

What about the color of the light?

So far, we have not dealt with the color of the light--the implicit assumption being that it does not change the color of anything.

This is clearly not the case!

Naïve (but common) model

Consider the color of the light to be specified by its (R,G,B)--technically the color of a perfect uniform reflector (white surface).

Similarly, now specify the albedo as a triple--one for each channel. The color of a Lambertian surface is then:

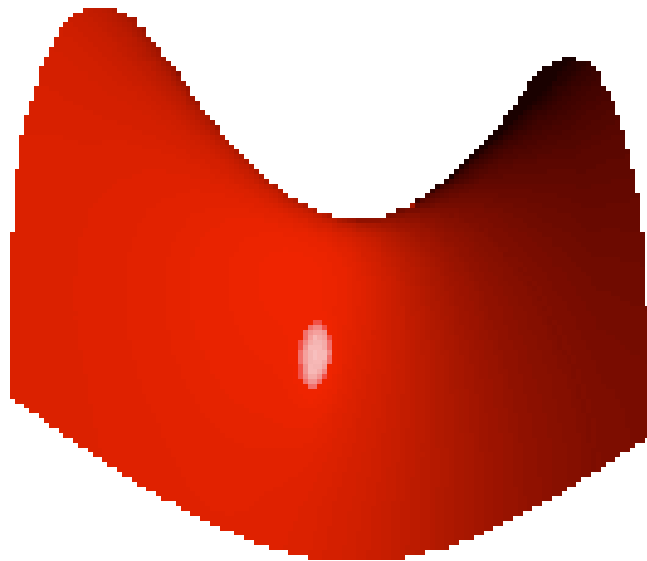
$$(R, G, B) = (\alpha_R S_R, \alpha_G S_G, \alpha_B S_B)(\mathbf{n} \bullet \mathbf{s})$$

Naïve (but common) model

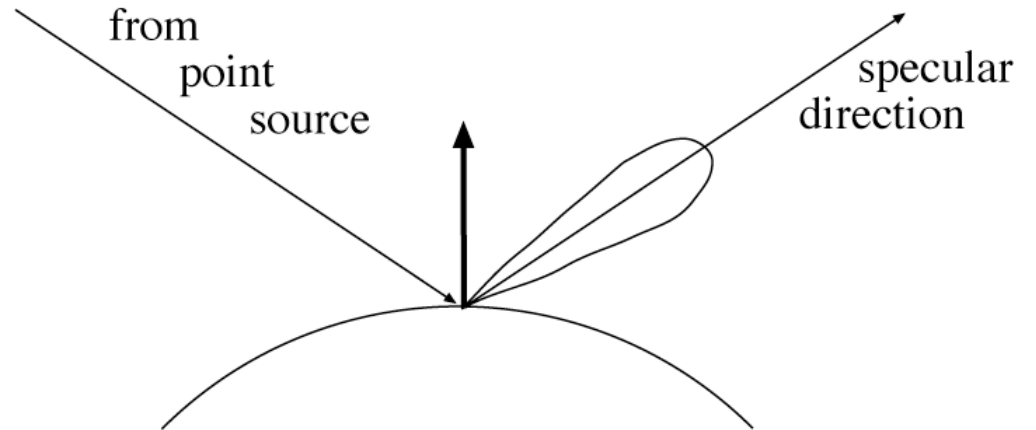
Naïve because we assume that the red part of the light does not interact with green or blue albedos, etc.

(Referred to as the diagonal model)

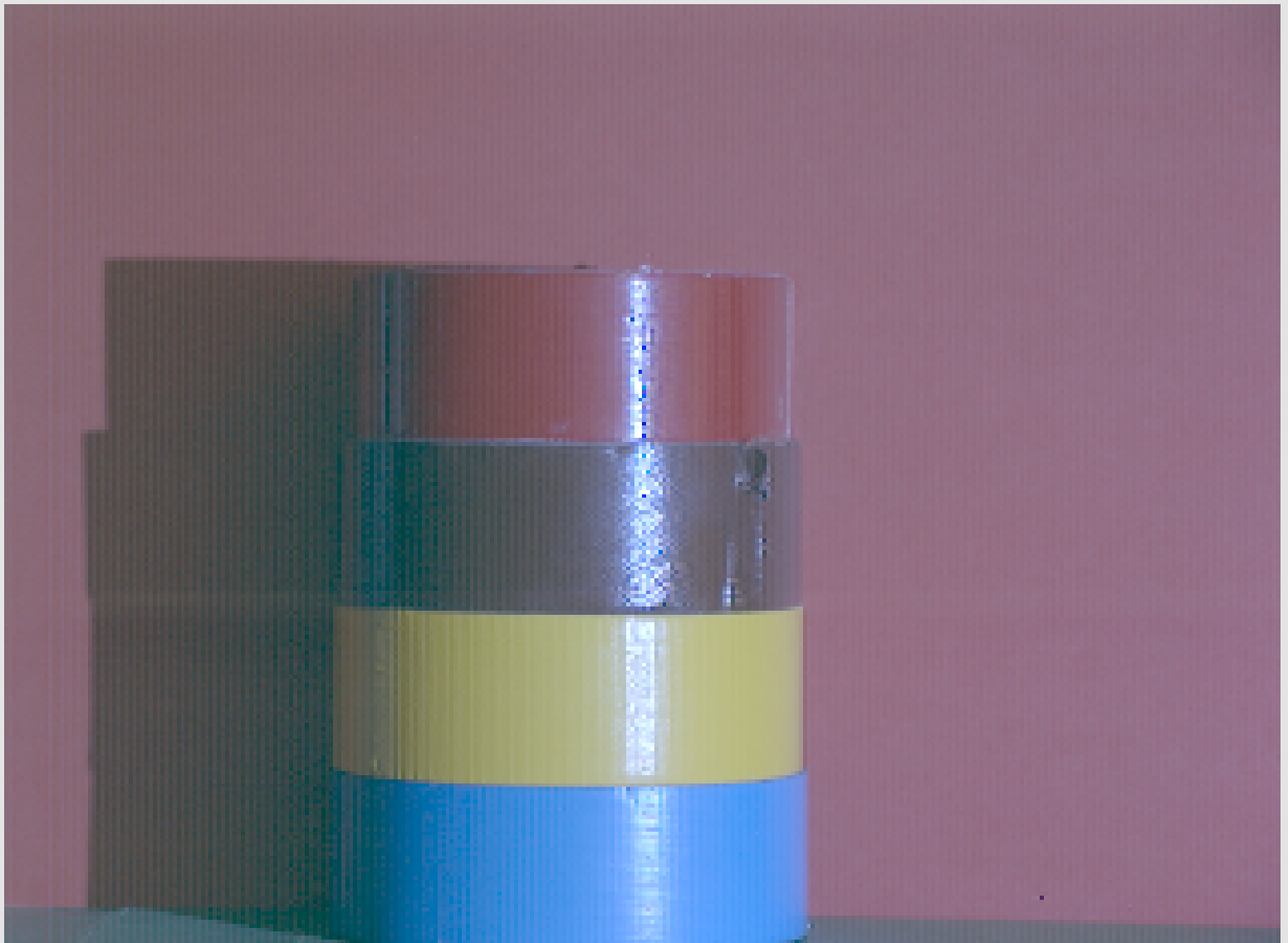
What about specular surfaces?



Specular surfaces



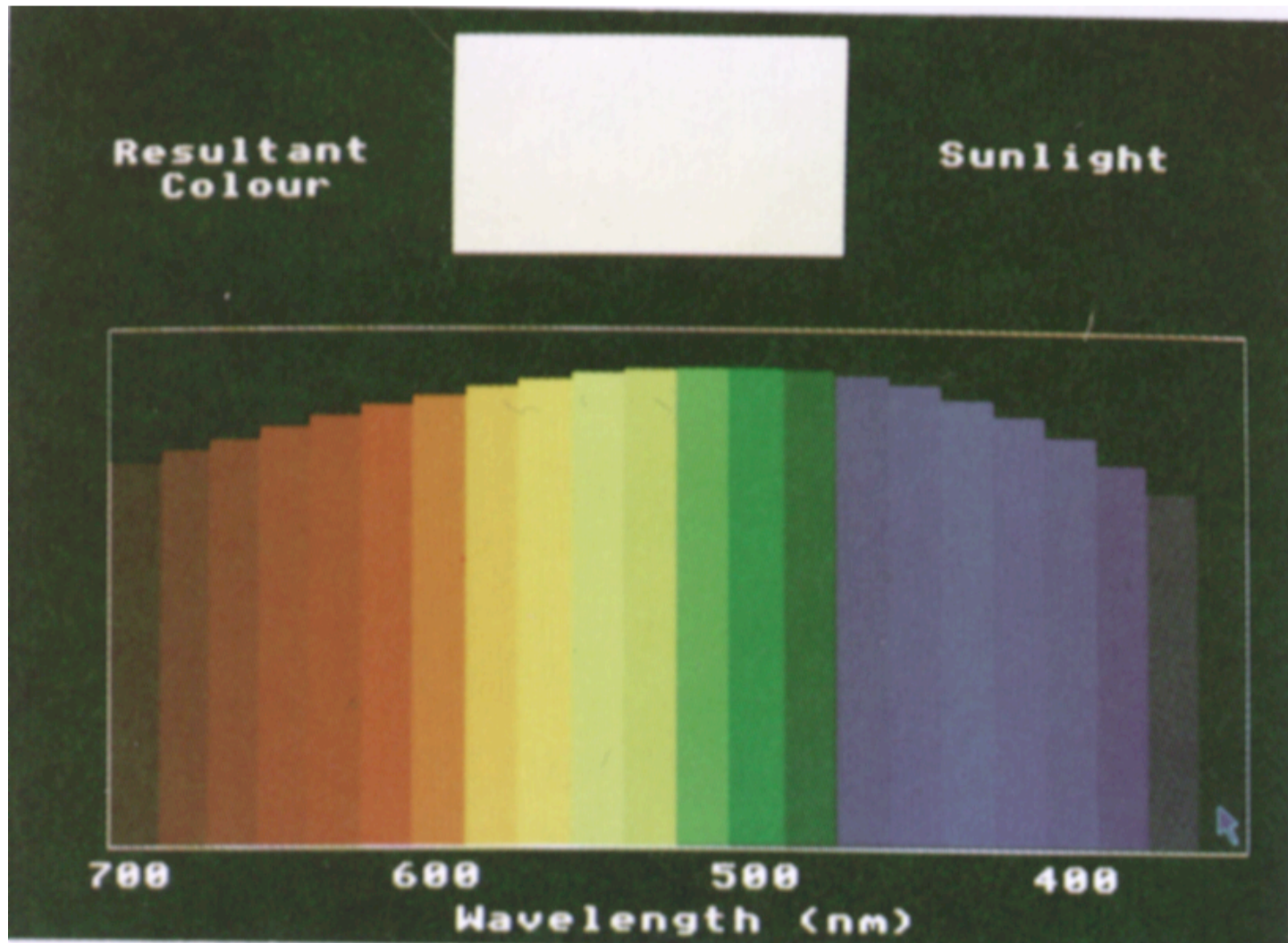
- Important point: The specular part of the reflected light usually carries the color of the **light**
- Technically, this is the case for dielectrics--plastics, paints, glass.
- Important exception is metals (e.g. gold, copper)



The colors of the rainbow

- Light is electromagnetic radiation, occurring at different wavelengths (or photon energies)
- The radiation around us is a mix of these
- Visible portion is about 400 to 700 nm
- Certain applications may require modeling some UV also.
- Light is specified by its spectrum recording how much power is at each wavelength.

Sunlight



Two disparate source spectra

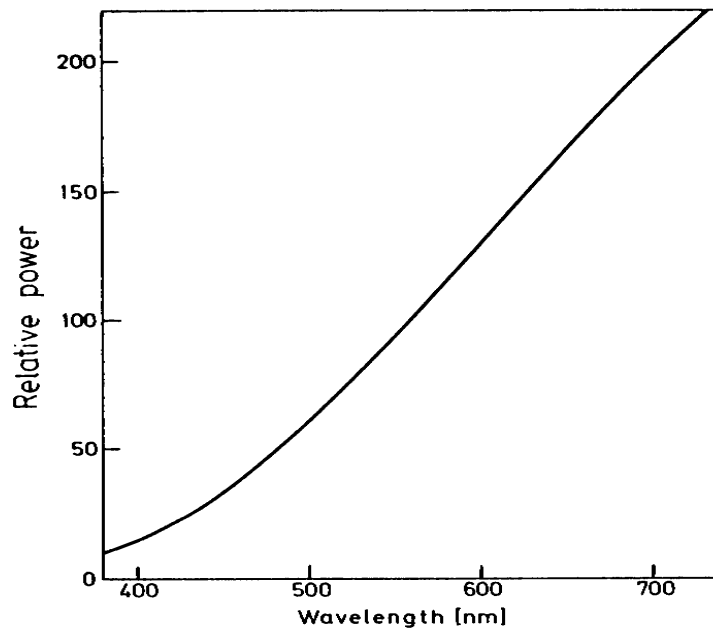


Fig. 4.1. Wavelength composition of light from a tungsten-filament lamp [typified by CIE ILL A (Sect. 4.6)]. Relative spectral power distribution curve. Color temperature: 2856 K

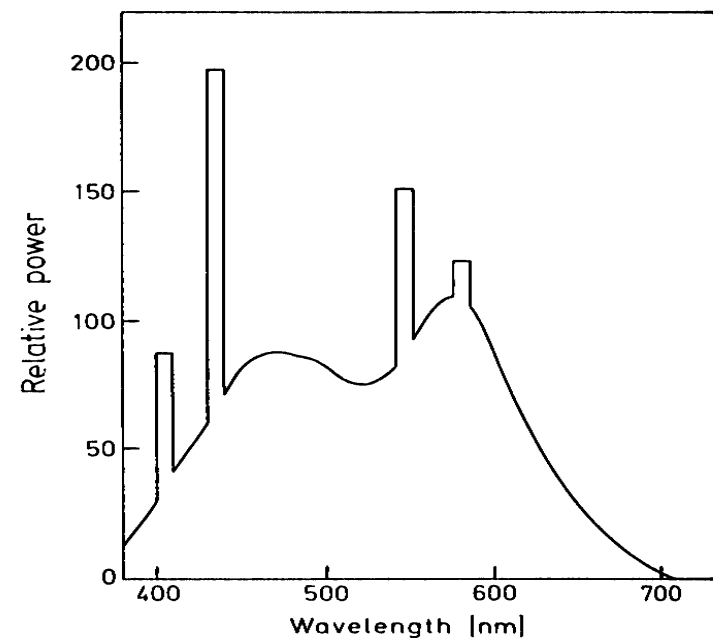
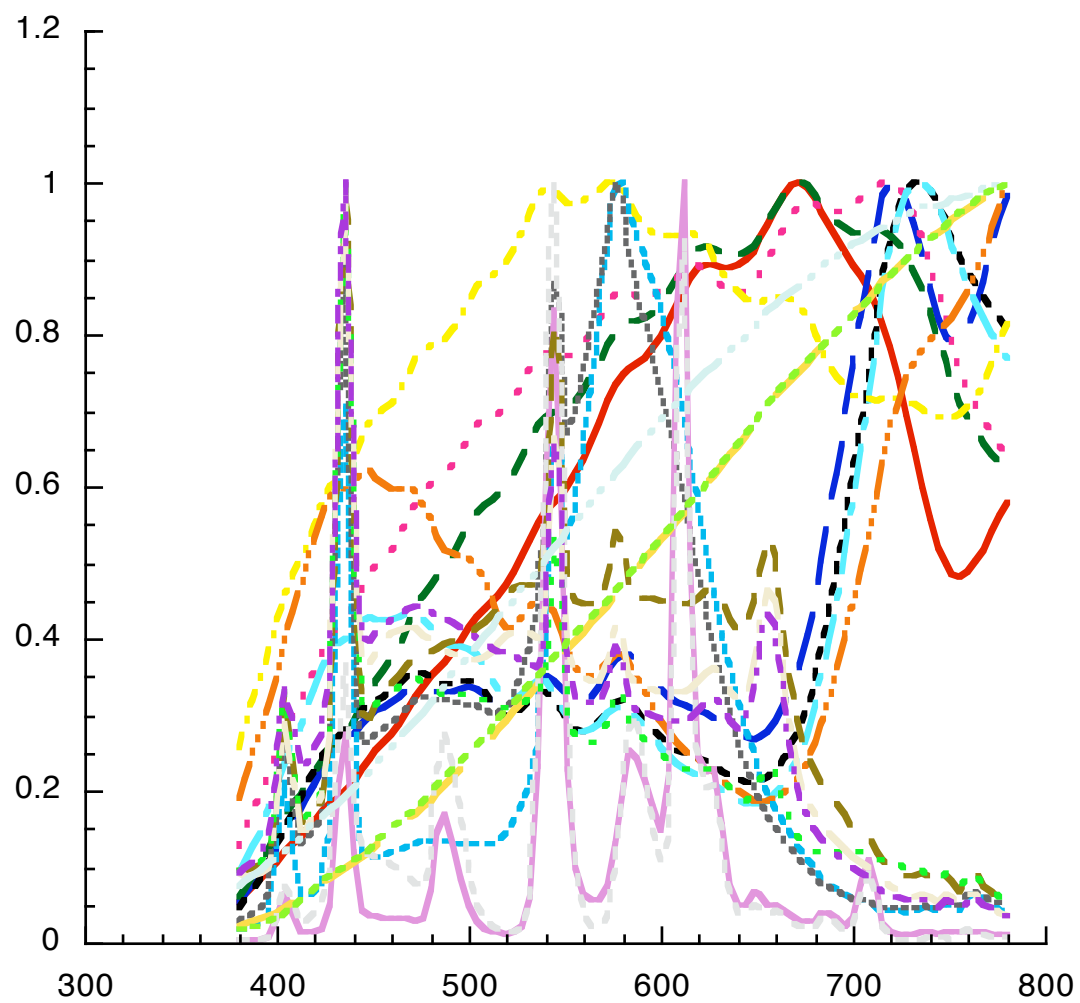


Fig. 4.2. Wavelength composition of light from a daylight fluorescent lamp. Typical relative spectral power distribution curve. Correlated color temperature: 6000 K. (Based on data of Jerome reported in [Ref. 3.14, p. 37])



Radiometry for colour

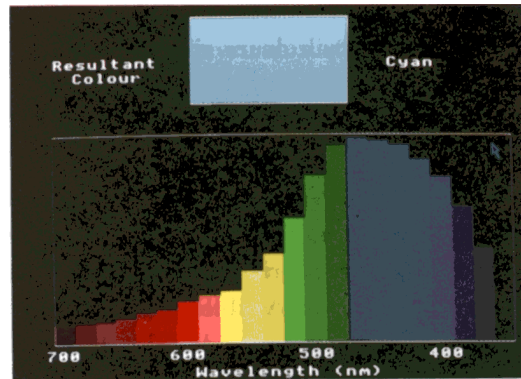
- All definitions are now “per unit wavelength”
- All units are now “per unit wavelength”
- All terms are now “spectral”
- Radiance becomes spectral radiance
 - watts per square meter per steradian per unit wavelength
- Radiosity --- spectral radiosity

Causes of colour

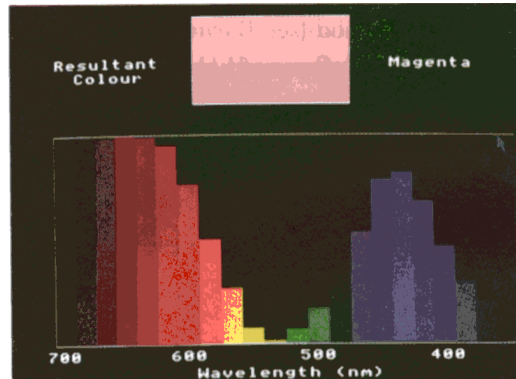
- The sensation of colour is caused by the brain.
- One way to get it is the response of the eye to the presence/absence of light at various wavelengths.
- Light could be emitted with wavelengths absent -e.g. fluorescent light vs. incandescent light.
- It could be differentially reflected - e.g. paint on a surface.
- It could be differentially refracted - e.g. Newton's prism
- Wavelength dependent specular reflection - e.g. shiny copper penny (actually most metals).
- Fluorescence - light at invisible wavelengths is absorbed and reemitted at visible wavelengths.
- Dreaming, hallucination, etc.
- Pressure on the eyelids

Absorbption spectra: real pigments

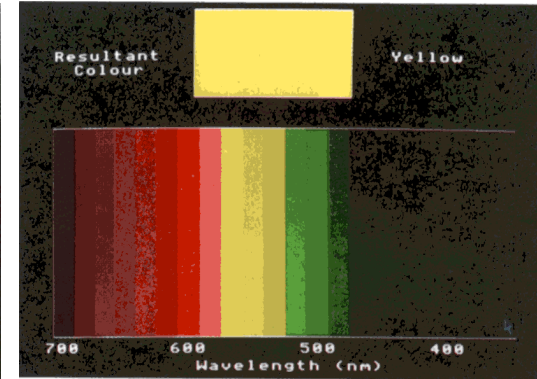
cyan



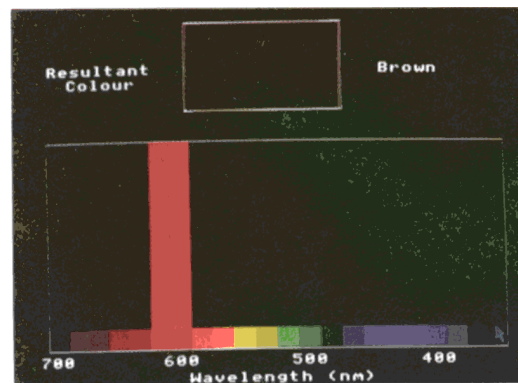
magenta



yellow

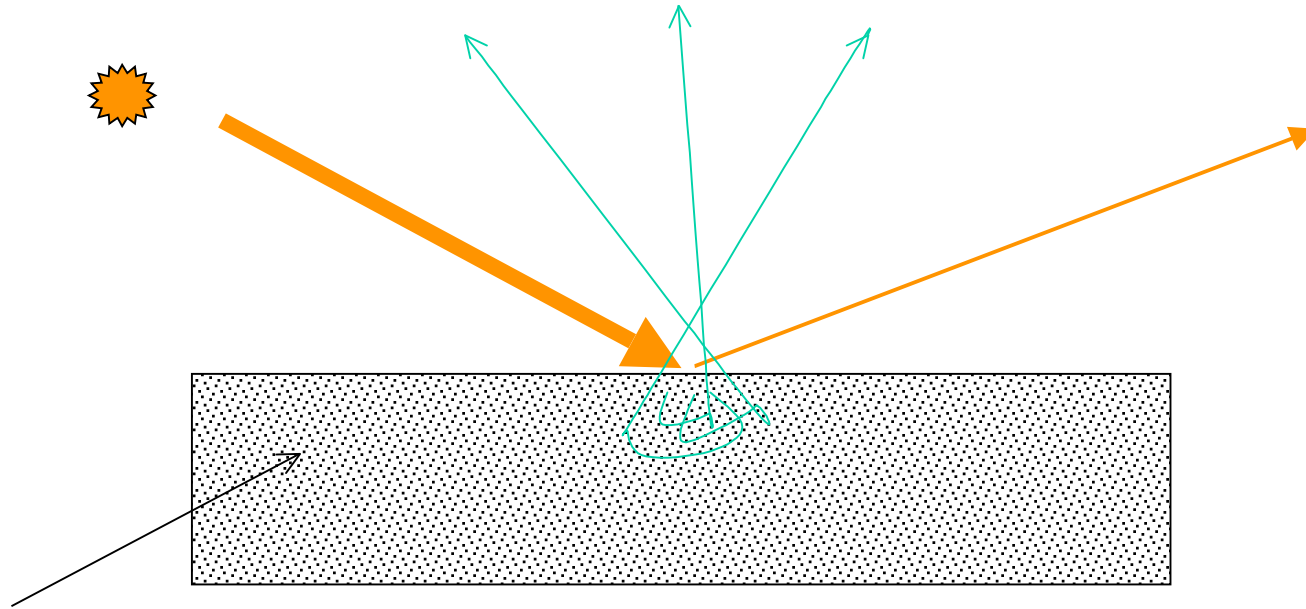


brown

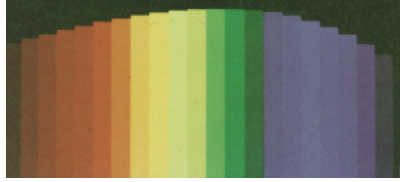


Example: Dielectrics

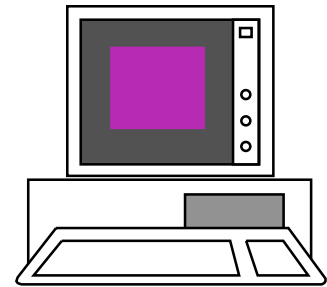
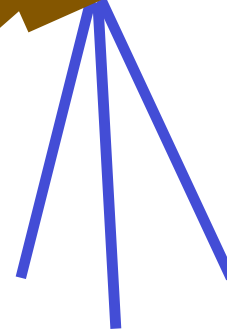
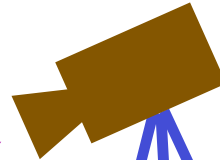
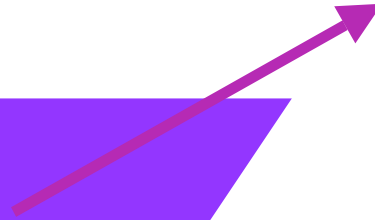
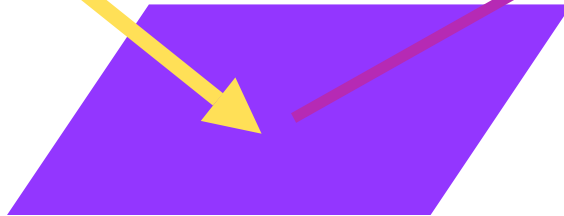
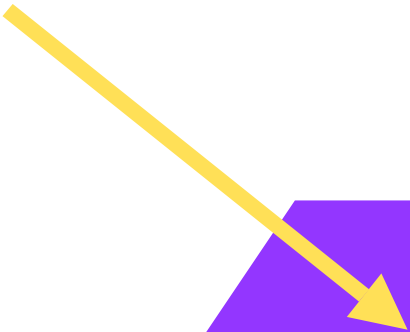
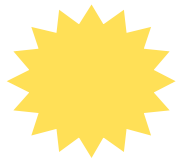
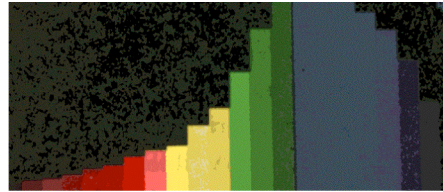
- Examples: Paints, plastics
- Reasonably well approximated by a specular part and a Lambertian body part.



Non conductive matrix with scattering particles of the order of the wavelength of light---note: the same general process explains why the sky is blue.



X

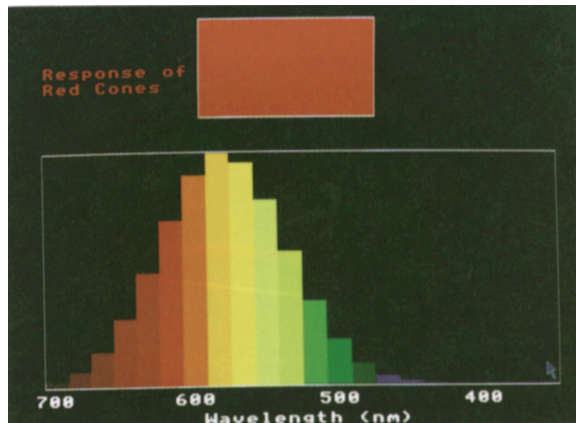


Trichromaticity

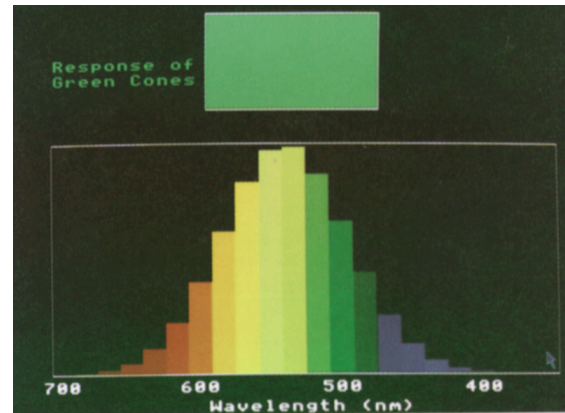
Empirical fact--colors can be approximately described/matched by three quantities (assuming normal color vision).

Need to reconcile this observation with the spectral characterization of light

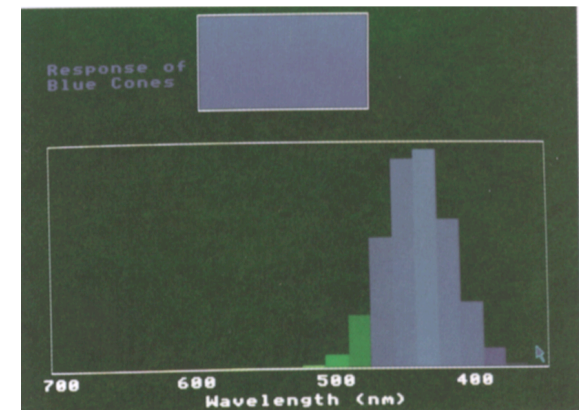
Color receptors



“Red” cone



“Green” cone



“Blue” cone

Principle of univariance: cones give the same kind of response, in different amounts, to different wavelengths. Output of cone is obtained by summing over wavelengths.

Responses measured in a variety of ways

$$\text{Response of } k\text{'th cone} = \int \rho_k(\lambda) E(\lambda) d\lambda$$