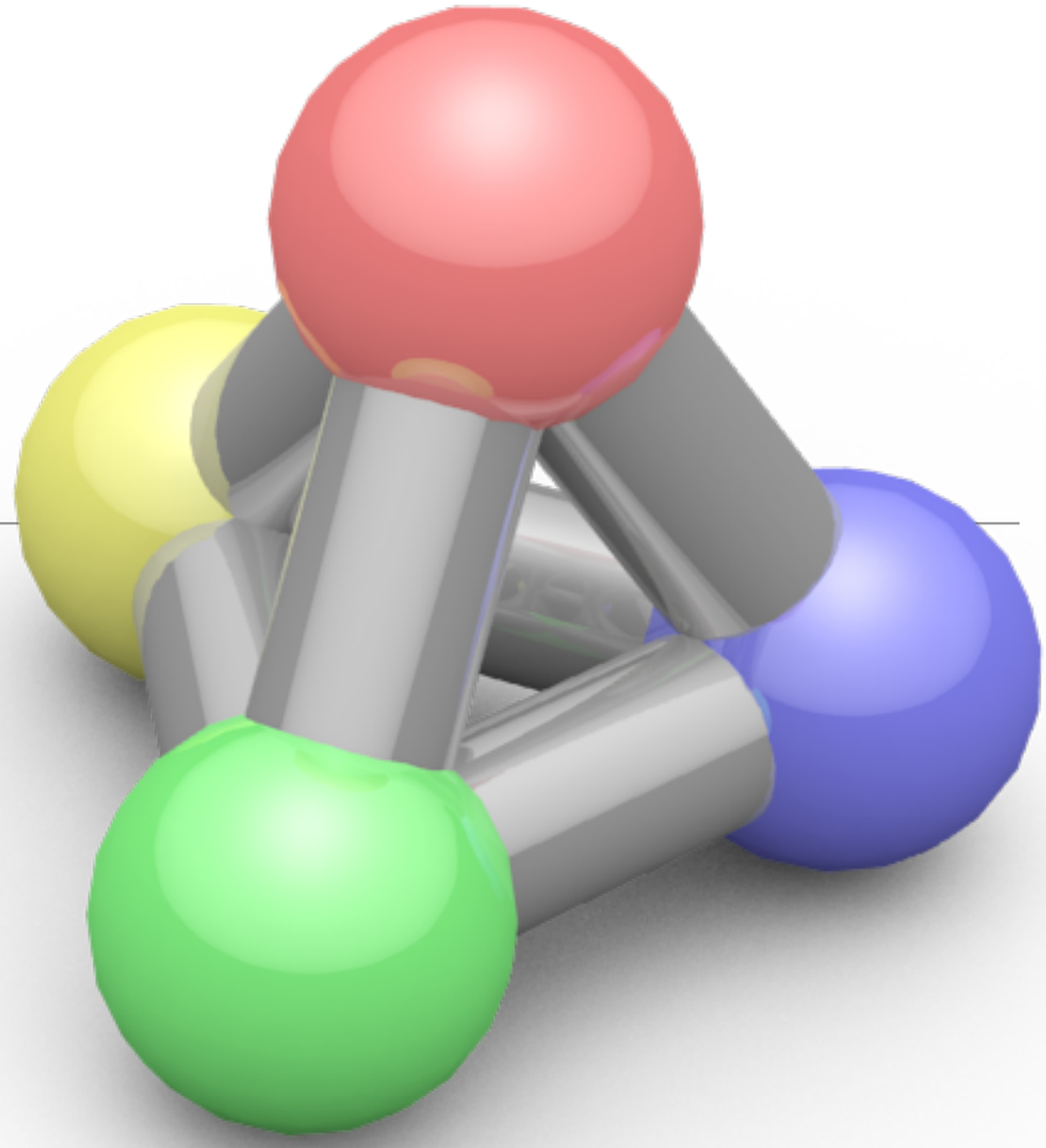
Graphics Displays



CPSC 453 – Fall 2016
Sonny Chan

Announcements

- Assignment #1 released!
  - Written component due Thursday, September 22
  - Program component due Friday, September 30
- Tutorial sections start next week
- Reminder: join us on piazza!
  - piazza.com/ucalgary.ca/fall2016/cspc453

Lecture Slides

- By popular demand, I will try to post slides on the course web page before lecture, with a few recommendations:

  - I don't use slides for all classes

  - They may not be the final version

  - They're mostly just pictures, not notes, but you can scribble your own notes on them during class

  - I encourage you **not** to read slides ahead of time, but instead read the corresponding chapter of your text

Graphics Displays

Not only these…

Graphics Displays

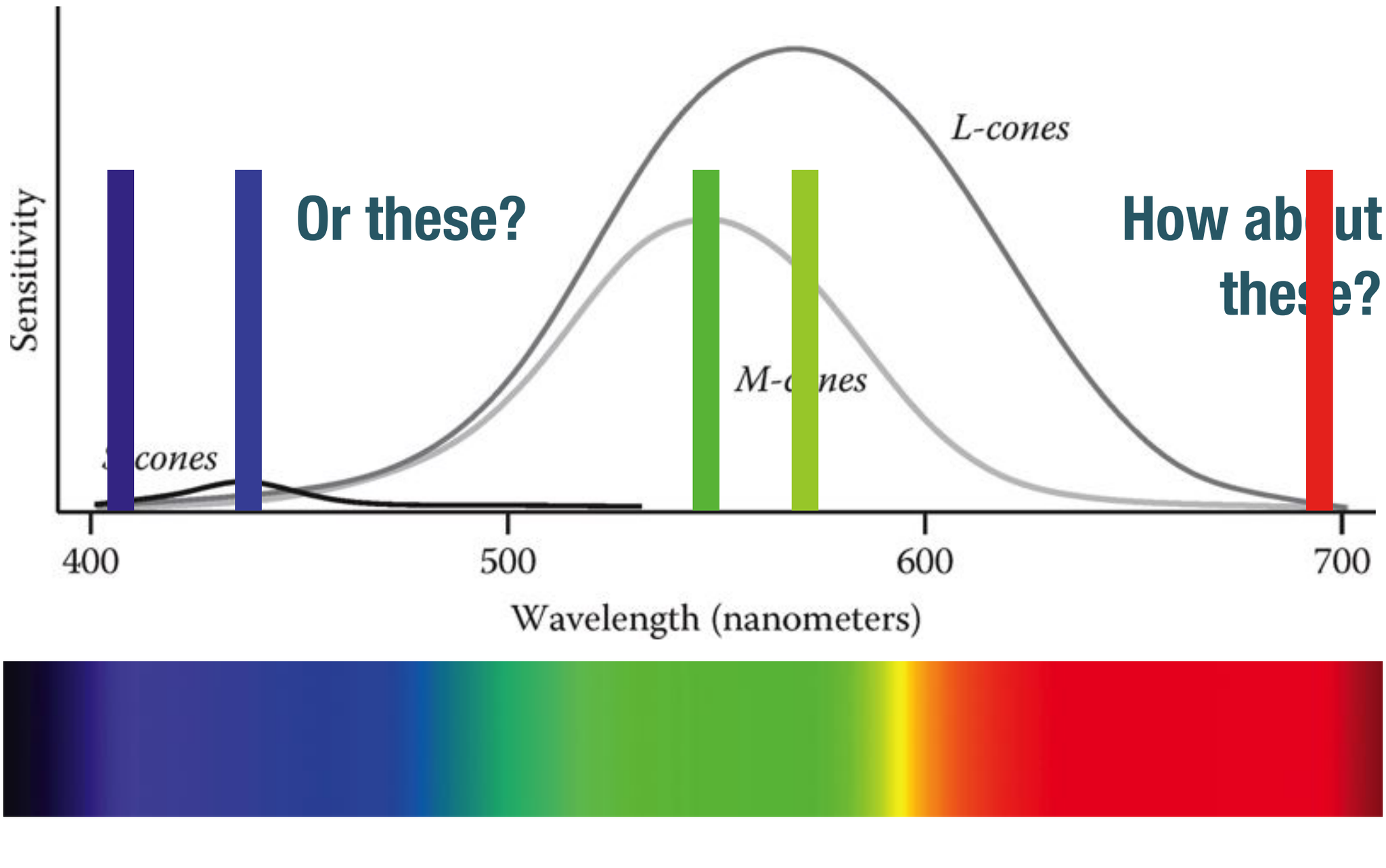
… but these too!

What are the

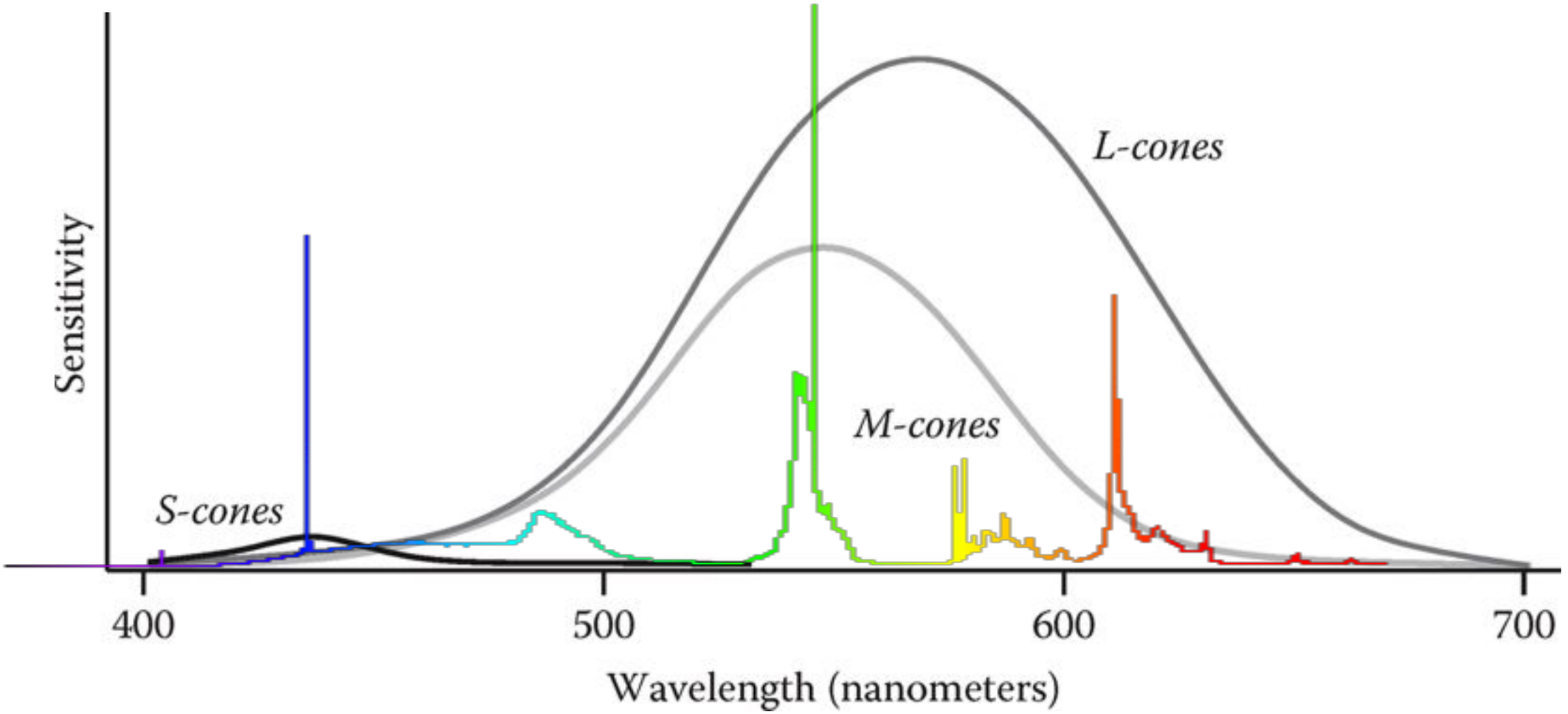
primary colours?

Back to Colour Perception

- Our goal: stimulate photoreceptors in some combination

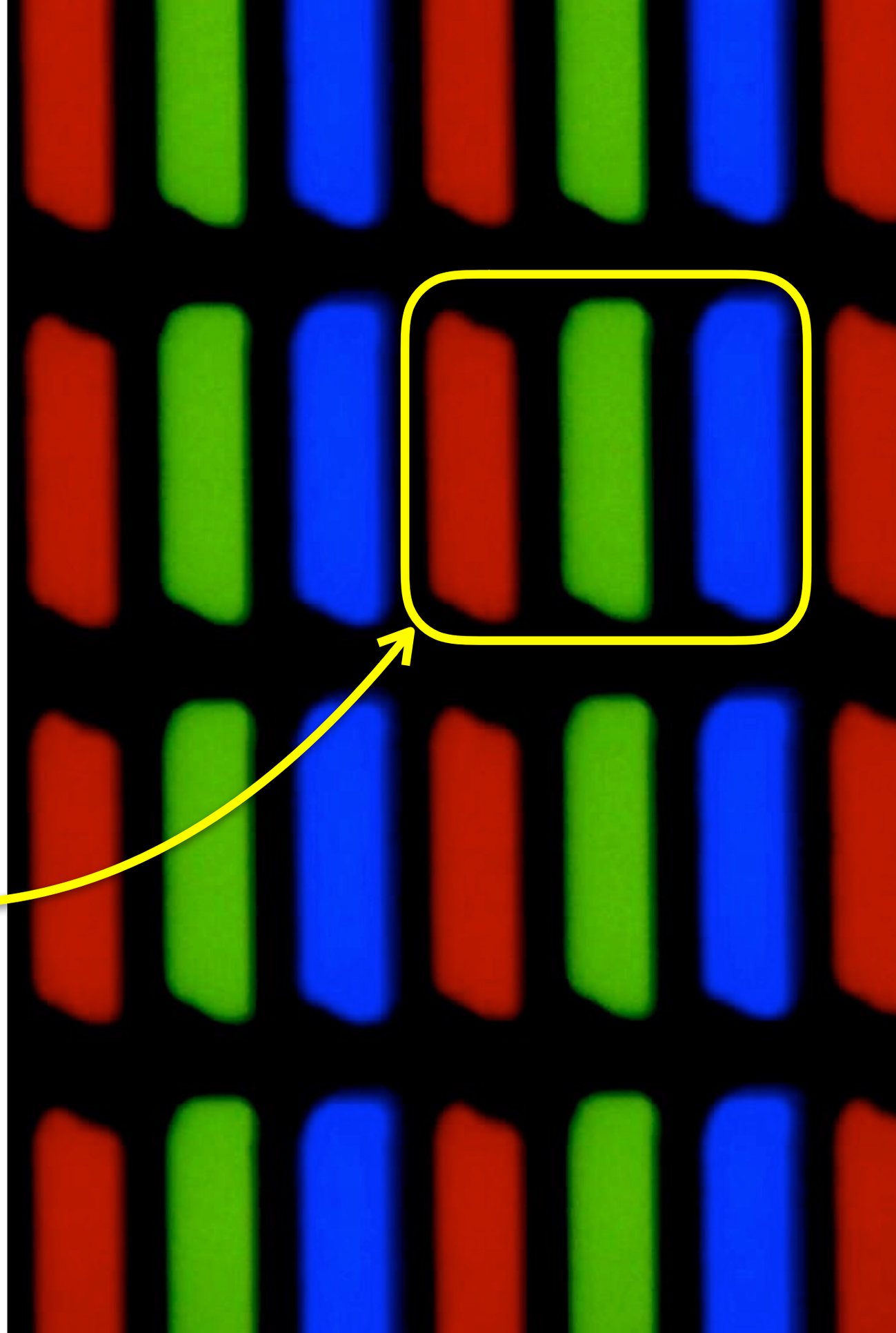


A Contemporary Liquid Crystal Display

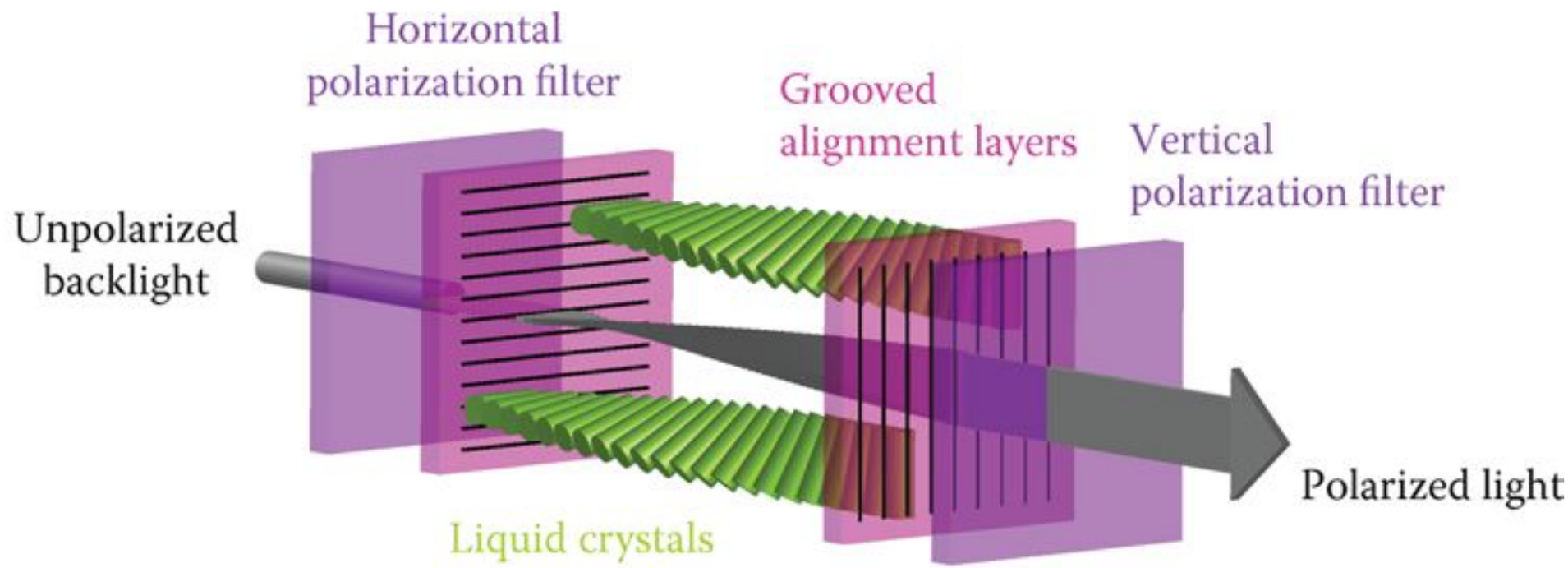


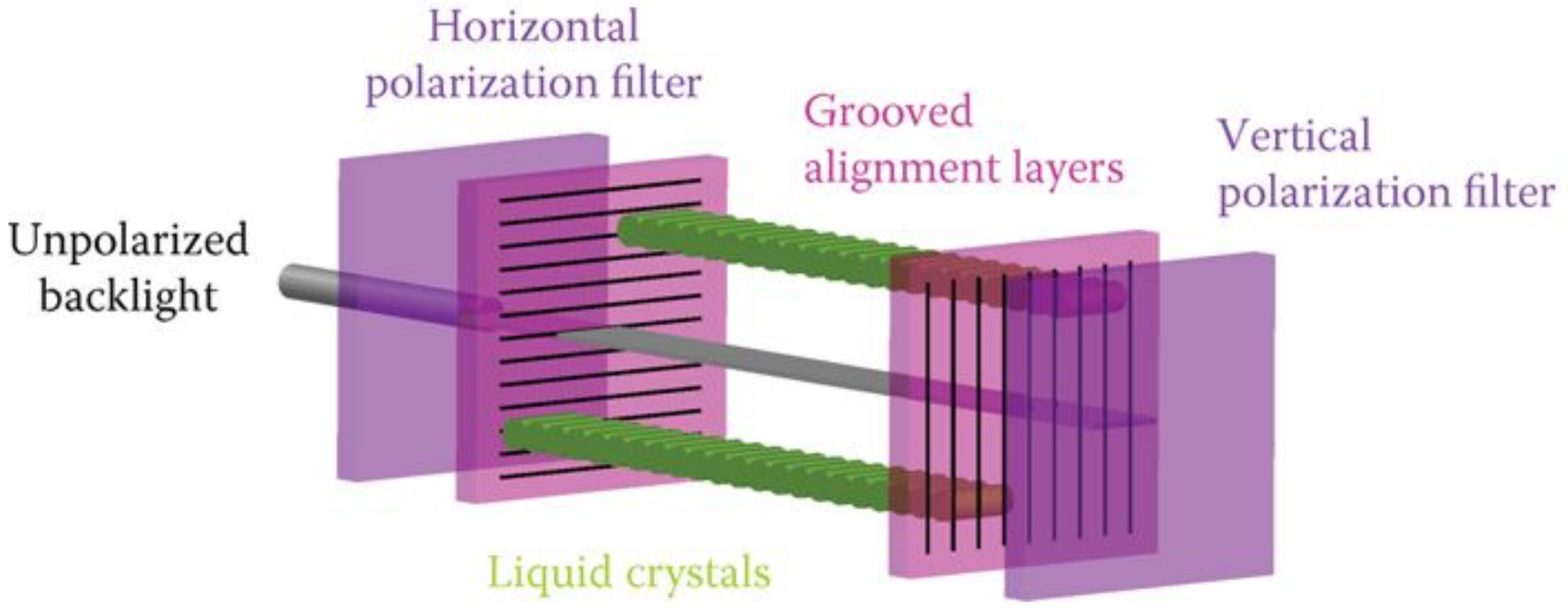
Magnified LCD

A display “pixel”

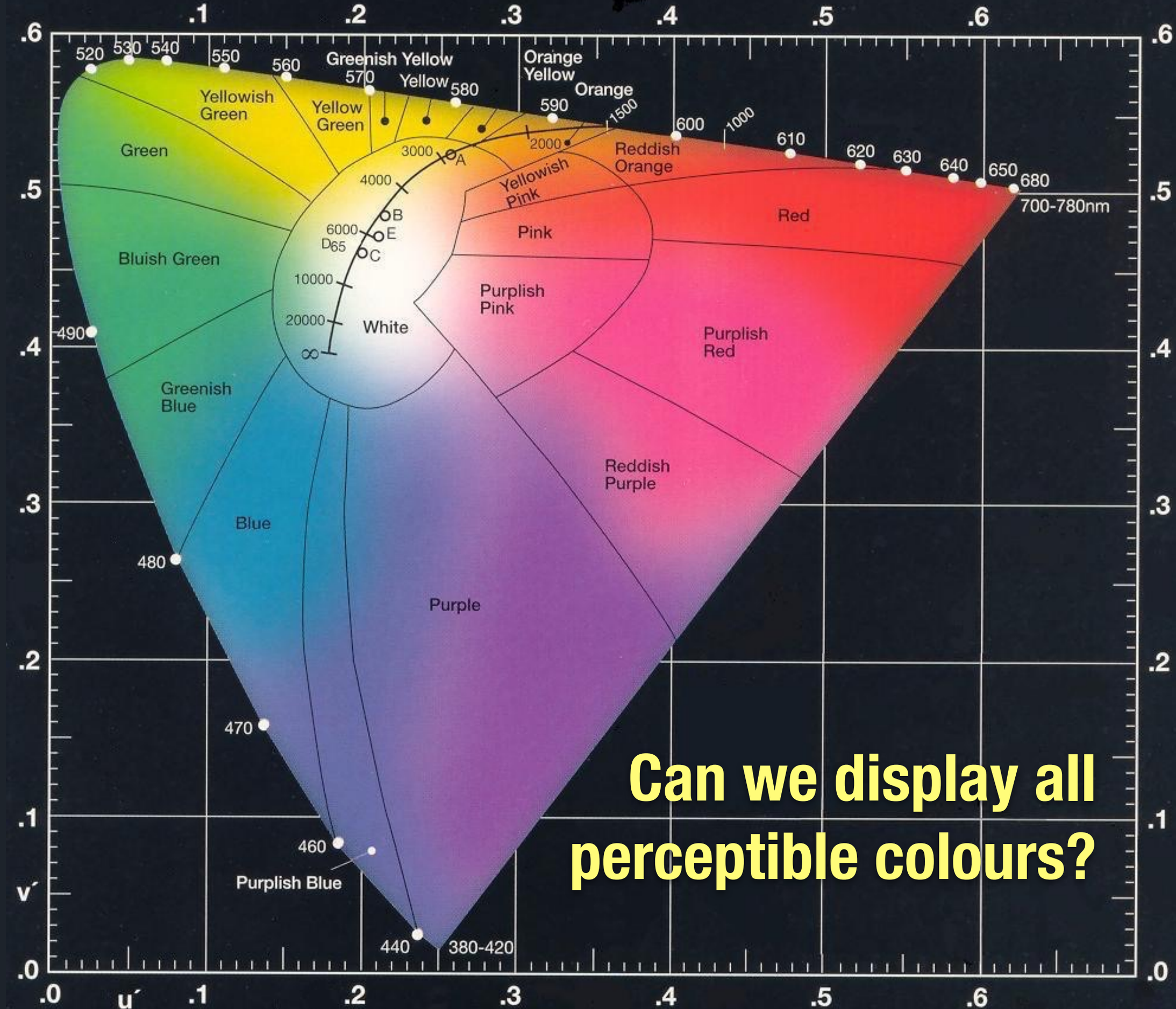


LCDs


Horizontal
polarization filter
Grooved
alignment layers
Vertical
polarization filter
Unpolarized
backlight
Polarized light
Liquid crystals


Horizontal
polarization filter
Grooved
alignment layers
Vertical
polarization filter
Unpolarized
backlight
Liquid crystals

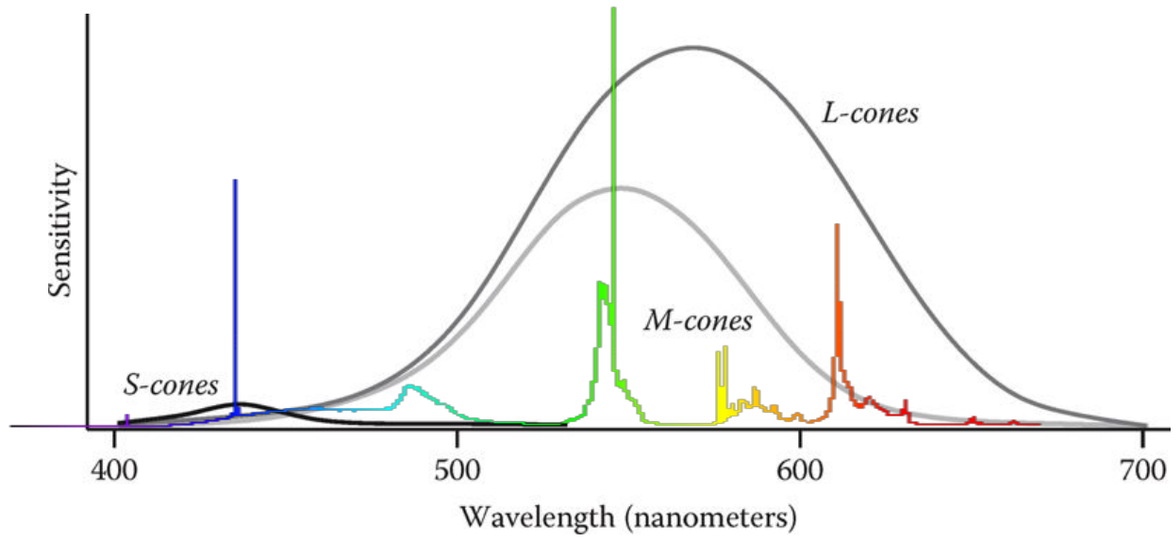
Additive Colour Blending

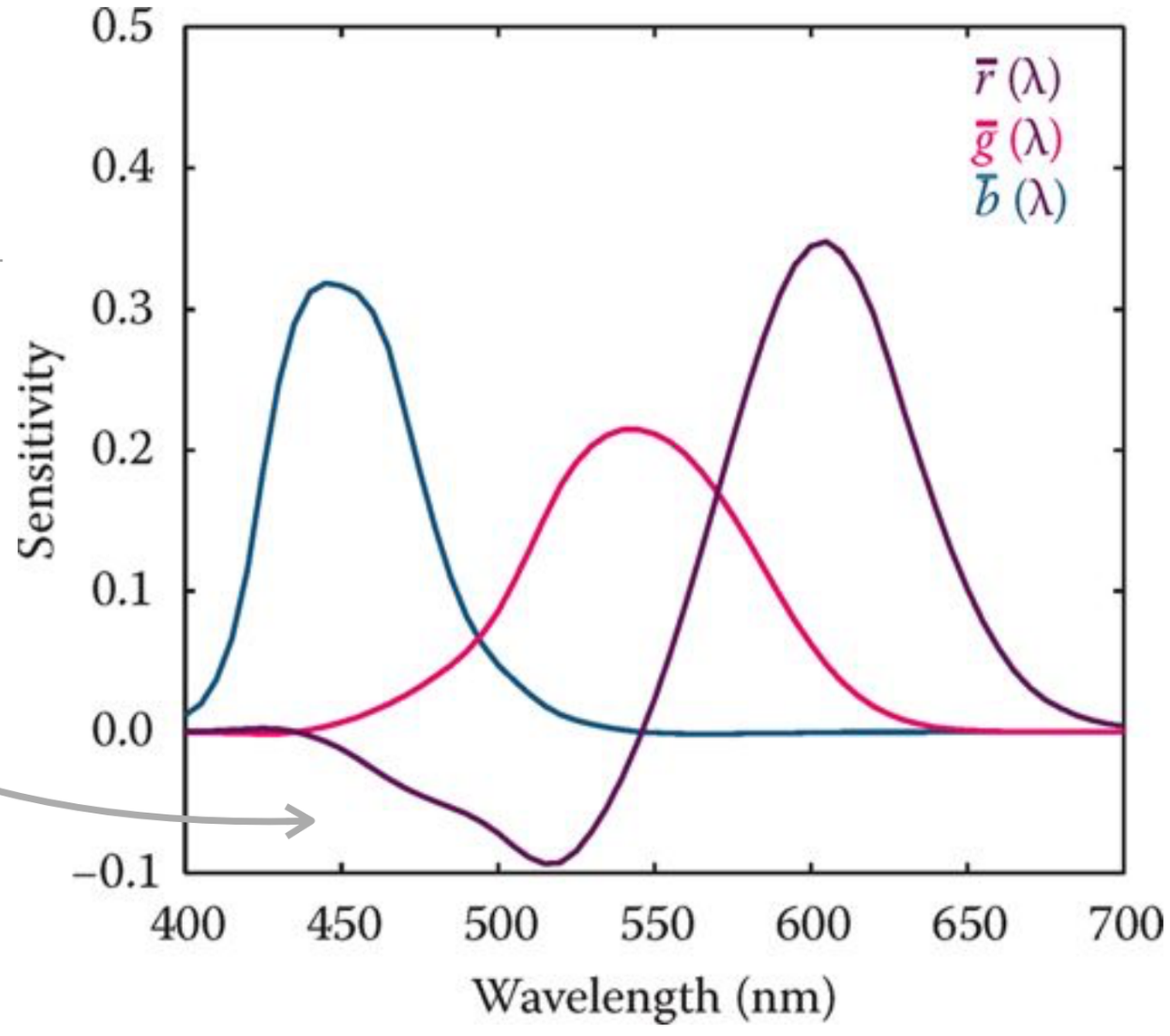


Can we display all perceptible colours?

Colour Matching

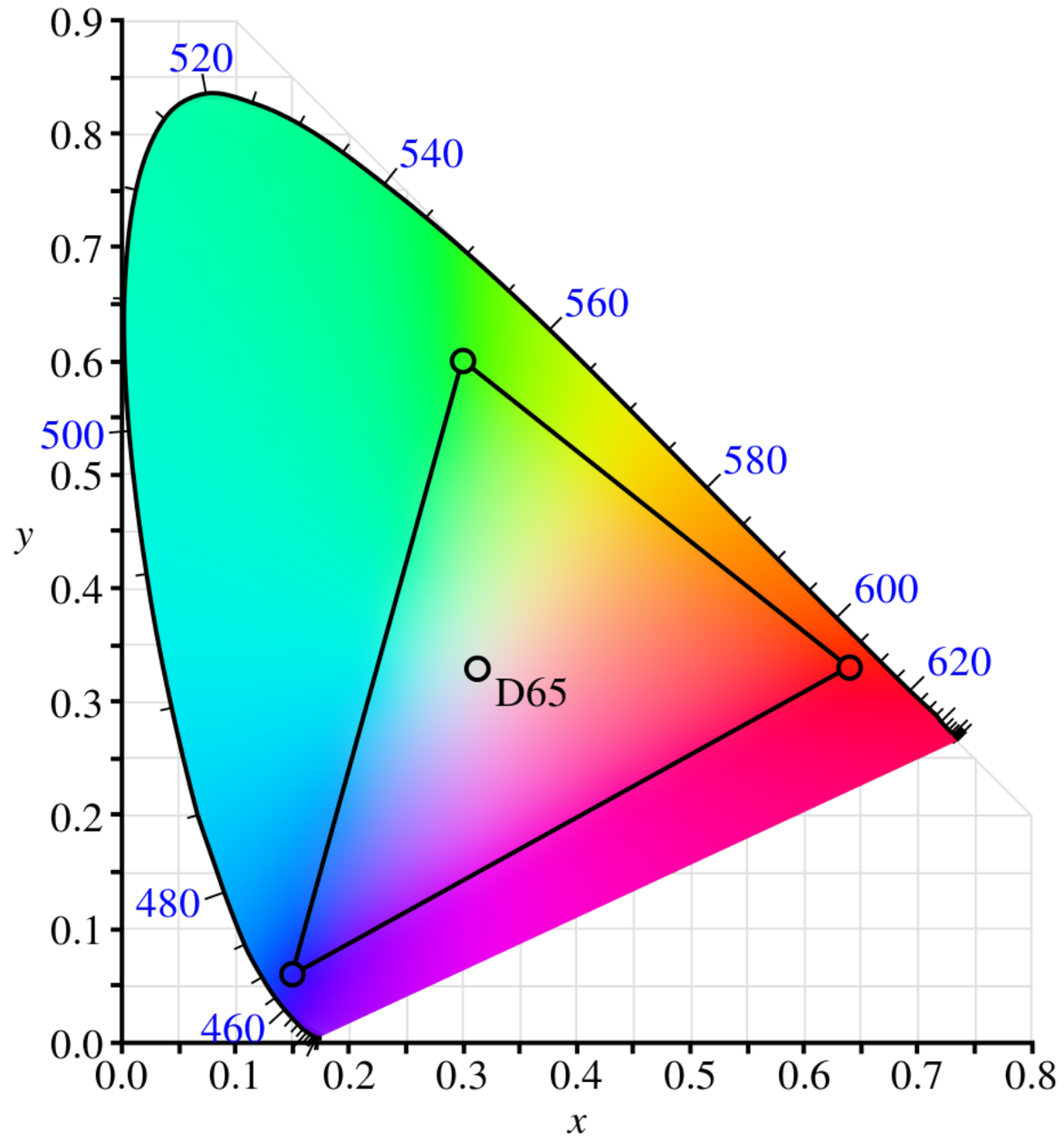
… isn’t always possible!



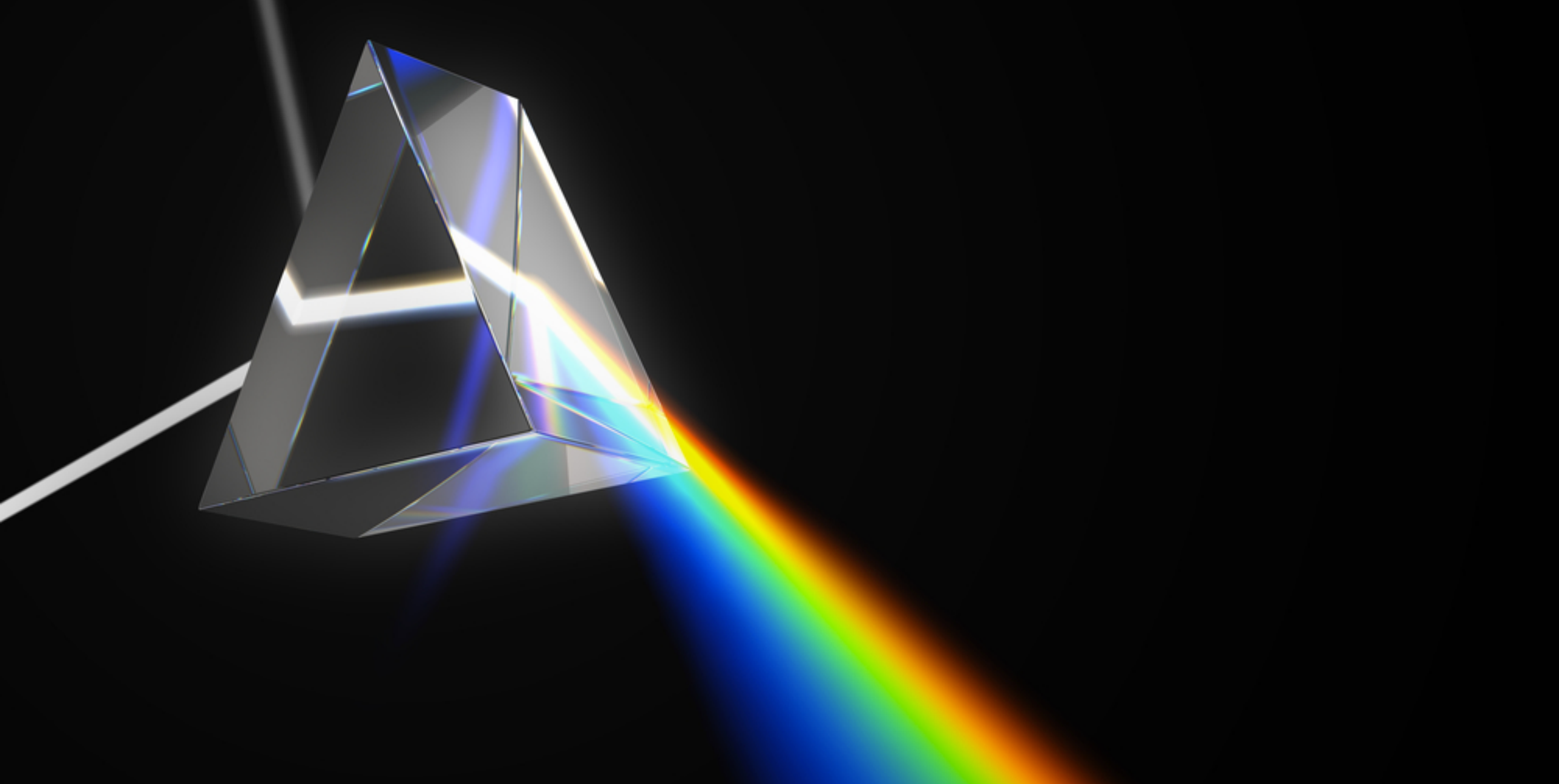


Standard RGB Gamut

In the CIE colour space



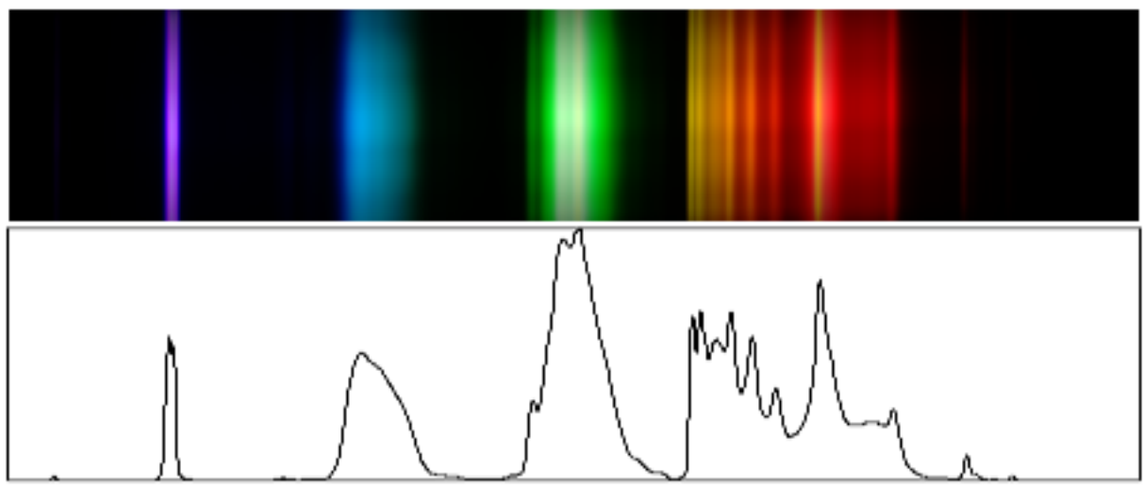
What about these graphics displays?



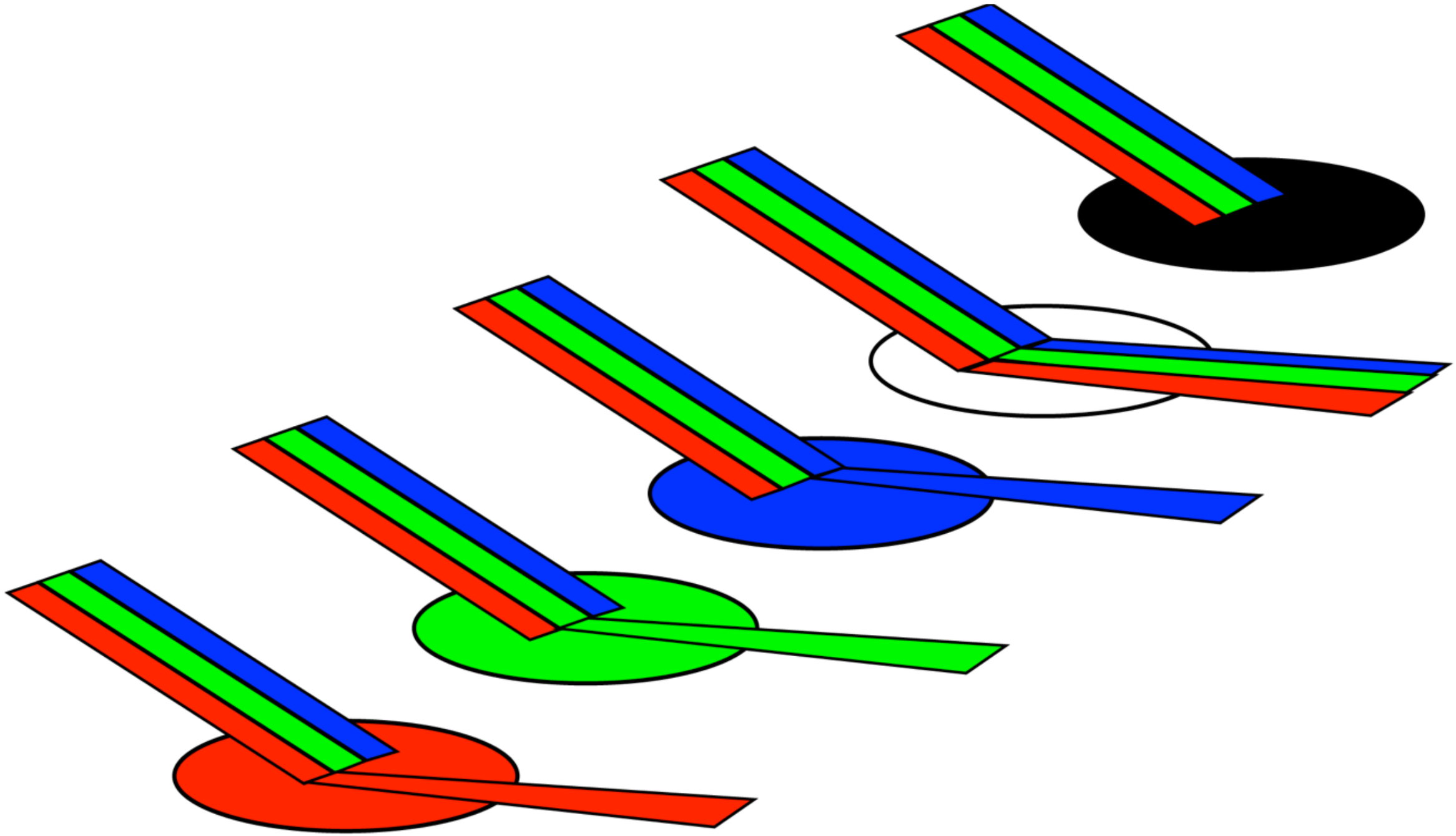
What is

white light?

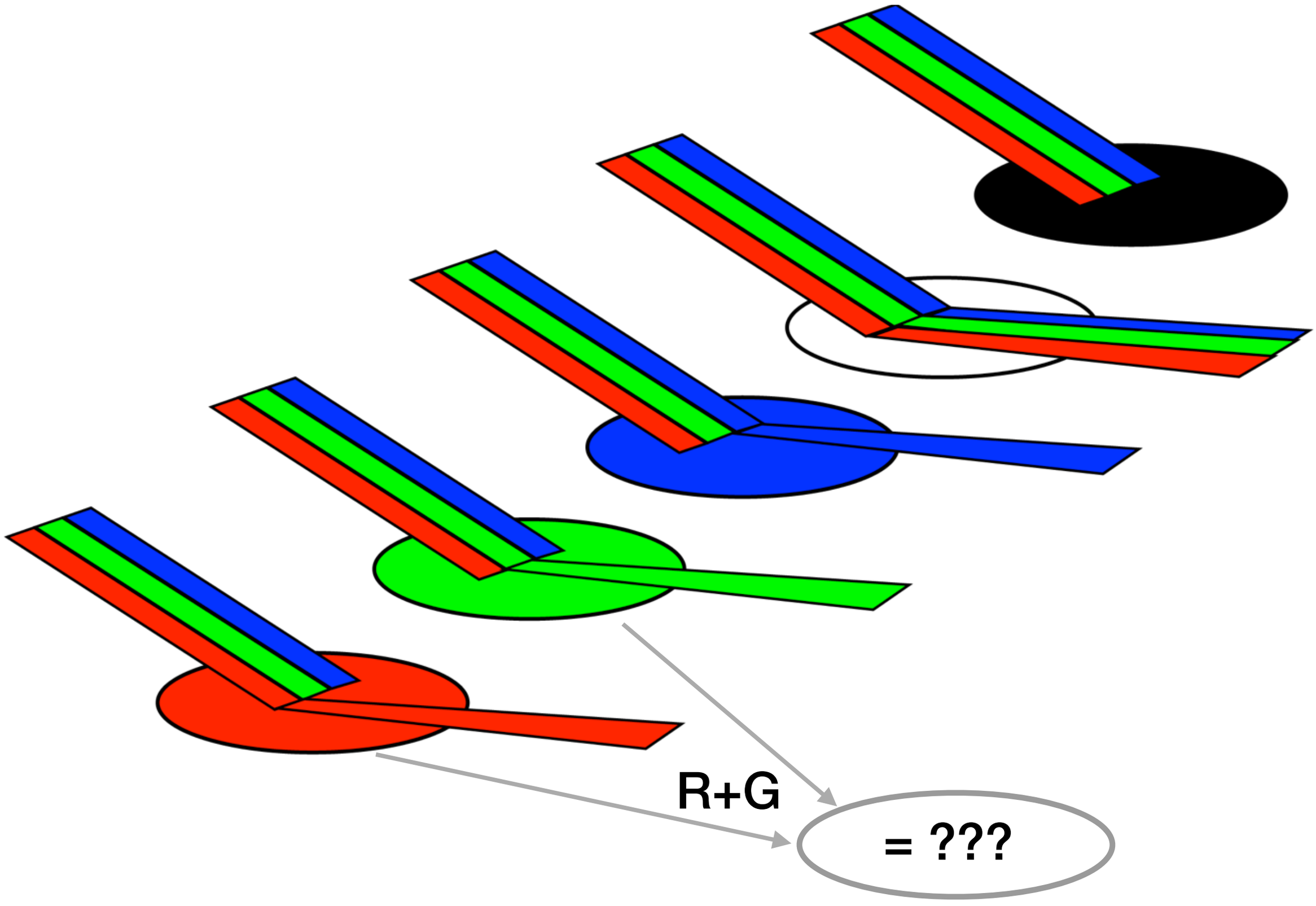
What kind of light do these things emit?



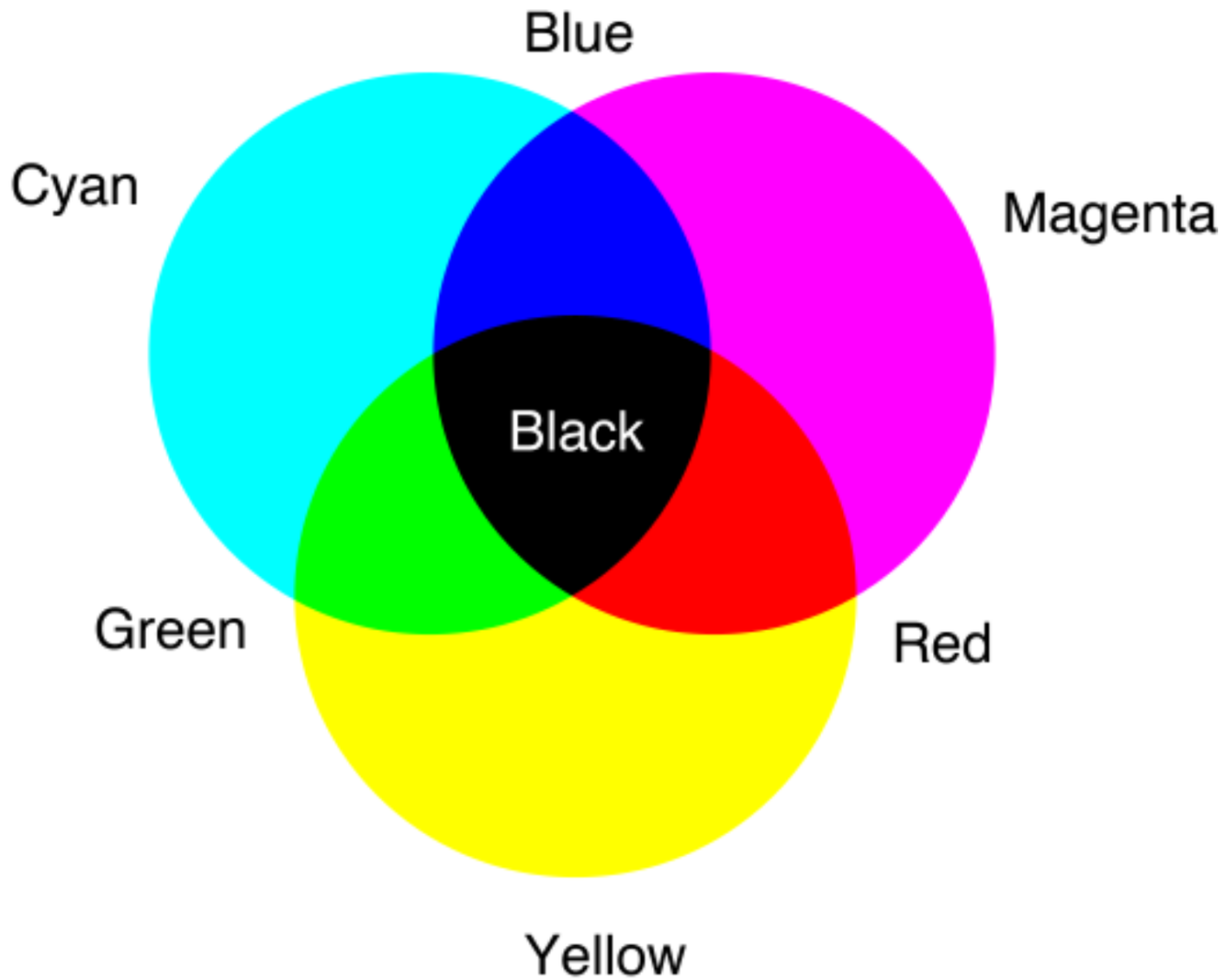
Colour Reflection



[courtesy of K. Breeden, Stanford University]


R+G
= ???

Subtractive Colour Blending



Colour Printing

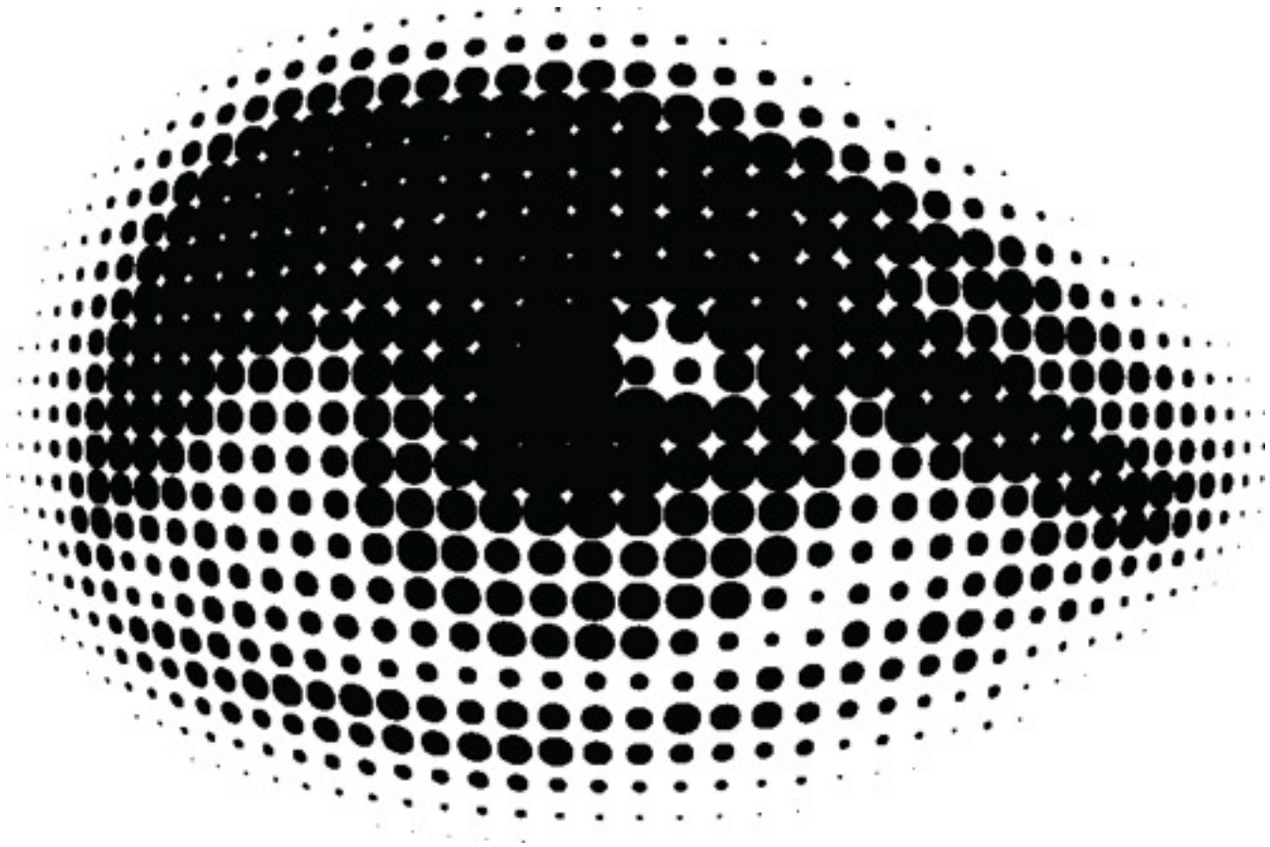
How do we control luminance?

Halftones

Primary Colours

Was your first grade teacher right?

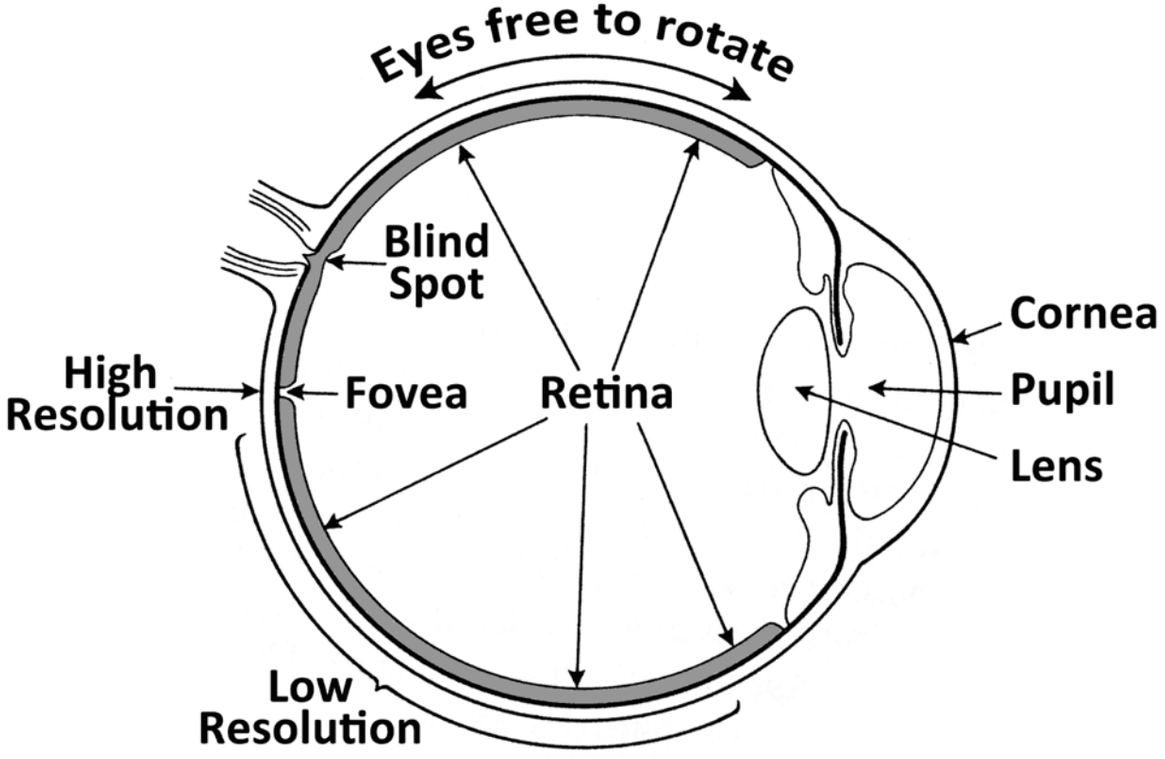
Resolution

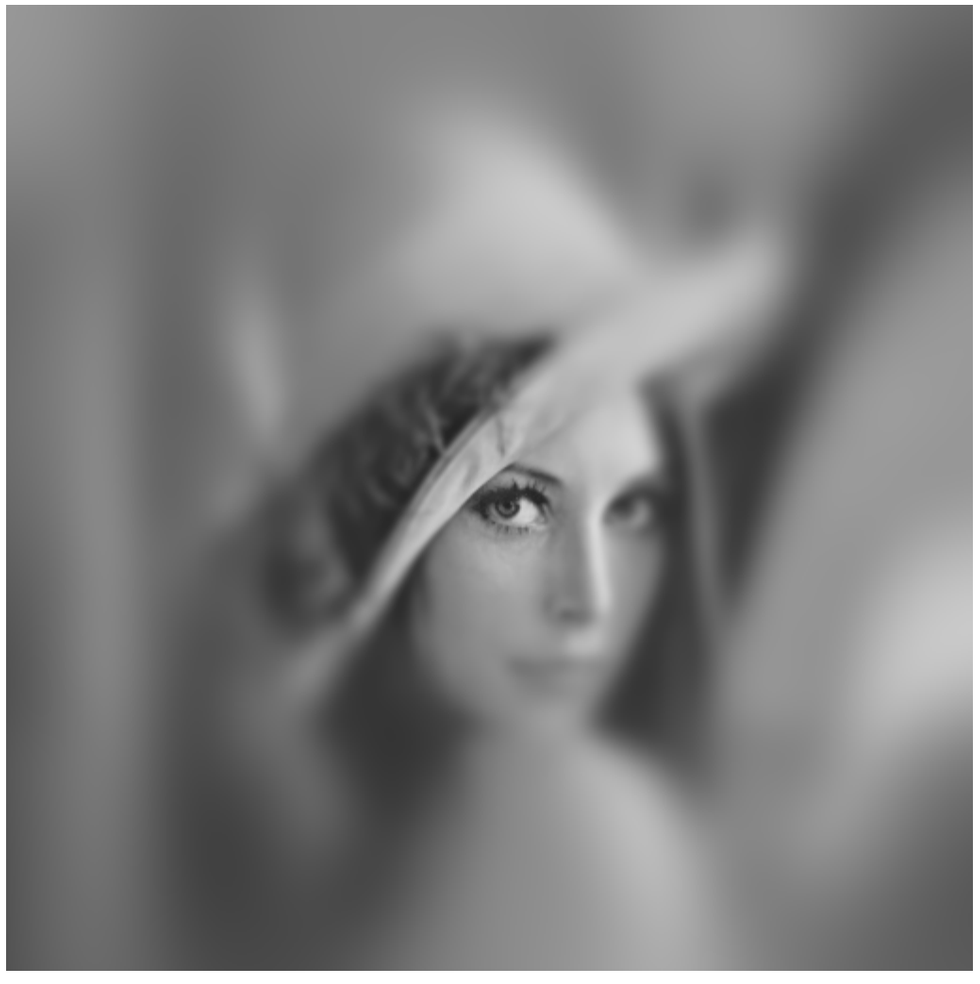


Does your **smart phone** have the same resolution as your **high definition TV**?

What units is resolution measured in?

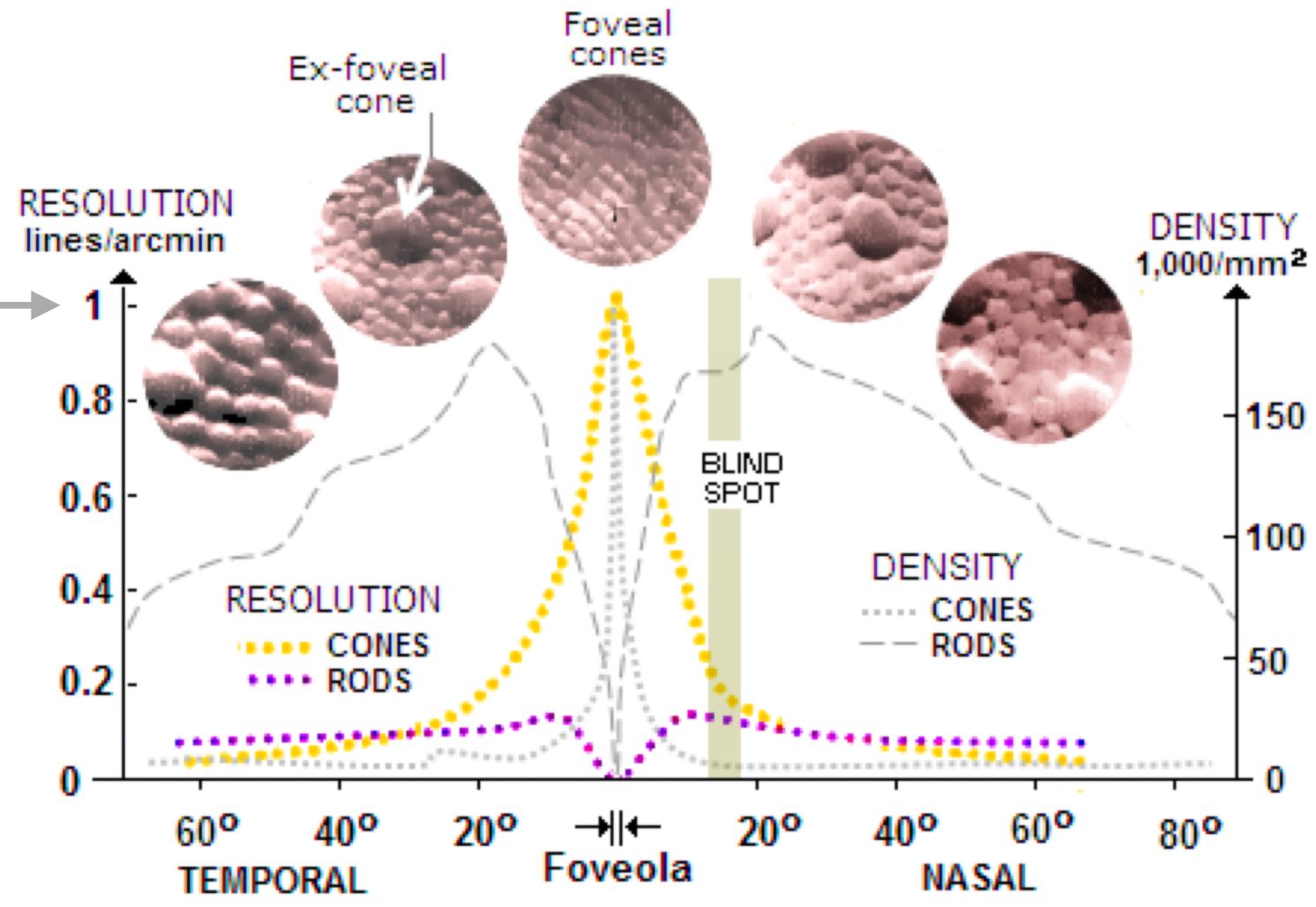
Human Visual Acuity





Human Visual Acuity

Highest visual resolution is about **one arc minute** (1/60 of a degree)



[telescope-optics.net]

is true for two reasons: first $x^2 = (-x)^2$, and second no members of the domain map to the negative portions of the target. Note that we can define an inverse if we restrict the domain and range to $\mathbb{R}^+$. Then $\sqrt{x}$ is a valid inverse.

inverse because element 1 of F has no element of d mapped to it.

2.1.2 Intervals

Often we would like to specify that a function deals with real numbers that are restricted in value. One such constraint is to specify an *interval*. An example of an interval is the real numbers between zero and one, not including zero or one. We denote this $(0,1)$. Because it does not include its endpoints, this is referred to as an *open interval*. The corresponding *closed interval* is denoted with square brackets: $[0,1]$. This notation can be mixed, i.e., $[0,1)$ includes zero but not one. When writing an interval $[a,b]$, we assume that $a \leq b$. The three common ways to represent an interval are shown in Figure 2.3. The Cartesian products of intervals are used often. For example, to indicate that a point $\mathbf{x}$ is in the unit cube in 3D, we say $\mathbf{x} \in [0,1]^3$.

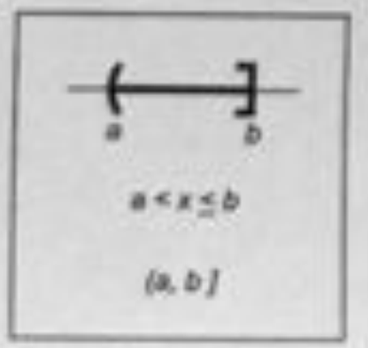
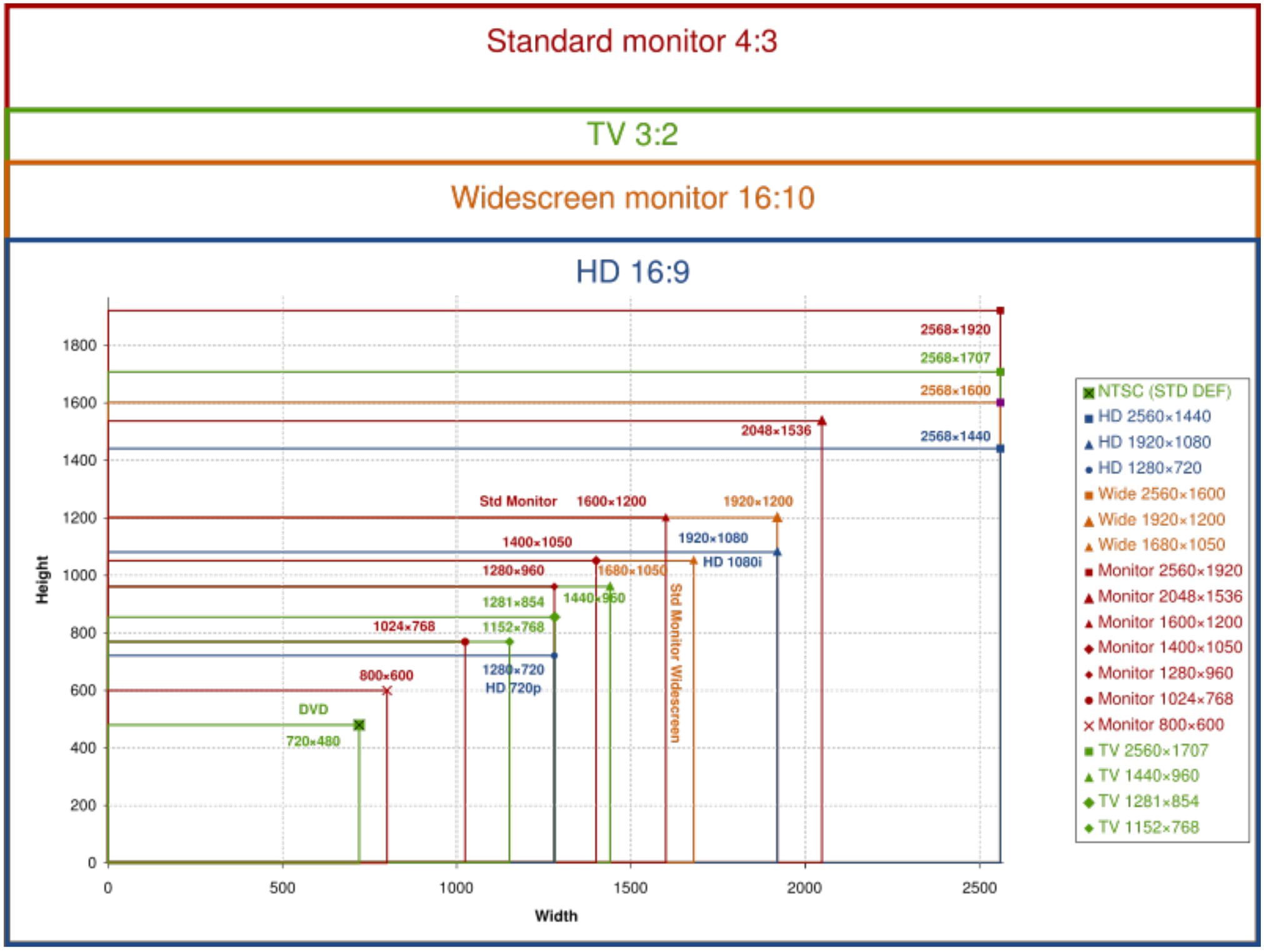


Figure 2.3. Three equivalent ways to denote the interval from a to b that includes b but not a.

Intervals are particularly useful in conjunction with set operations: *intersection*, *union*, and *difference*. For example, the intersection of two intervals is the set of points they have in common. The symbol $\cap$ is used for intersection. For example, $[3,5) \cap [4,6] = [4,5)$. For union, the symbol $\cup$ is used to denote points in either interval. For example, $[3,5) \cup [$ [illegible] Unlike the first two operators, the difference operator produces diff[illegible]ending on argument order.



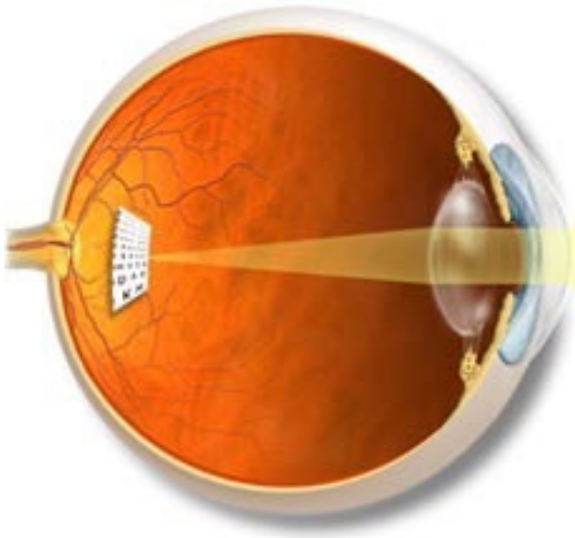
So how many pixels do we actually need?

Let’s try a quick exercise

How many pixels do we need?

Does your **smart phone** have the same resolution as your **high definition TV**?

What is a digital image?

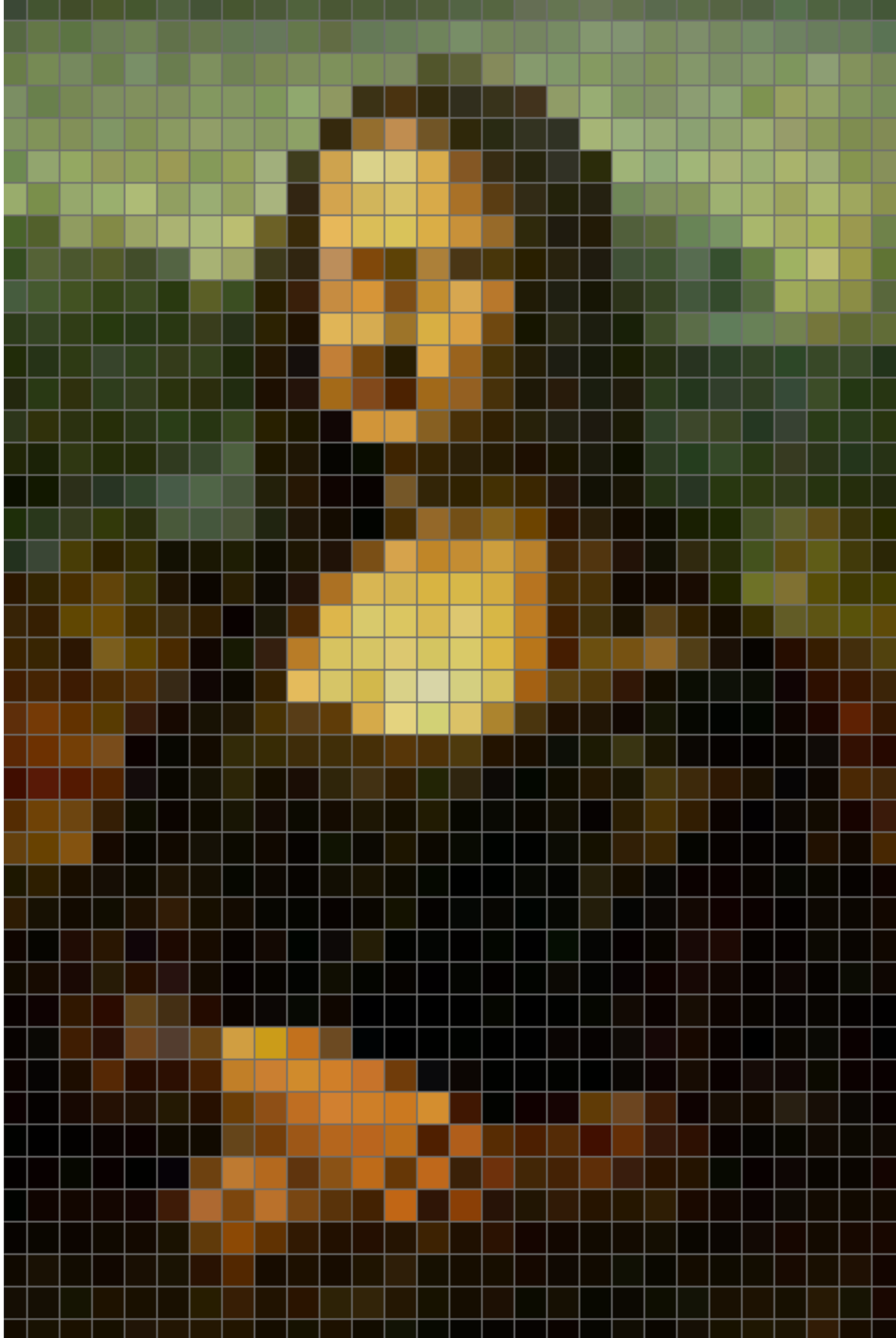


A record of something we (may) observe?

```
0000000 0000 0001 0001 1010
0000010 0000 0016 0000 0028
0000020 0000 0001 0004 0000
0000030 0000 0000 0000 0010
0000040 0004 8384 0084 c7c8
0000050 00e9 6a69 0069 a8a9
0000060 00fc 1819 0019 9898
0000070 0057 7b7a 007a bab9
0000080 8888 8888 8888 8888
0000090 3b83 5788 8888 8888
00000a0 d61f 7abd 8818 8888
00000b0 8b06 e8f7 88aa 8388
00000c0 8a18 880c e841 c988
00000d0 a948 5862 5884 7e81
00000e0 3d86 dcb8 5cbb 8888
00000f0 8888 8888 8888 8888
0000100 0000 0000 0000 0000
*
0000130 0000 0000 0000 0000
000013e
```

Digital Images

- Two key elements:
- Colour
  - usually **R**, **G**, **B**
  - can be **C**, **M**, **Y**, **K**
- Resolution
  - samples, or “pixels”, arranged in a two-dimensional grid
  - may or may not correspond to pixels on a display



The discipline concerned with generating or manipulating **visual imagery** using computational devices and methods.

Things to Remember

- Displays are engineered to human visual perception
- Resolution is not (necessarily) measured in pixels
- Digital images are the goal of computer graphics