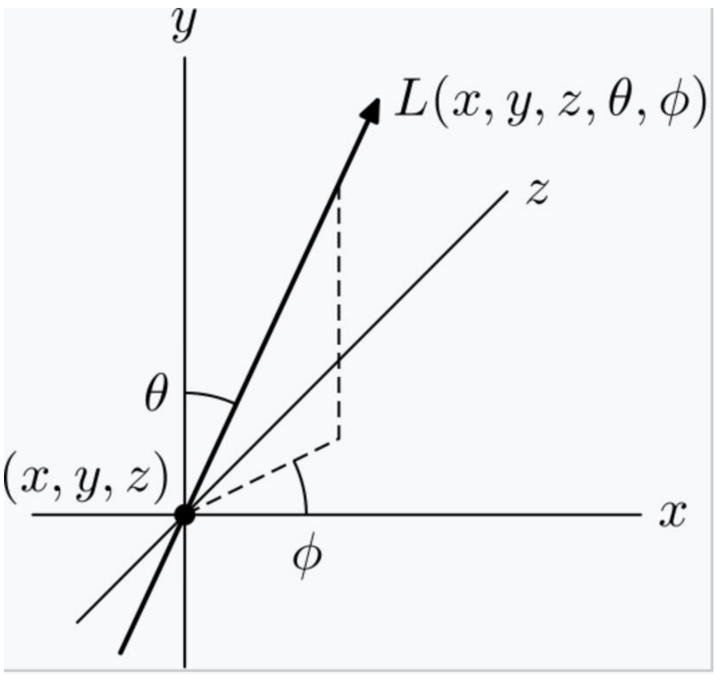
Light Field
(also called plenoptic function)

- Vector function describing amount of light (radiance) flowing in every direction through every point in space.

It is also a function of wavelength



Parameterizing a ray in 3D space by position (x, y, z) and direction (θ, ϕ).

Radiance is a function of wavelength $L(\lambda)$

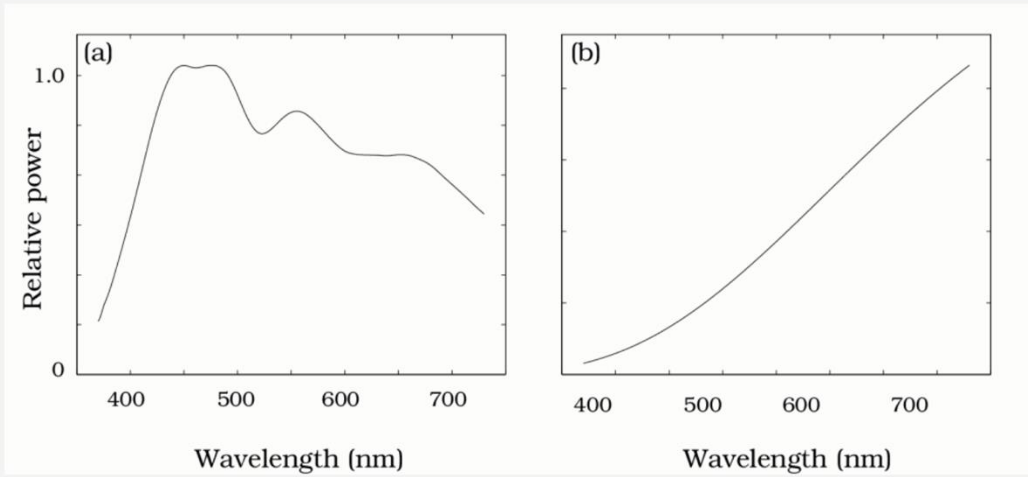
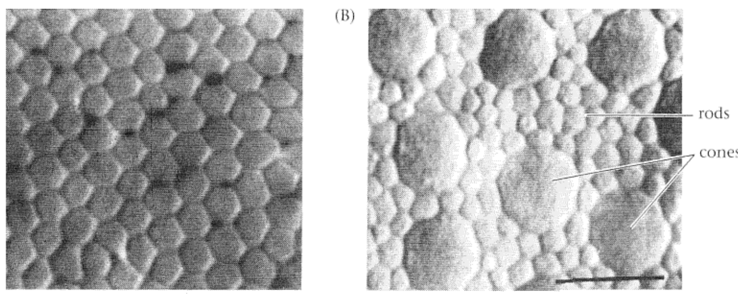


Figure 4.4. The spectral power distribution of two important light sources are shown: blue skylight (a) and the yellow disk of the sun (b).

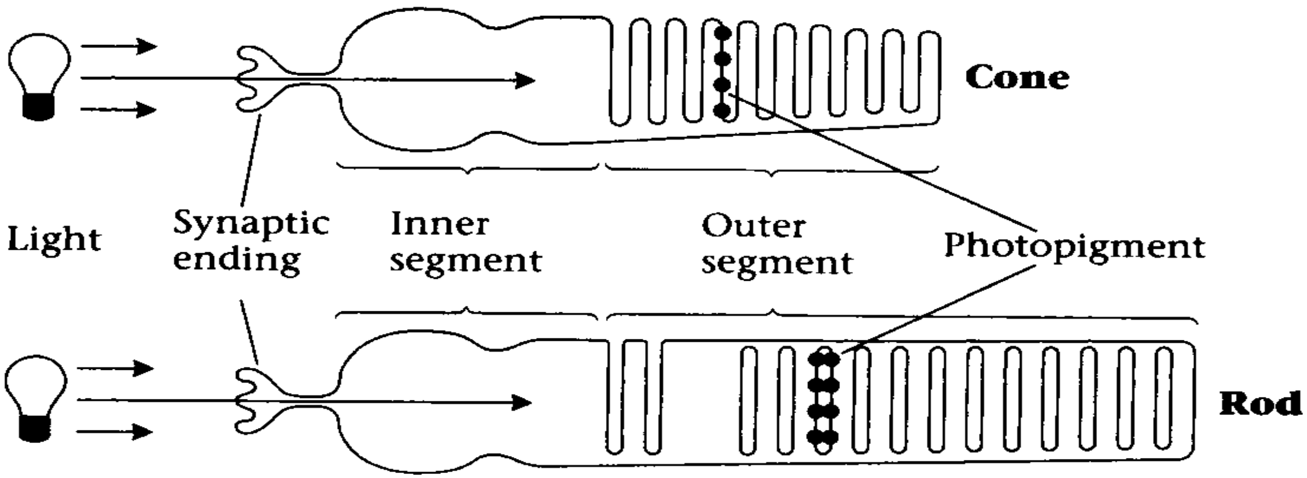
A photoreceptor's sensitivity is also a function of wavelength, $R(\lambda)$

Response = $\int L(\lambda)R(\lambda)d\lambda$

The photoreceptor mosaic: rods and cones are the eye's pixels

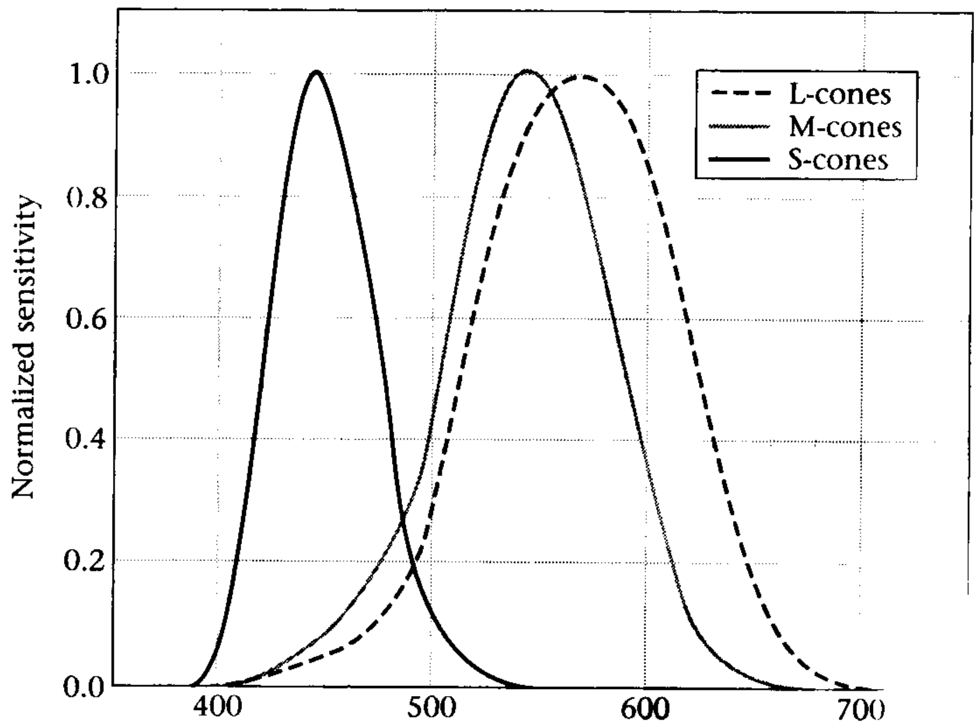


Cones and Rods

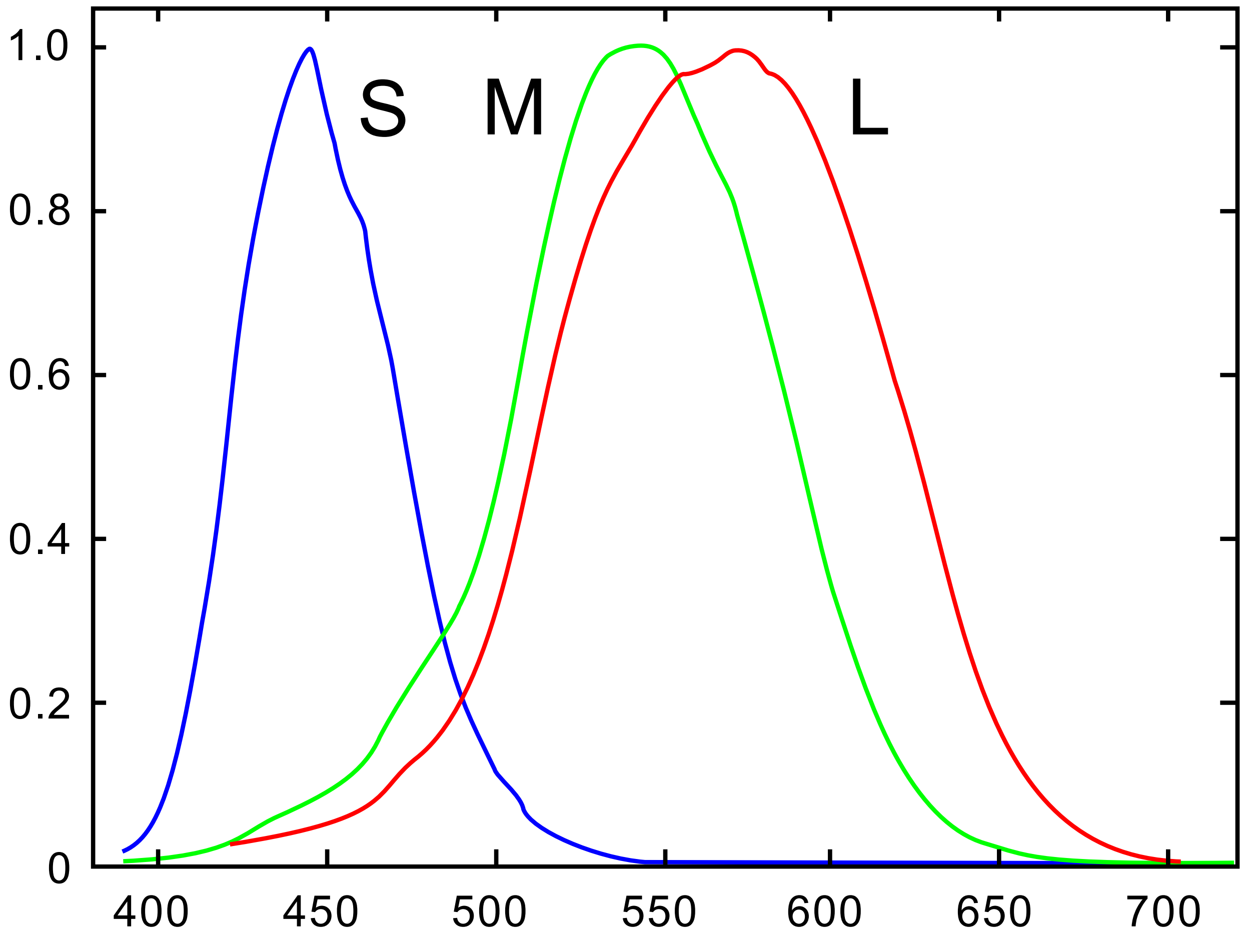


After dark adaptation, a single rod can respond to a single photon

The three cone types have different spectral sensitivity functions

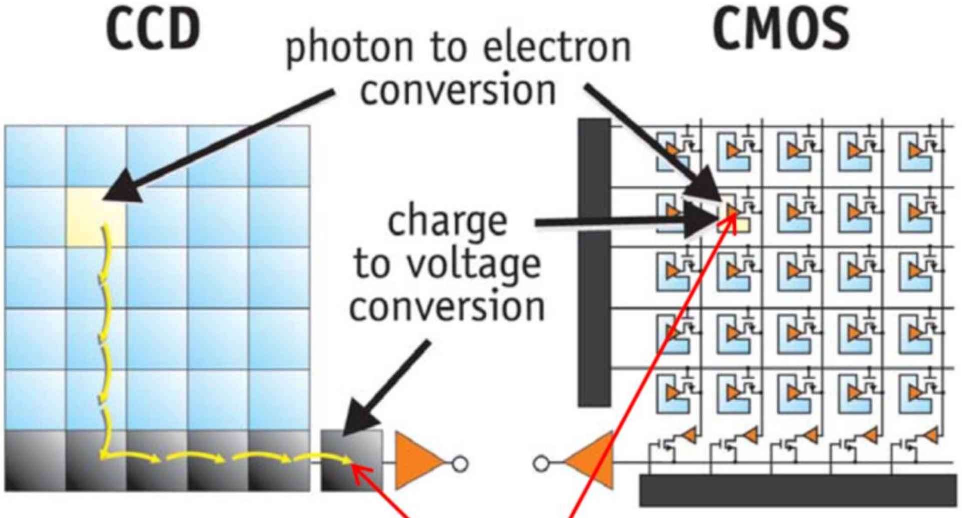


Human cone spectral sensitivity curves



Digital Cameras

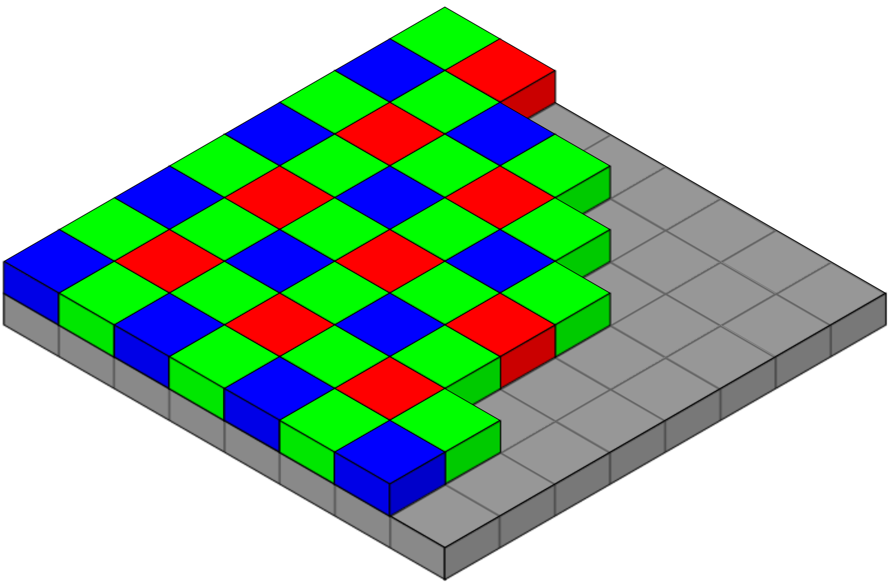
- The Charge Coupled Device was invented in 1969, based on exploiting the fact that silicon atoms can release electrons when hit by photons. Nowadays CMOS imagers are more common. The key difference is in how the charge generated is converted to a voltage (when digitized this becomes the pixel brightness value)

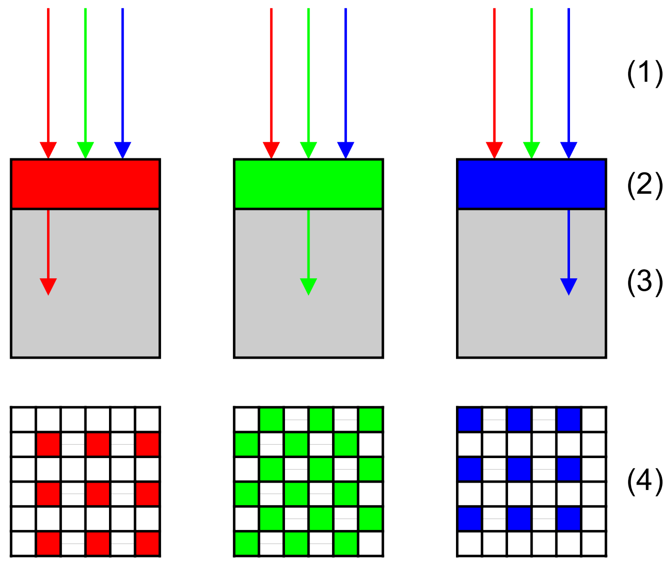


CCDs move photogenerated charge from pixel to pixel and convert it to voltage at an output node. CMOS imagers convert charge to voltage inside each pixel.

“Bayer” patterns are used in digital cameras

3 different filters are put in front of each pixel





The principle of univariance

- The response of a photoreceptor is a function of the number of photons absorbed
- Thus a weak light at the wavelength of peak sensitivity could have the same response as a strong light at a wavelength of lower sensitivity

We can approximate the spectral power distribution and receptor sensitivity function as vectors indexed by wavelength

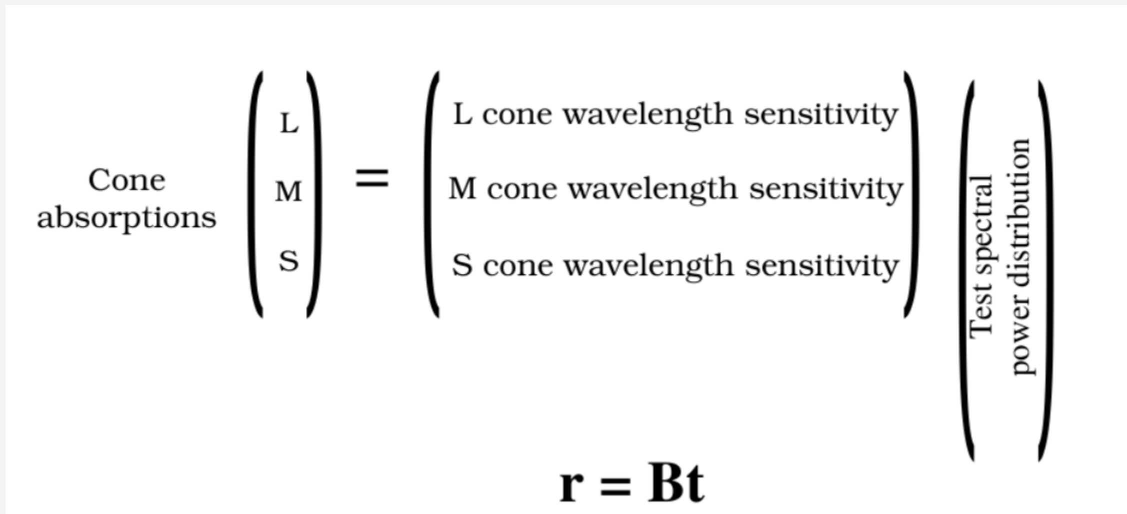
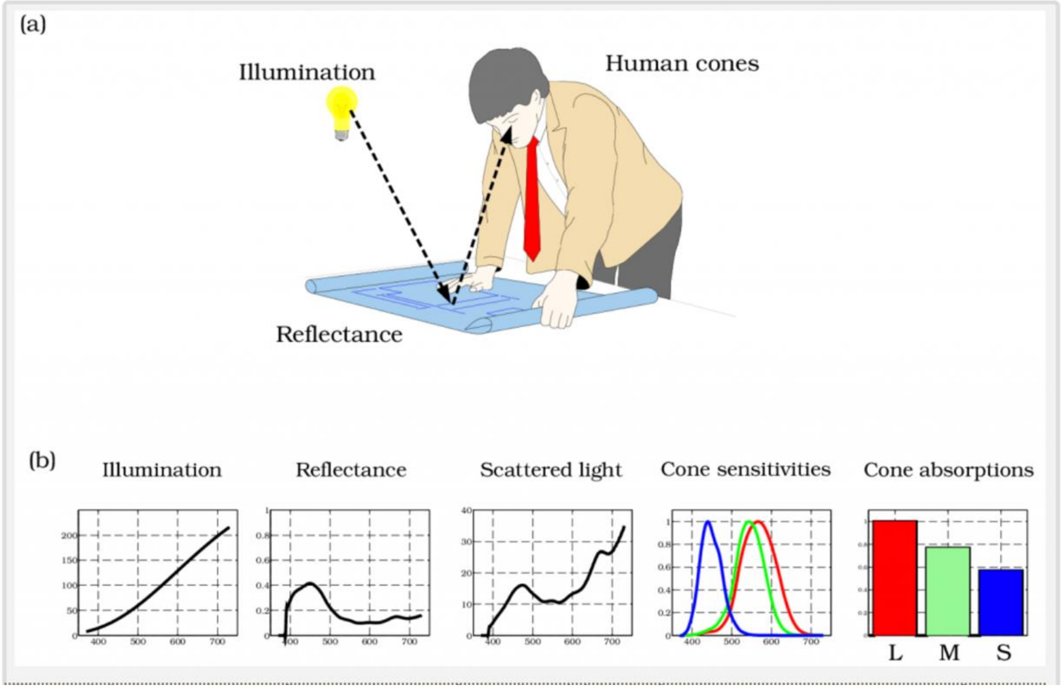
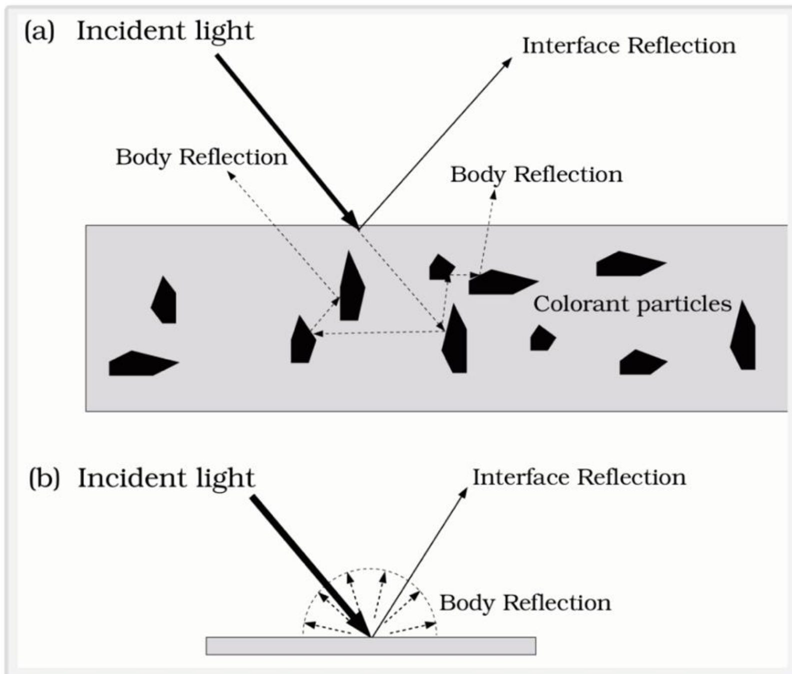


Figure 4.18: Cone photopigments and the color-matching functions. If we measure the wavelength sensitivity of each of the cone photopigments, we can create a 3 x N system matrix to describe the cone absorptions. Then, we

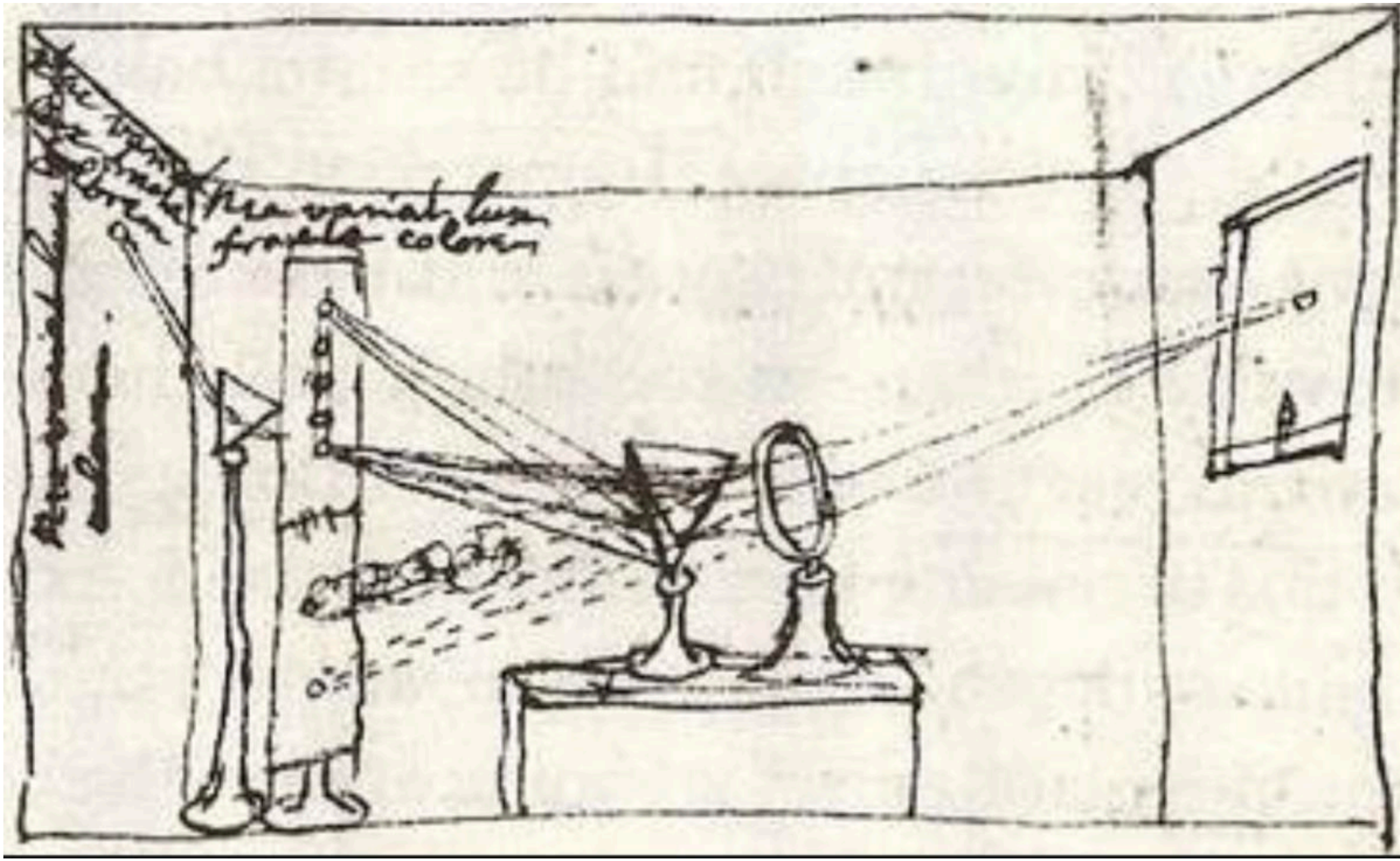
Outgoing = Reflectance * Incoming



Dichromatic model of color



Newton vs. the painters



Are there three colors or infinitely many?

Any test light can be matched by a mixture of three lights

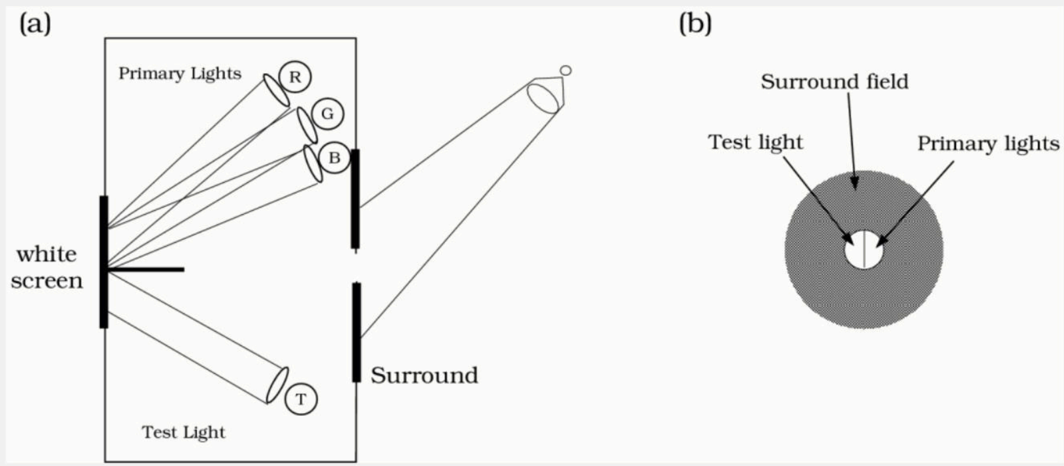


Figure 4.12: The color-matching experiment.} The observer views a bipartite field and adjusts the intensities of the three primary lights to match the appearance of the test light. (a) A side-view of the experimental apparatus. (b) The appearance of the stimuli to the observer. (After Judd and Wyszecki, 1975.

Young-Helmholtz Trichromacy theory

- There are three cone types with different spectral sensitivity curves
- Because of this, metamers will exist – lights with different spectral power distribution which evoke exactly the same response in the three different cone types. A human observer will not be able to distinguish among these lights.

An extreme example of metamerism

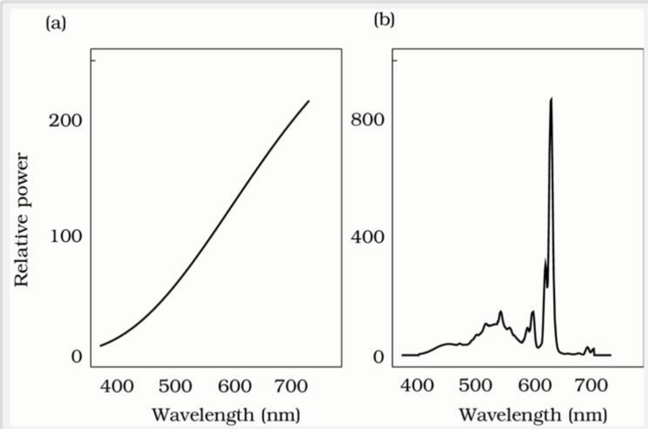
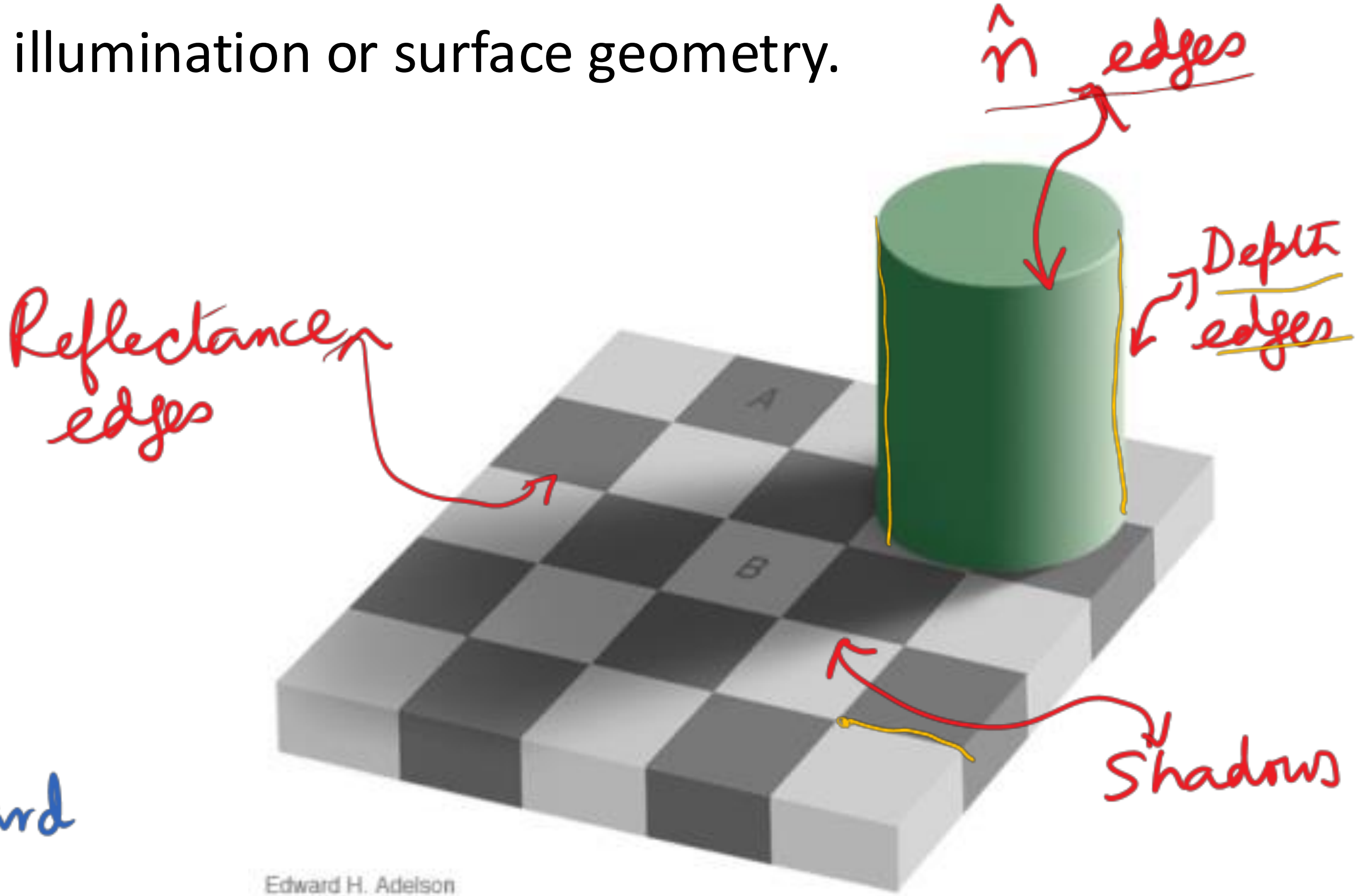


Figure 4.13: Metameric lights. Two lights with these spectral power distributions appear identical to most observers and are called metamers. The curve in part (a) is an approximation to the spectral power distribution of the sun. The curve in part (b) is the spectral power distribution of a light emitted from a conventional television monitor whose three phosphor intensities were set to match the light in (a) in appearance.

Edges are important

- Edges are curves in the image, across which the brightness changes “a lot”. These arise because of discontinuities in reflectance, illumination or surface geometry.



Adelson's checkerboard illusion