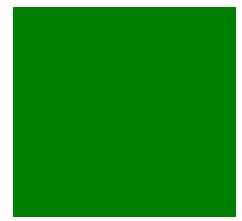


Color science for conservators

An introduction into color and metamerism

Frank Ligterink



Metameric retouches...



Photo: Berns (2000) The Science of Digitizing Two-Dimensional Works of Arts for Color-Accurate Image Archives

PART 1 - SPECTRAL THINKING



Geordi La Forge with his spectral glasses

Precise Color Communication



**PRECISE COLOR
COMMUNICATION**

COLOR CONTROL FROM PERCEPTION TO INSTRUMENTATION



The best (short) online introduction into color

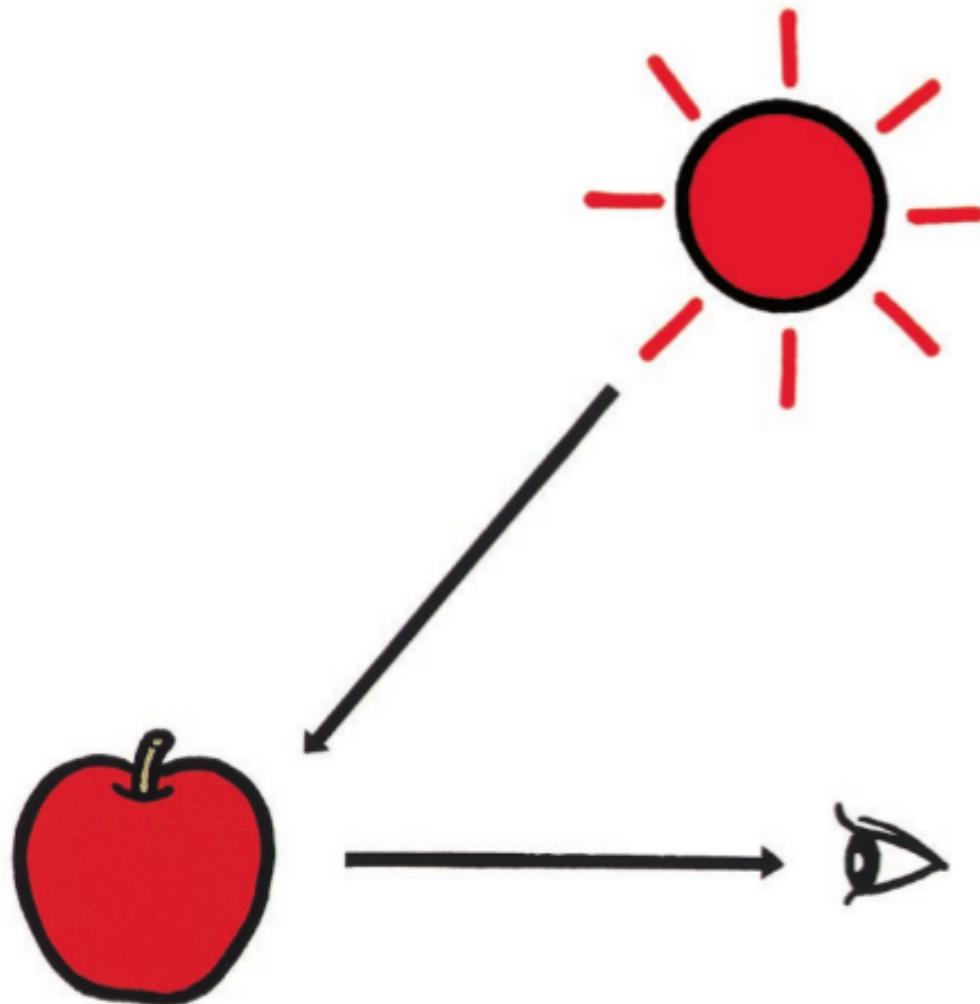
Why does an apple look red?



Can someone turn on the light?

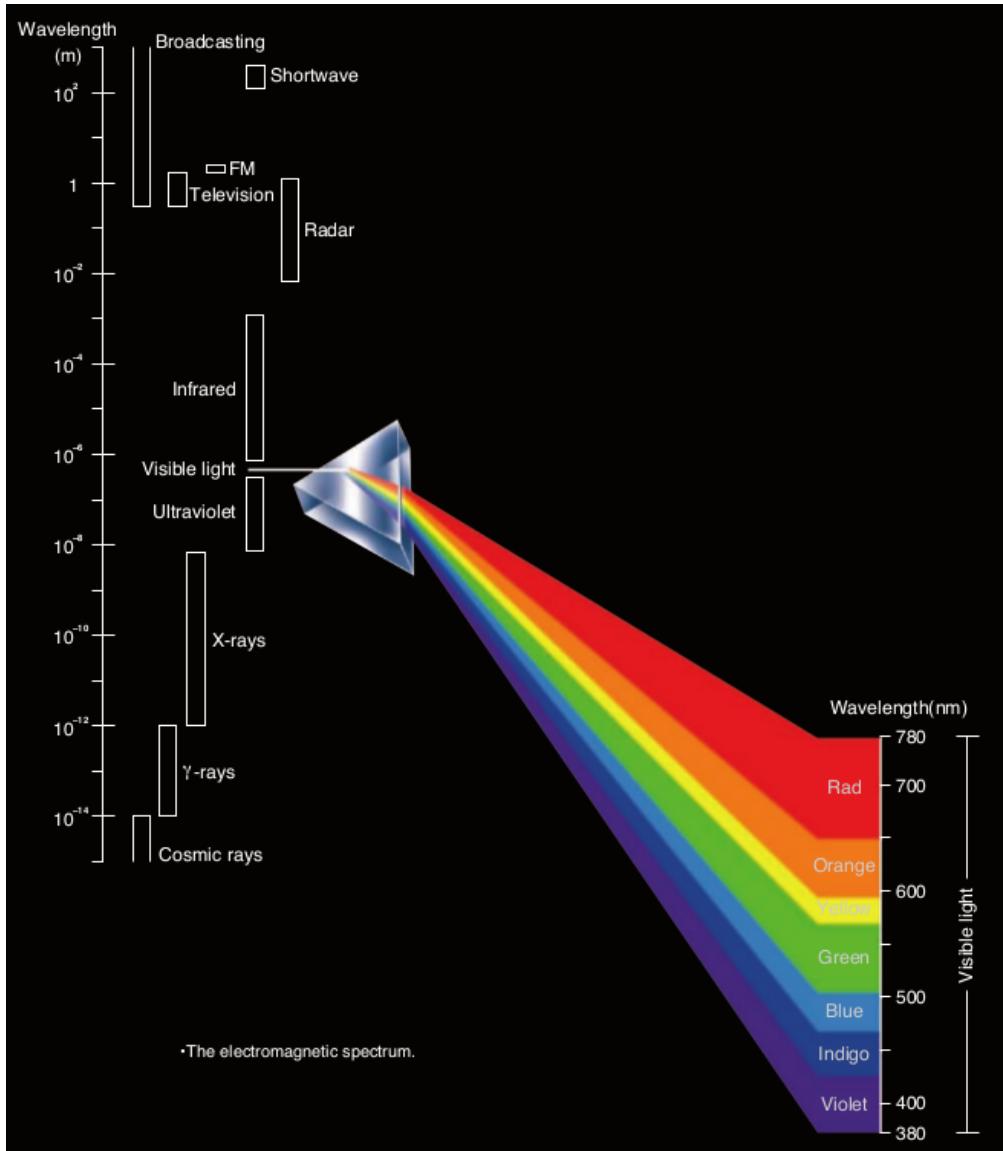


Light source - object - observer



The color triangle

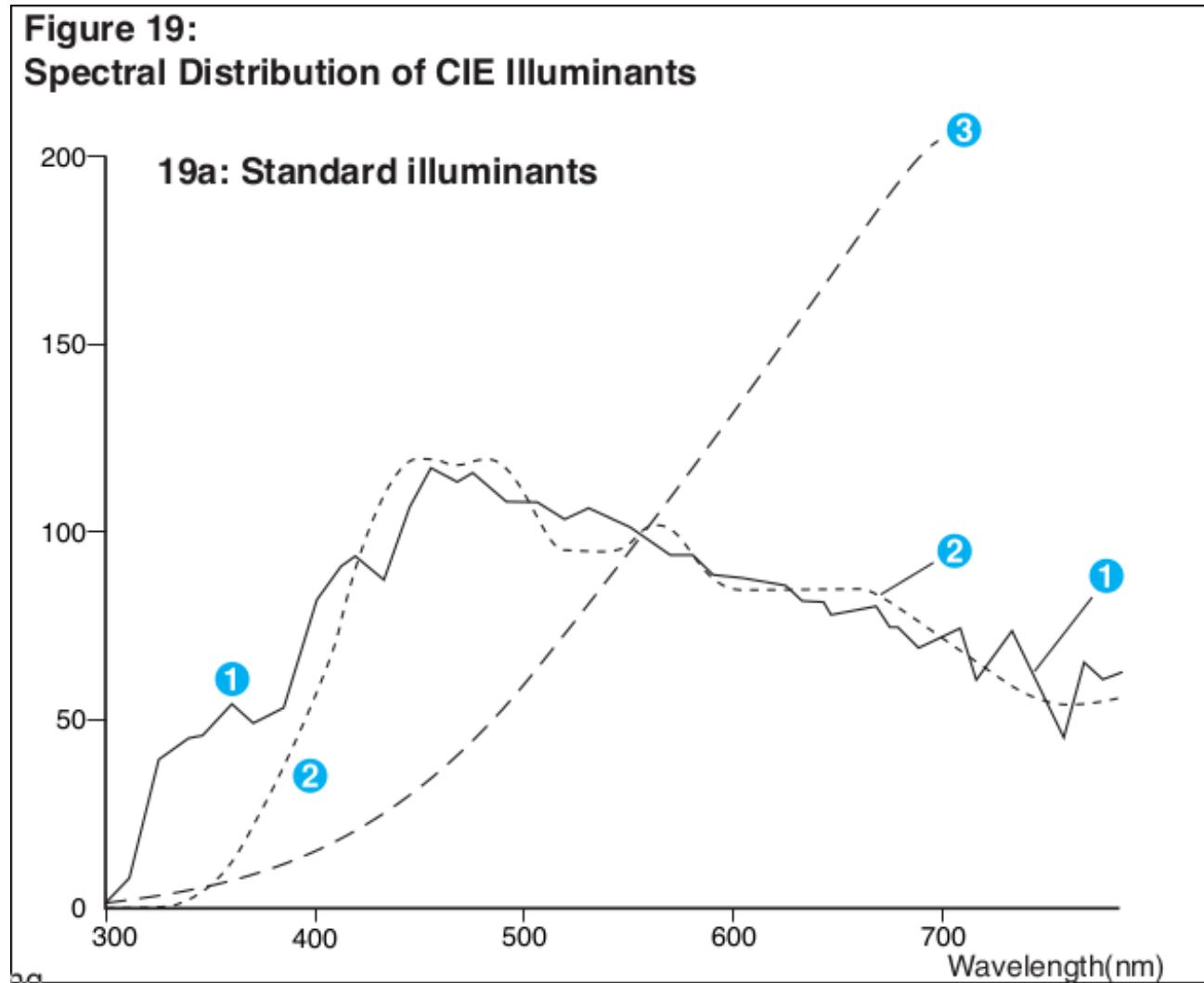
The electromagnetic spectrum



VISIBLE = 400–700 nm (REMEMBER THIS!)

CIE standard illuminants

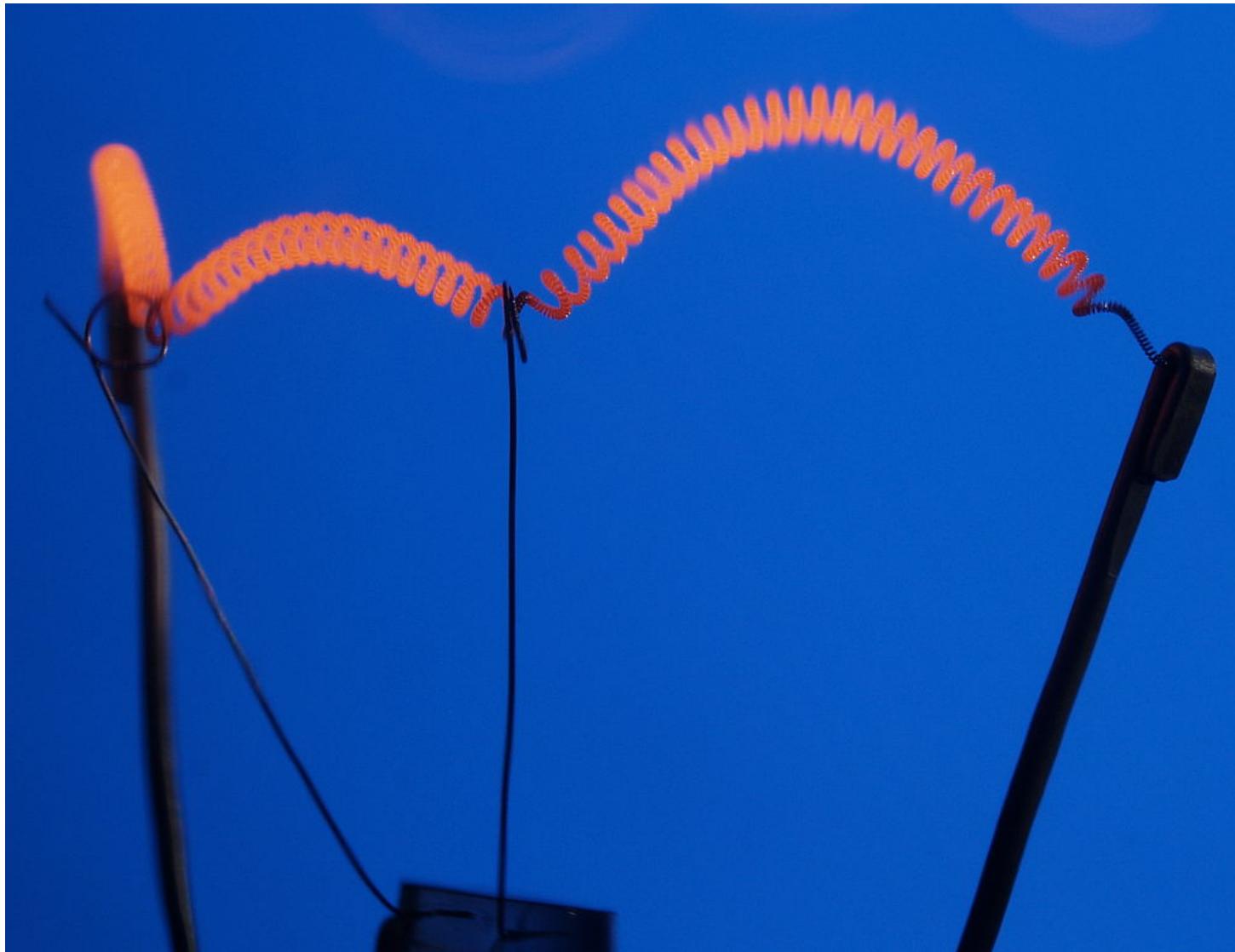
Figure 19:
Spectral Distribution of CIE Illuminants



CIE standard illuminants D65(1), C(2) and A(3).

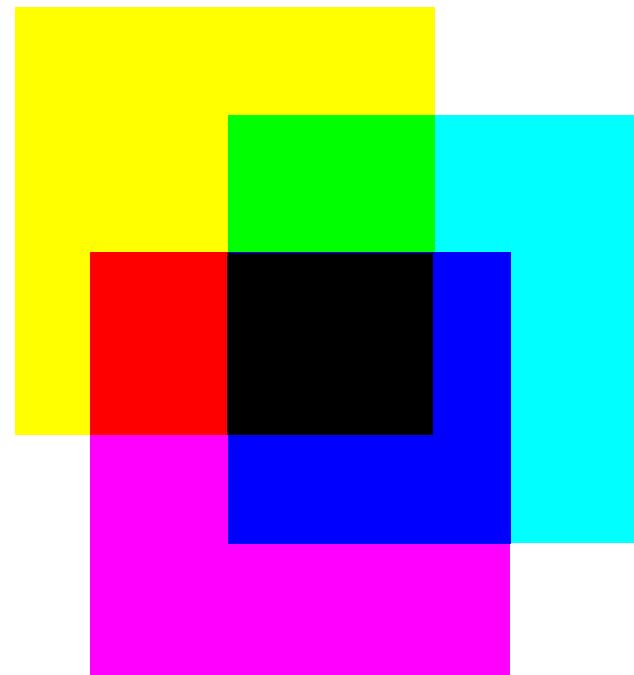
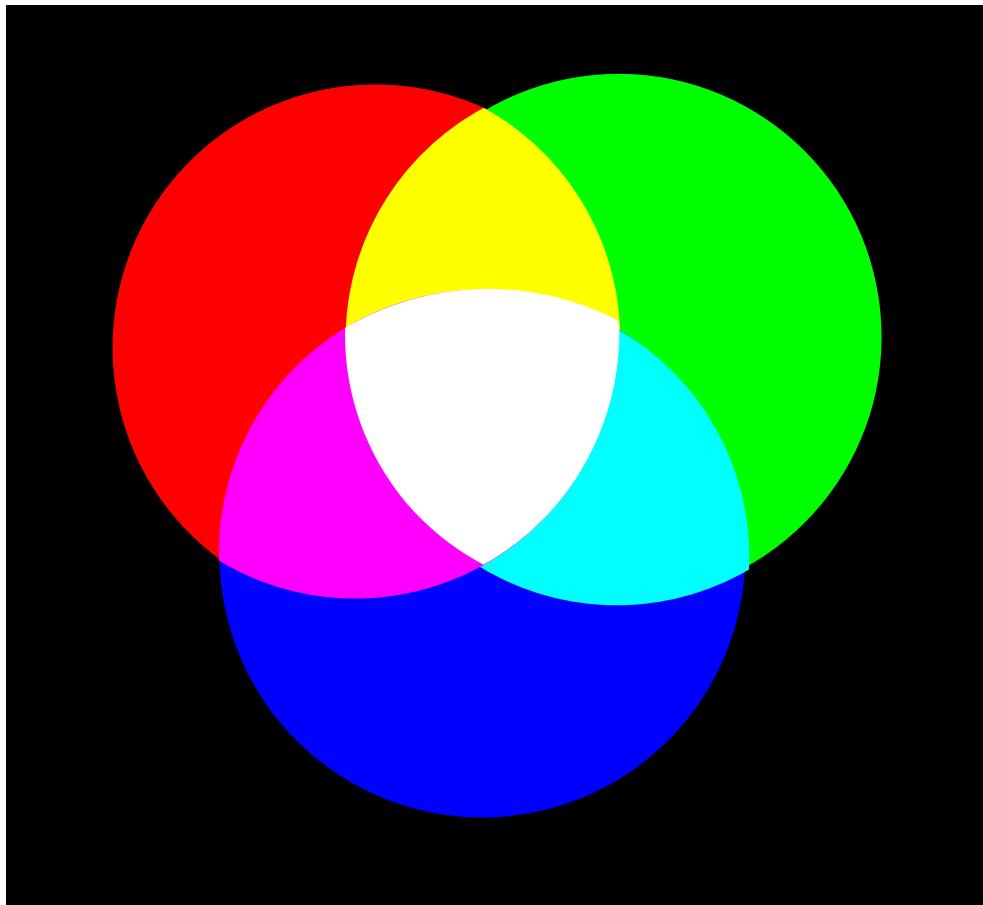
https://en.wikipedia.org/wiki/Standard_illuminant

Black body radiation



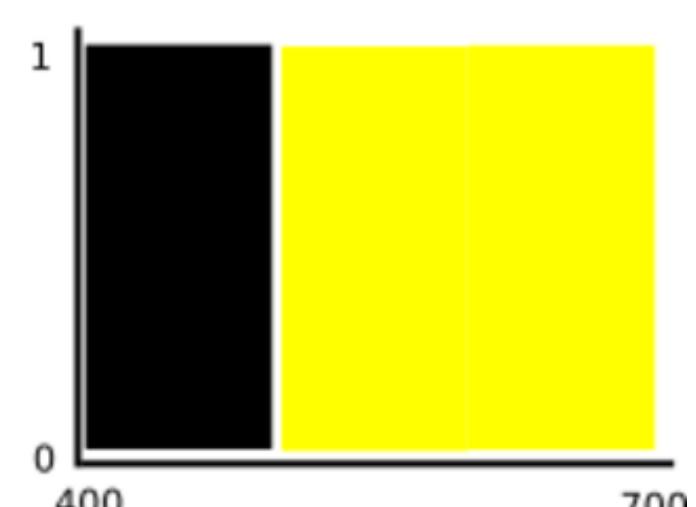
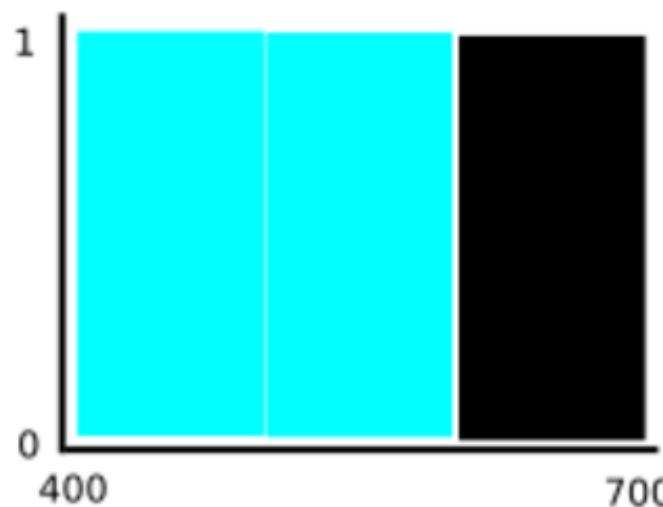
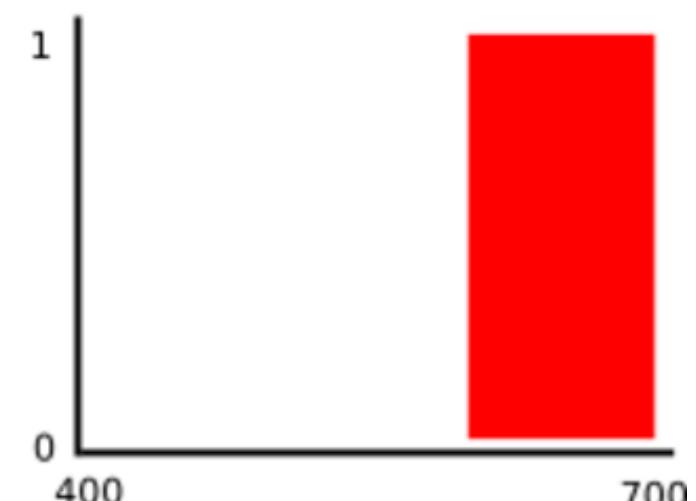
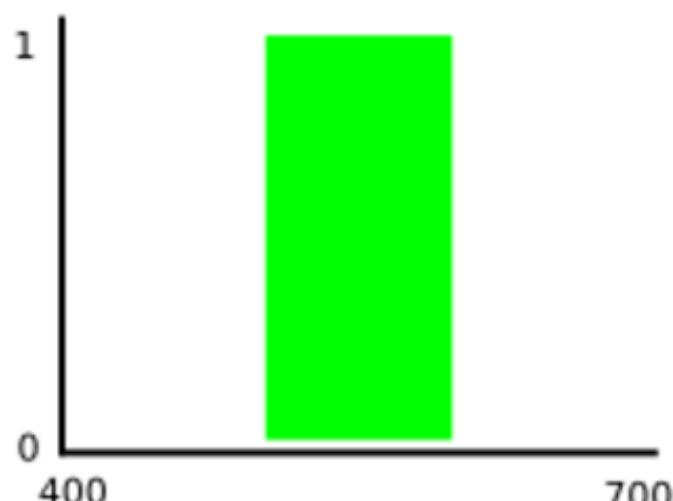
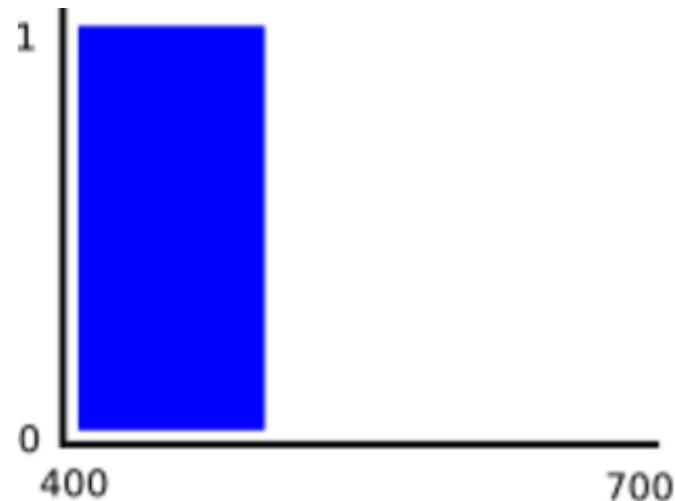
A glowing hot Tungsten filament

Color mixing



Additive and subtractive color mixing

Block spectra



Idealised block spectra for blue, green, red and cyan, magenta and yellow

The reflectance of an apple

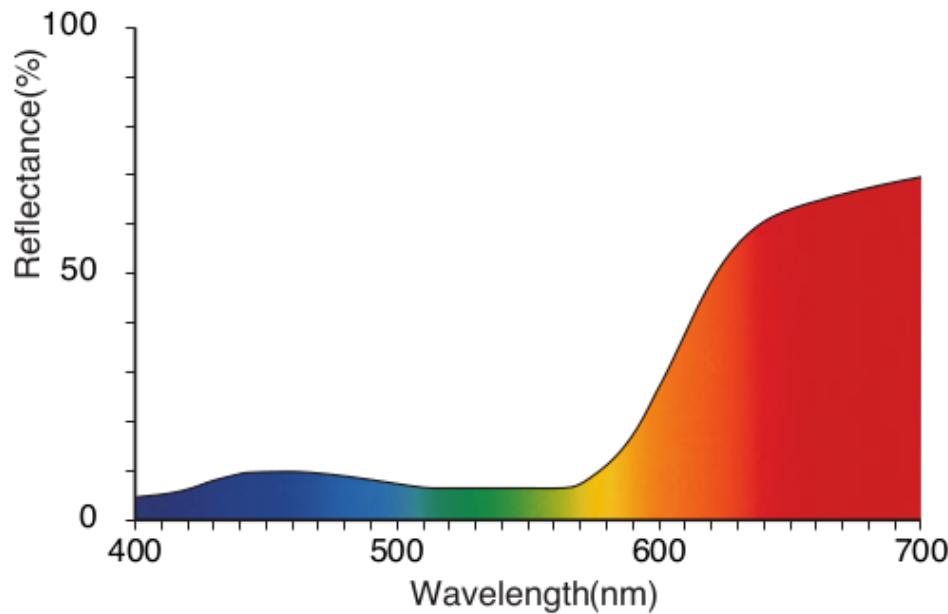
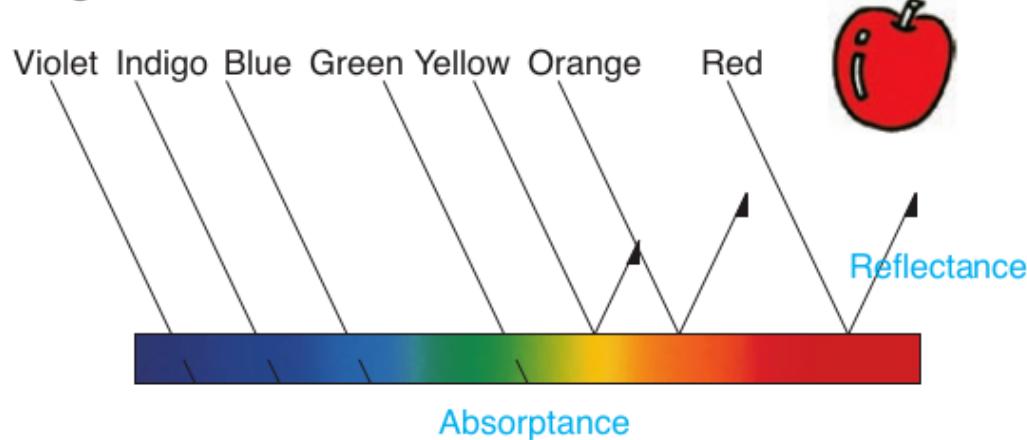


Figure 17b:



The reflectance of a lemon

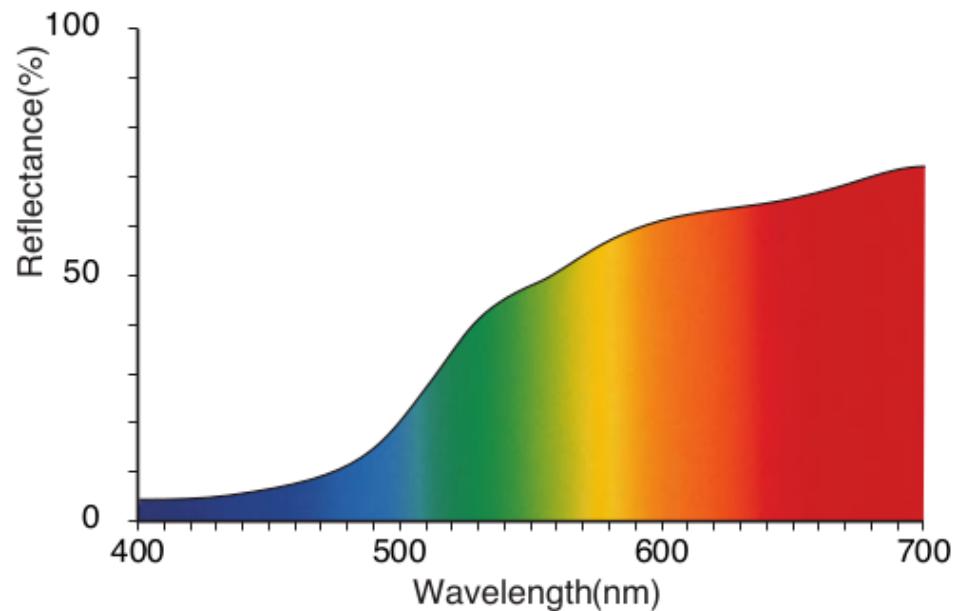
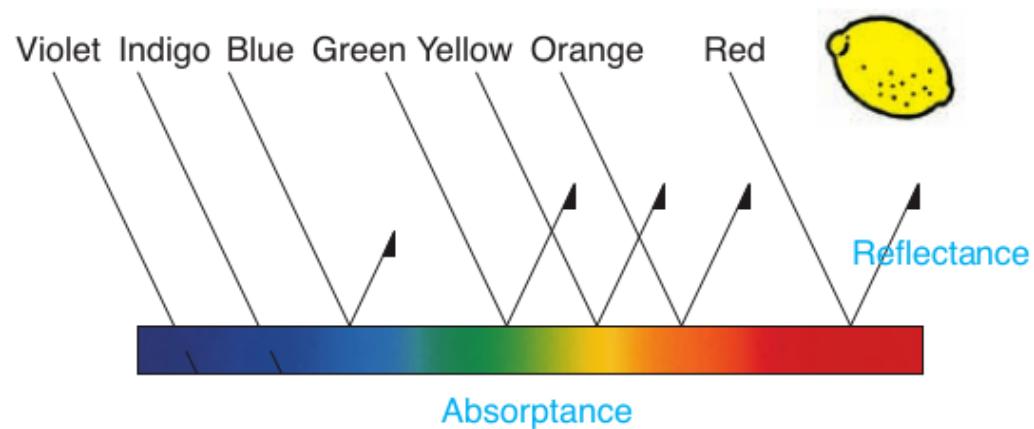


Figure 18b:

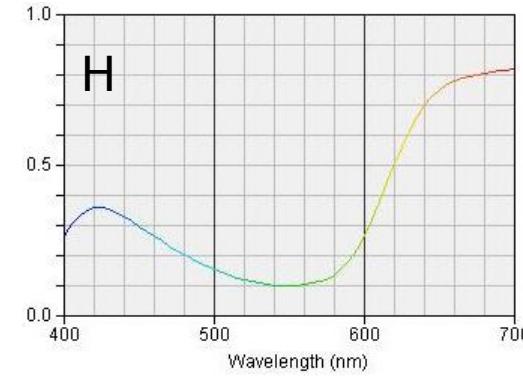
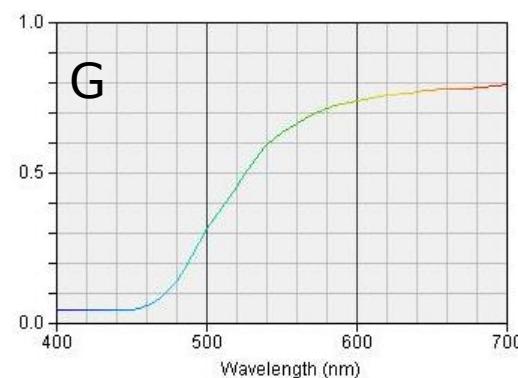
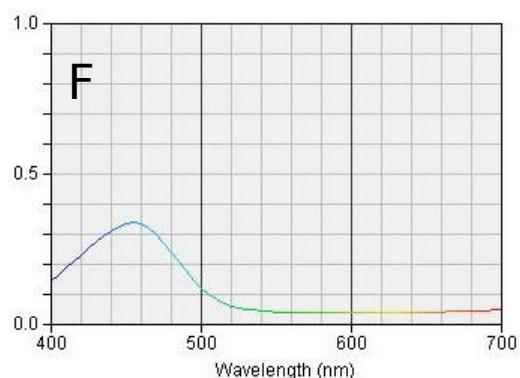
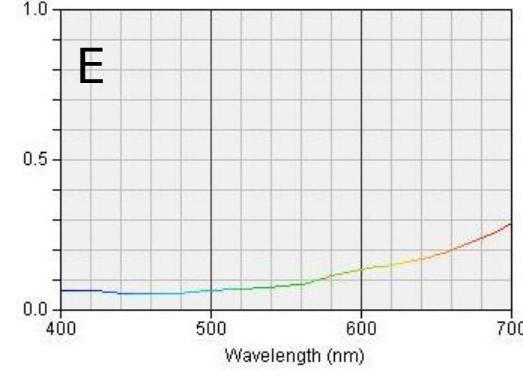
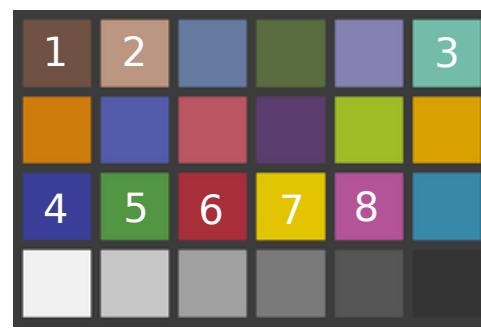
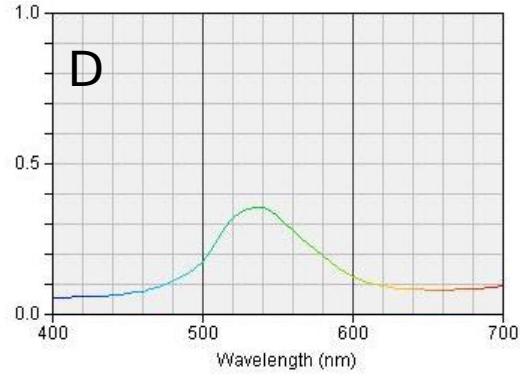
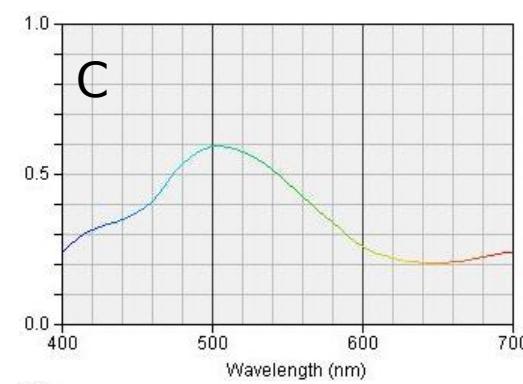
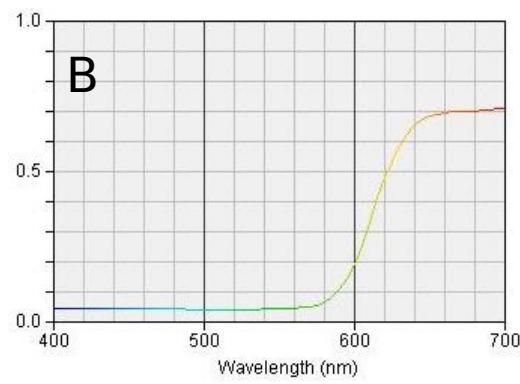
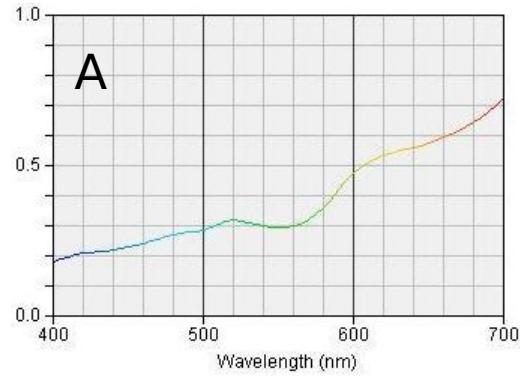


Exercise 1: Spectral Thinking

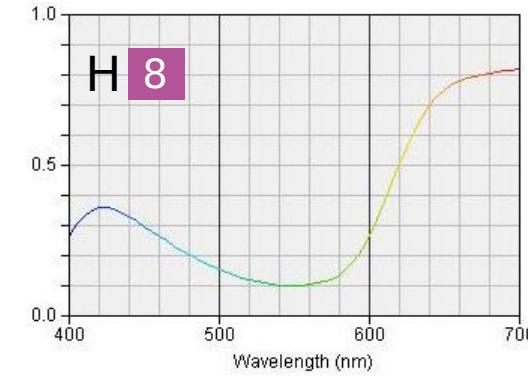
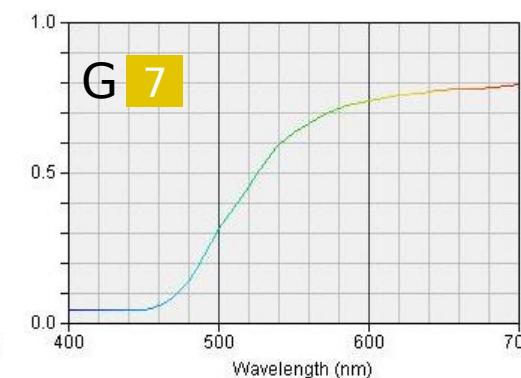
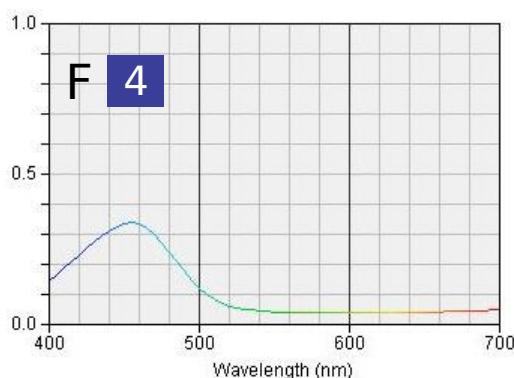
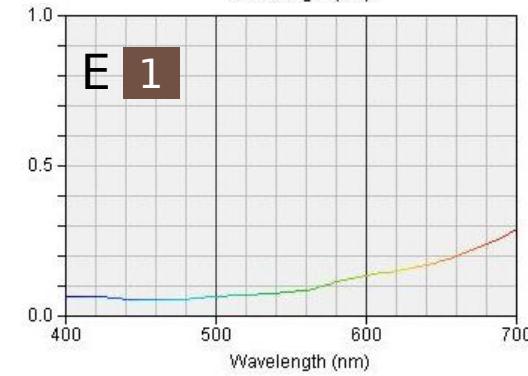
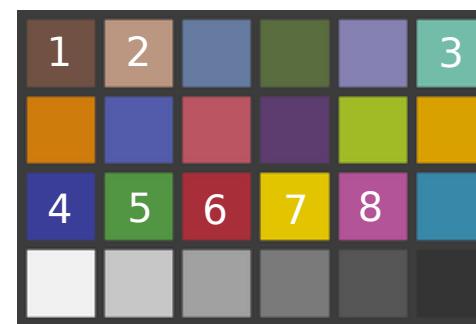
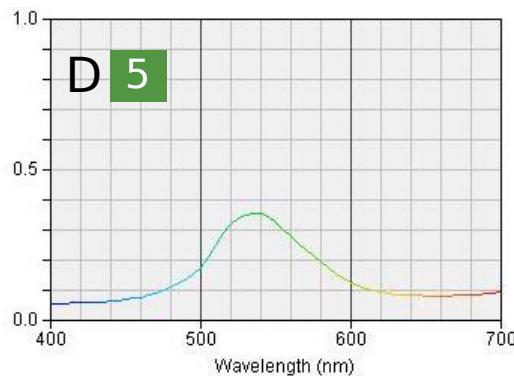
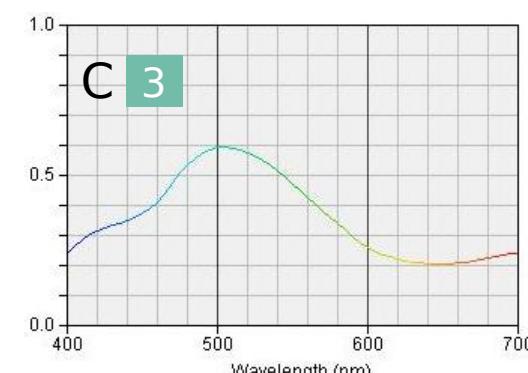
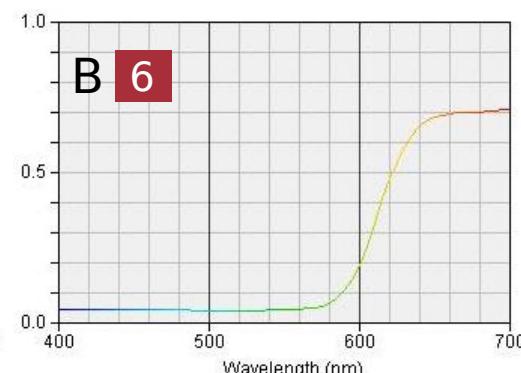
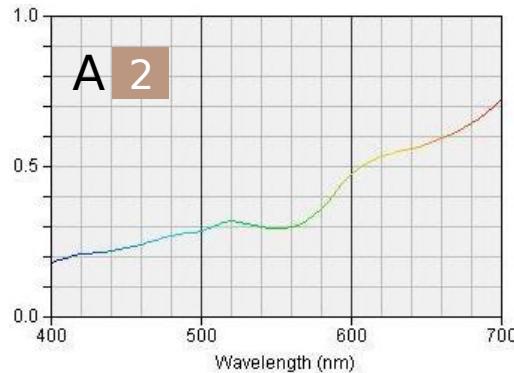


The X-Rite Classic Color Checker card

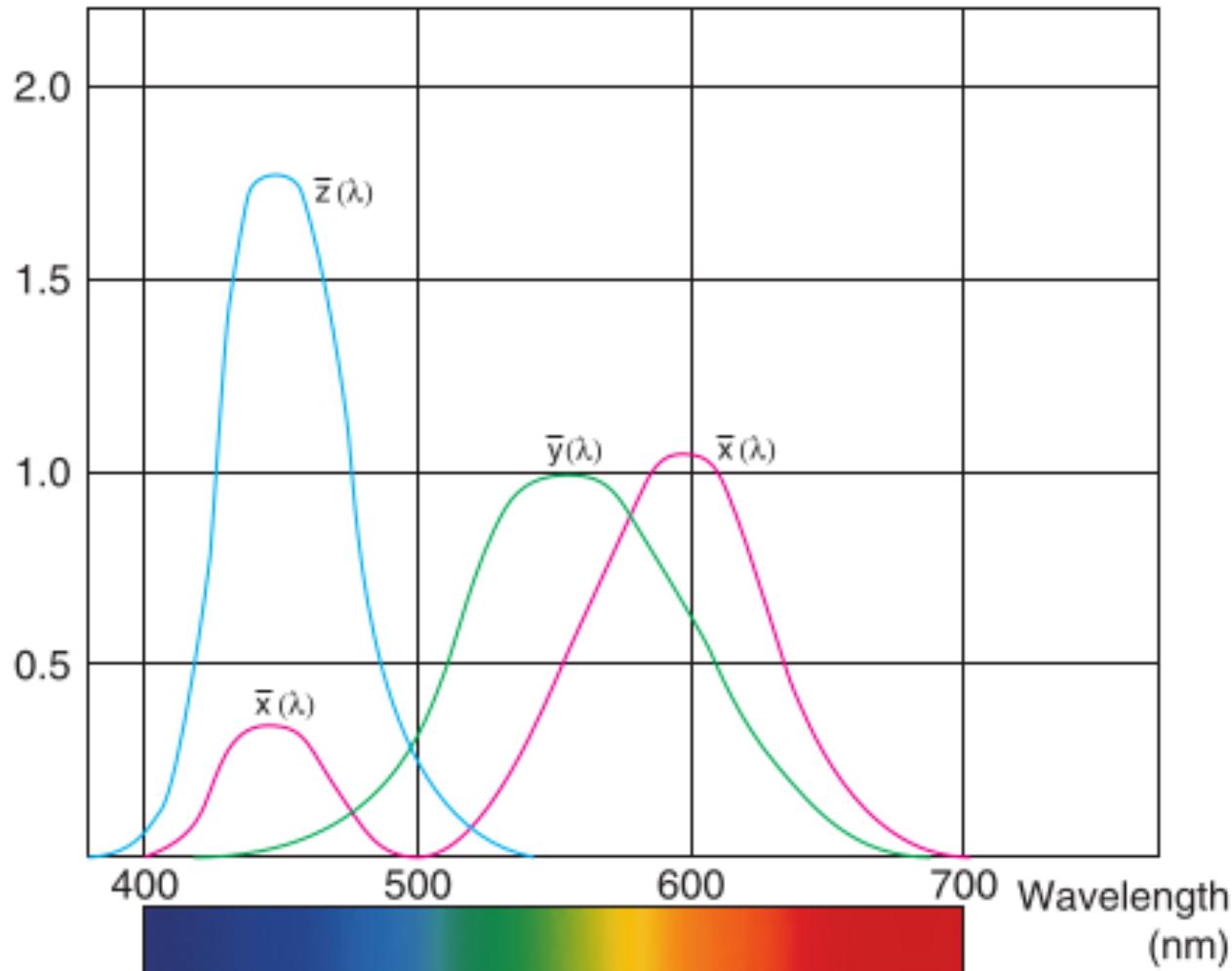
Which spectrum is which color?



Answers

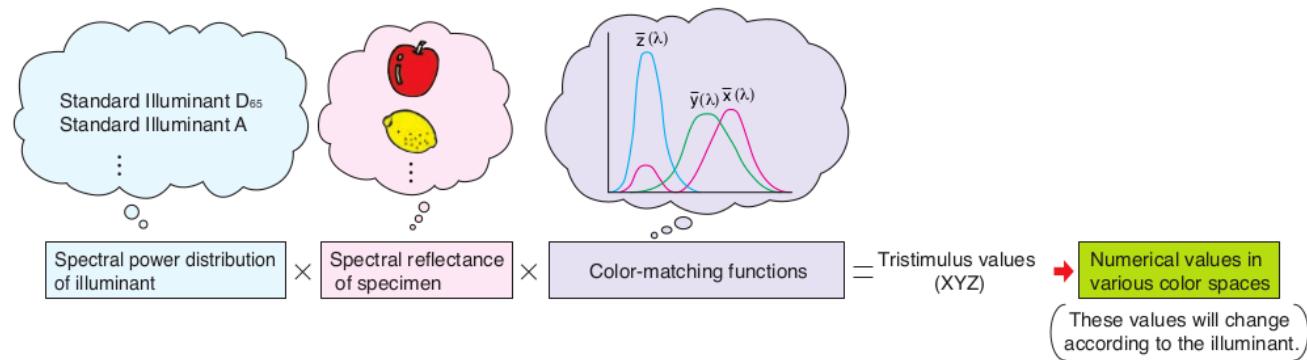


The human eye

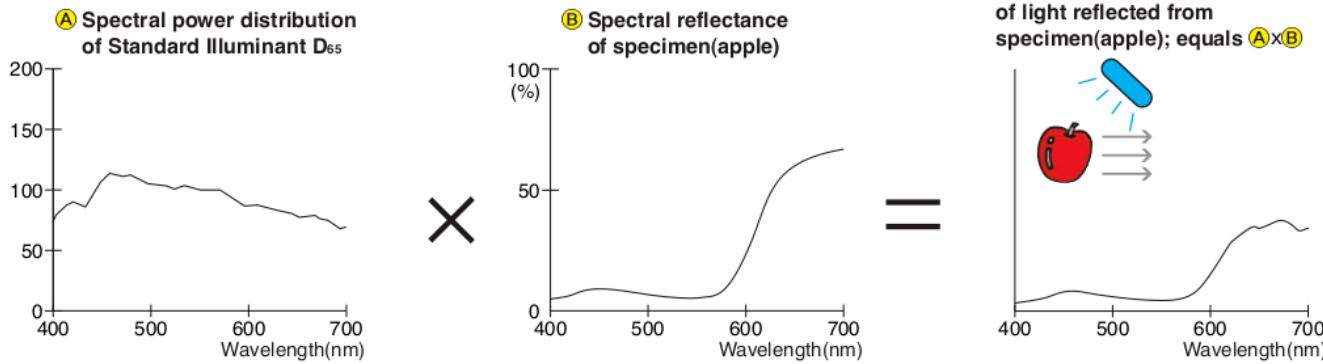


Spectral sensitivity functions for the three types of cone cells in the human eye

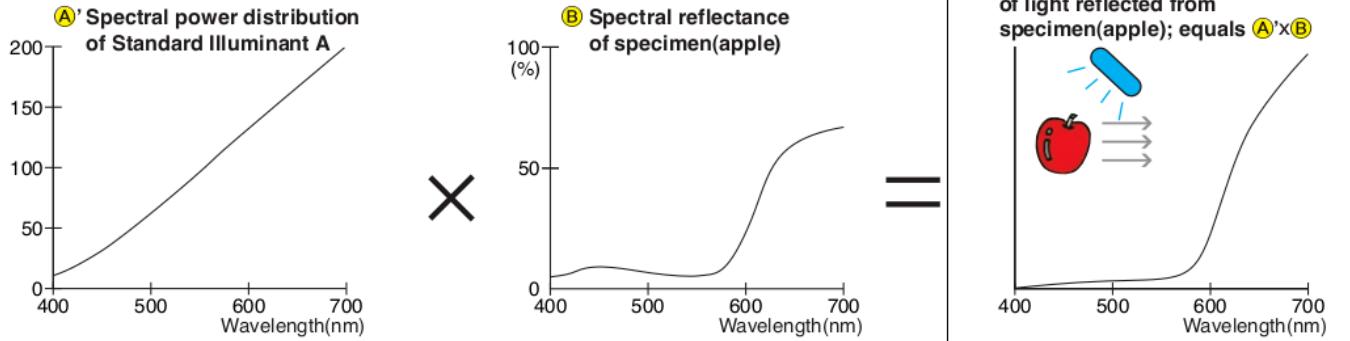
Apple and lemon



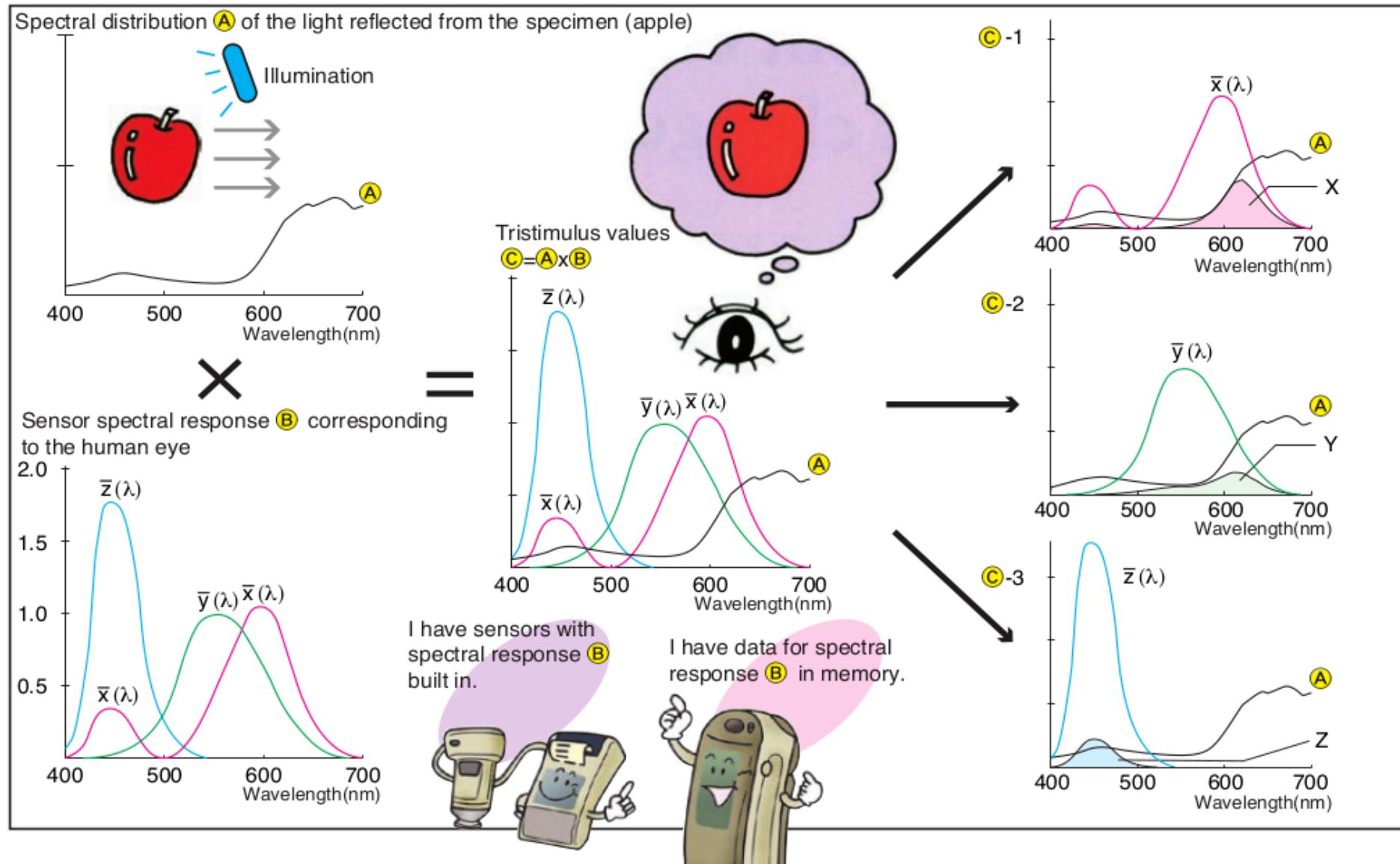
Example 1



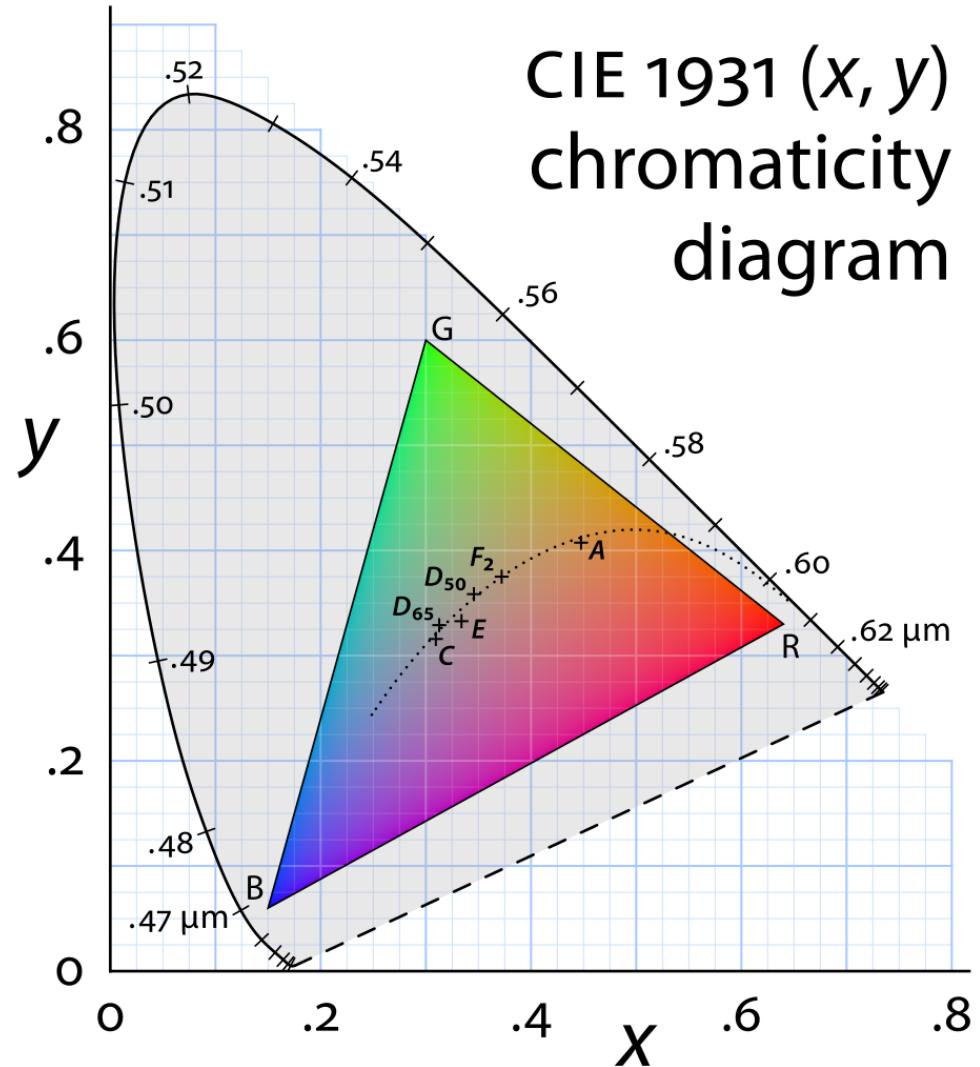
Example2



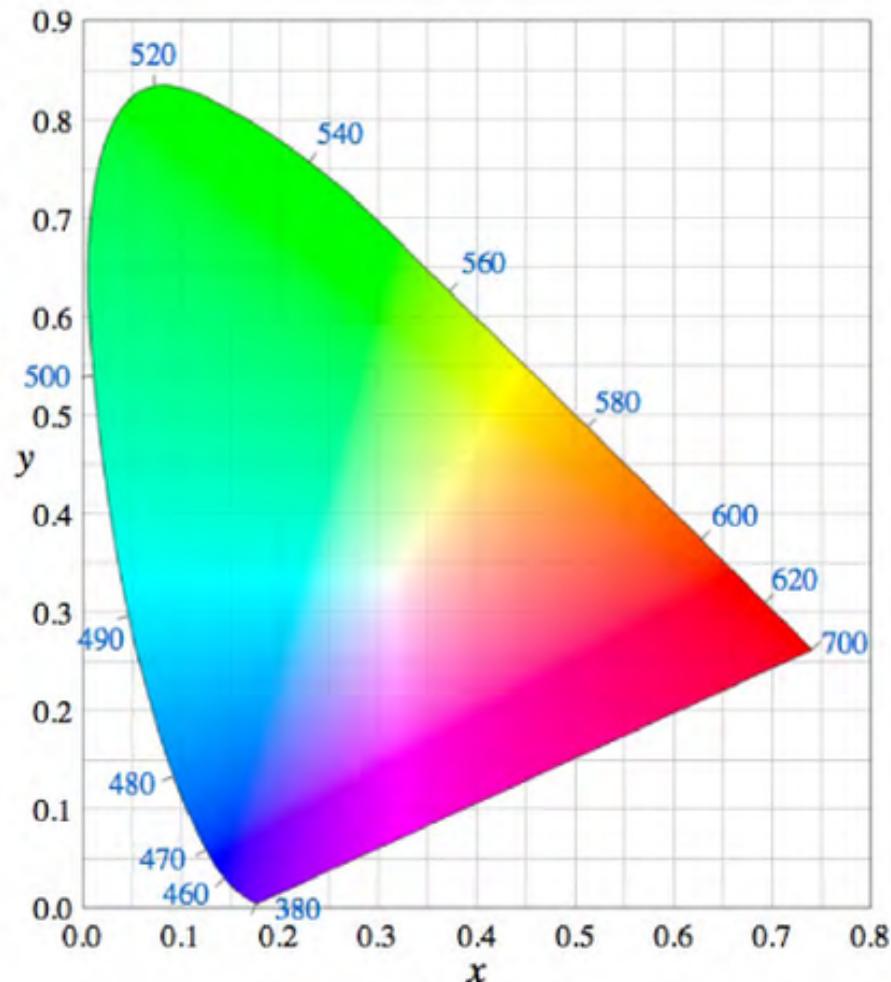
Tristimulus XYZ



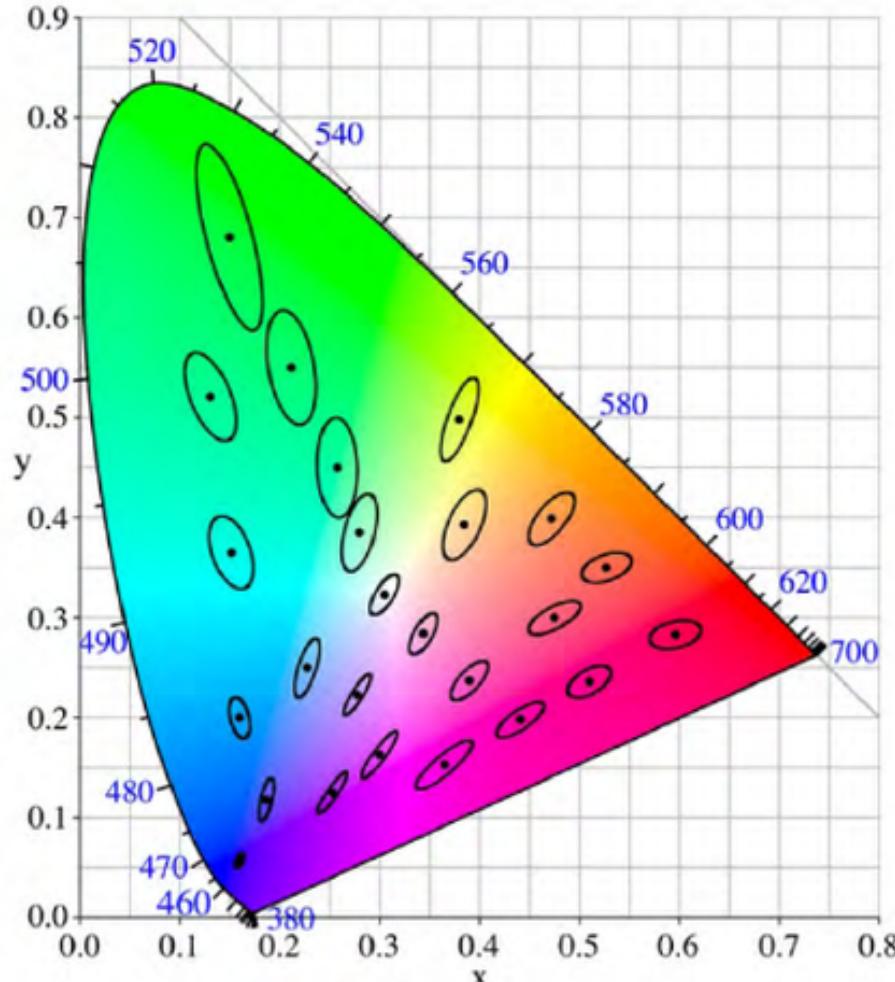
The CIE chromaticity diagram...



... is a non-uniform color space



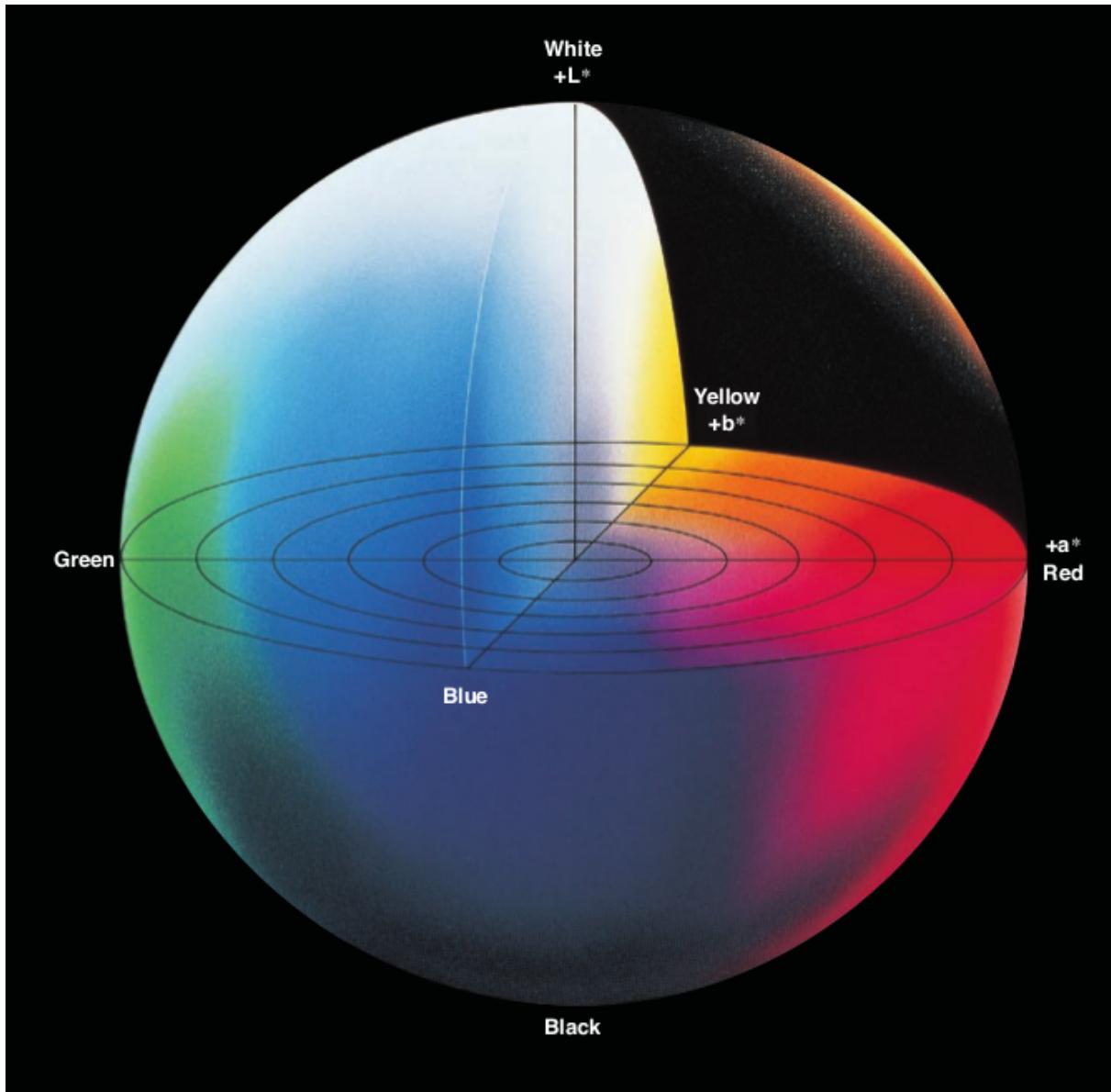
A



B

MacAdams ellipses showing just perceptible color differences

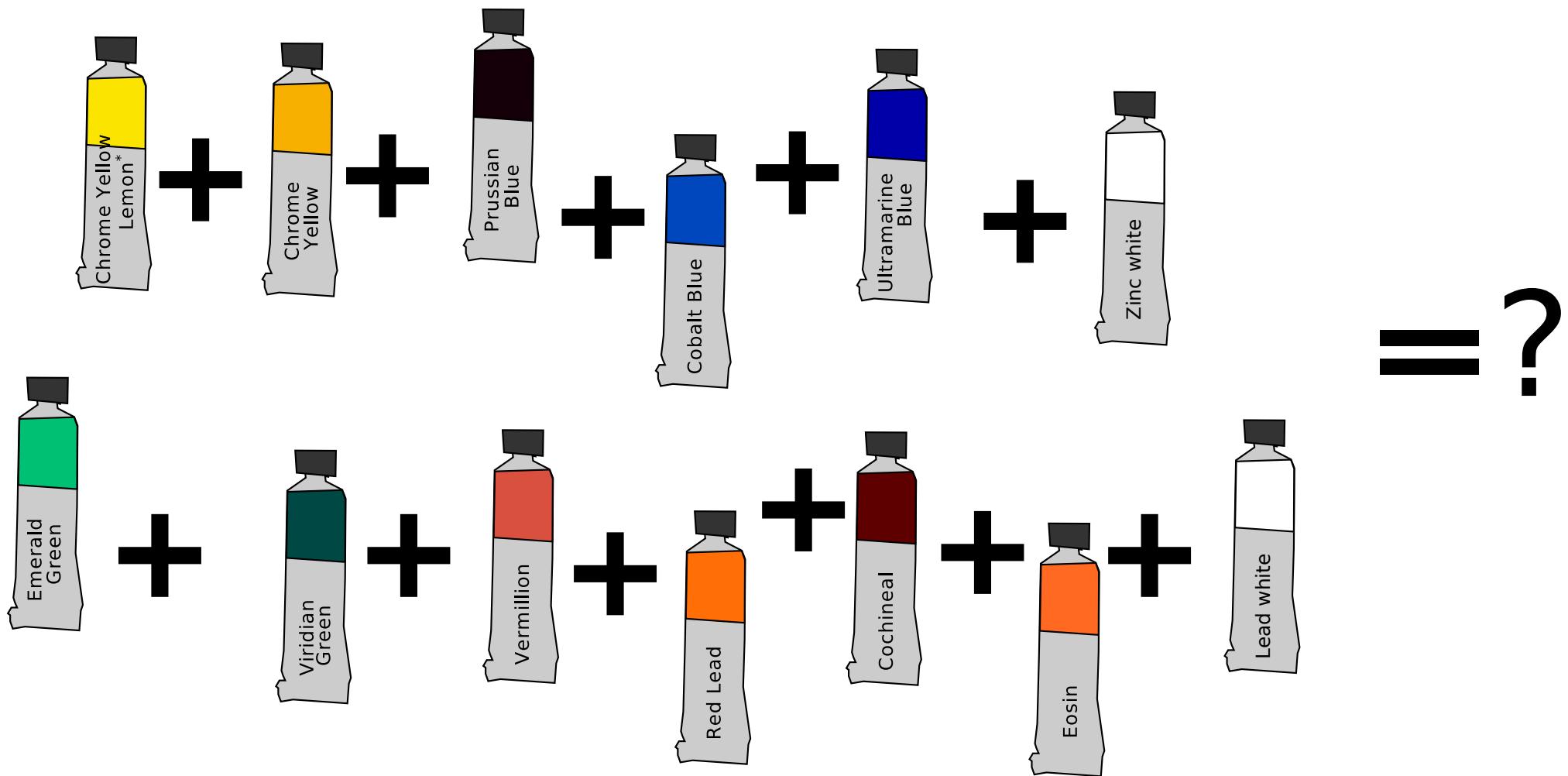
Uniform color space: CIELAB



Color difference: deltaE

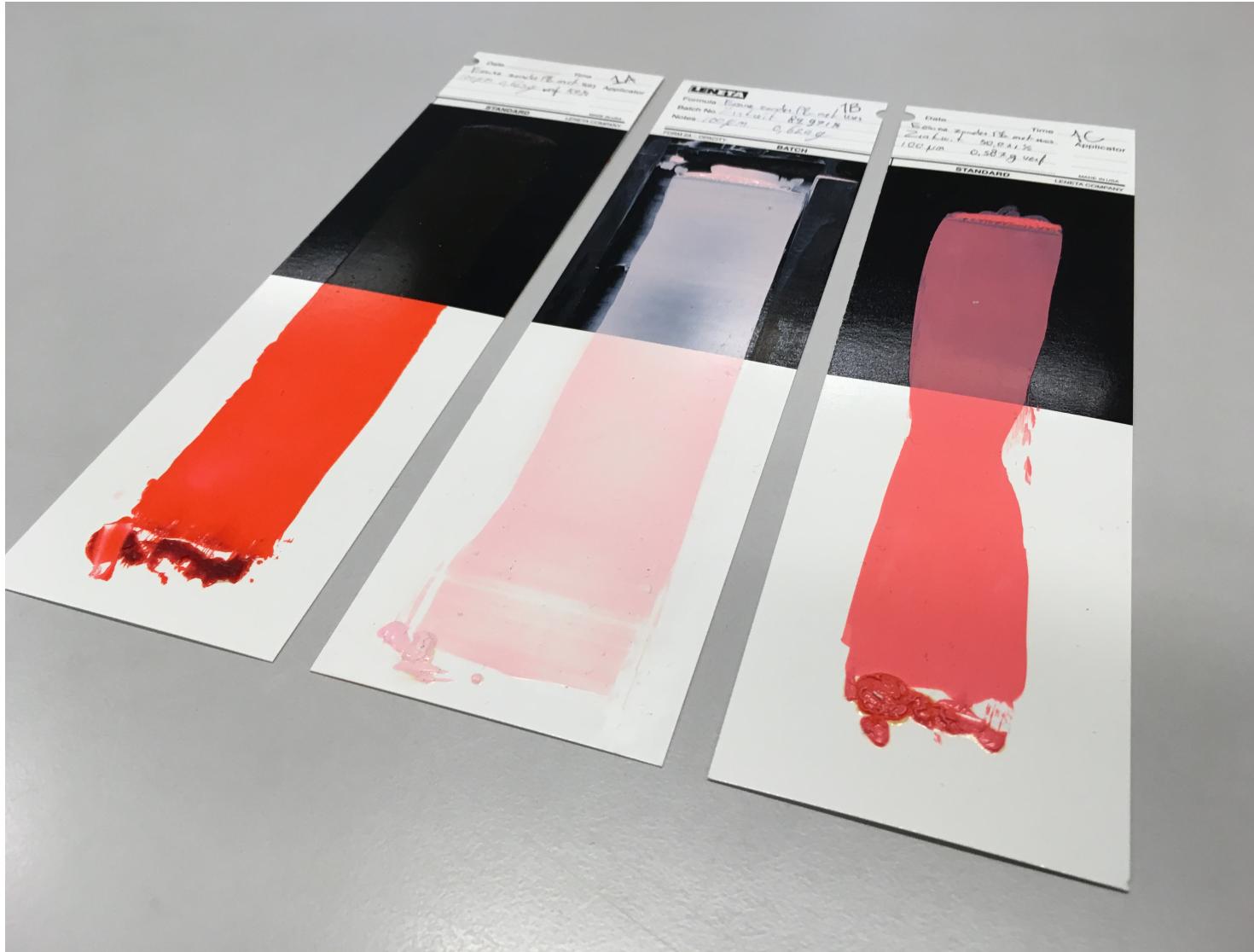
$$[\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}]$$

PART 2 - COLOR SCIENCE OF COLORANTS



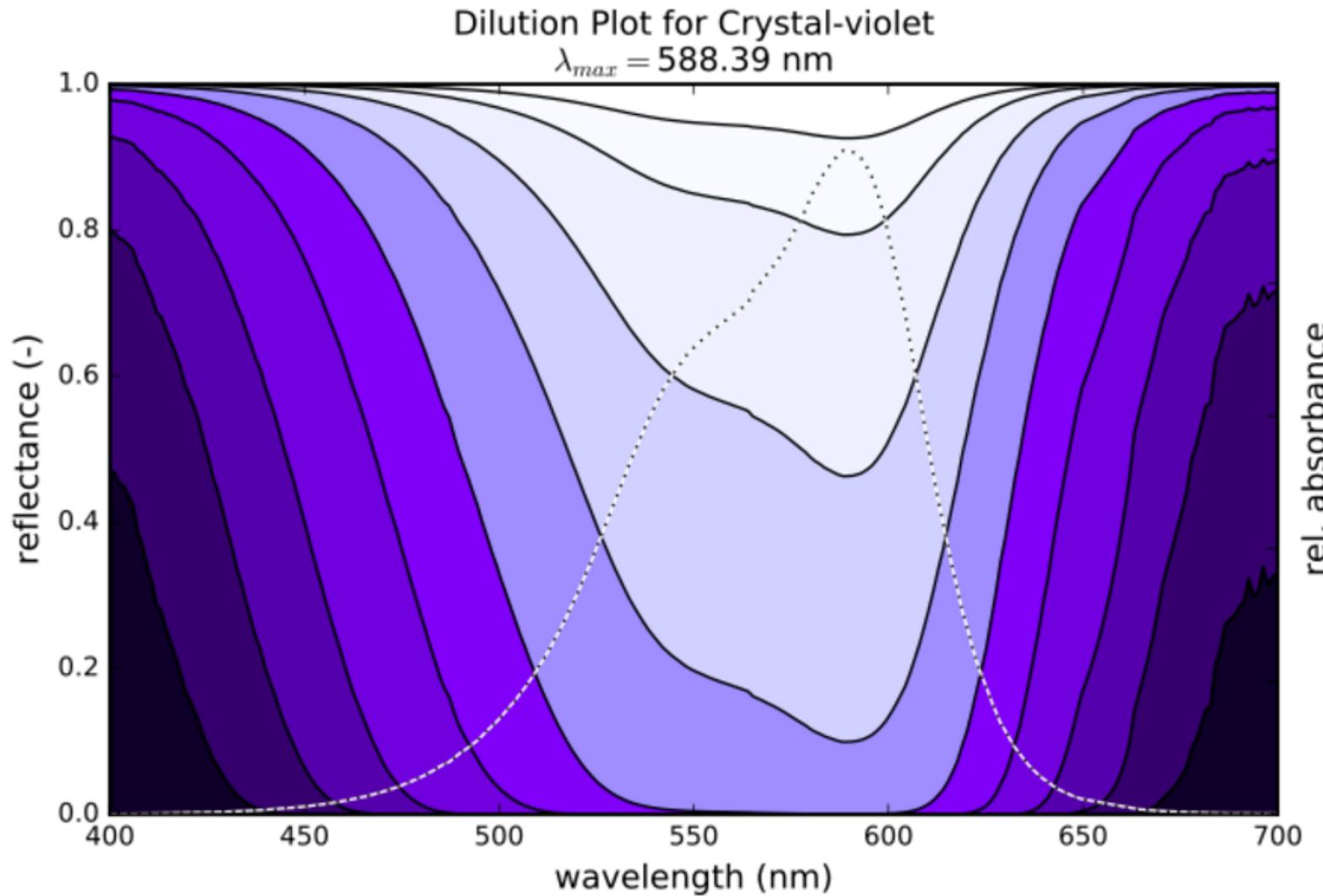
Reconstructing van Gogh's Field with Irises near Arles <https://www.youtube.com/watch?v=TkkEMimZmSs>

Transparency , translucency and opacity



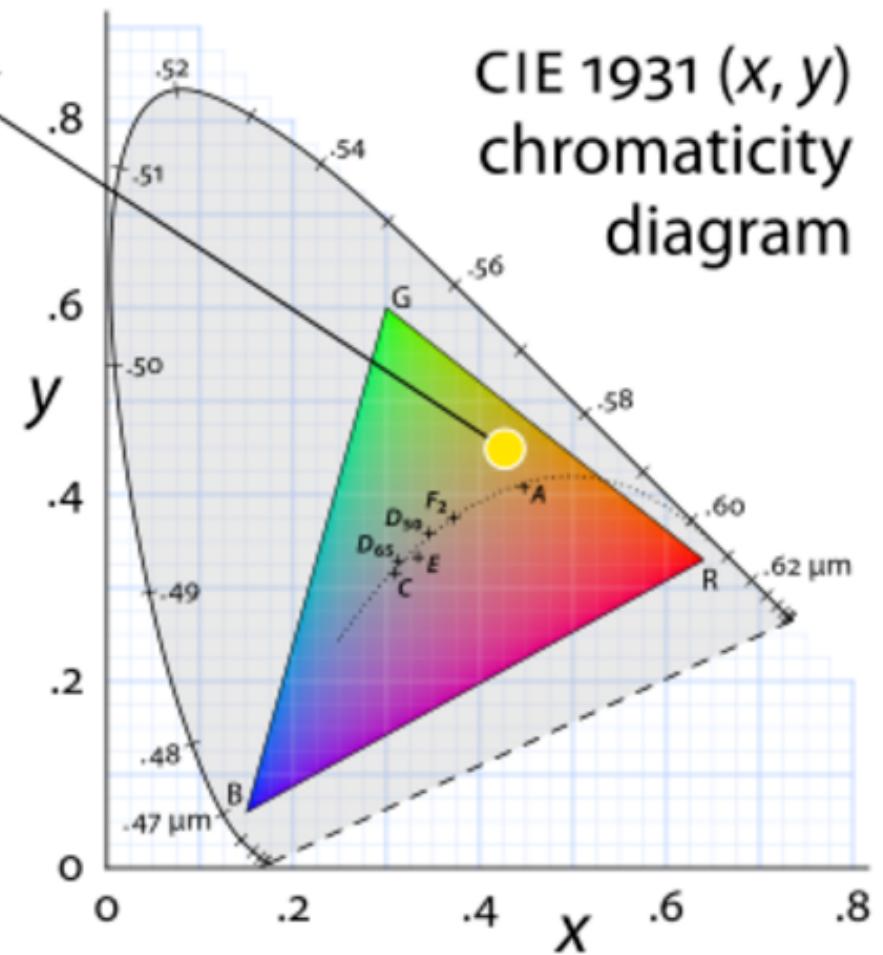
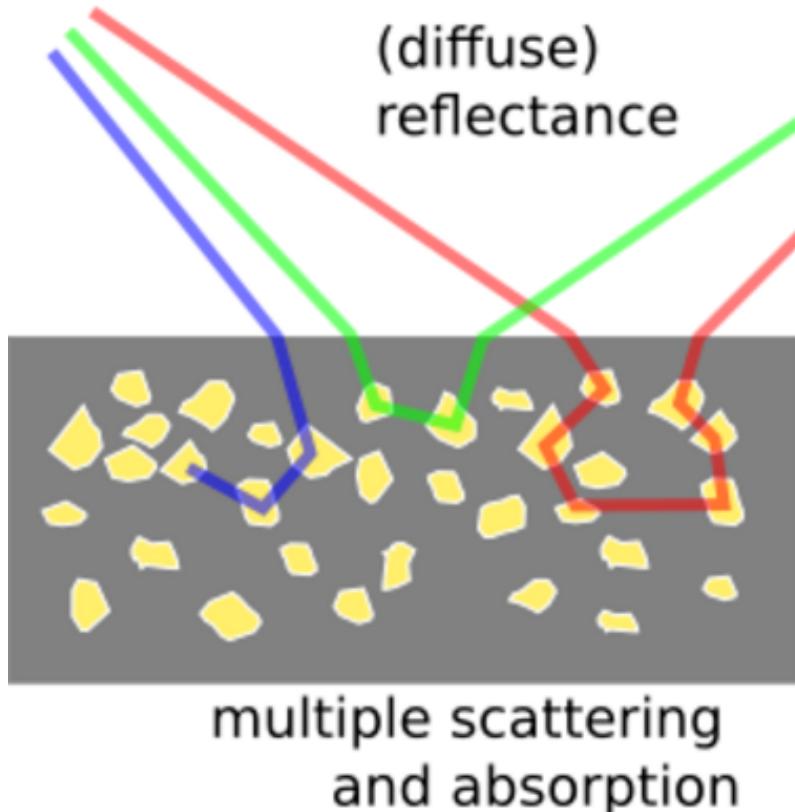
Transparent on black is black.

Why are all inks black?



Subtractive mixing of crystal-violet dye solution..

Multiple scattering and absorption



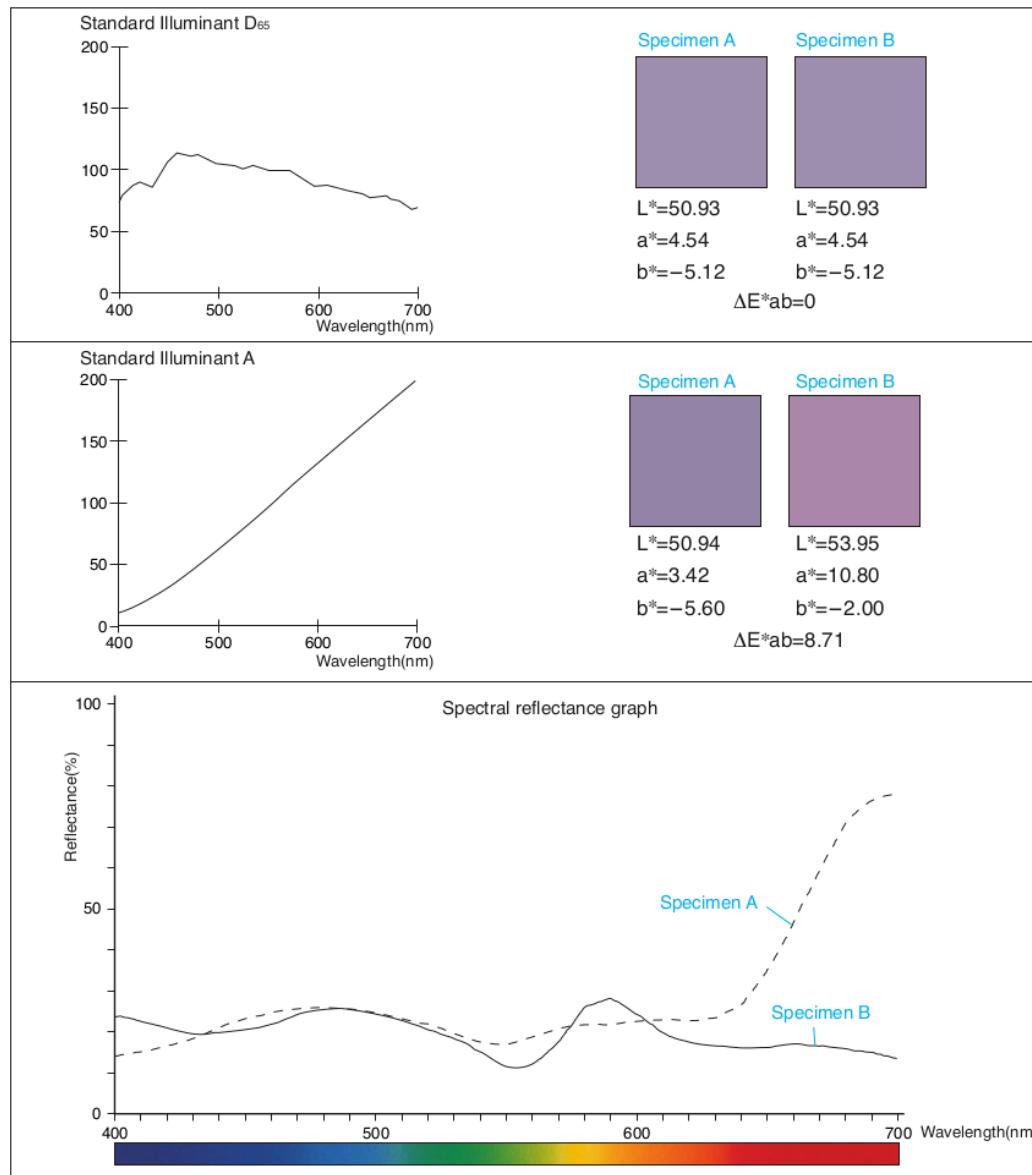
Multiple scattering and absorption in paints

Kubelka-Munk theory

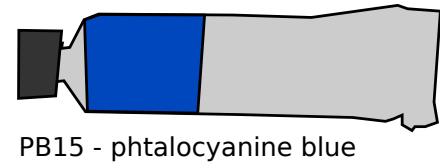


A translucent paint application modeled with KM-theory

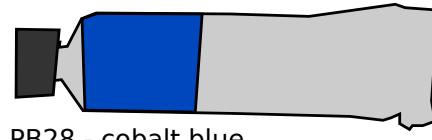
Retouching and metamerism



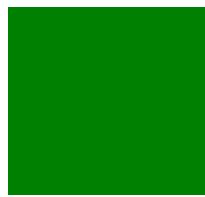
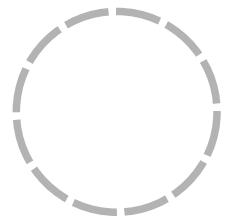
Exercise 2: Choosing blue to make green



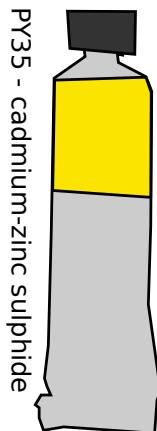
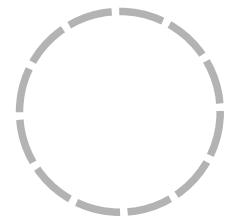
PB15 - pthalocyanine blue



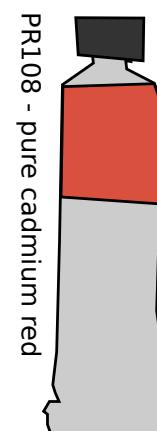
PB28 - cobalt blue



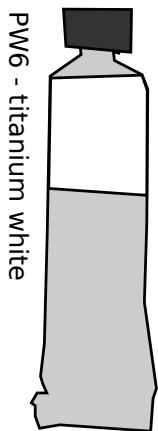
X



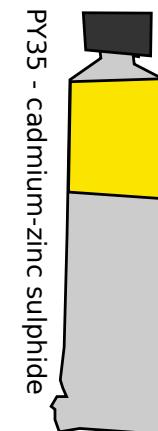
PY35 - cadmium-zinc sulphide



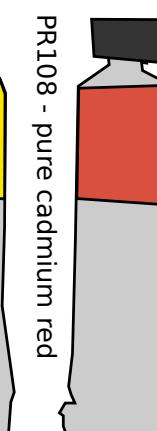
PR108 - pure cadmium red



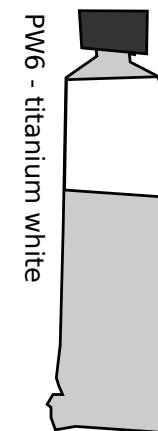
PW6 - titanium white



PY35 - cadmium-zinc sulphide



PR108 - pure cadmium red



PW6 - titanium white