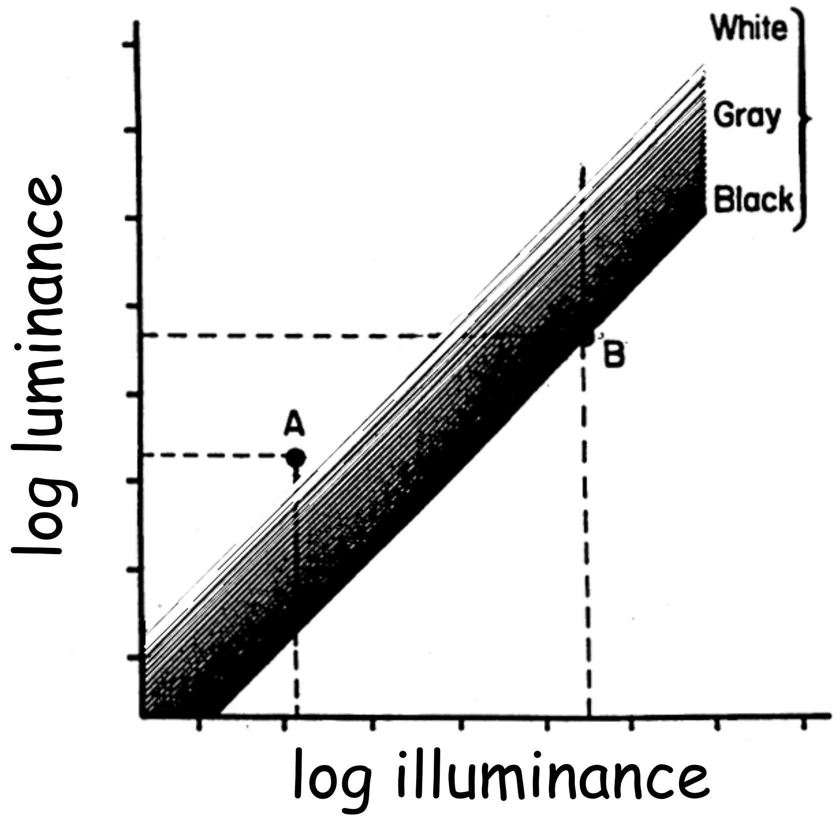
Background =

90 units 9000 units

Response ∝ Difference/Background

80/90 (89%) 8000/9000 (89%)

# The eye's sliding scale of brightness




A piece of white paper that is dimly lit (A) looks white because its luminance lies at the top of its local scale, even though this luminance may be less than that of a piece of black paper that is brightly lit (B).

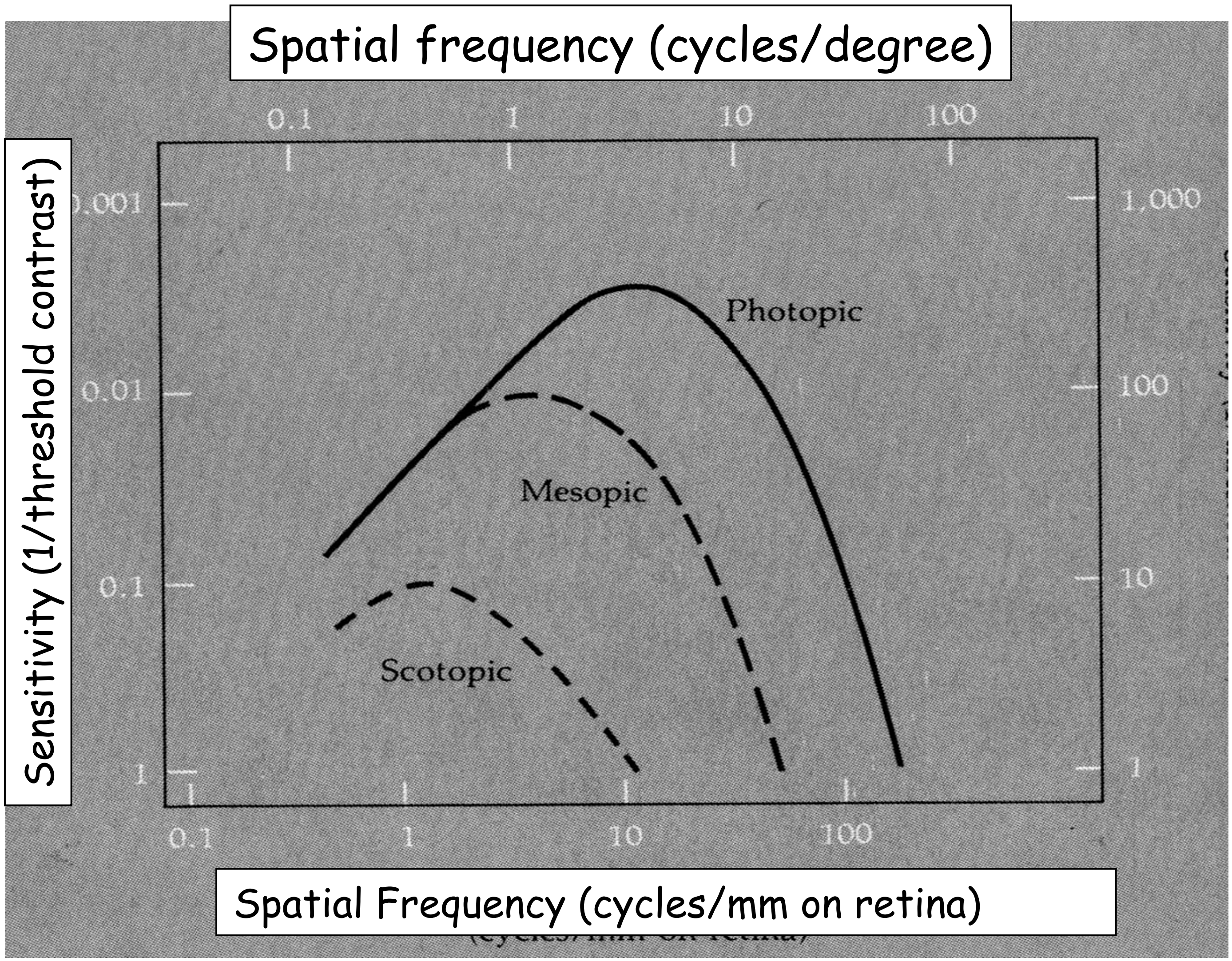
# Mechanisms that enable us to see over a wide range of light intensities:

- Pupil changes
- Duplex retina: rods & cones ➡
- Dark adaptation & pigment bleaching
- Light adaptation of the visual system and individual neurons (Webers Law)

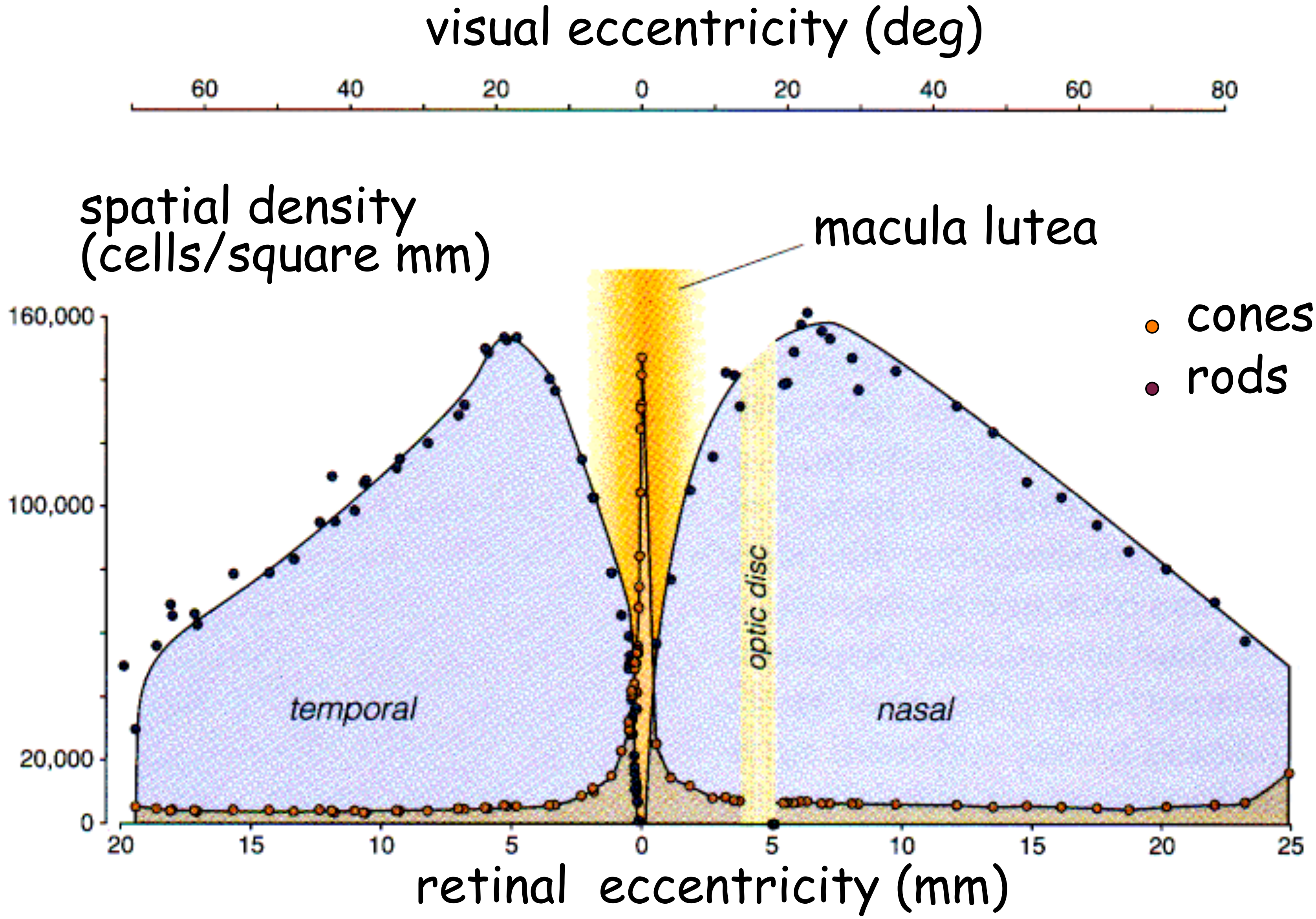
# Rods & cones: 4 key differences between scotopic and photopic vision

- Contrast sensitivity
- Distribution of rods and cones
- Spectral sensitivity of rods and cones
- Sensitivity to light of rods and cones.

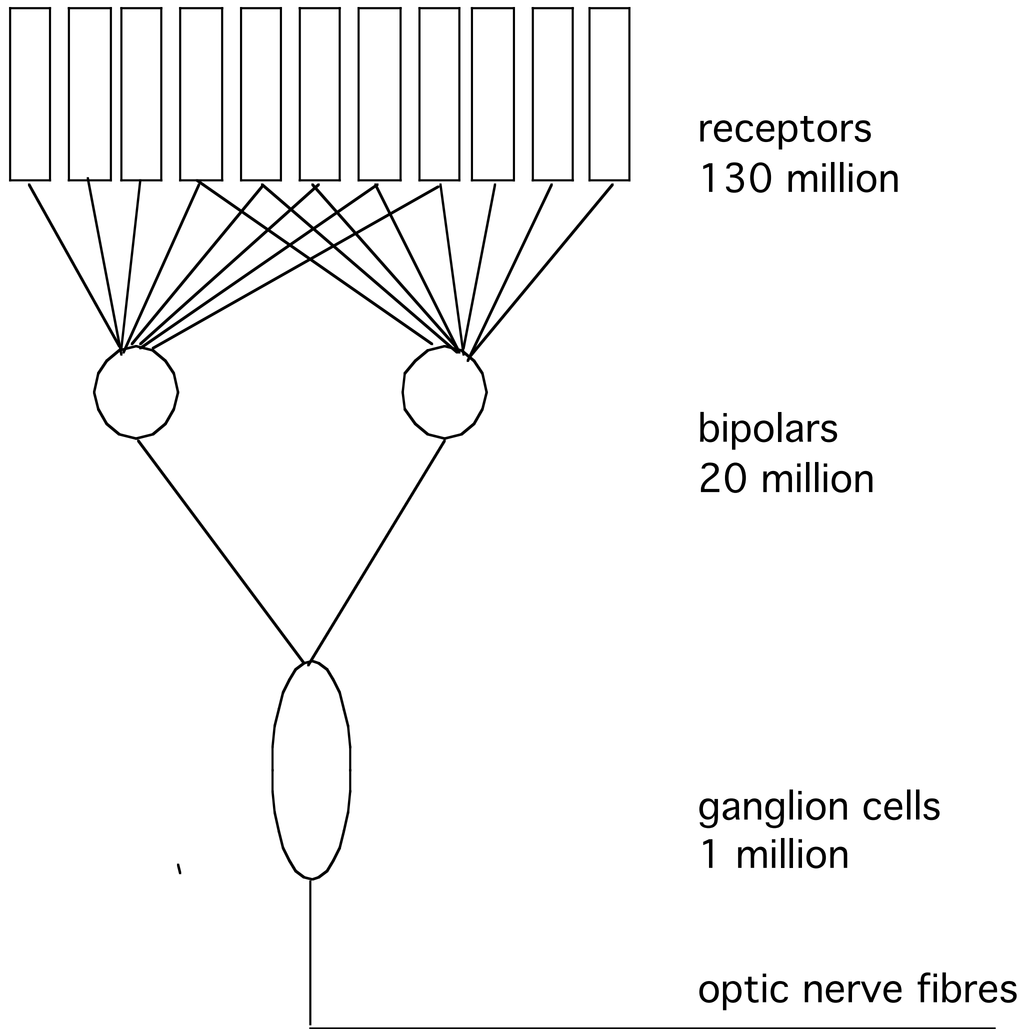
# 1. Contrast sensitivity functions at three different light levels



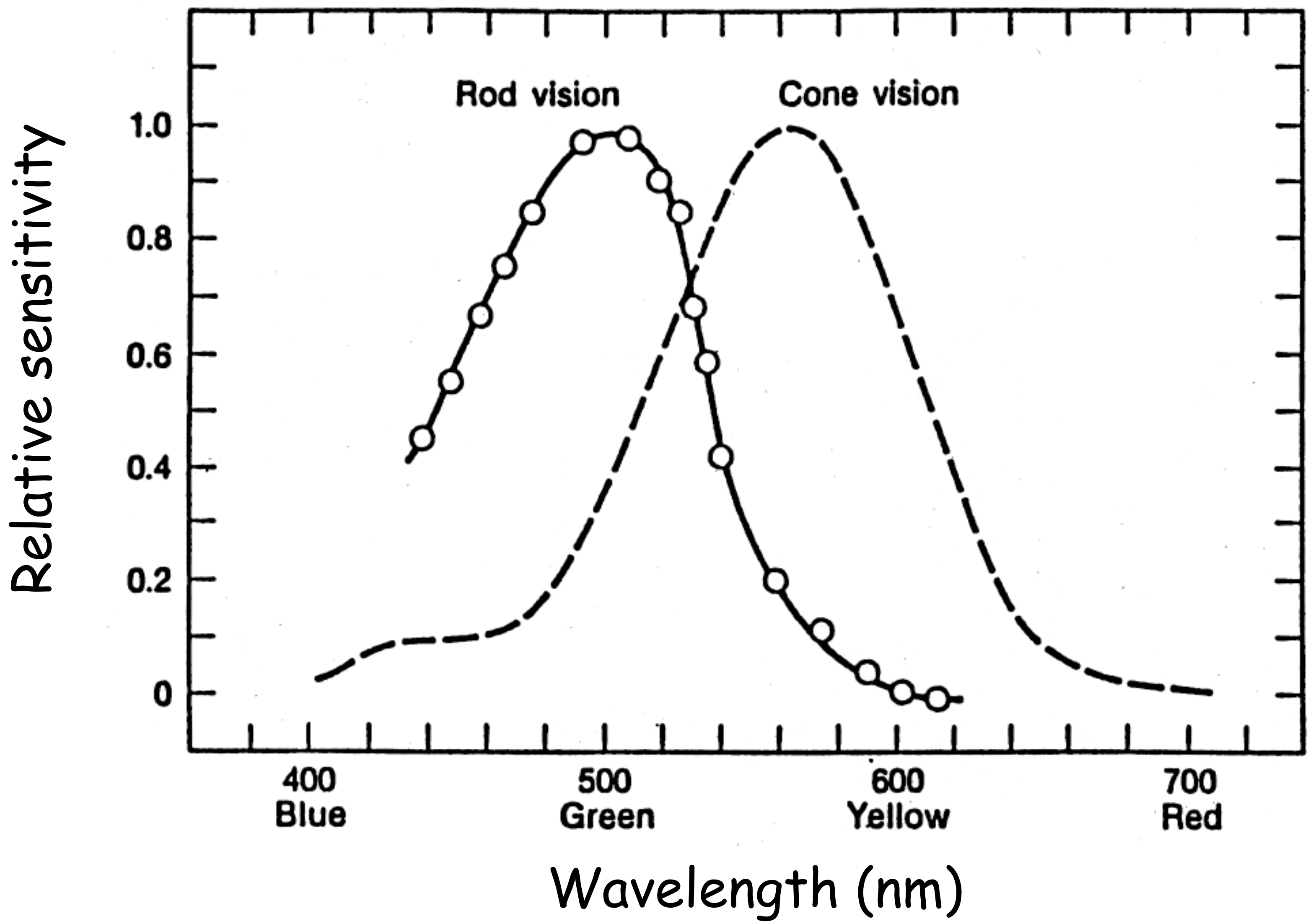
# 2. Distribution of rods and cones



# Convergence



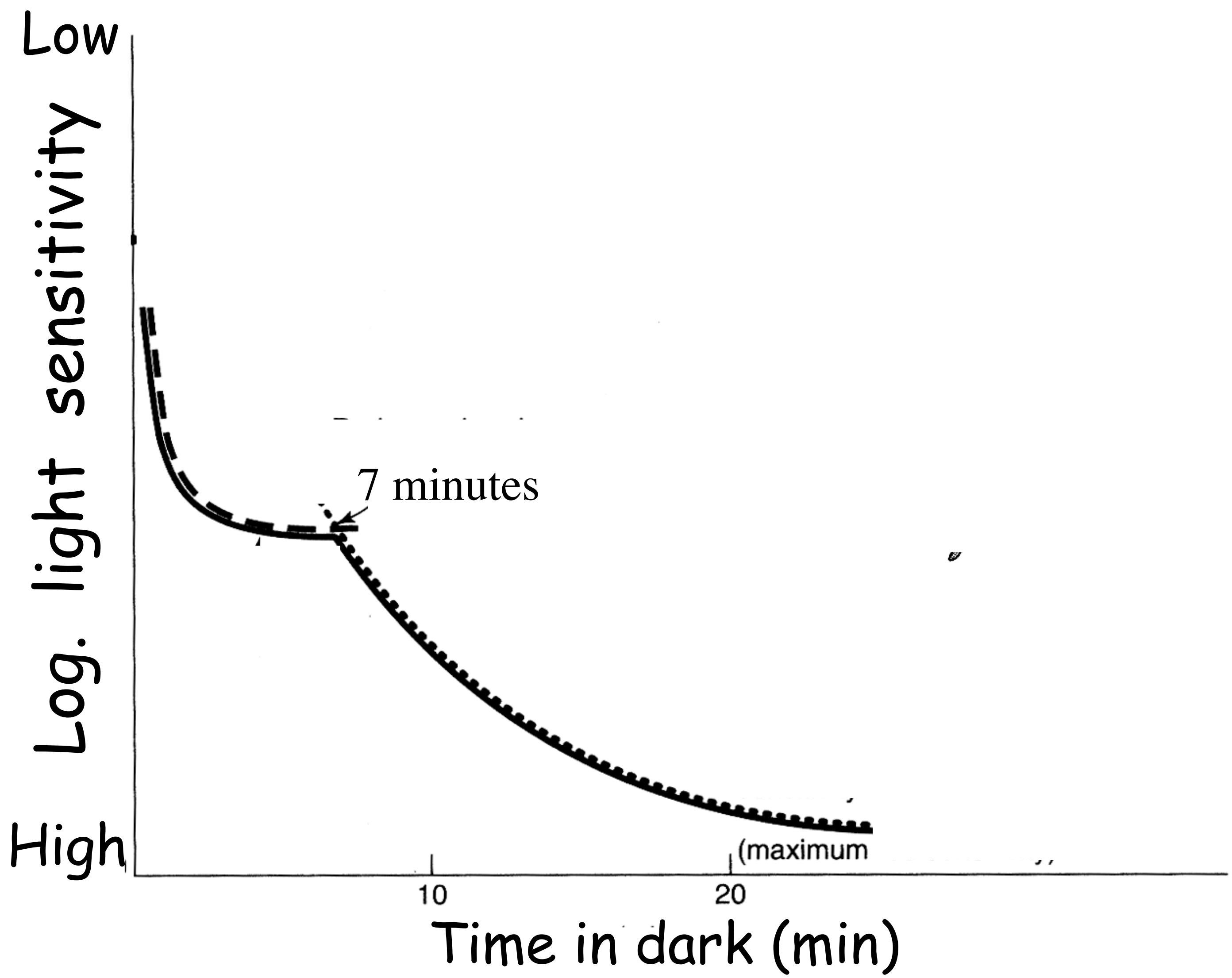
# 3. Spectral sensitivity curves for rod and cone vision



# Purkinje effect

- A shift in the colour appearance at dusk.
- Reds look darker, blues look brighter

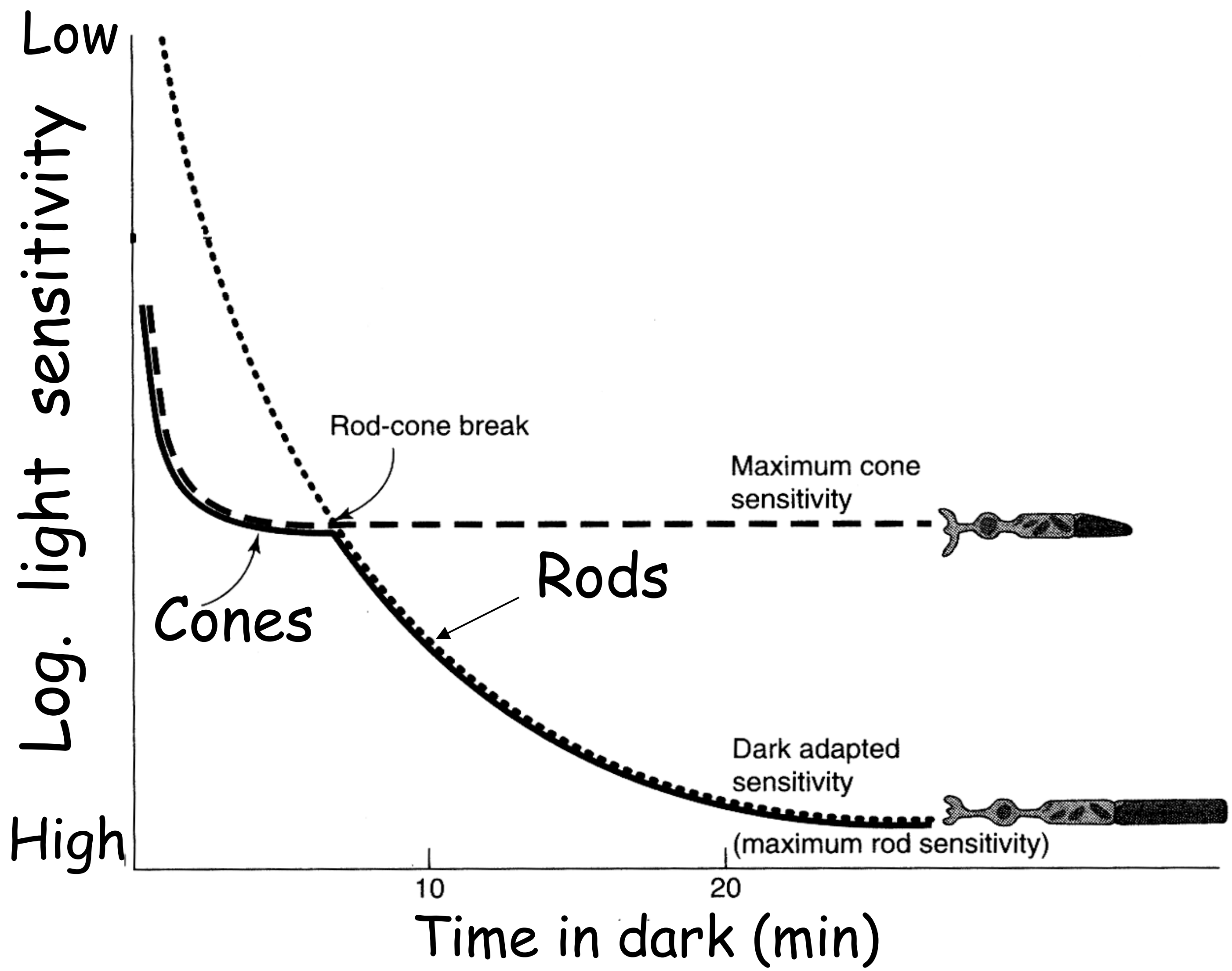
# 4. Sensitivity to light of rods & cones: Dark Adaptation



# Duplex function

- 1. Rods are more sensitive than cones (x50)
- 2. There are more rods than cones (x10)
- 3. Ganglion cells have larger RFs for rods than cones (i.e. more post-receptoral summation)

# Dark adaptation curves



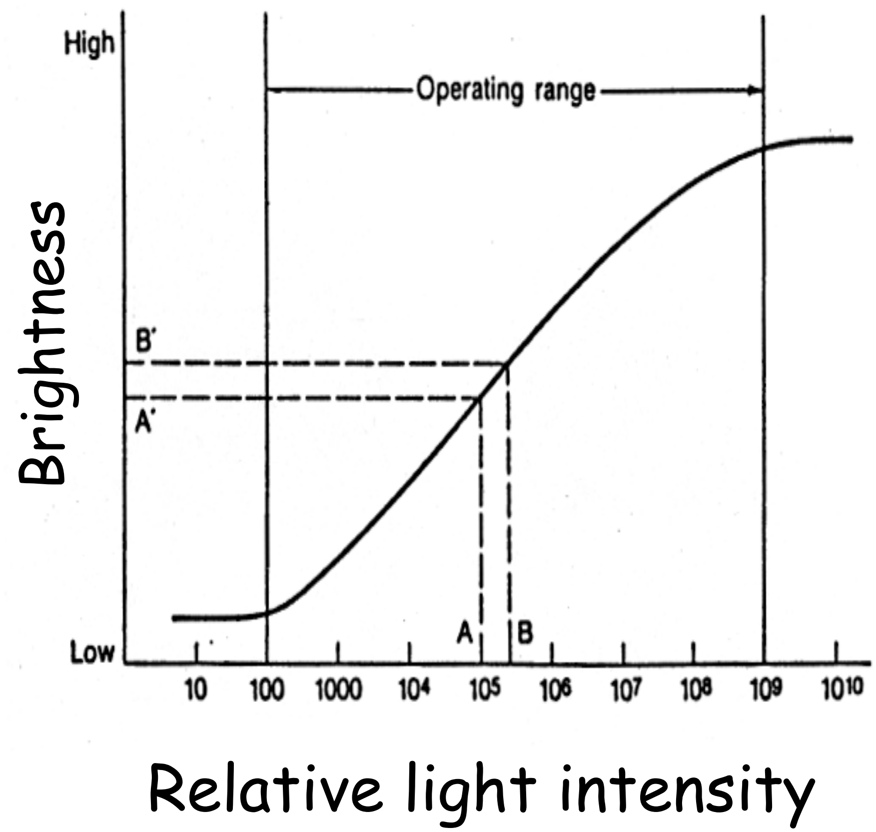
# The "design" problem

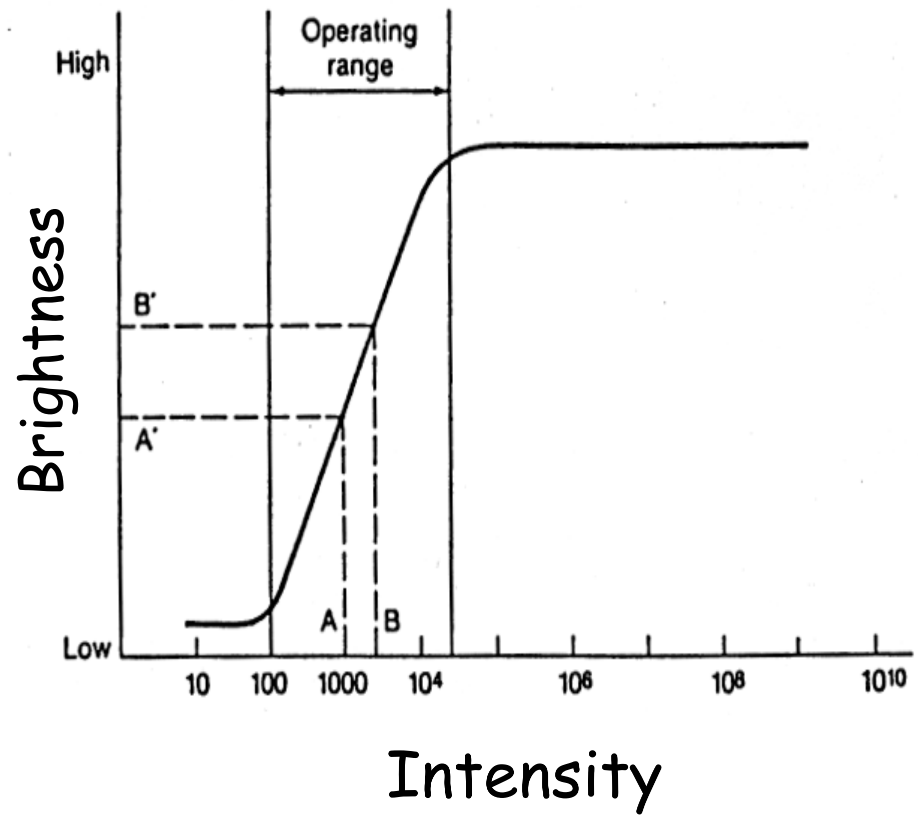
- To detect differences in luminances across the visual scene
- Scale the response to these differences according to the ambient light level

In solving the problem, we must:

1. Have good sensitivity to luminance differences
2. Be able to operate across a wide range of ambient light levels
3. Cope with a limited neural response range

# Contrast sensitivity and operating range

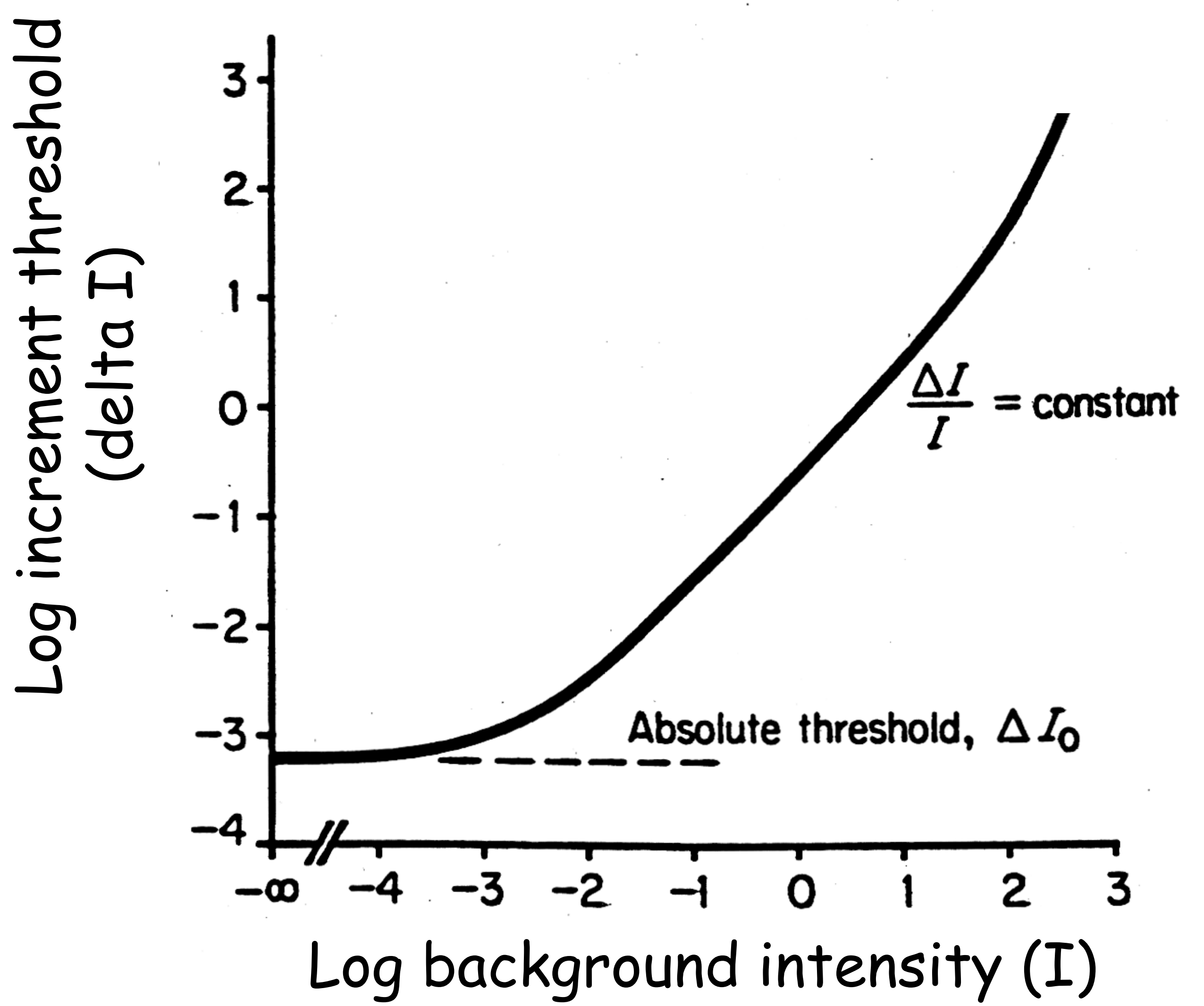



**Large operating range but poor contrast sensitivity**

**Good contrast sensitivity but small operating range**

# Increment threshold curve



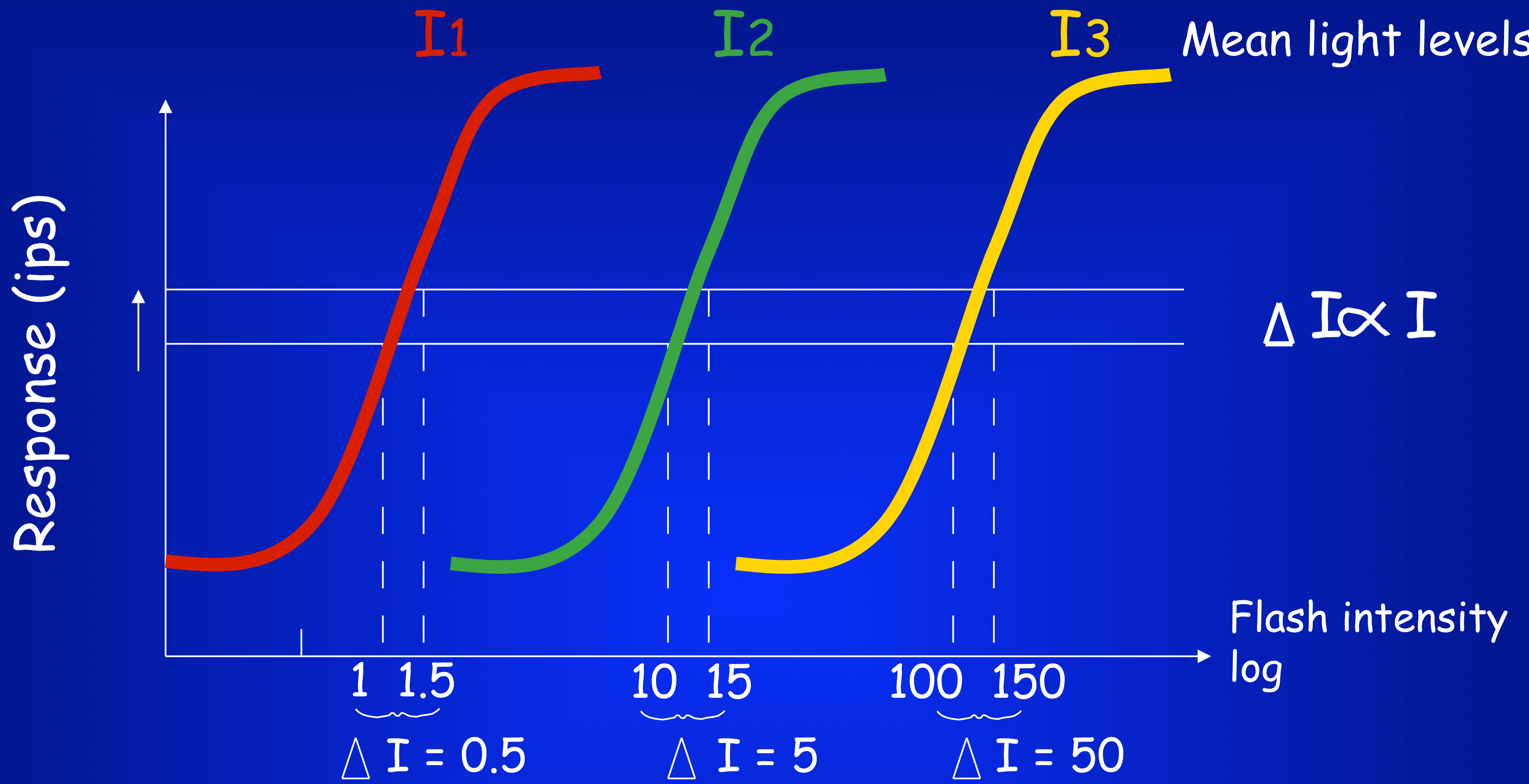

WEBER'S LAW

# Weber's Law

$$\Delta I / I = \text{constant}$$

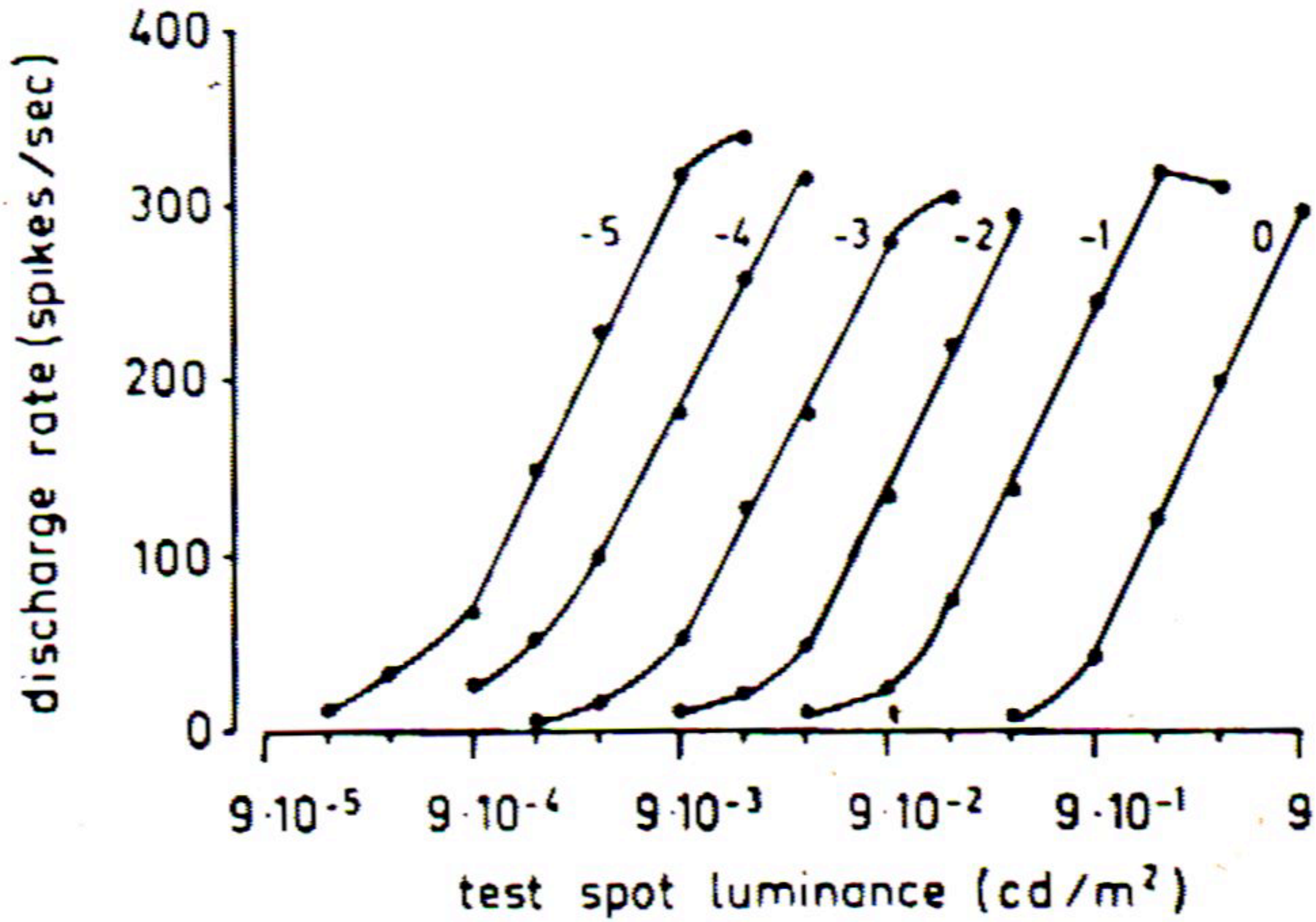
- Our sensation is determined by the percentage difference in the luminance of a surface <u>relative</u> to its background

- This holds over a wide range of background (ambient) luminances




A single neuron can shift its operating range according to the mean light level. The light increment (delta I) required to obtain a criterion response is scaled up or down, according to the mean light level. This is known as GAIN CONTROL.

# Ganglion cell adaptation



# Receptoral adaptation