



Colour Vision

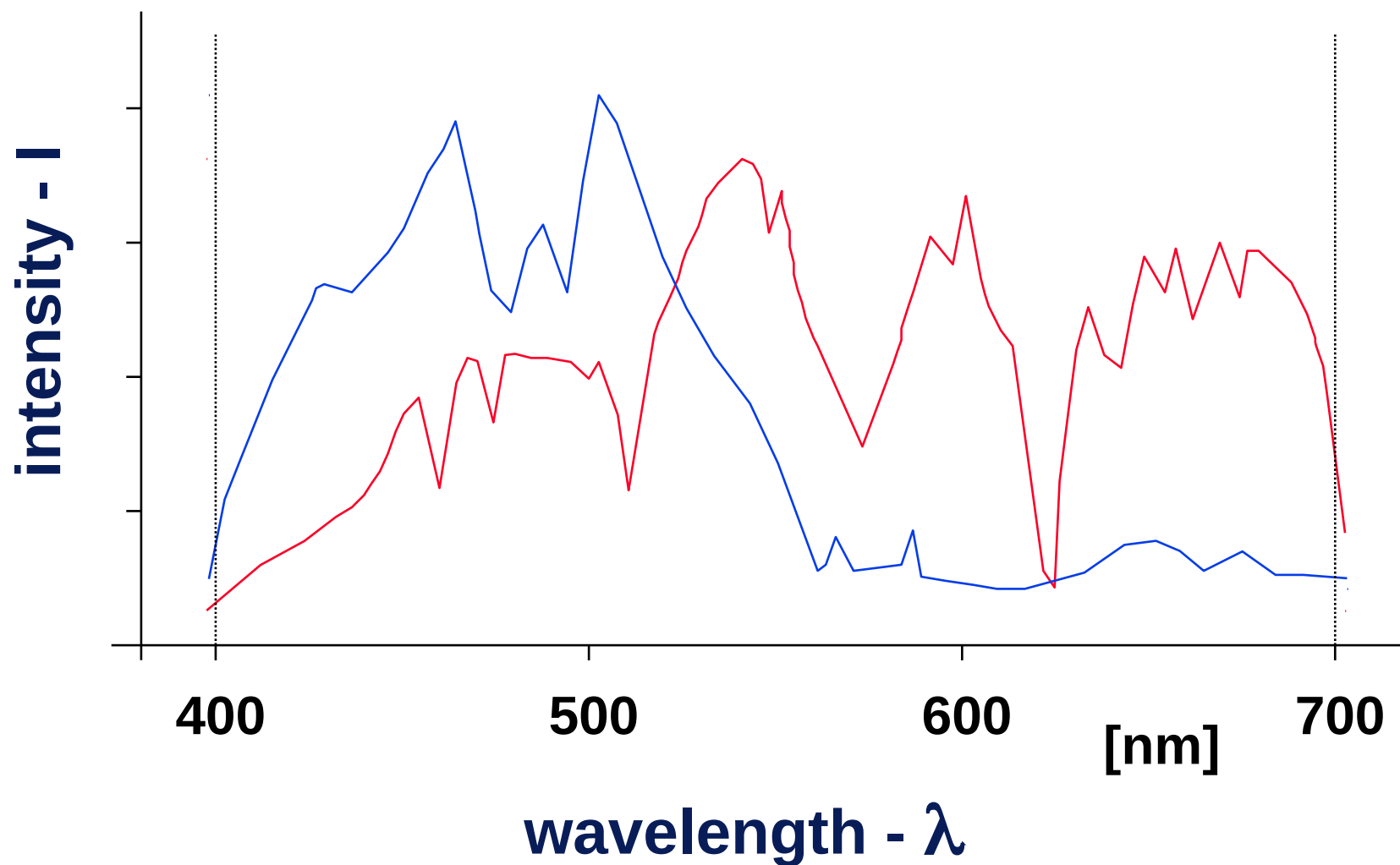
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Visible light, spectrum

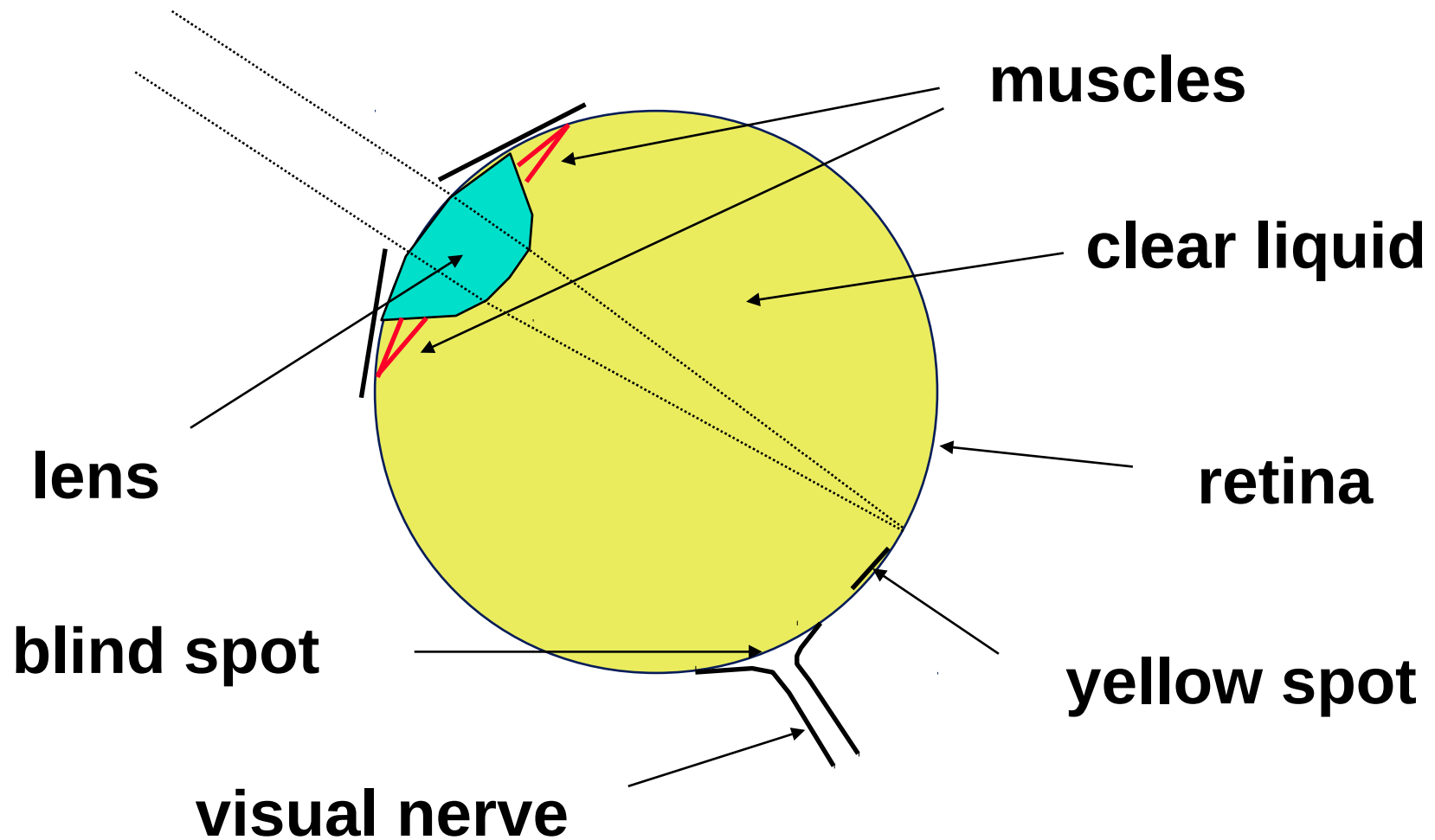




Colour Perception

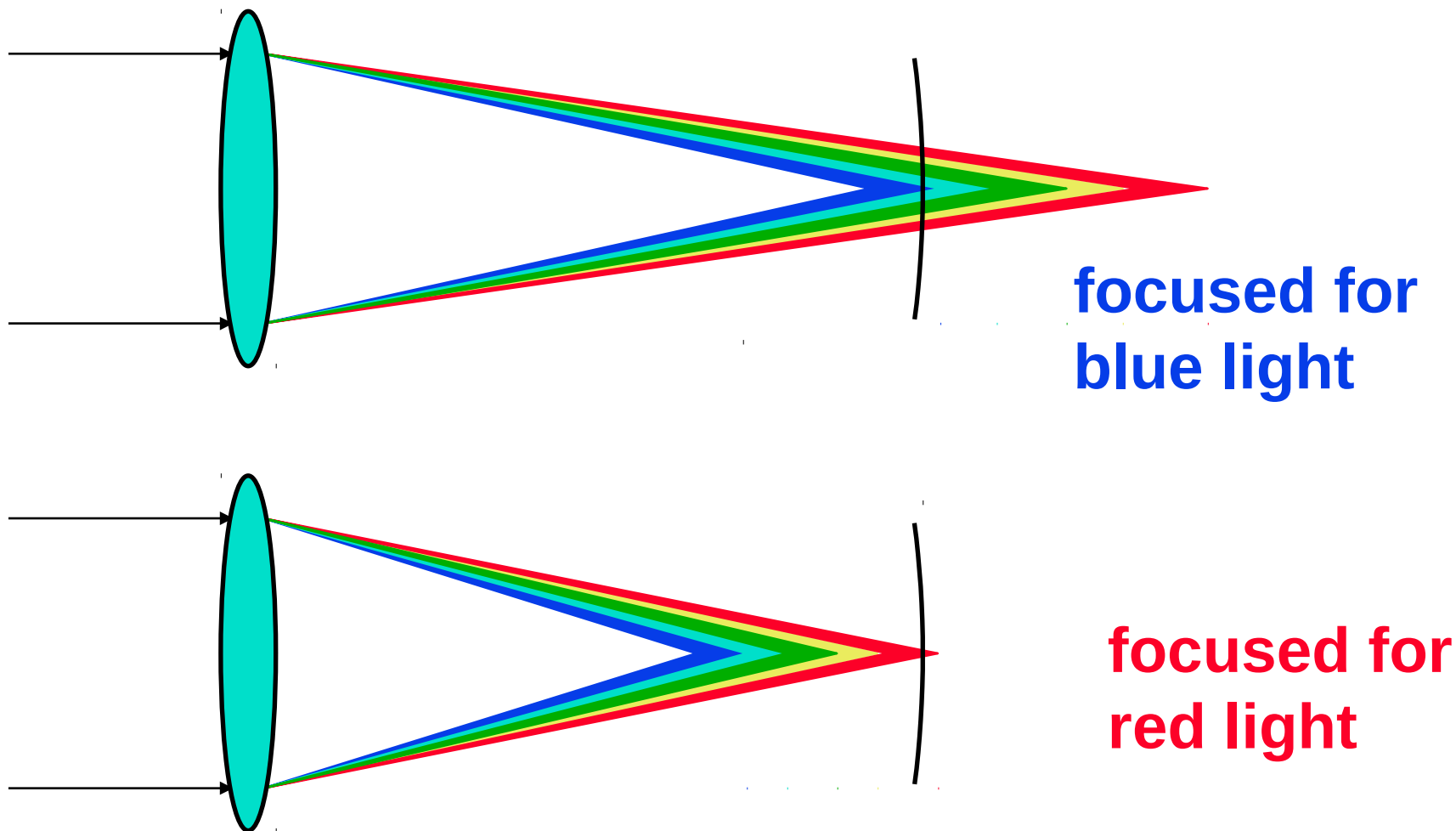
- ▶ The body of all spectra has **infinite dimension**
 - The human visual system is not able to distinguish between all possible inputs (“metamers”)
 - ▶ **Grassman's laws (1854)** – the human eye discerns:
 - **Dominant wavelength** („hue”)
 - **Colour purity** („saturation”)
 - **Intensity** („brightness”)
- Colours can be composed additively (only valid for light!)
(**$A = B, C = D \Rightarrow A + C = B + D$**)

The Human Eye

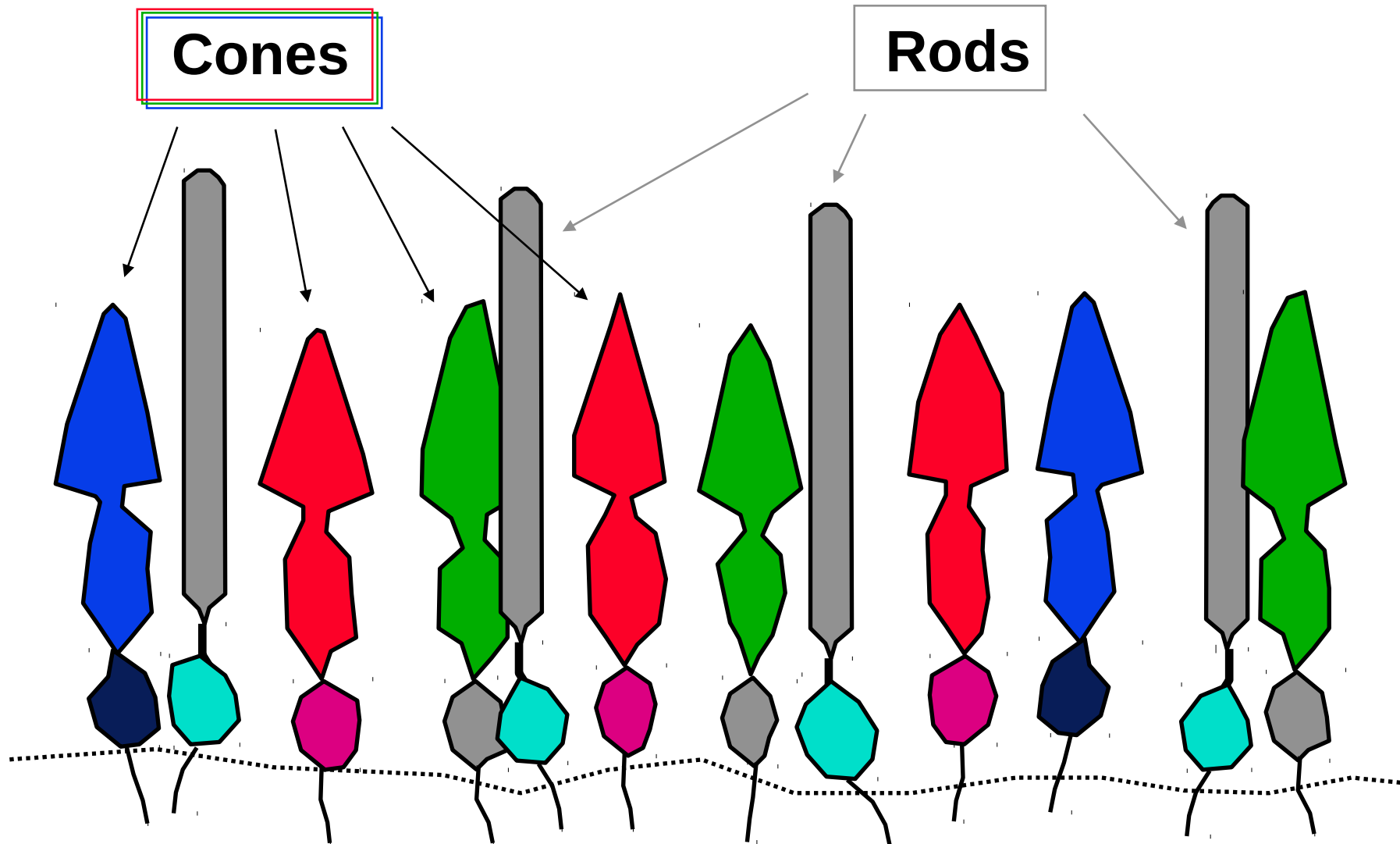




Colour Aberration

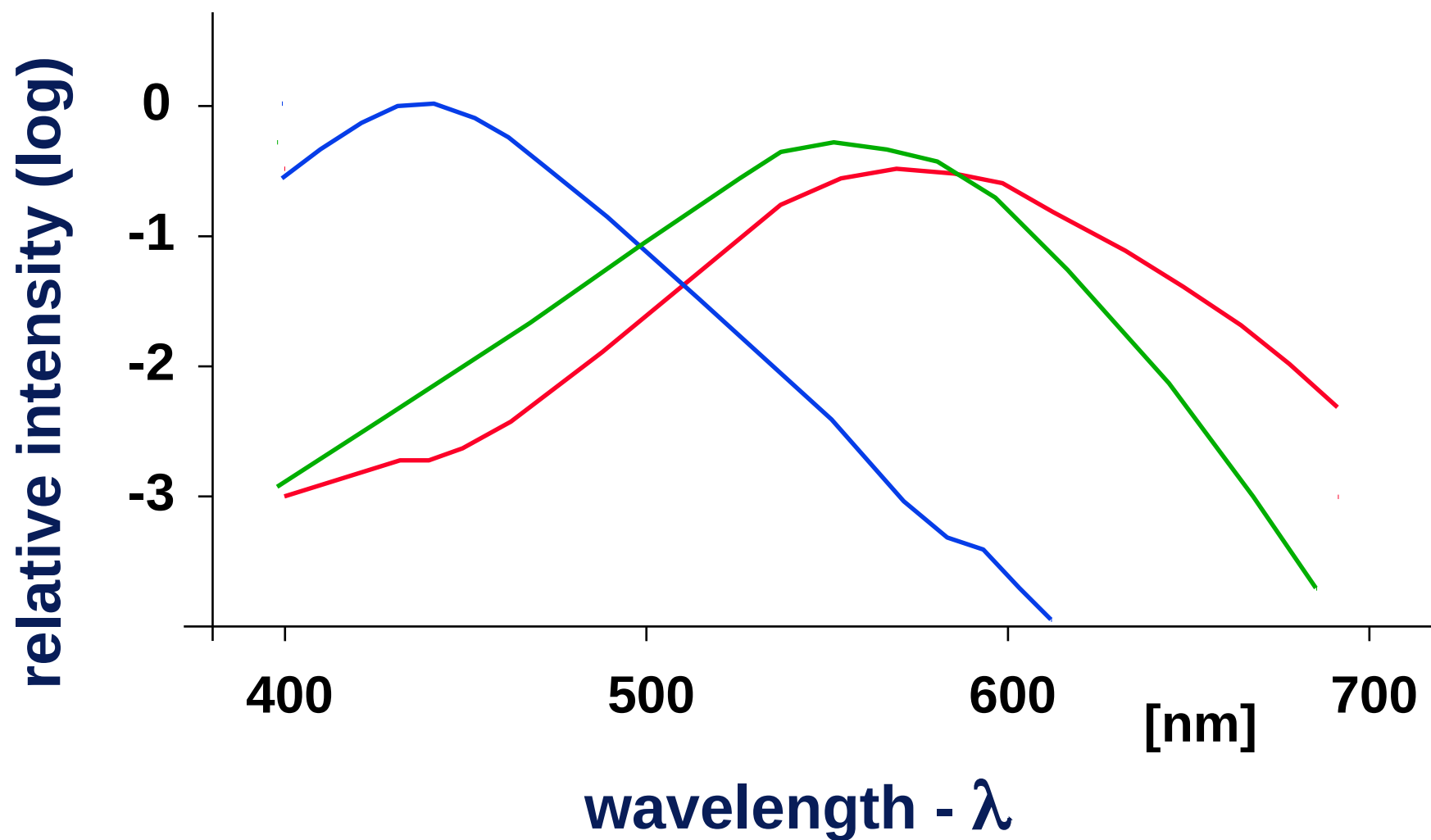


Retina

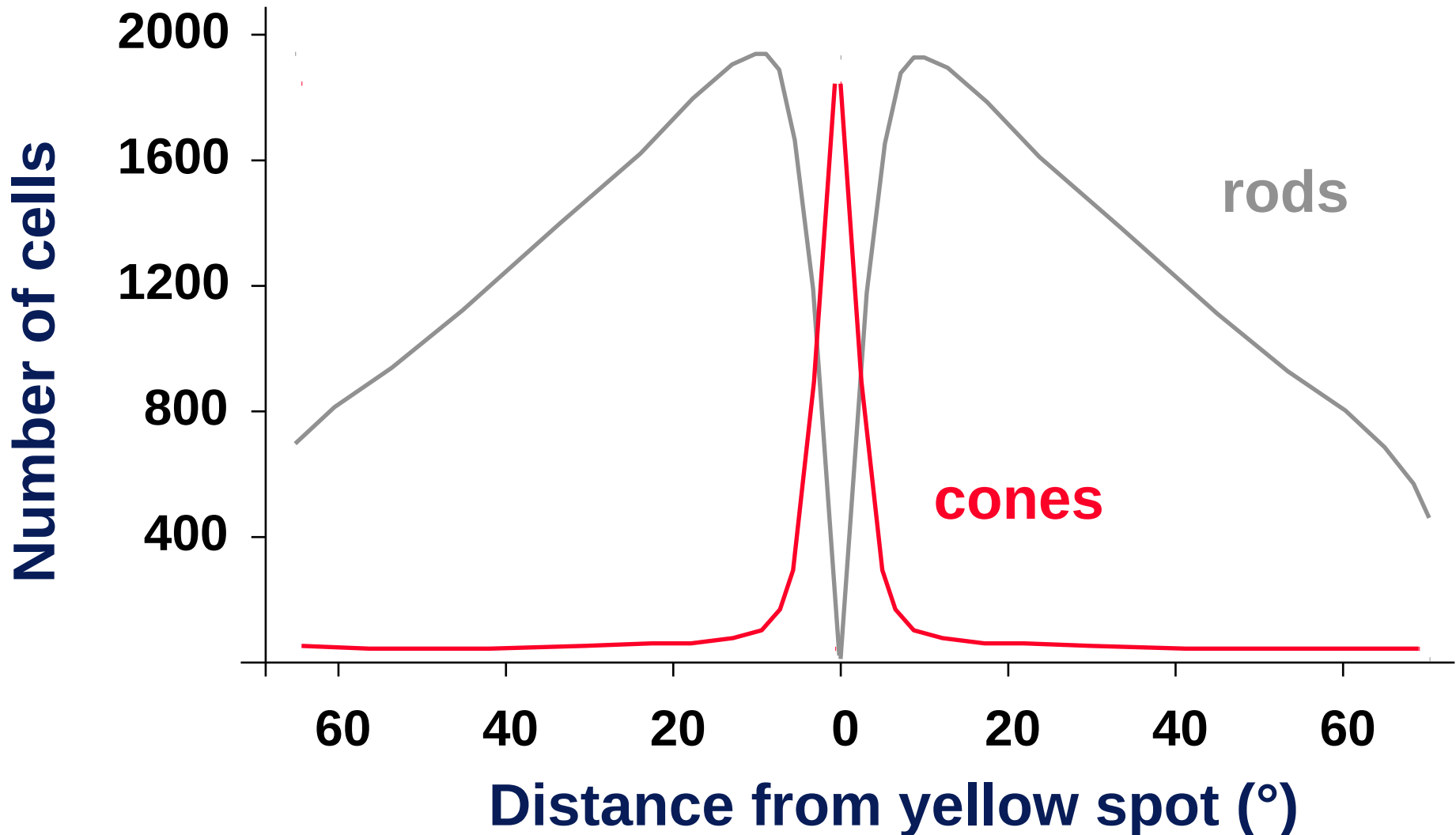




Three Photo-Pigments

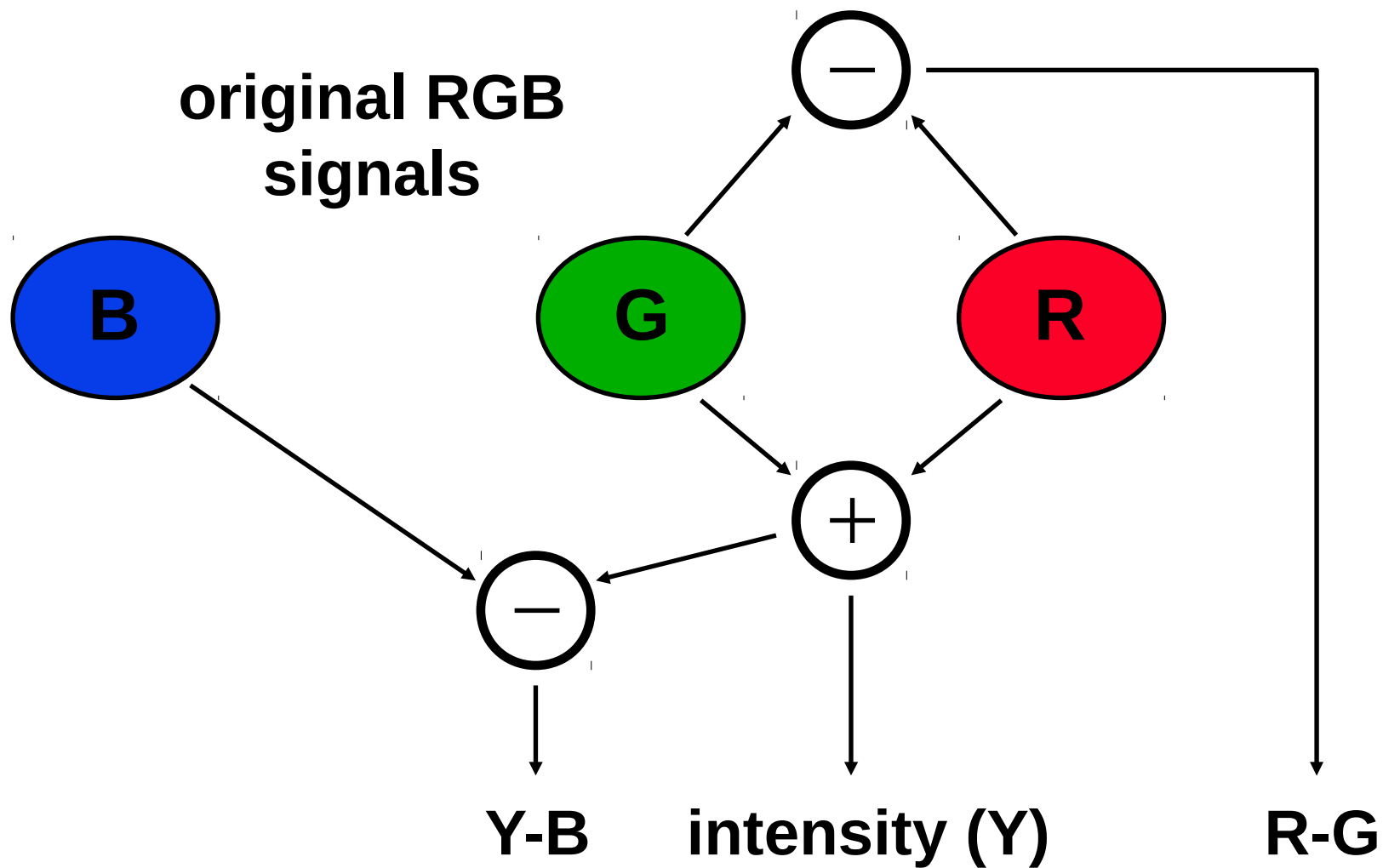


Distribution of Photo-Receptors





Retinal Colour Processing





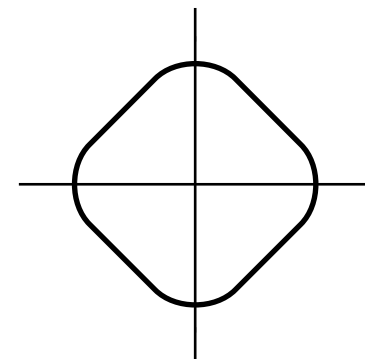
Visual System Facts

- ◆ Our relative sensitivity is different for **red** (0.3), **green** (0.6) and **blue** (0.1).
 - In addition to this, there are almost no blue cones in the yellow spot.
- ◆ Focus mainly depends on **luminance** ($Y = R + G$)
 - Which is why focusing on blue structures is hard
- ◆ **Integrating properties** of the retina
 - We are capable of seeing individual dots and their average
 - This allows the use of dithering techniques



Visual System Facts II

- ◆ **Greater resolution** in the horizontal and vertical directions
 - In the diagonals, up to 30% less
- ◆ **Focus point** varies by wavelength
- ◆ **Inertia** („afterimage”)
 - Lateral inhibition of nerve cells
- ◆ **Complex post-processing & perceptual effects**
 - Our brain compensates for deficiencies of our eyes





Visual System Facts III

- **Influence of the Environment („surround”)**
 - Colour preception depends on the surround
 - Brown does “not exist” as a primary colour
- **Lens and vitreous humour turn yellow** as we age
 - In old age, perception of short wave light is diminished
- **Colour vision defects:**
 - Fusion of the red and green receptors (or absence of either) – **the most common defect**
 - Missing blue receptors
 - Completely missing colour receptors („monochromats”)



Recommendations

- **Use colour sparingly**
 - Maximum of 4-6 main colours: tones do not count
- **Do not colour small objects and thin lines blue**
 - There are comparatively few blue sensitive cells!
- **Do not use red and green as background colour**
 - Blue and yellow work better
- **Do not draw saturated colours that are far from each other in the spectrum next to each other**
- **Use colour in a logical and consistent fashion**



Literature

- **G. Murch: *Human Factors of Color Displays***, in *Advances in Computer Graphics II*, Springer, 1986, 1-27
- **D. Pritchard: *U.S. Color Television Fundamentals - A Review***, *IEEE Transactions on Consumer Electronics*, vol. CE-23, #4, 467-478
- **J. Foley, A. van Dam, S. Feiner, J. Hughes: *Computer Graphics, Principles and Practice***, 574-579