Flat shading

- Compute shading value inside polygon using interpolate
- Flat shading
  - Use polygon normal for Lambertian shading
  - Advantages:
    - fast -- one shading value per polygon
  - Disadvantages:
    - inaccurate -- looks blocky

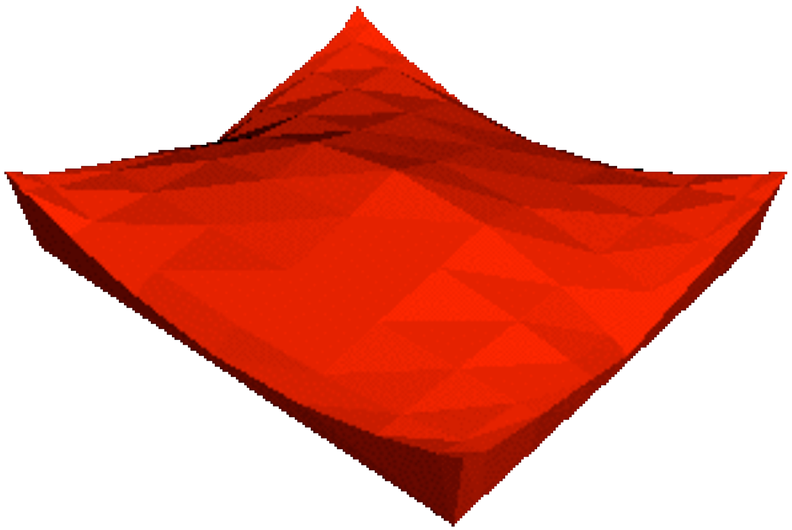
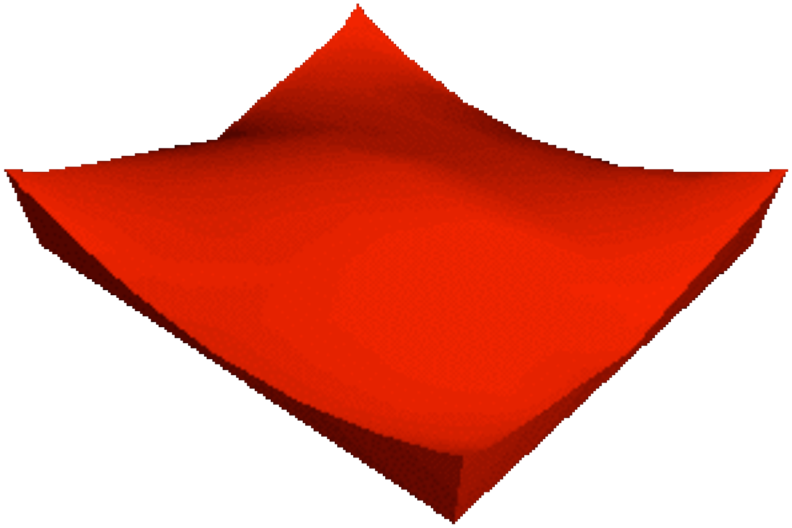


Figure from http://freespace.virgin.net/hugo.elias/graphics/x_polygo.htm

Gouraud (Interpolated) Shading

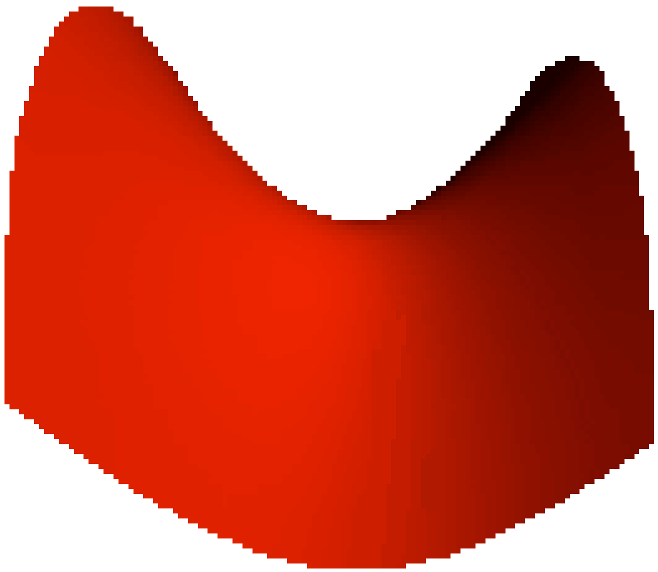
- Use normal at each vertex of polygon
  - known either from the “mesh” construction, OR, average normals where polygons meet.
- Shade these, and linearly interpolate
- Advantages
  - fast (interpolation can even be put into scan line algorithm)
  - much smoother
- Disadvantages:
  - specularities get lost



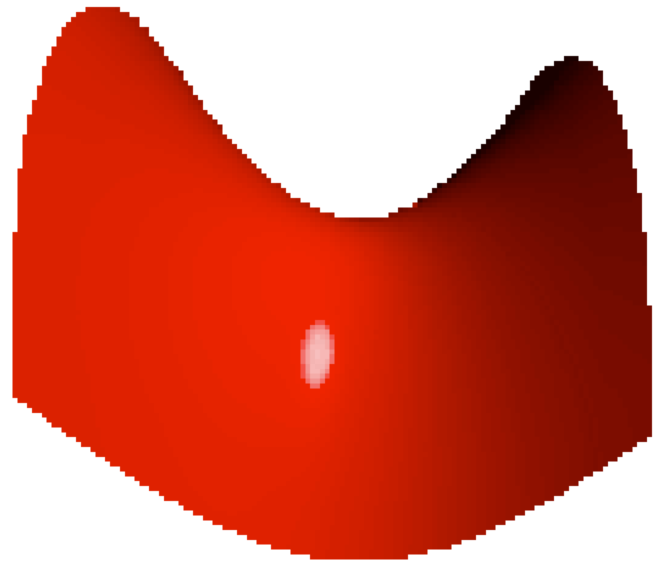
Phong Shading

- Interpolate normals instead of pixel values
  - Shade using normal estimate for each point
  - Advantag
    - high quality, narrow specularities
  - Disadvantage
    - more expensive than Gouraud

Gouraud



Phong



from
http://www.geocities.com/SiliconValley/Horizon/6933/shading.html

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 is “white” and thus does not change the color of anything.

This is often 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:

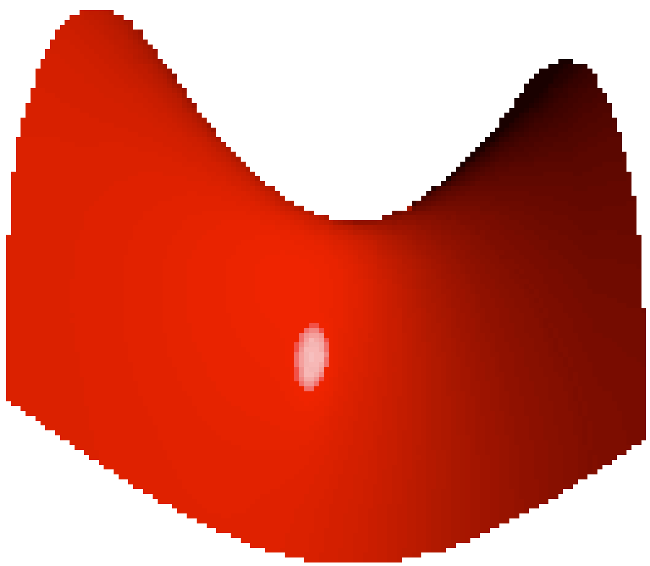
$$(R, G, B) = (\rho_R S_R,\ \rho_G S_G,\ \rho_B S_B)(\mathbf{n} \bullet \mathbf{s})$$

Naïve (but common) model

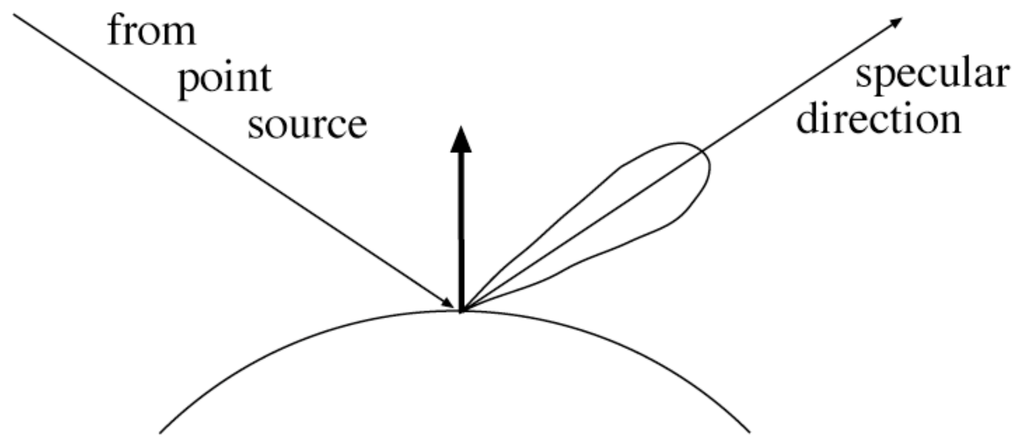
Naïve because we assume that the red part of the light does not interact with green or blue albedos, etc.

(Referred to as the diagonal model)

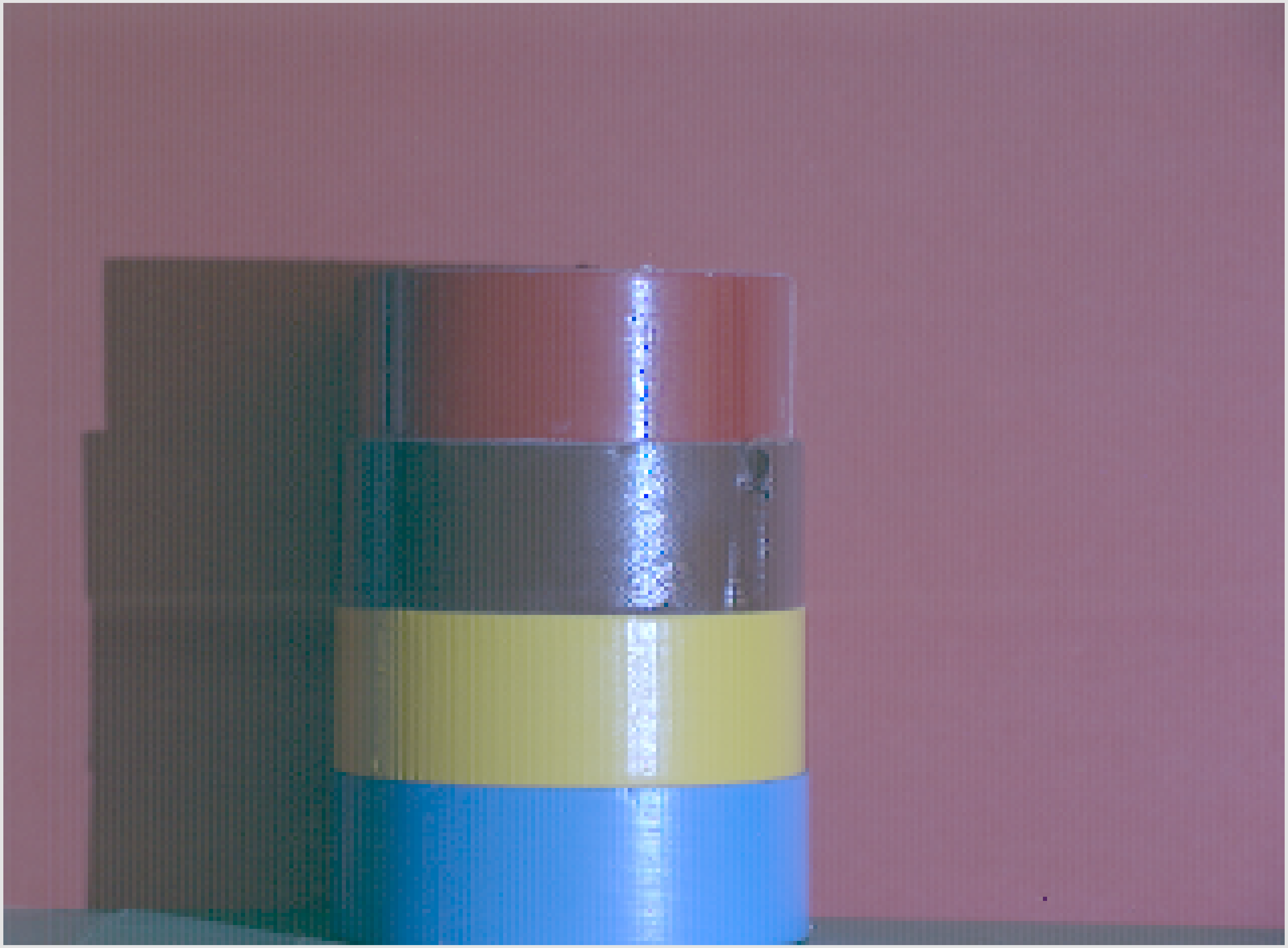
What about specular surfaces?



Specular surfaces

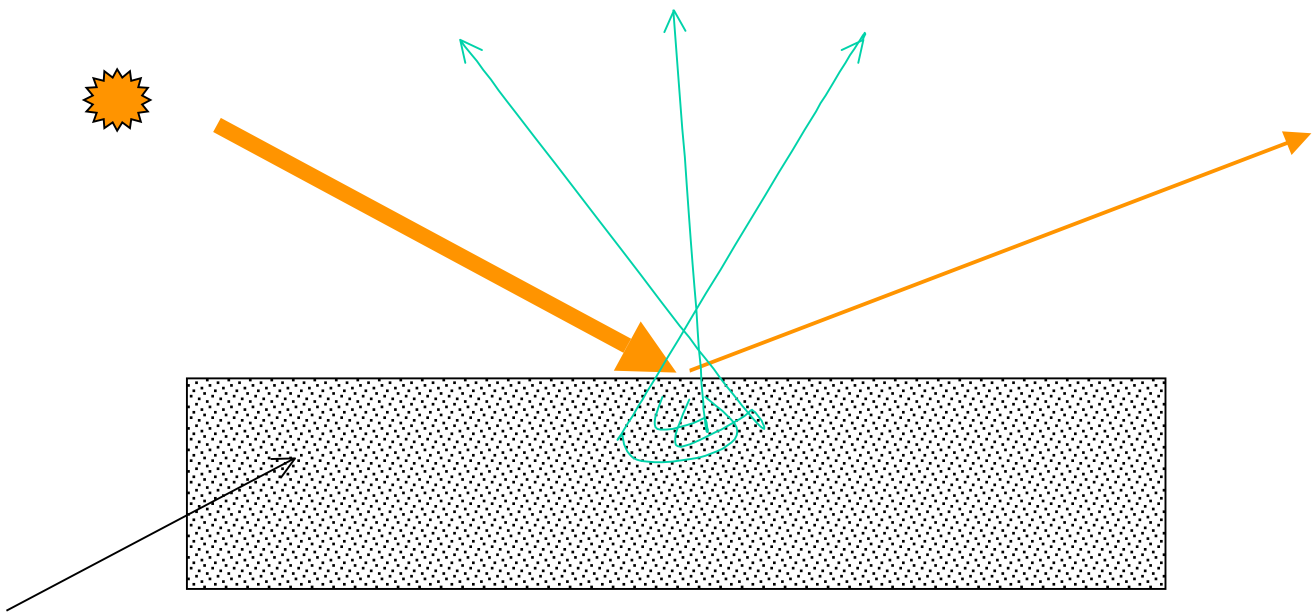


- Important point: The specular part of the reflected light usually carries the color of the **light**
- Technically, this is the case for dielectrics--plastics, paints, glass.
- Important exception is metals (e.g. gold, copper)



Example: Dielectrics

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

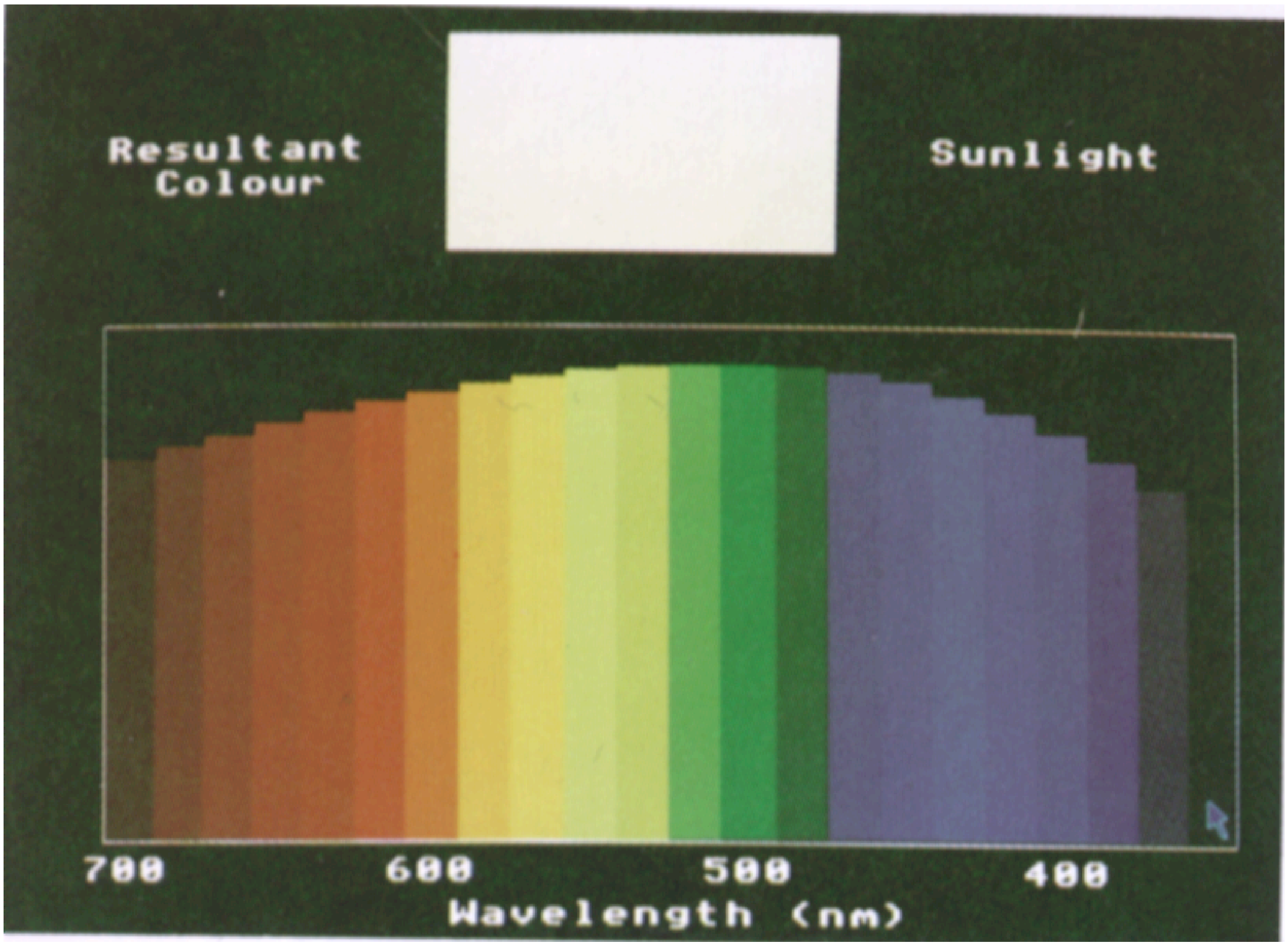


Non conductive matrix with scattering particles of the order of the wavelenth of light---note: the same general process explains why the sky is blue.

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

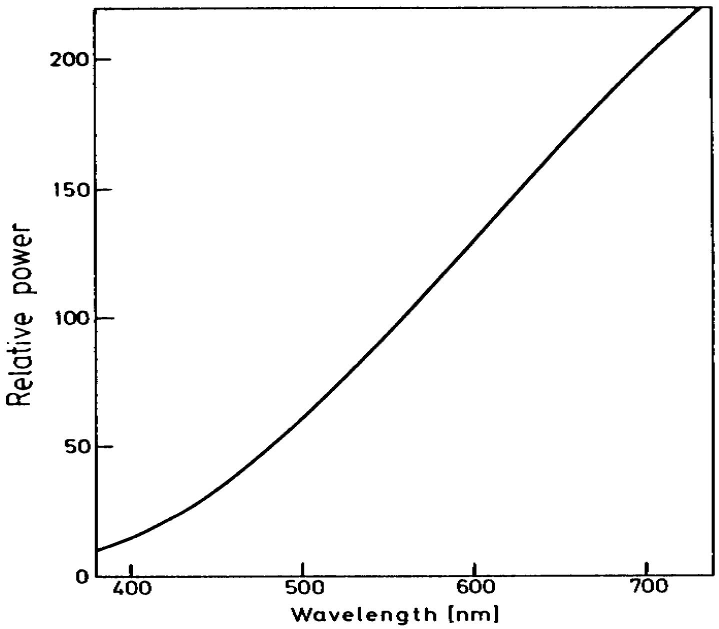


Fig. 4.1. Wavelength composition of light from a tungsten-filament lamp [typified by CIE ILL A (Sect. 4.6)]. Relative spectral power distribution curve. Color temperature: 2856 K

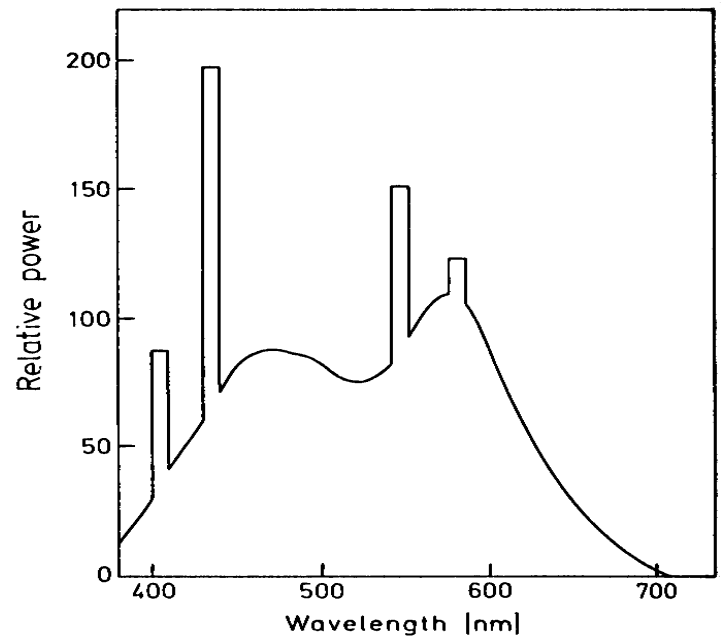
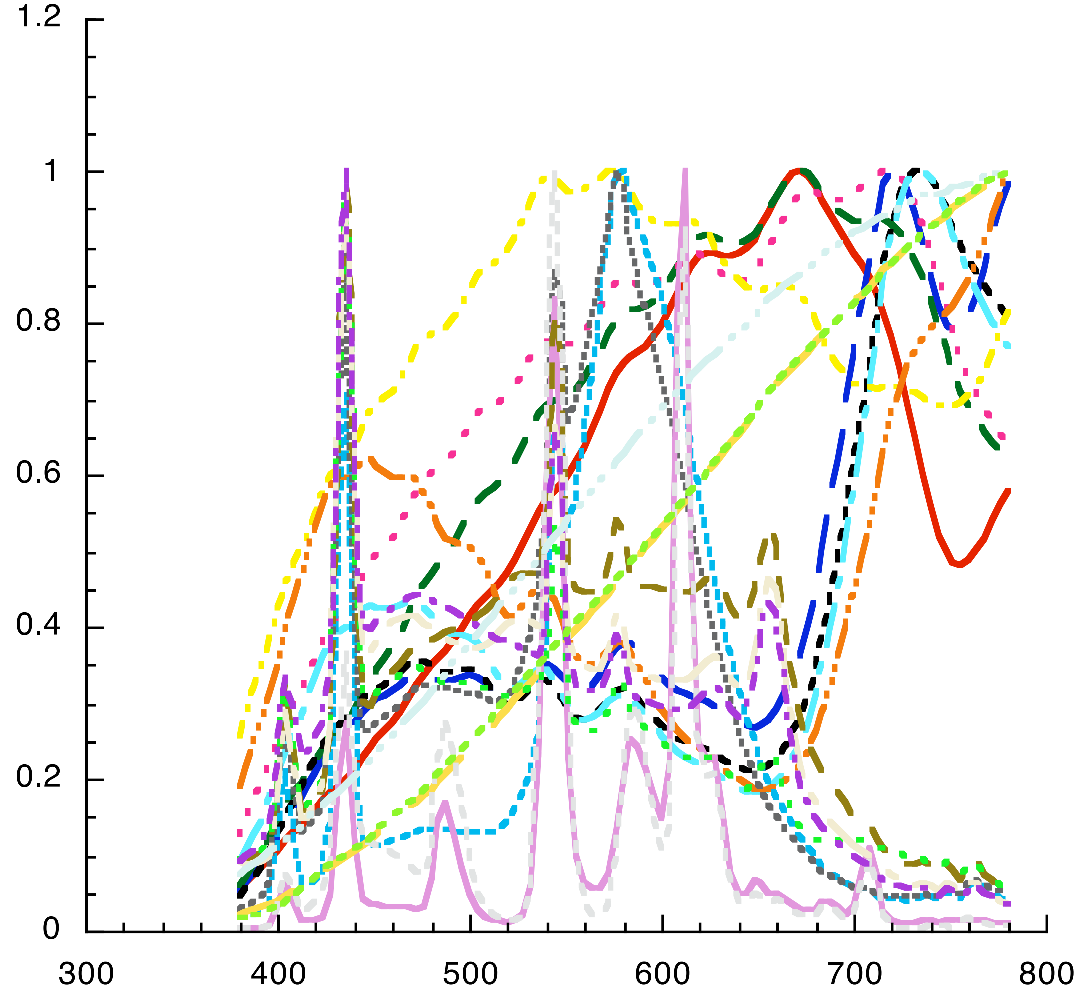


Fig. 4.2. Wavelength composition of light from a daylight fluorescent lamp. Typical relative spectral power distribution curve. Correlated color temperature: 6000 K. (Based on data of Jerome reported in [Ref. 3.14, p. 37])



1.2
1
0.8
0.6
0.4
0.2
0
300
400
500
600
700
800

Radiometry for colour

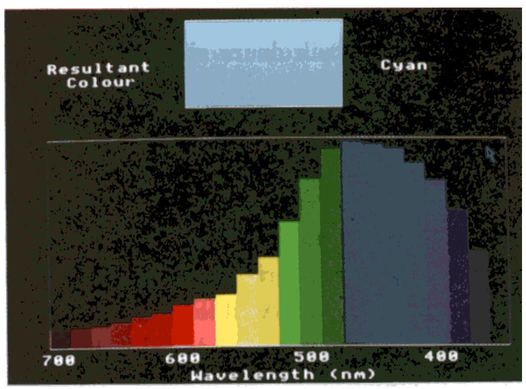
- All definitions are now “per unit wavelength”
- All units are now “per unit wavelength”
- All terms are now “spectral”
- Radiance becomes spectral radiance
  - watts per square meter per steradian per unit wavelength
- Radiosity --- spectral radiosity

Causes of colour

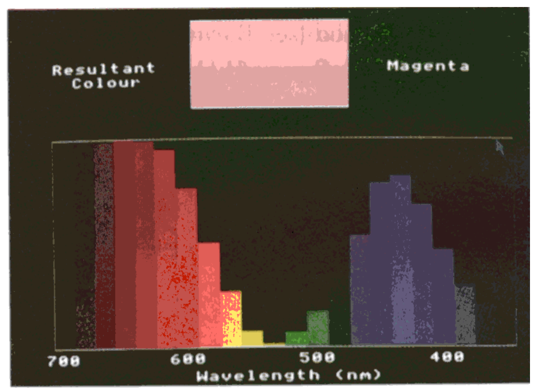
- The sensation of colour is caused by the brain.
- One way to get it is through a **response** of the eye to the presence/absence of light at various wavelengths.
  - Light could be emitted with a particular distribution, and, perhaps filtered.
  - It could then be differentially reflected - e.g. paint on a surface.
  - Wavelength dependent specular reflection - e.g. shiny copper penny (actually most metals).
  - Flourescence - light at invisible wavelengths is absorbed and reemitted at visible wavelengths.
- Dreaming, hallucination, etc.
- Pressure on the eyelids

Absorbtion spectra: real pigments

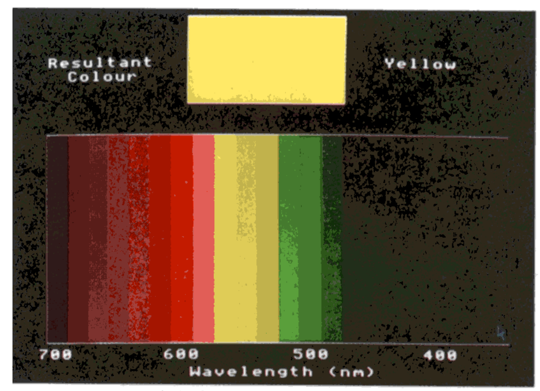
cyan



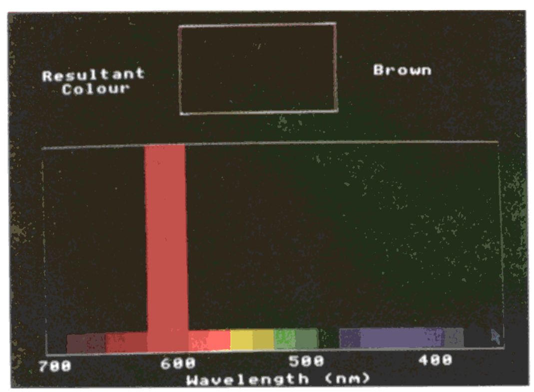
magenta

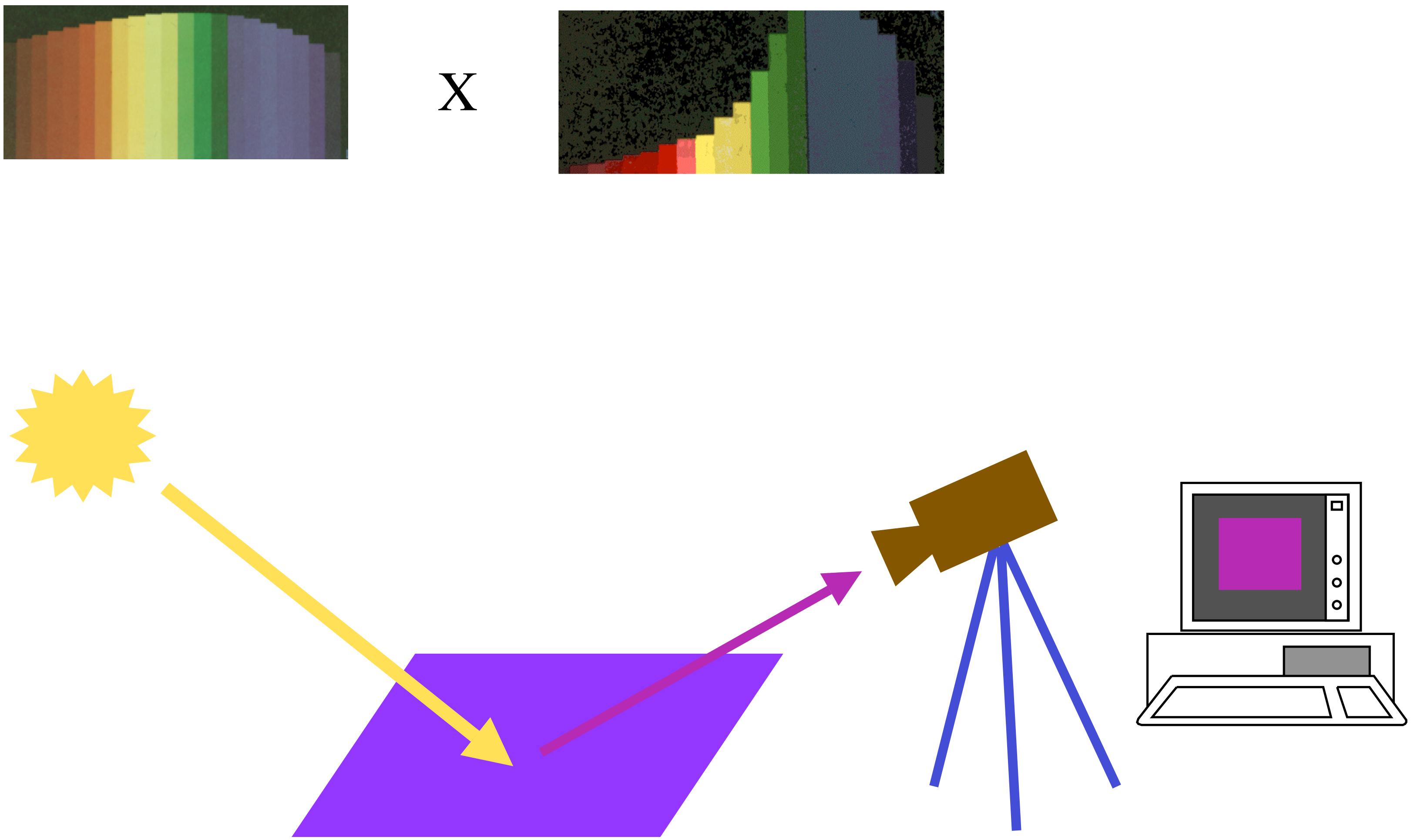


yellow



brown



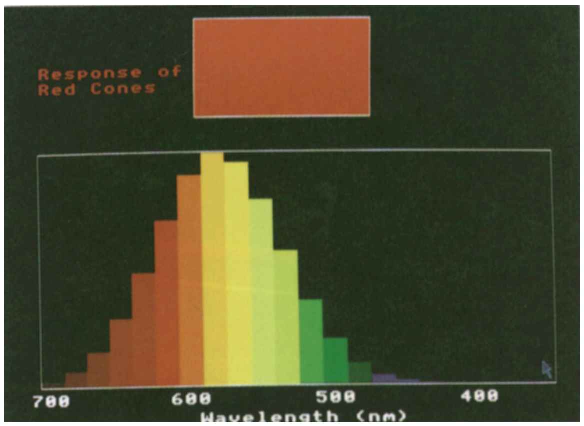

X

Trichromaticity

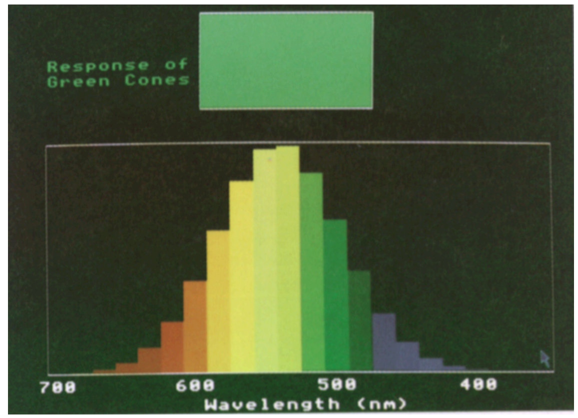
Empircal fact--colors can be approximately described/matched by three quantities (assuming normal color vision).

Need to reconcile this observation with the spectral characterization of light

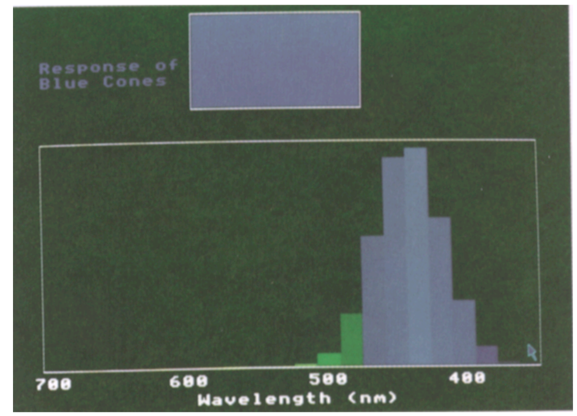
Color receptors



"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

Response of k'th cone = $\int \sigma_k(\lambda) E(\lambda) d\lambda$