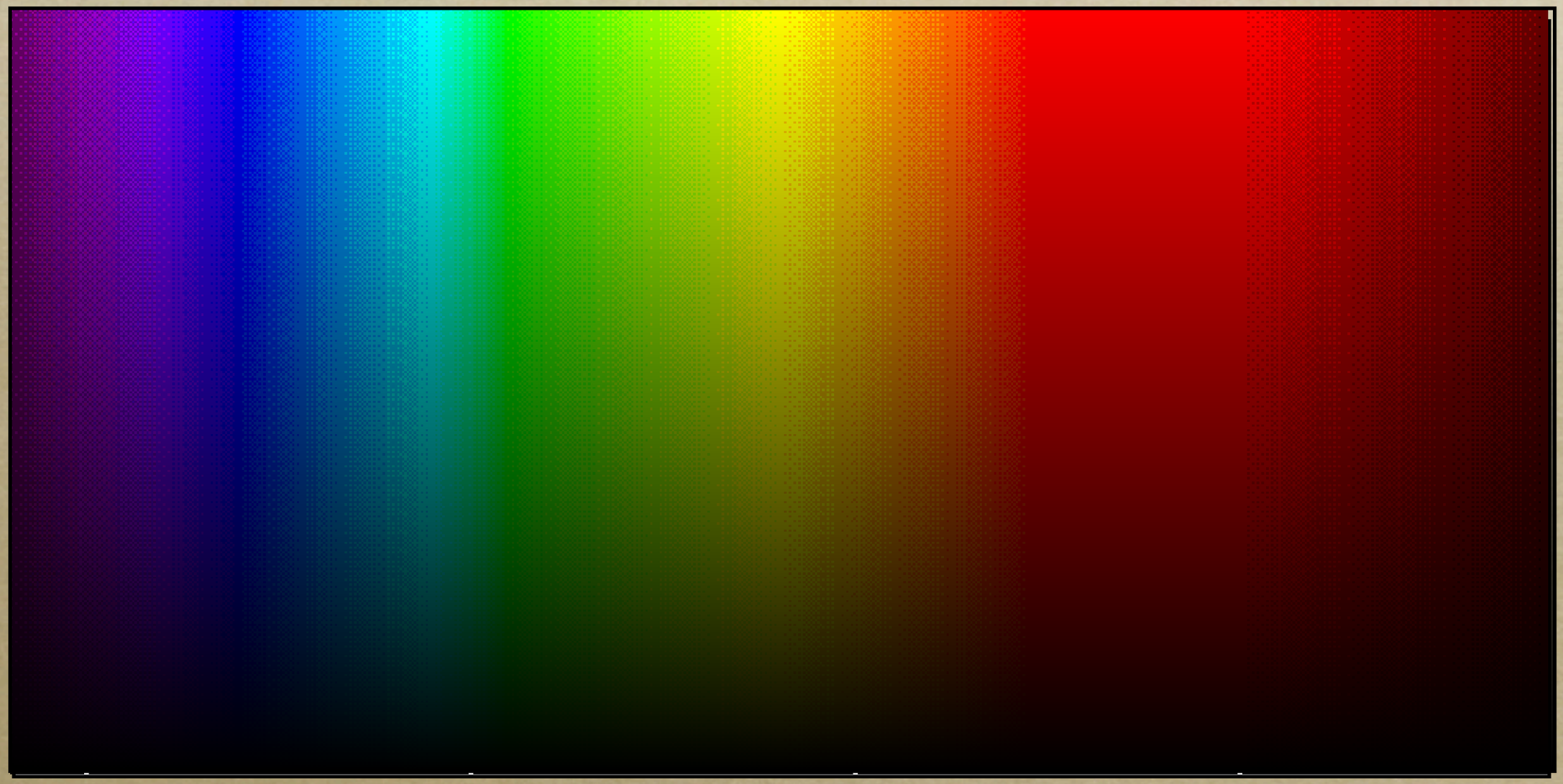
Colour Theory

Why do we get green when we mix blue and yellow paint?

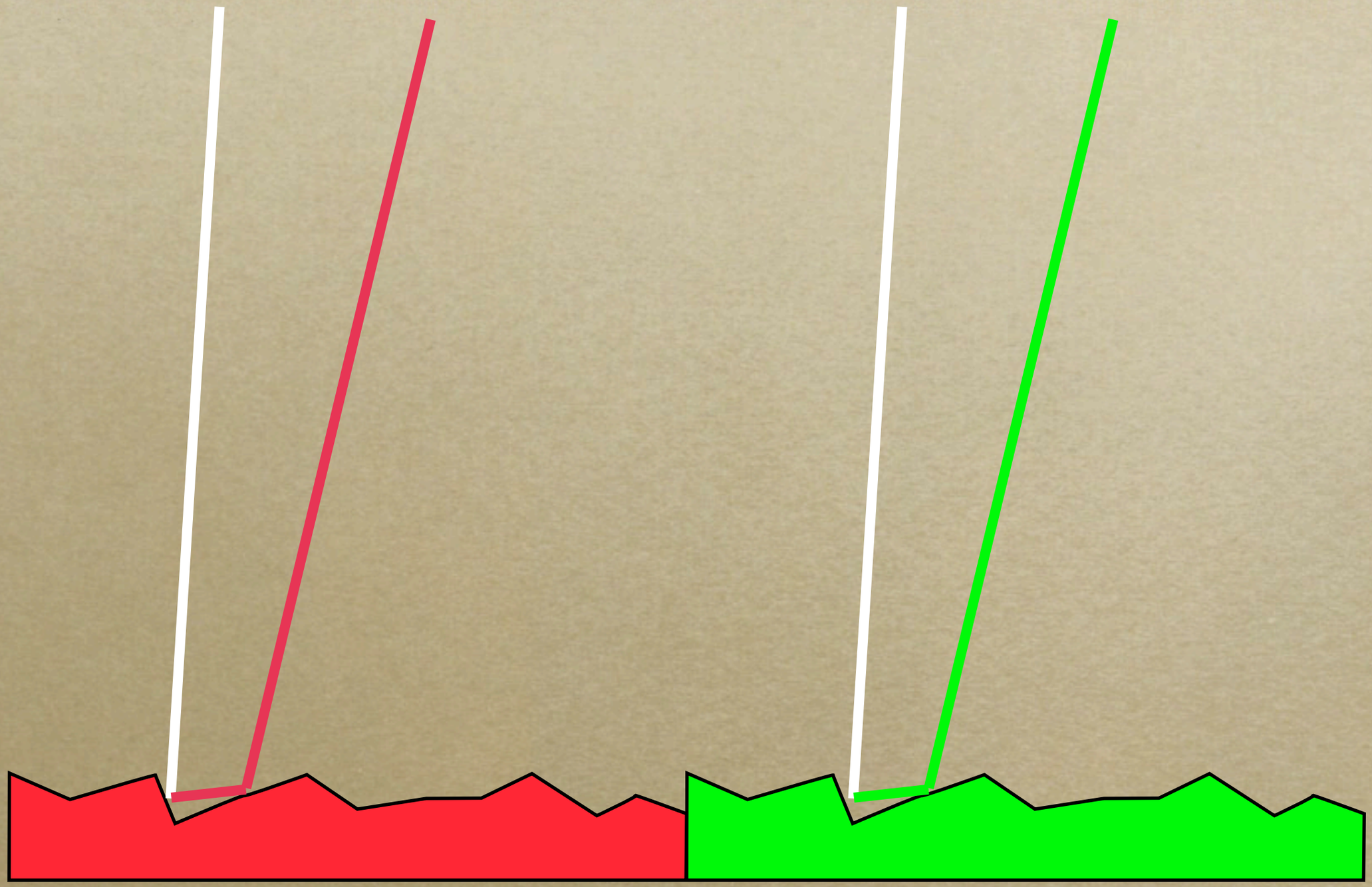
Physics

Intensity (energy) and wavelength.

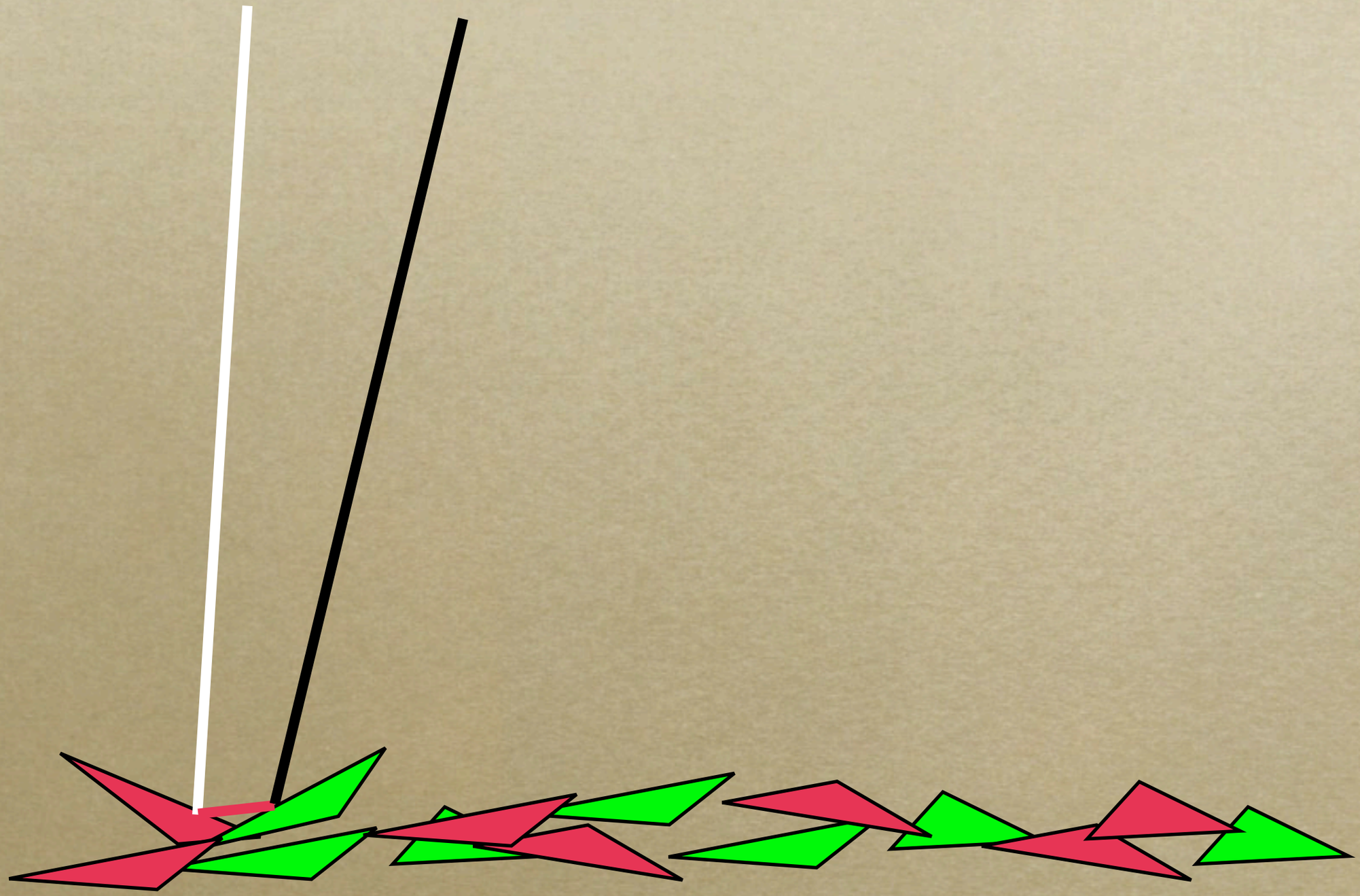


380 nM *740 nM*

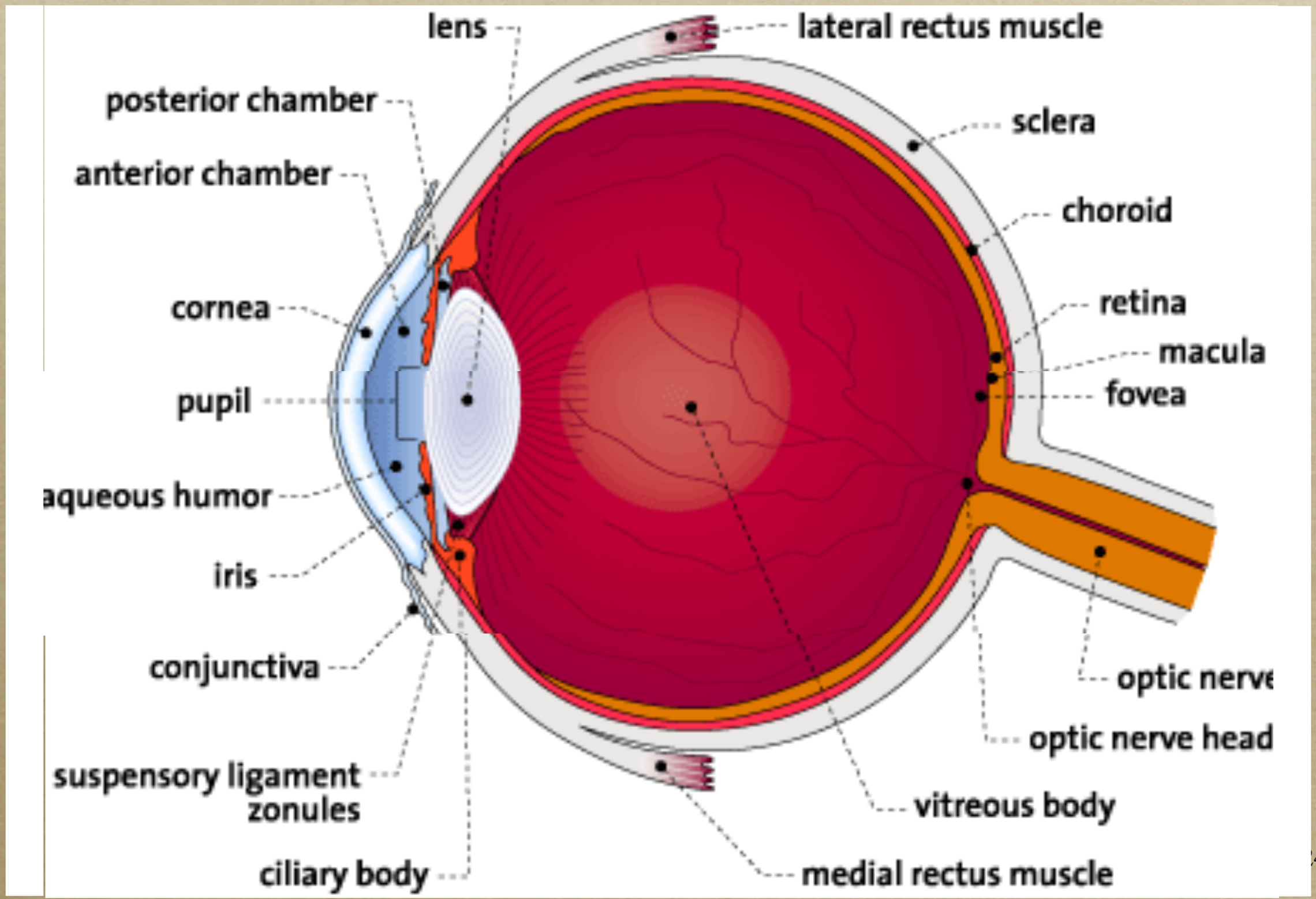
Side by side and mixed pigment



Side by side and mixed pigment



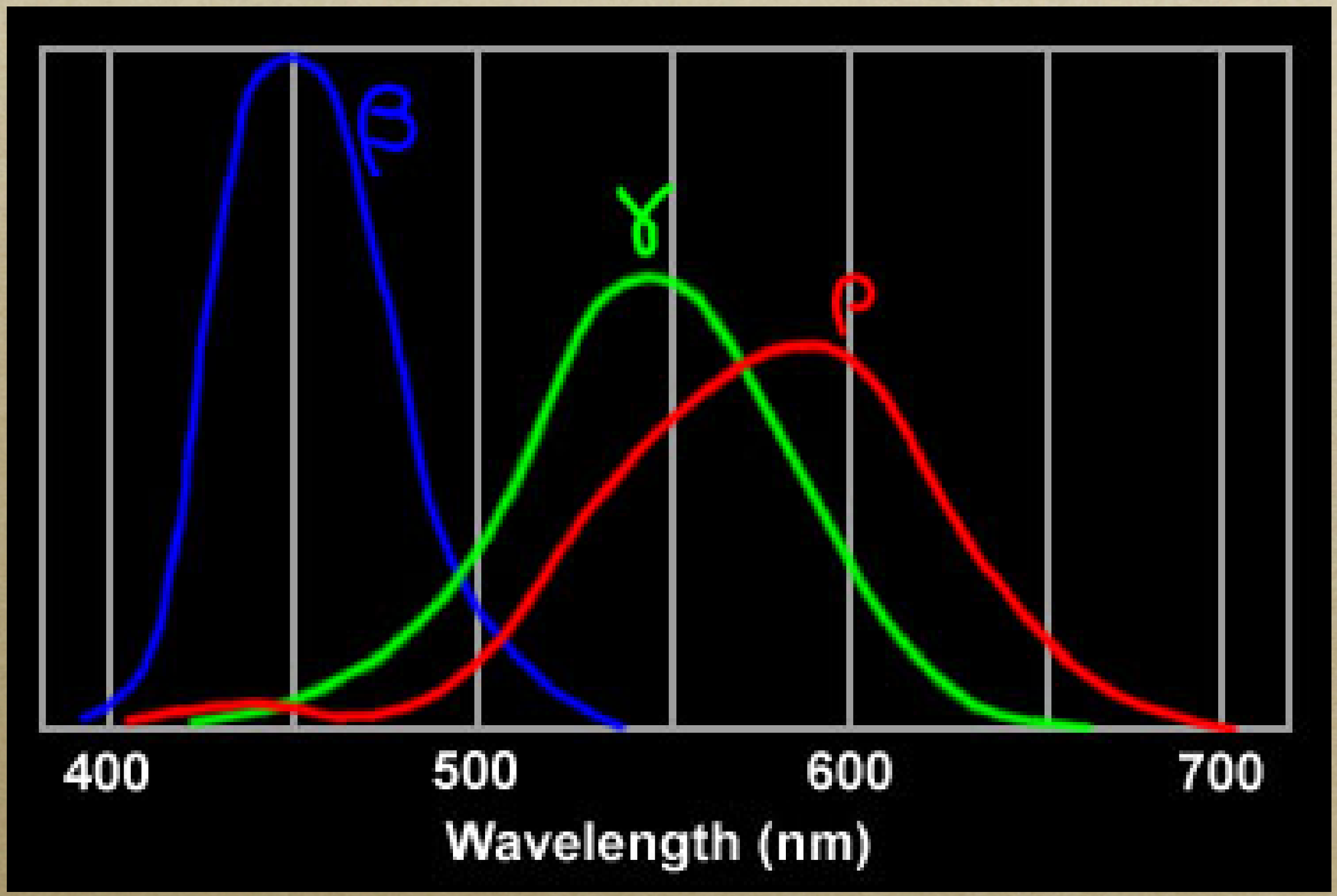
The Eye


lens
lateral rectus muscle
posterior chamber
sclera
anterior chamber
choroid
cornea
retina
macula
pupil
fovea
aqueous humor
iris
conjunctiva
optic nerve
optic nerve head
suspensory ligament
zonules
vitreous body
ciliary body
medial rectus muscle

Receptors

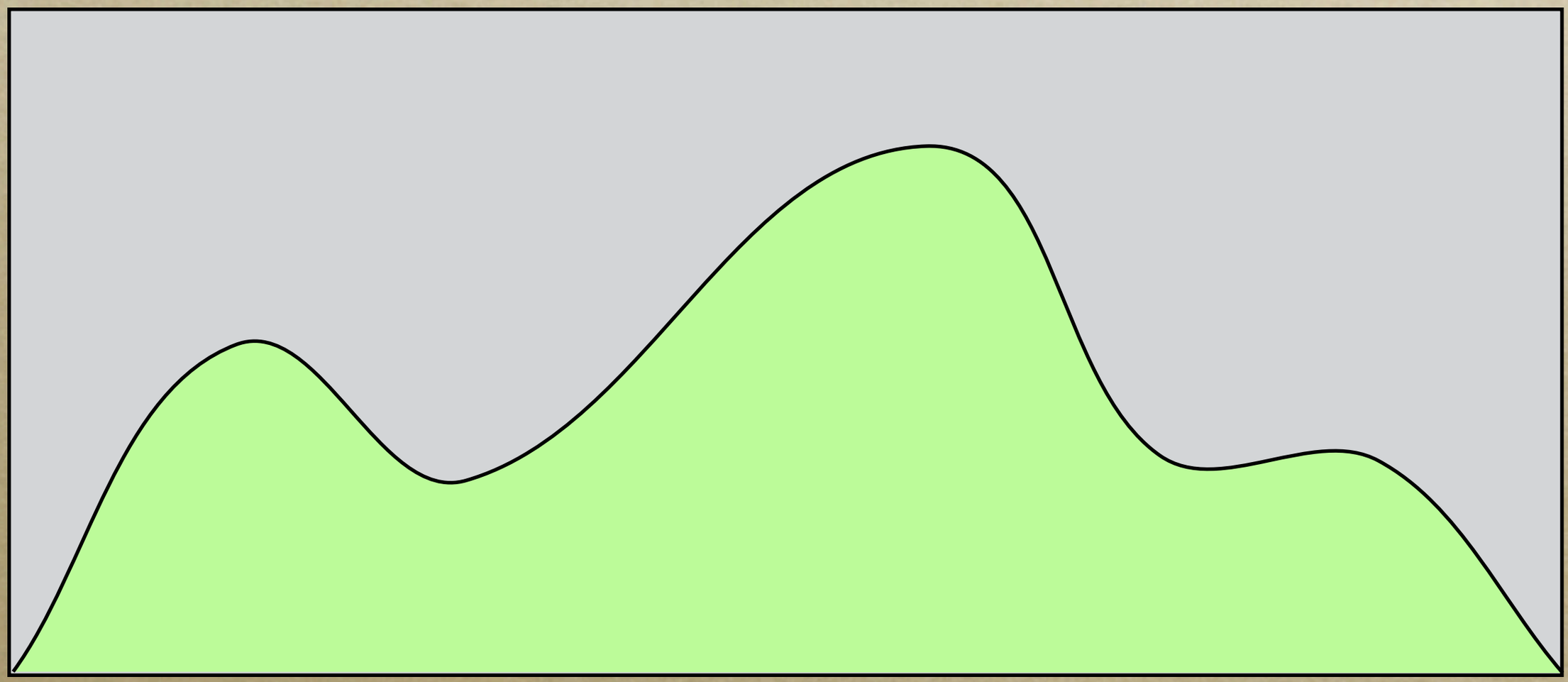
- *Rods - fine detail black and white*
- *Cones - 3 kinds sensitive to different ranges of wavelength*

Response of cones



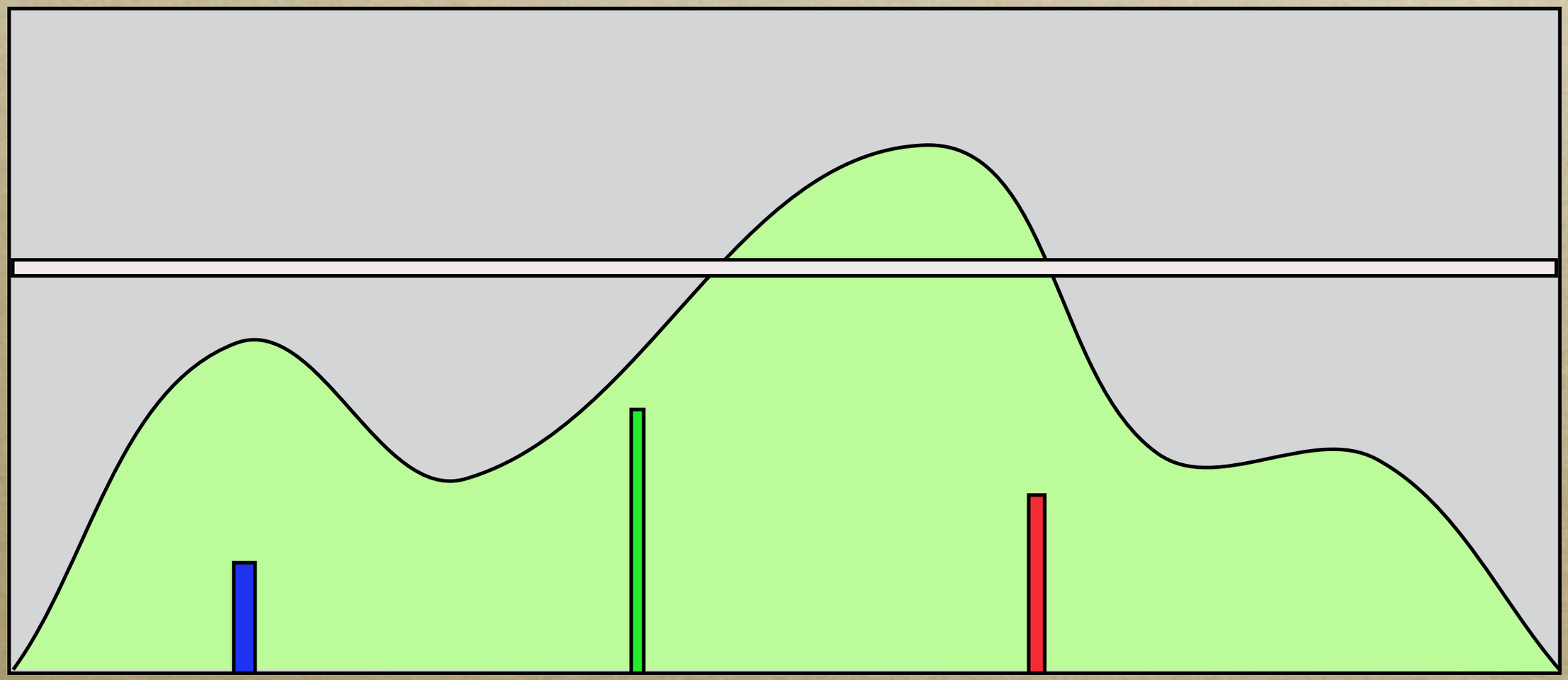
A spectrum describes a colour

Intensity (energy) and wavelength.



380 nM *740 nM*

But we get only four data



380 nM

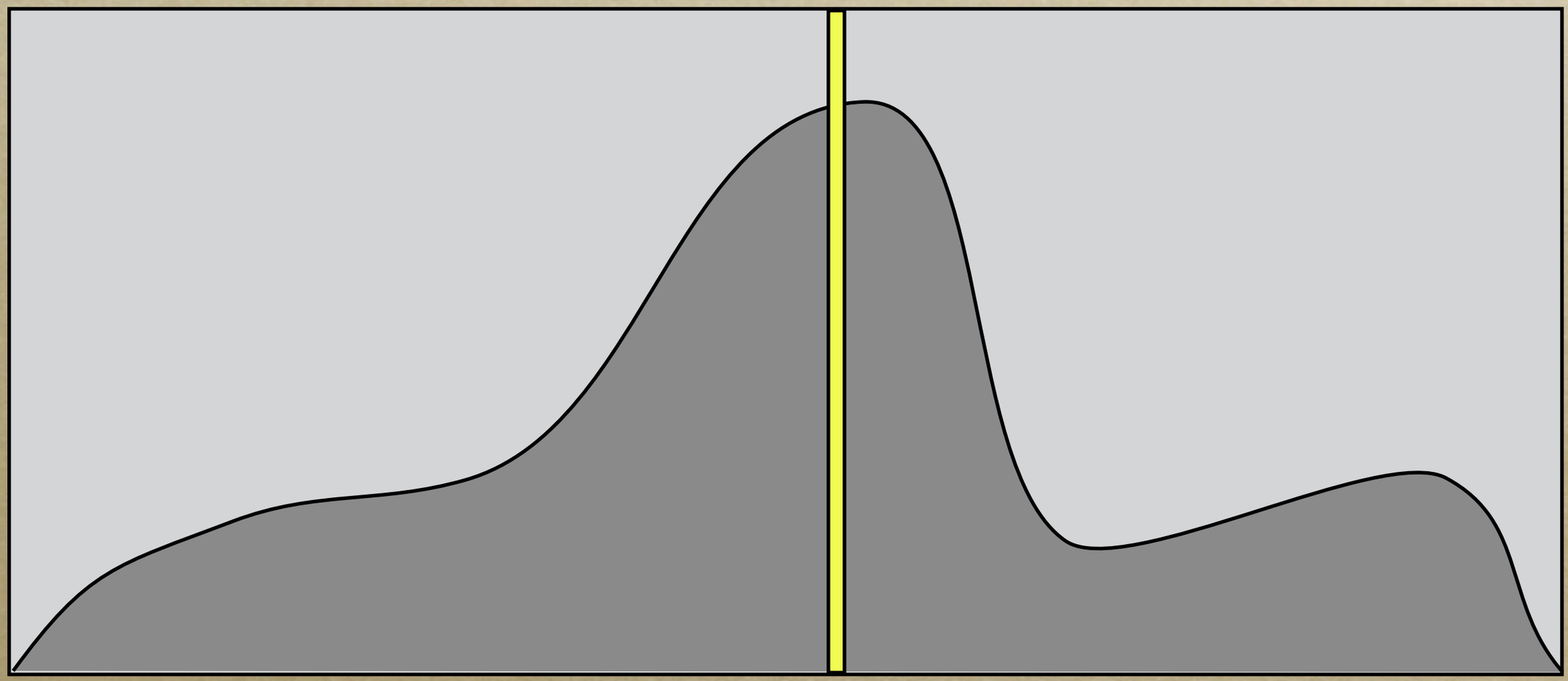
740 nM

Metamerism

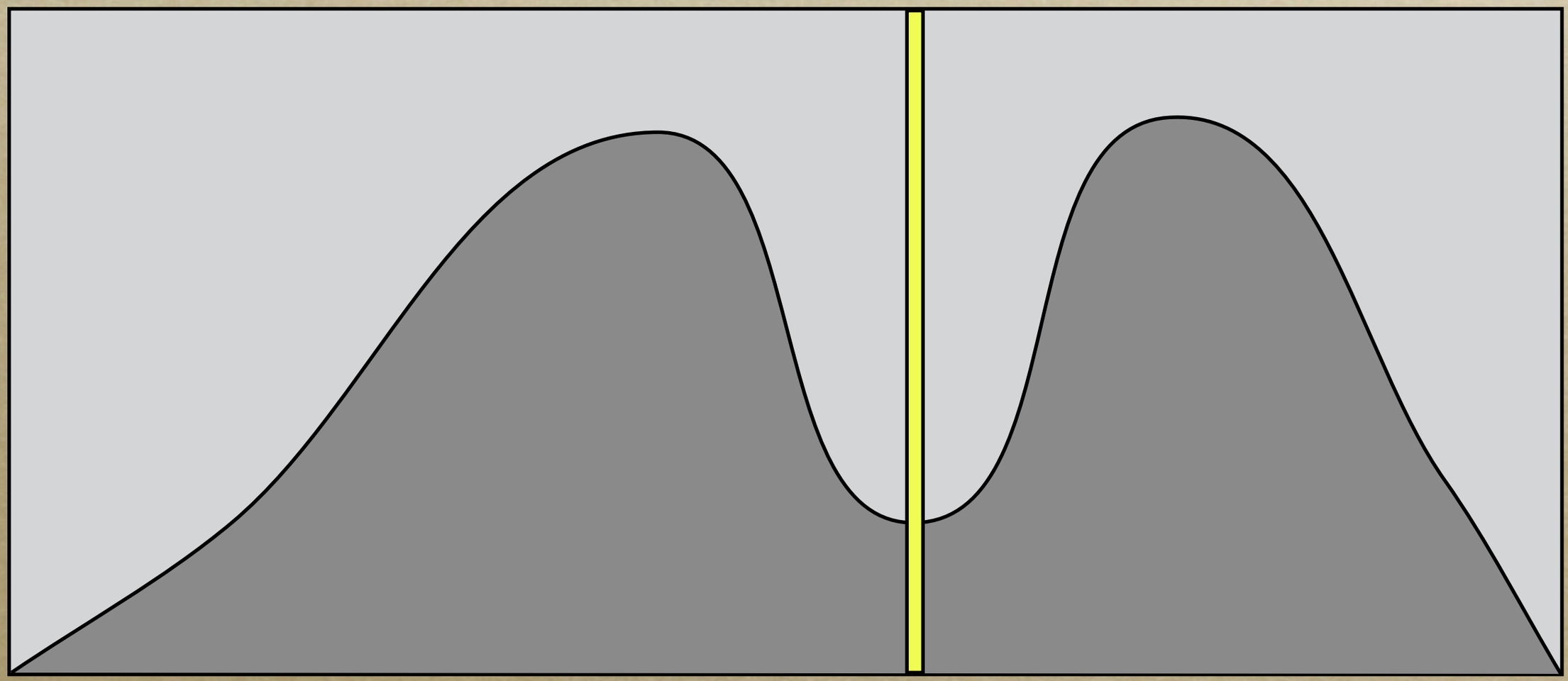
- *The same perceived colour can come from different spectra.*
- *Different spectra that look the same are called metamers or metameric matches.*

Dominant Wavelength

Colour looks the same as one spectral line



Red plus Green = Yellow



More Metamerism

- *Match under light A but not B (Sample metamerism)*
- *B matches C only under light A (Illuminant metamerism)*
- *Observers see different matches (Observer metamerism)*
- *A, B match viewed from one angle (Geometric metamerism)*

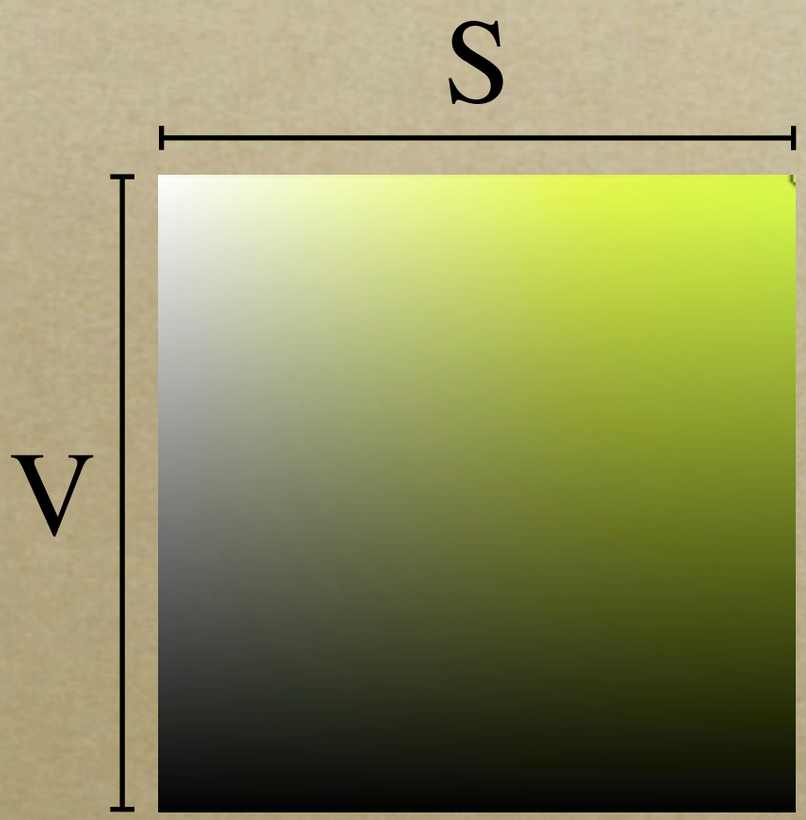
Colour Models

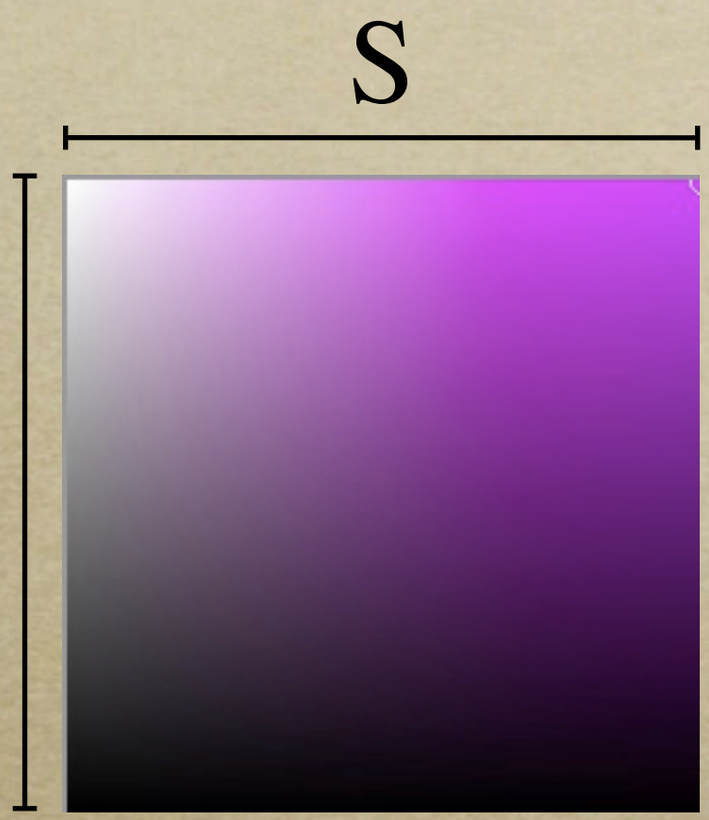
- *RGB, Red, Green, Blue*
- *HSV, Hue, Saturation, Value*
- *CMYK, Cyan, Magenta, Yellow, Black*
- *CIE model*

Hue Saturation Value

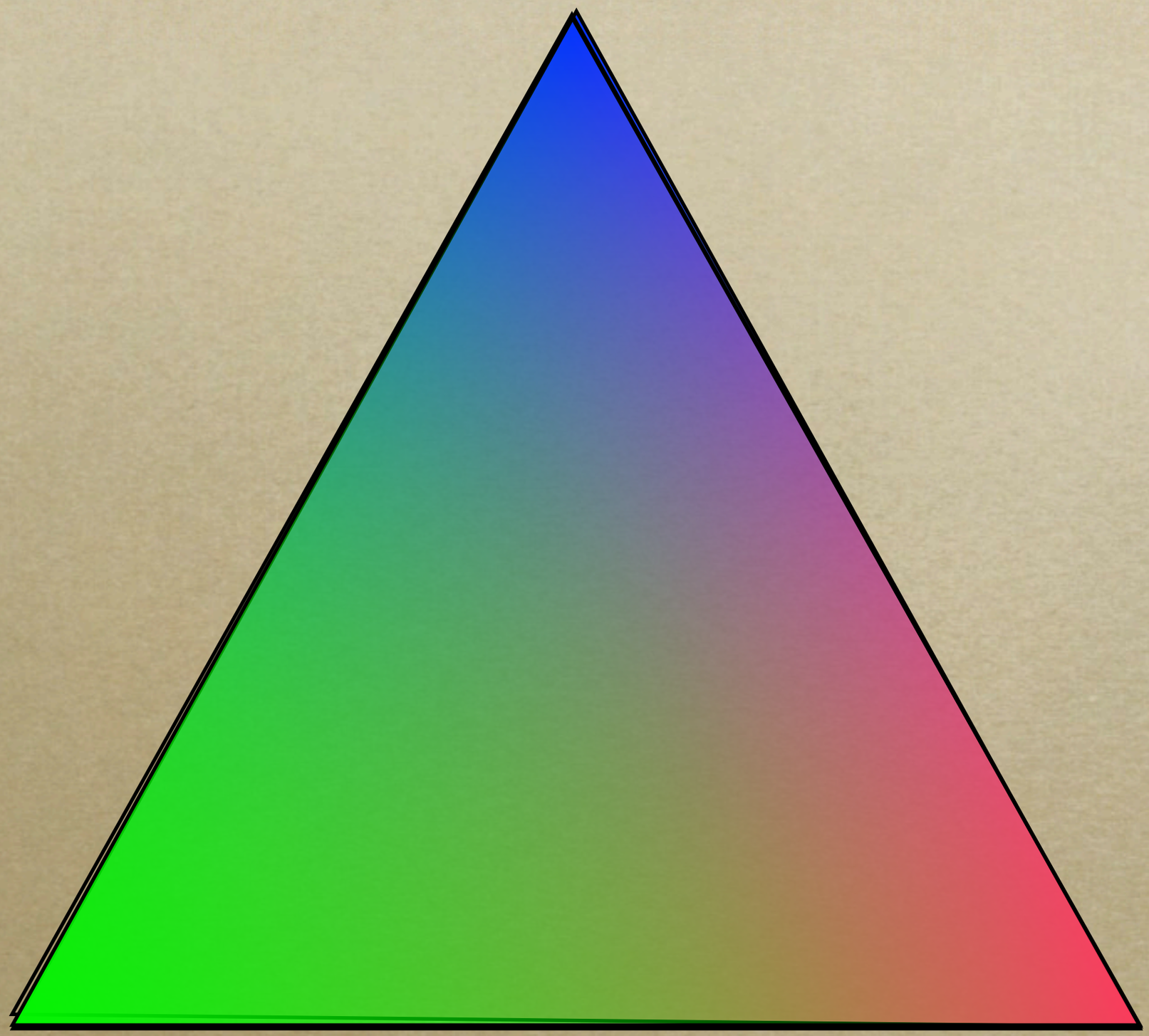
- *Hue refers to spectral characteristic*
- *Less saturated colours include white*
- *Low value colours include black*

Examples of fixed H, varied SV

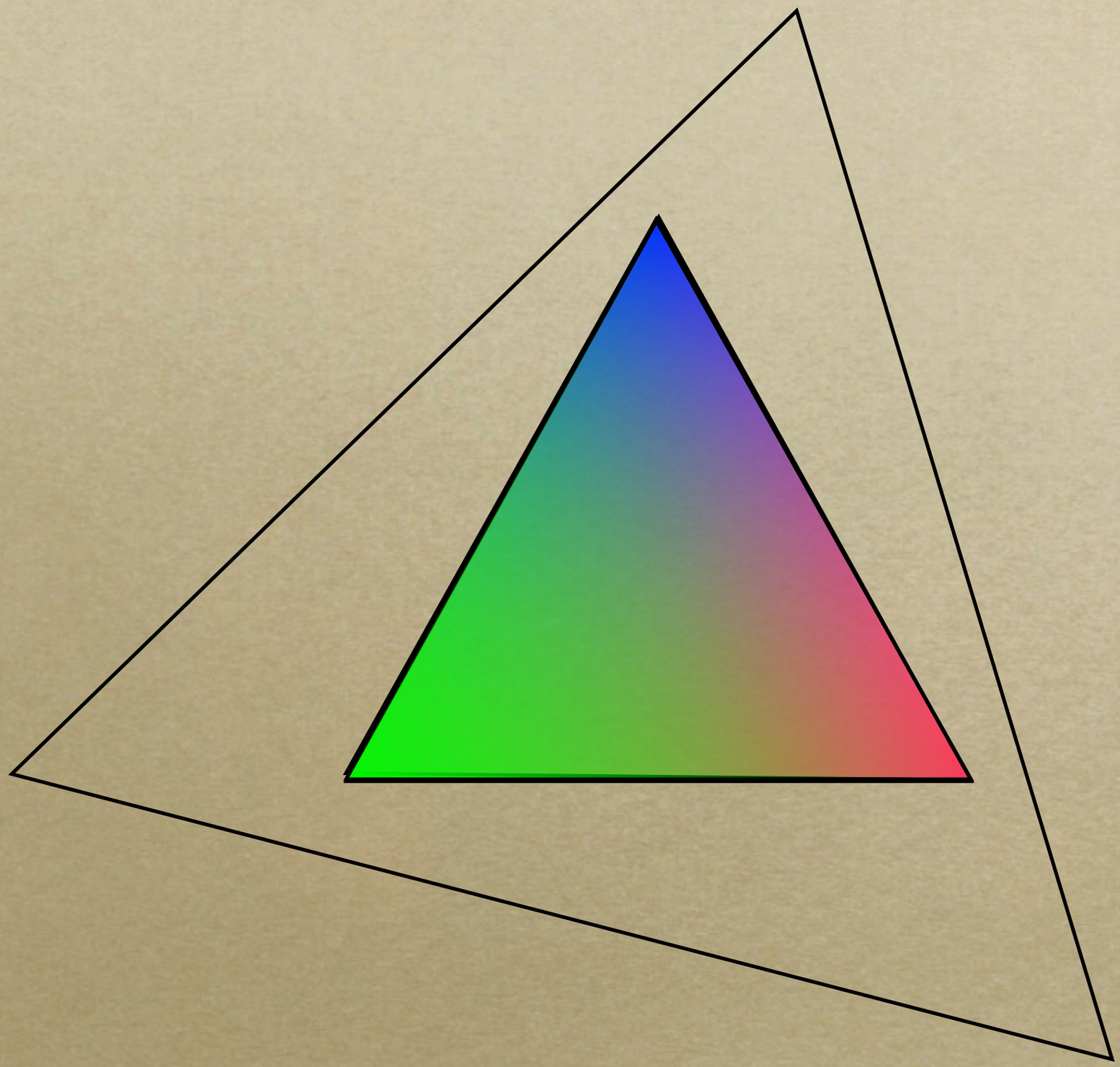




RGB is not enough



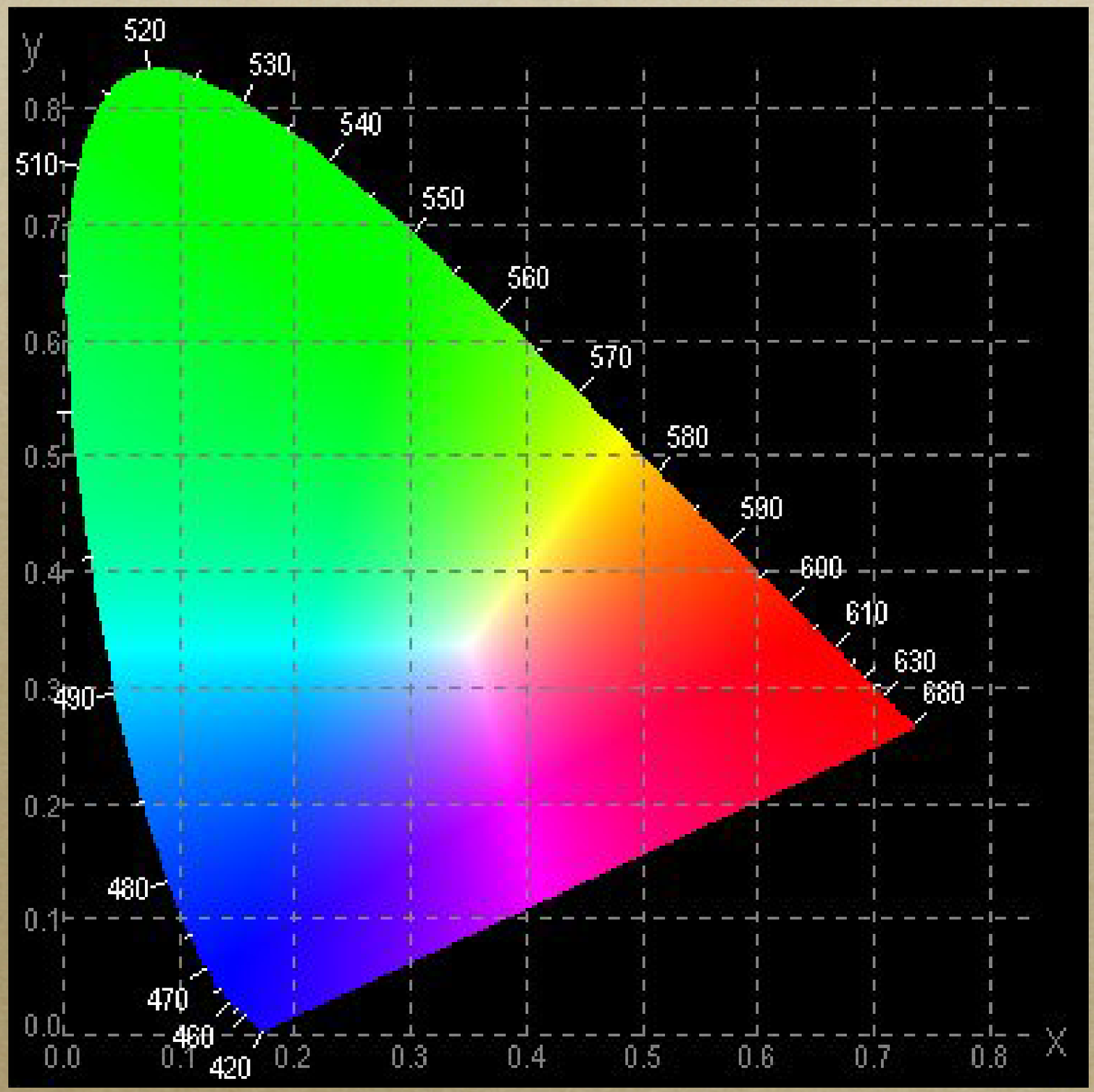
Make a bigger triangle

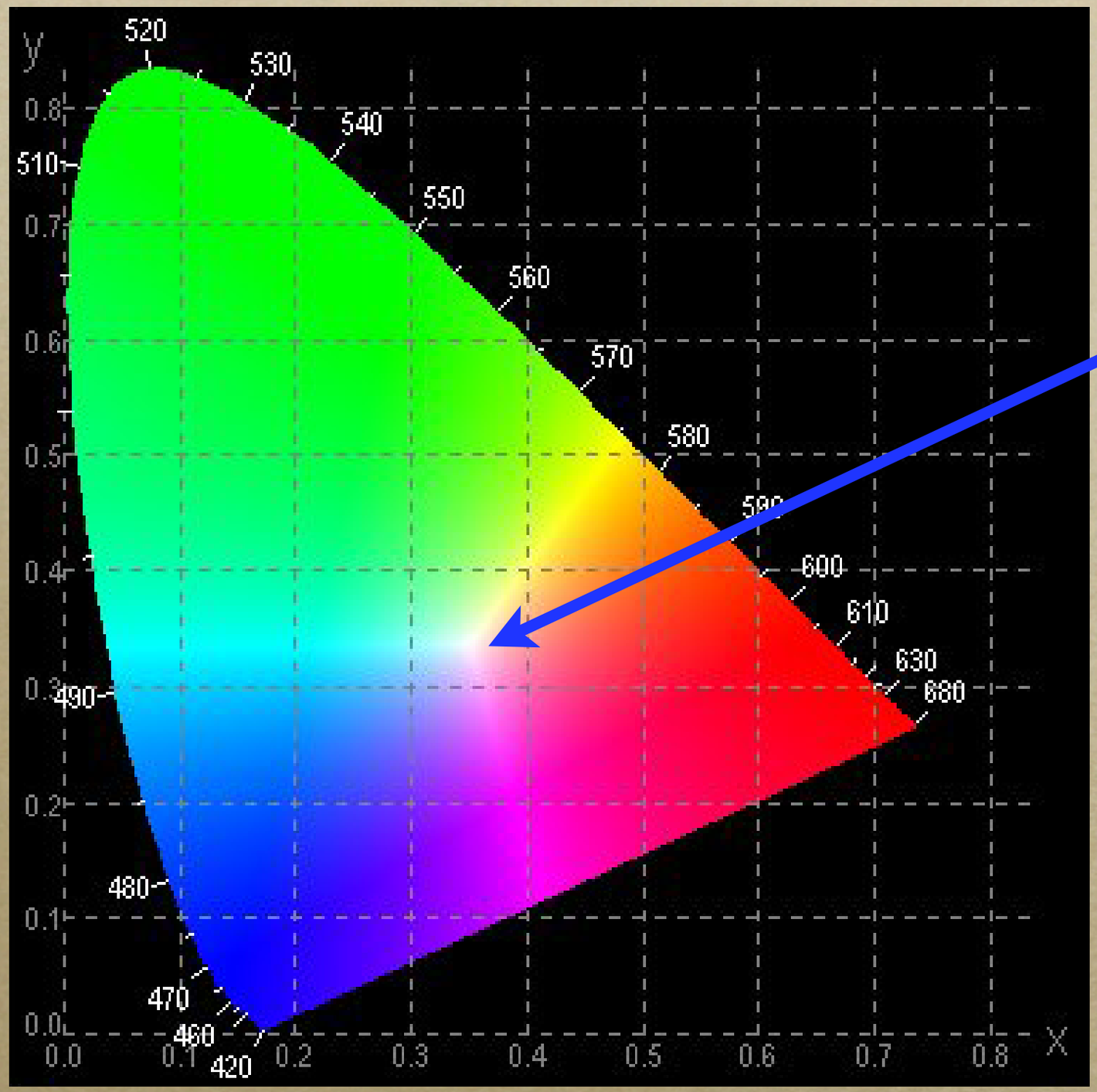


CIE idea

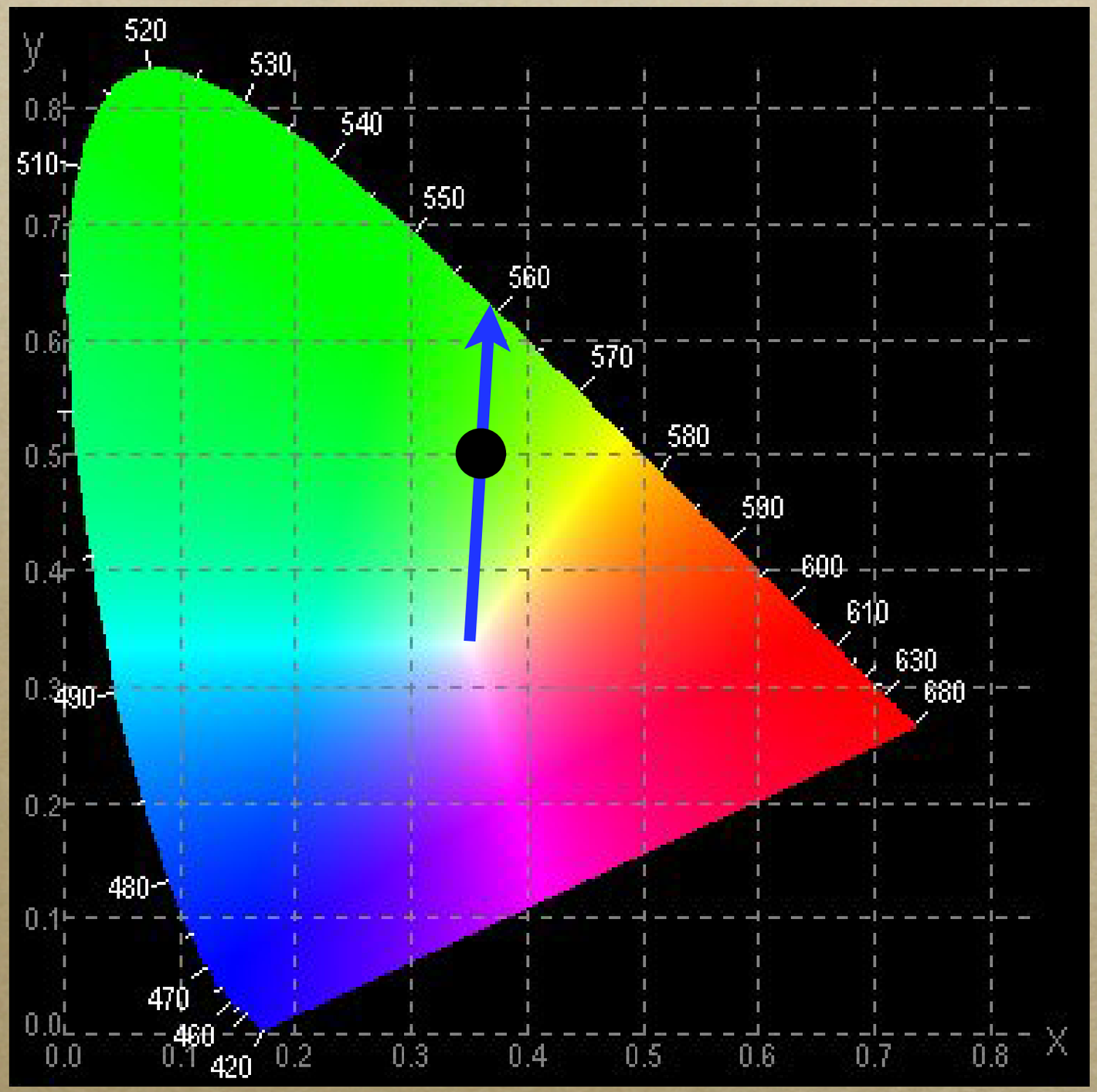
- *Define three 'primaries' X, Y, Z*
- *These are outside our perceptual range*
- *Linear sum of X, Y, Z can represent all colours*
- $x = X/(X + Y + Z) \quad y = Y/(X + Y + Z)$
- *Plot x, y*

CIE Chromaticity Diagram

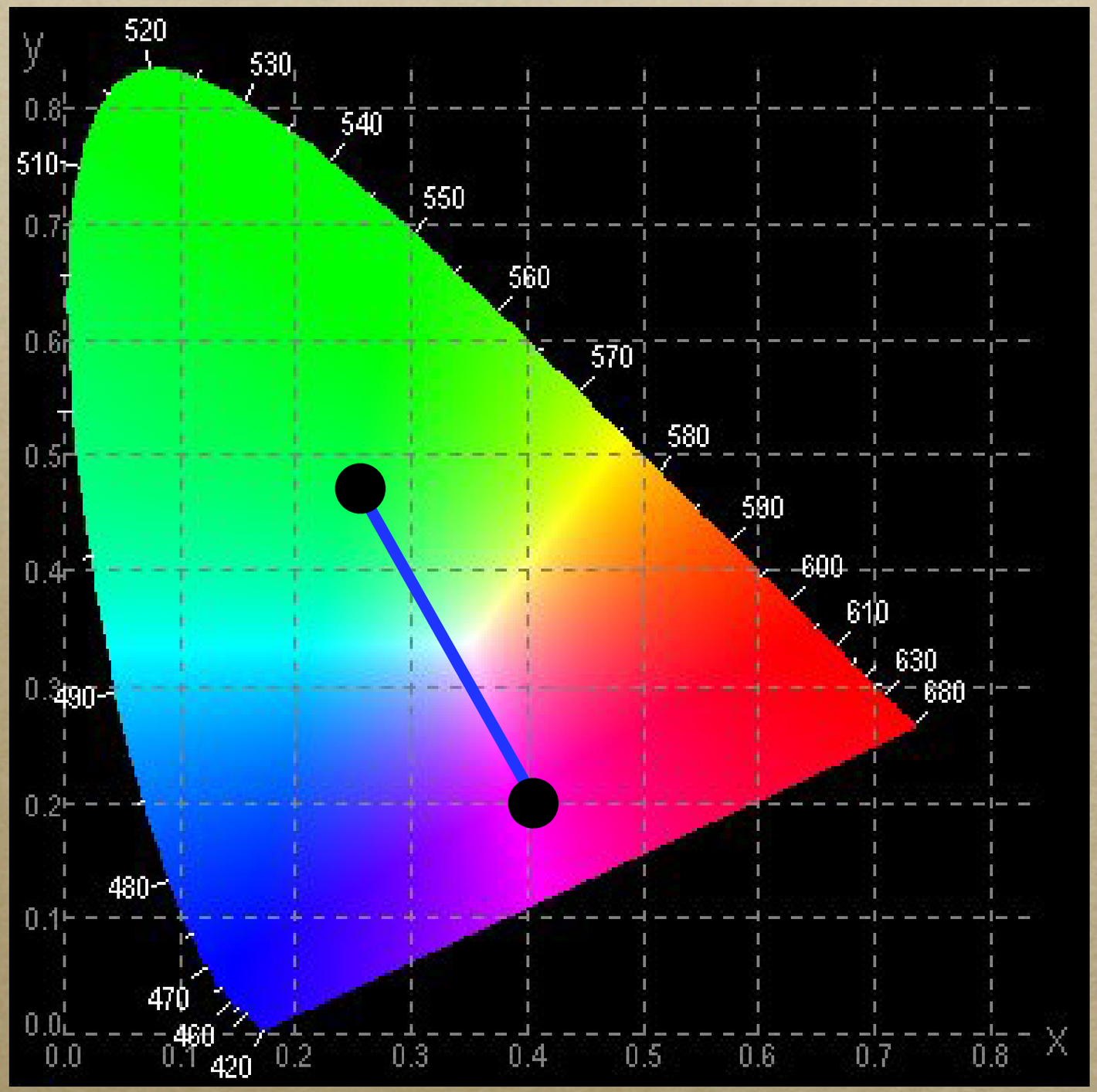




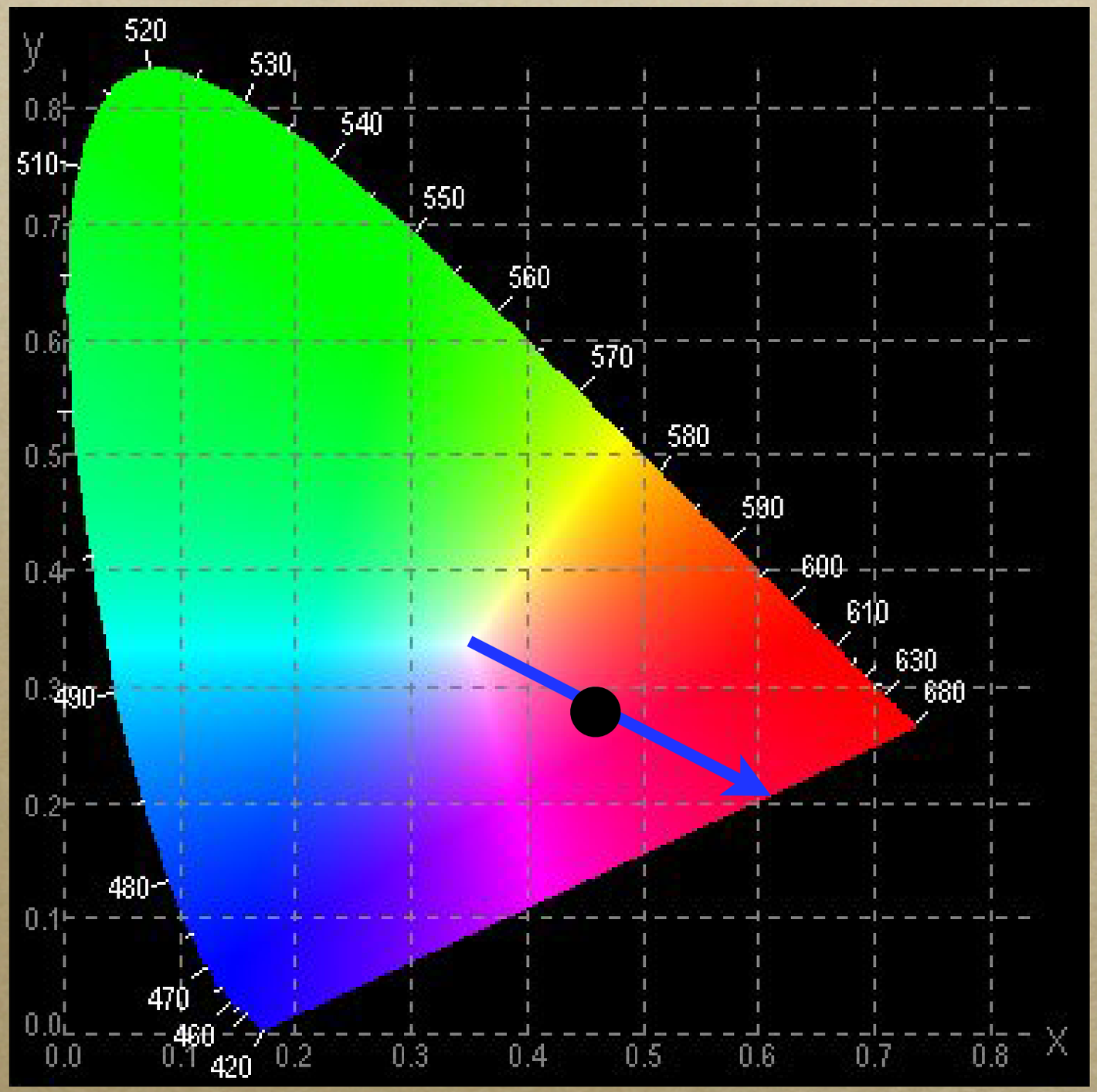
White Spot 1/3, 1/3



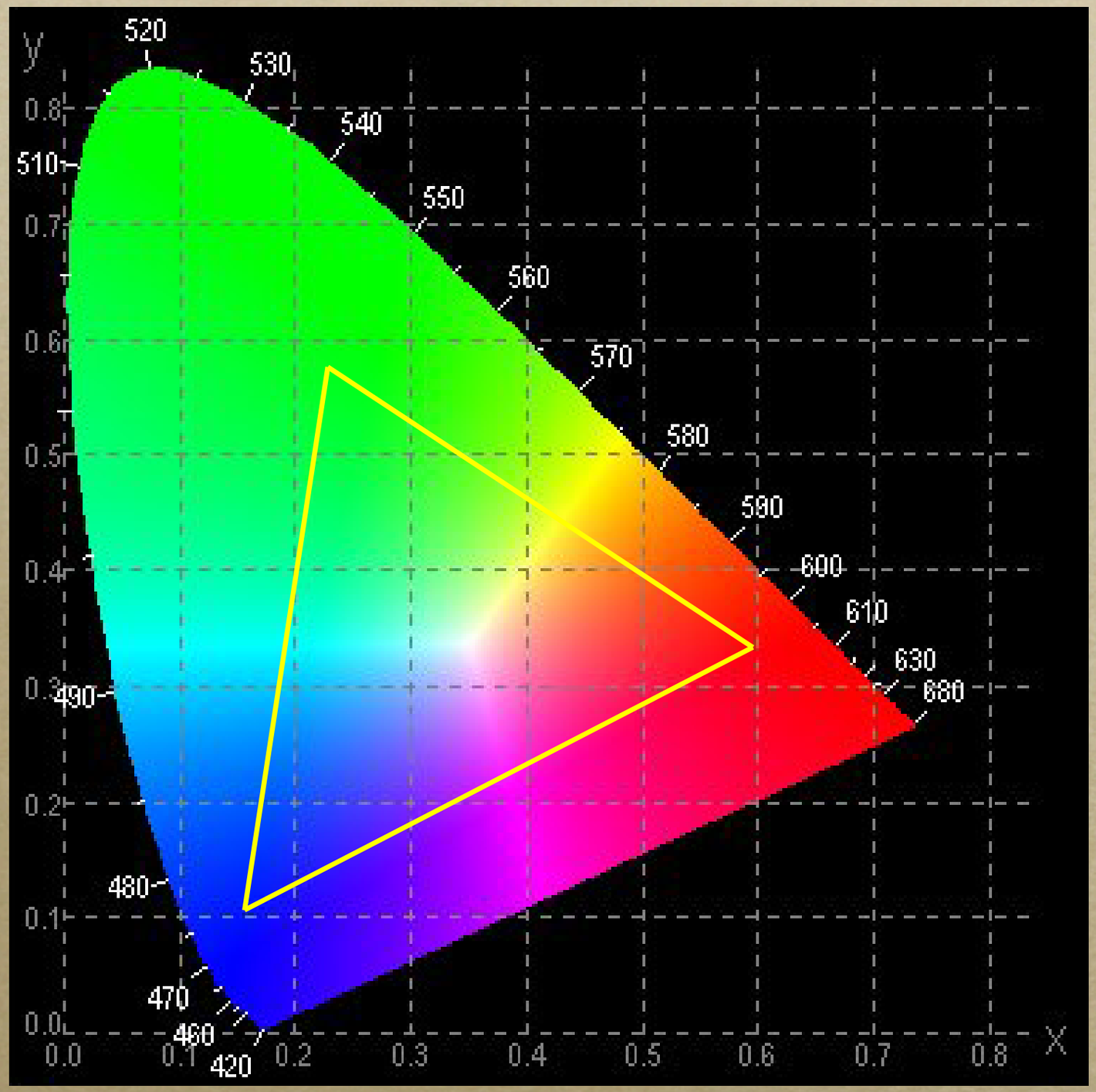
Dominant Wavelength



Complementary colours



Non spectral colour

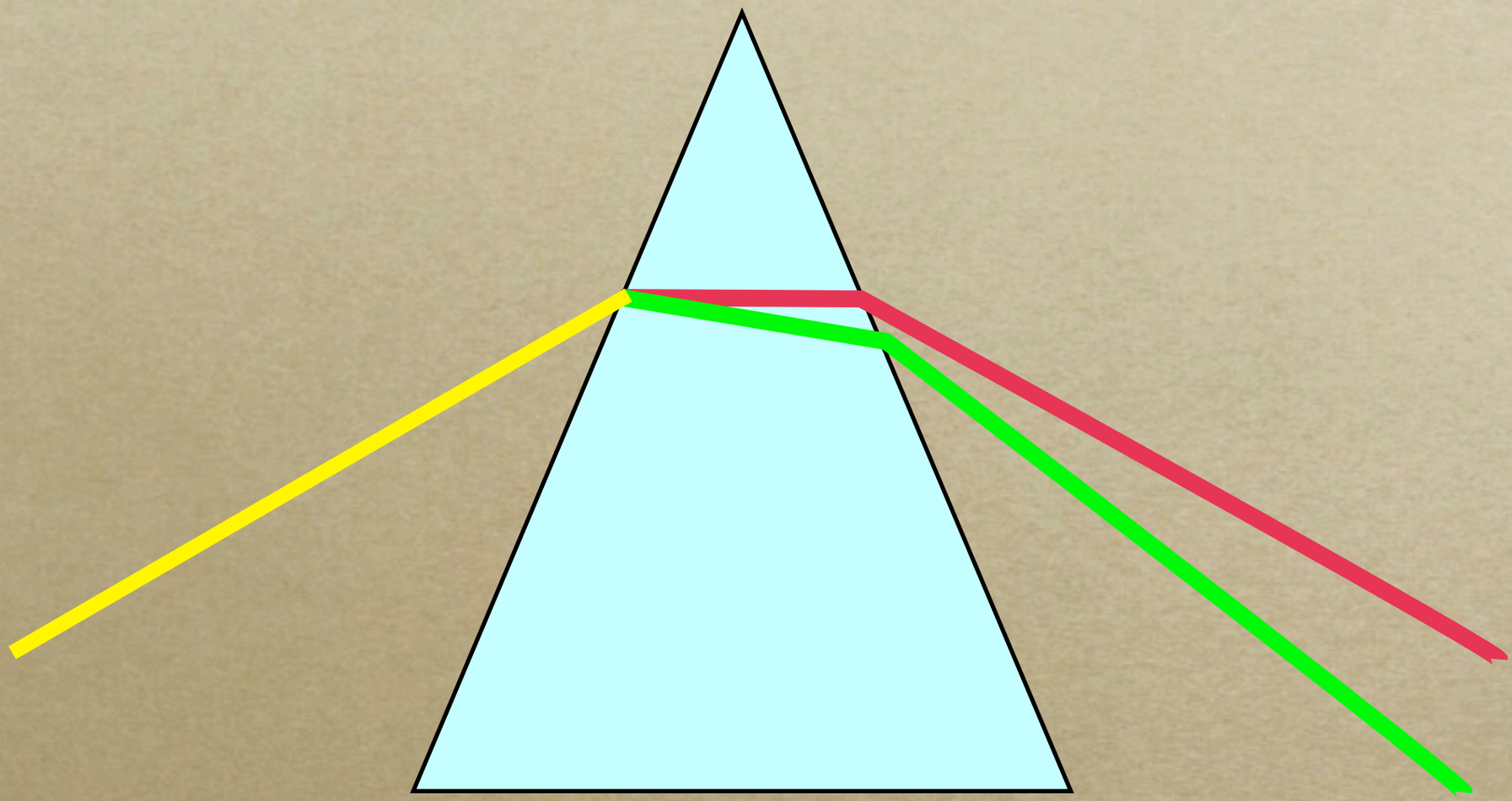

y
x
520
530
540
550
560
570
580
500
600
610
630
680
490
480
470
460
420
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

RGB Gamut

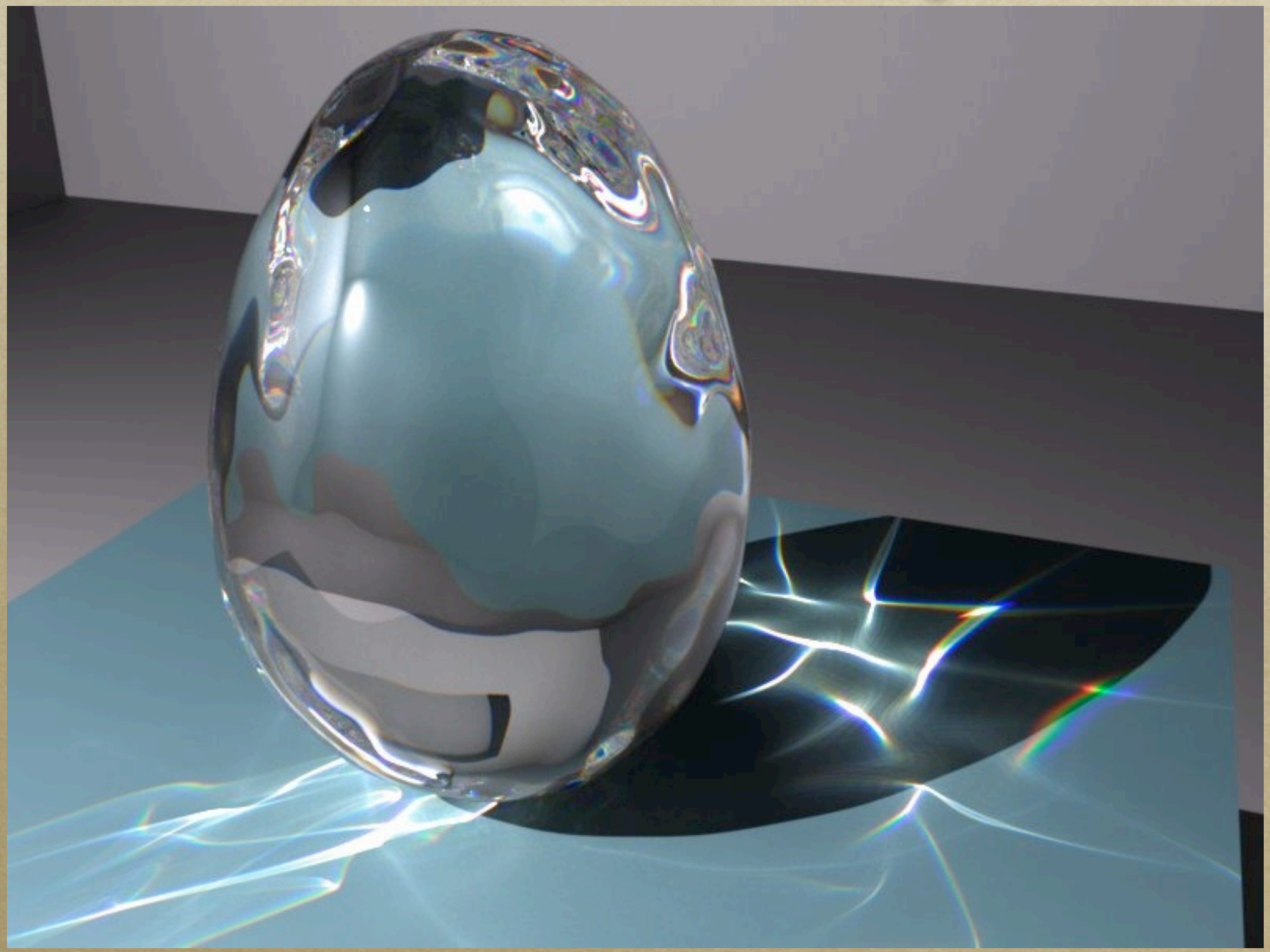
Colour ray tracing

- *Use RGB and do illumination three times, or...*
- *Use fine spectral bands and combine later to make RGB*

How do you do this



LuxRender example



An exercise for the reader

- *Find out how to change a colour from RGB to CIE or HSV etc.*
- *Hint it's a bit like transforming coordinates*

That's it!

Over to you to put that knowledge to use somewhere…

- *A Field Guide to Digital Color*
  - *http://www.stonesc.com/book/*
  - *http://www.amazon.com/Field-Guide-Digital-Color/dp/1568811616*
- *Color in Information Display: Principles, Perception, and Models*
  - *http://www.stonesc.com/signotes/*
- *Color Lecture - Stanford University's Visualization Course*
  - *http://www.graphics.stanford.edu/courses/cs448b-04-winter/lectures/color/*