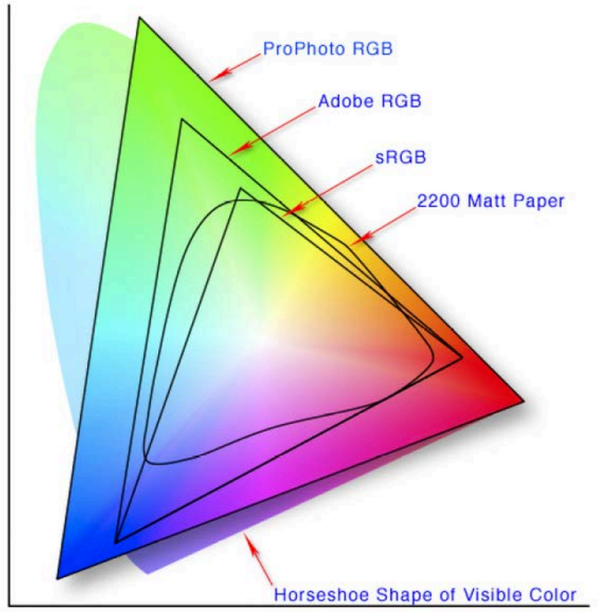
Tech Talk:
Color Space & Digital Color

Doc II • Session 10
Spring 2020

color space

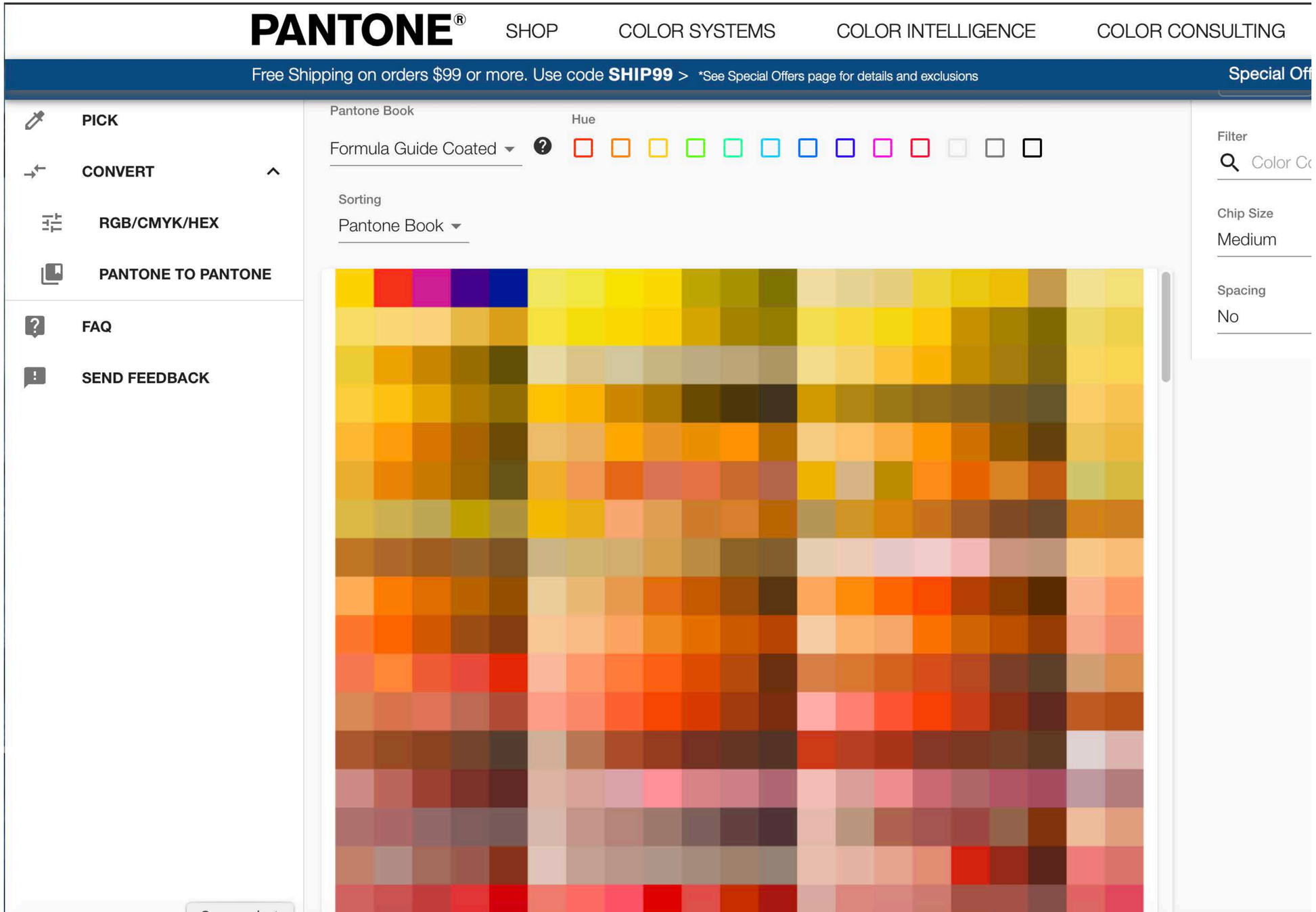


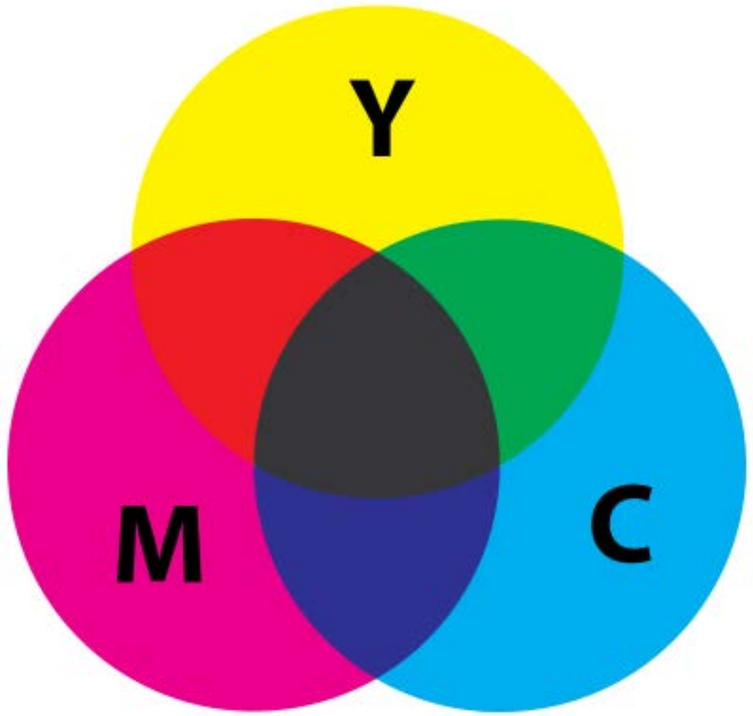
- RGB = computer color space
- CMYK = print color space
- YUV = video color space

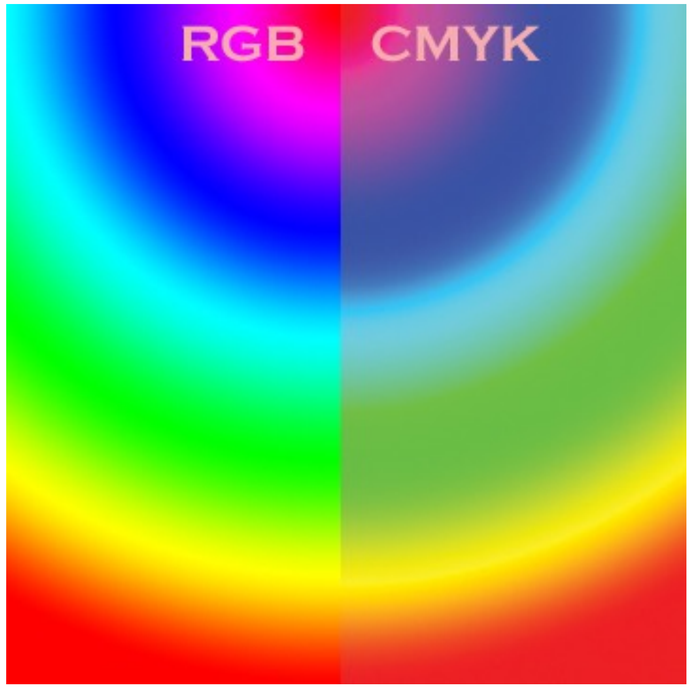
A **color space** is a specific organization of colors. In combination with physical device profiling, it allows for reproducible representations of color, in both analog and digital representations. You could say that for any system it gives you what colors can be created and viewed in that system.

The color systems can be for either creation, capture or reproduction of color images.

A print color space







CMYK, a print color space, is a ‘subtractive’ color space, where putting all the colors together creates black, which makes sense when you think of it as used for printing.

The trick is to think of ‘subtractive’ as removing light, so if you remove all light, you get black.

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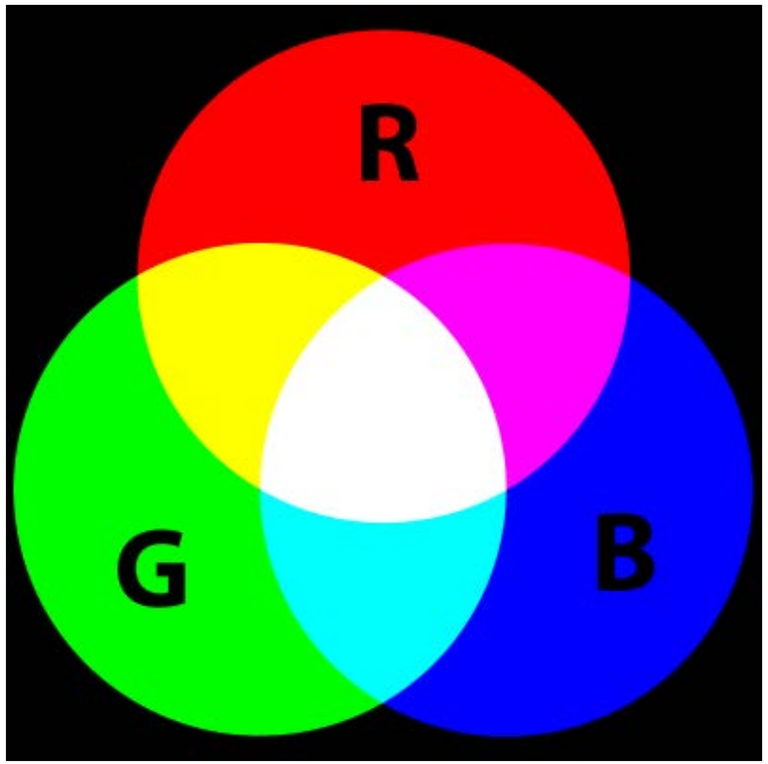
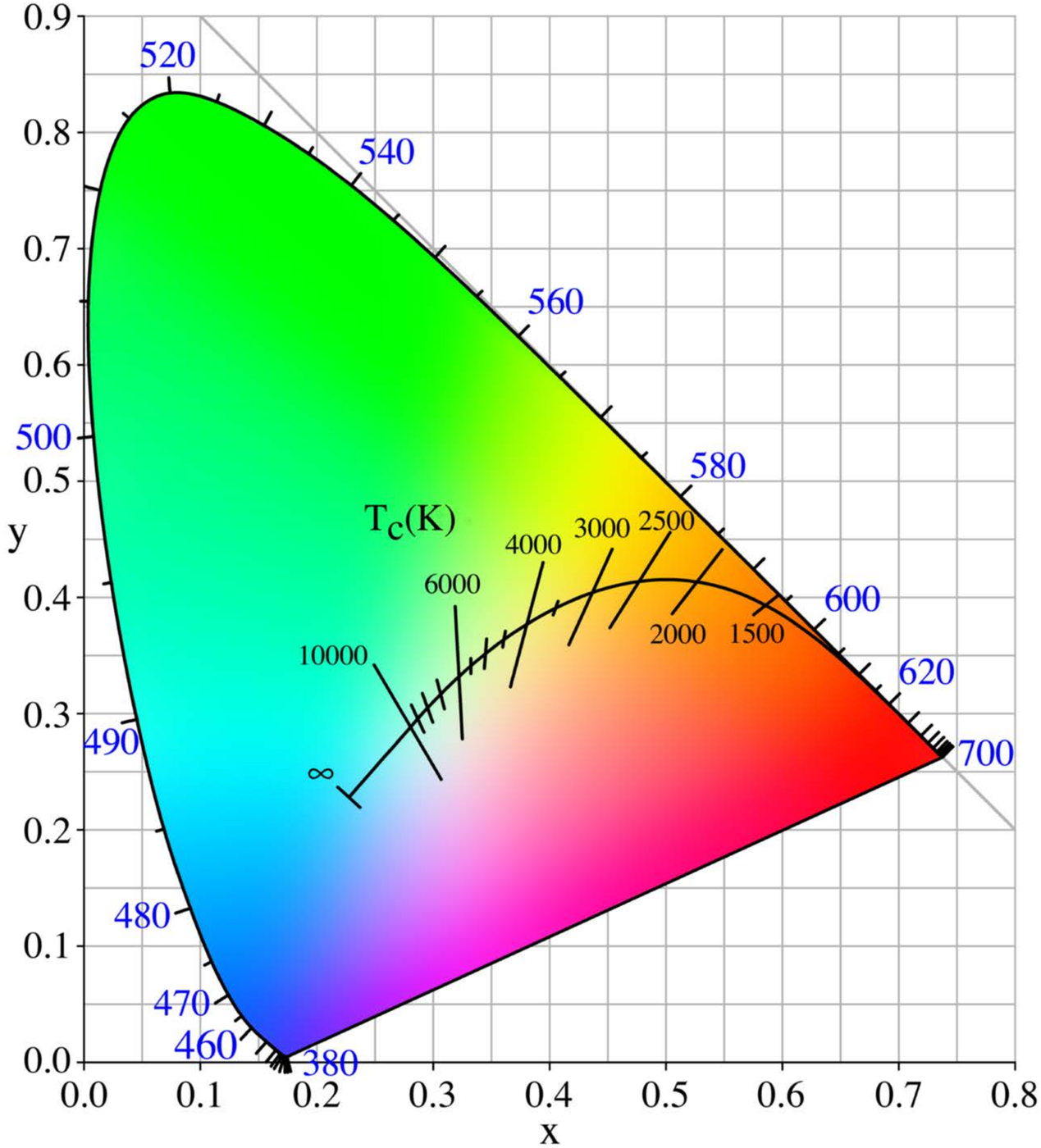
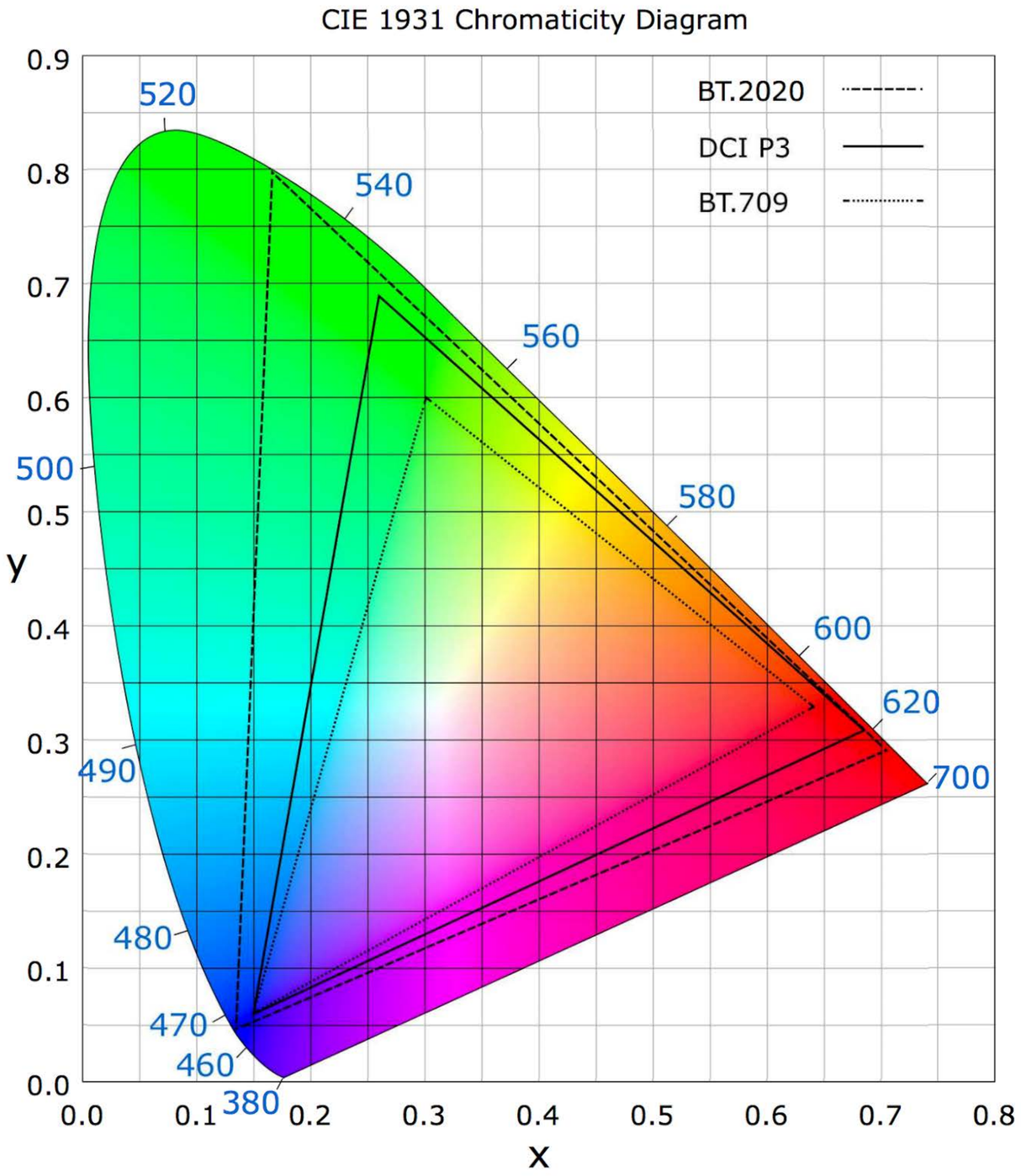
RGB is an ‘additive’ color space where the light is “incident” rather than reflective.





CIE 1931
The First Color Space

In 1931 The Commission internationale de l'éclairage put this map together based on experiments done in the 1920s by two British scientists…. It show all of the colors that human beings can derive from the three cone color sensors on the human retina.

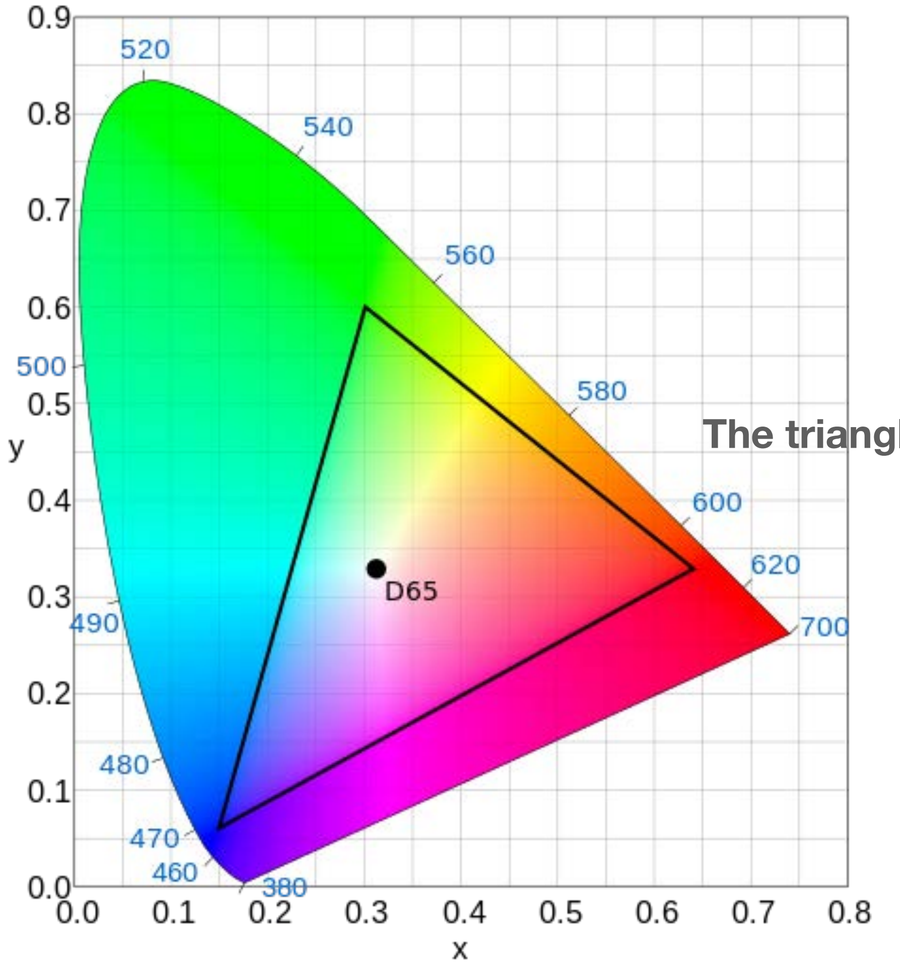


NO system, either digital or otherwise, can reproduce all of the color that the human eye can see. Here you can see three color systems with an indication of what they do and do cover in terms of the range of human color vision.

The three triangles in this image represent the gamuts for Rec. 709, Rec. 2020 and DCI-P3 color spaces inside the CIE 1931 diagram.

REC 709 - The HD color space

This is the color gamut that is both recorded and played back on a video monitor in the HD system.



The triangles three points are Red, Blue and Green

ITU-R Recommendation BT.709, more commonly known by the abbreviation Rec. 709, standardizes the format of high-defin
television. First adapted in 1990. IT is a “narrow” color space, but still the standard for video.

REC 2020 - The UHD color space

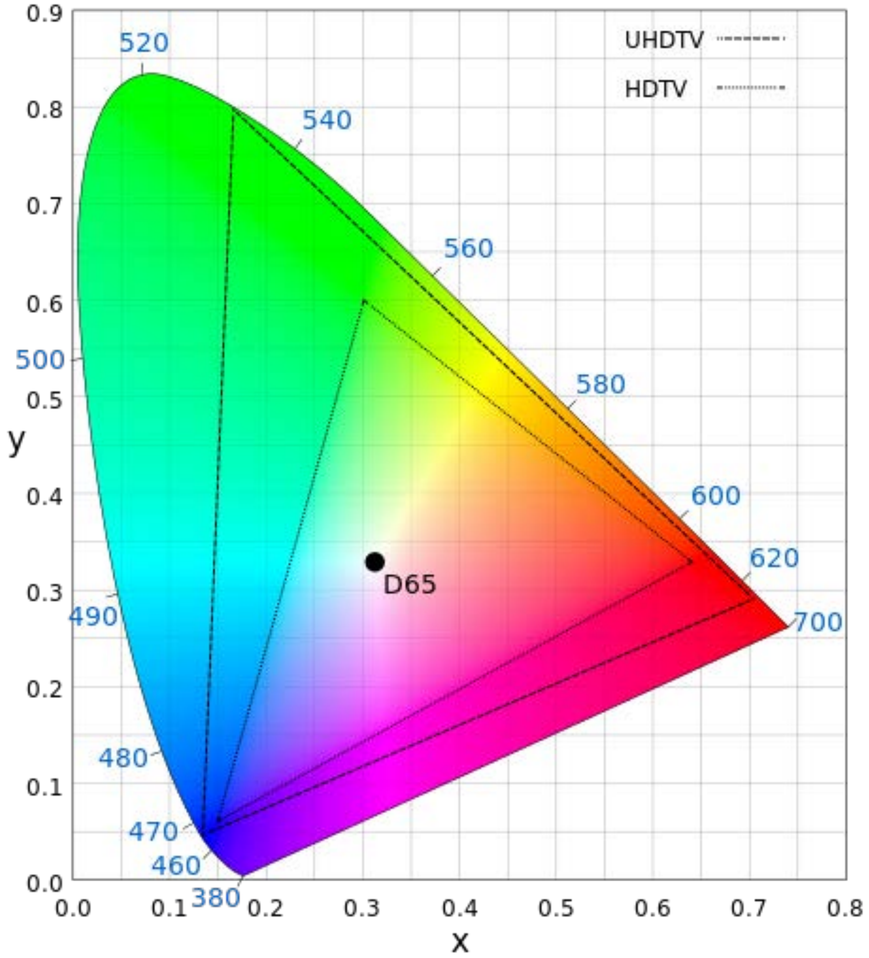
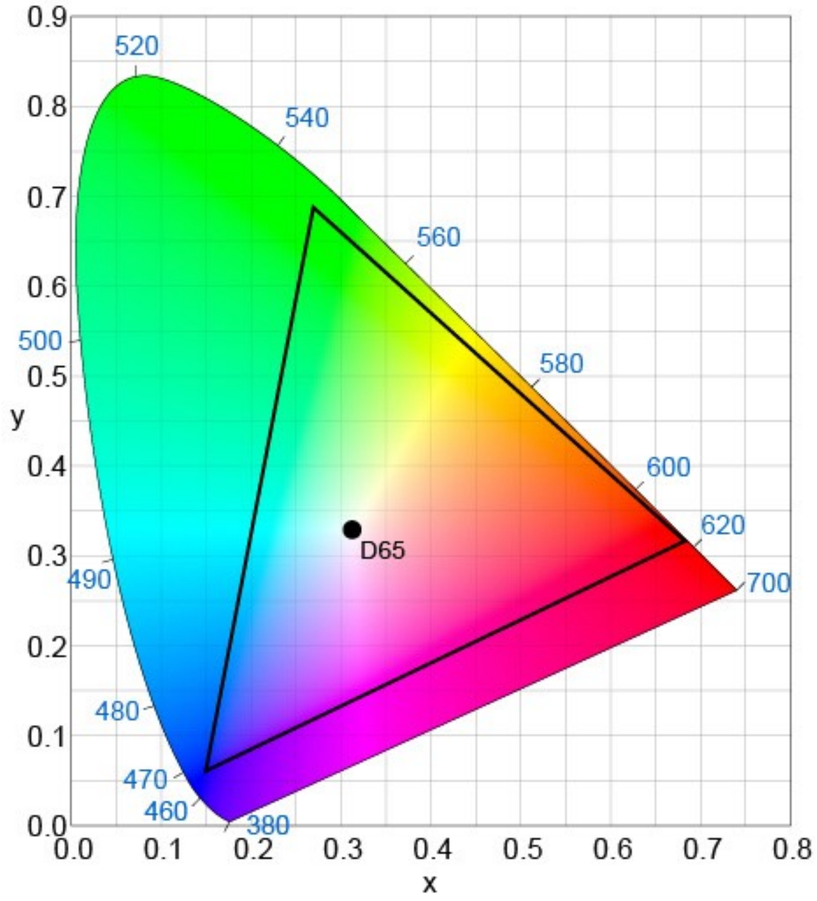


Diagram of the CIE 1931 color space that shows the Rec. 2020 (UHDTV) color space in the outer triangle and Rec. 709 (HDTV) color space in the inner triangle. Note that the Rec. 2020 came out in 2016 from the "UHD Alliance" an industry group, not from an international organization like the ITC nor a national one like SMPTE.

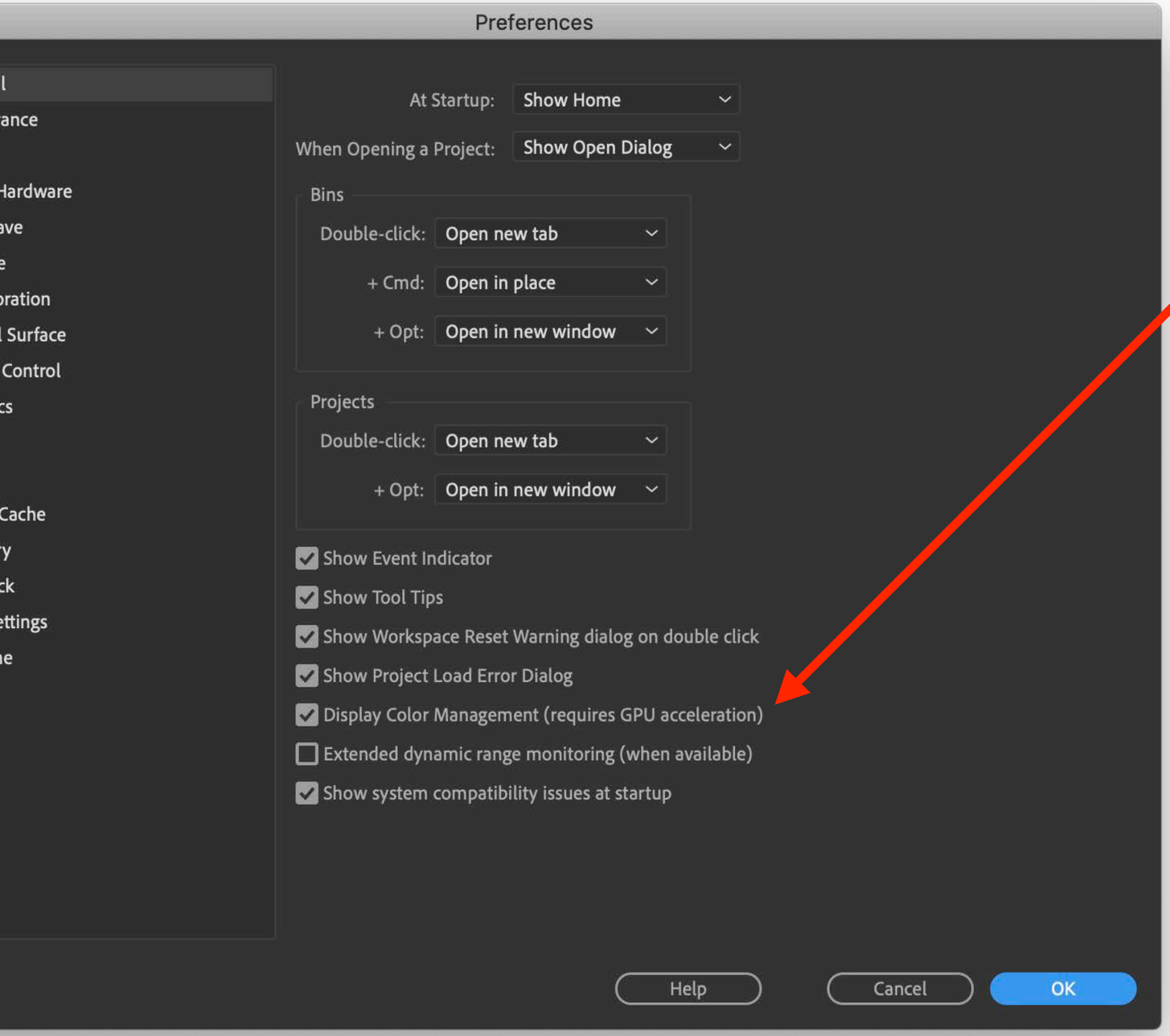


The DCI -P3 COLOR SPACE

The CIE 1931 chromaticity diagram for DCI-P3-D65 with the spectral colors and purple line along the rim. The corners of the triangle are the primary colors of the DCI-P3 color space. The white point shown here is Illuminant D65. However DCI-P3 uses a slightly warmer and greener whitepoint with a correlated color temperature of approximately 6300K (not shown).

This color space became standard on Mac's in 2015…
Note that this is a color space used for display, not for creating color images, except for computer graphics.

sRGB (**standard Red Green Blue**) is the RGB color space that HP and Microsoft created cooperatively in 1996 to use on monitors, printers, and the Internet.



Display Color Management

Try turning on "color management to see what effect it has on the images you are editing.

New since 2018…

- Will it make your wide gamut P3 display show correct colors in Premiere? **Yes!**
- Will it make your Rec. 2020 video look good on your non-Rec. 2020 display? **Yes!**
- Will it make your Rec. 709 video look correct on your sRGB display? **Almost, but not quite.**
- Will it make sure contrast and colors on your YouTube videos are correct? **No.**
- Will it make the dreaded QuickTime gamma shift problem go away? **No.**
- Can it make your footage look the same in Premiere Pro and After Effects? **Yes!**

FROM: https://premierepro.net/color-management-premiere-pro/

The Color Signal

LUMINANCE = Brightness (B&W)

CHROMINANCE = Color Information
(Red, Green, Blue)

Video Color Space vs. Computer Color Space

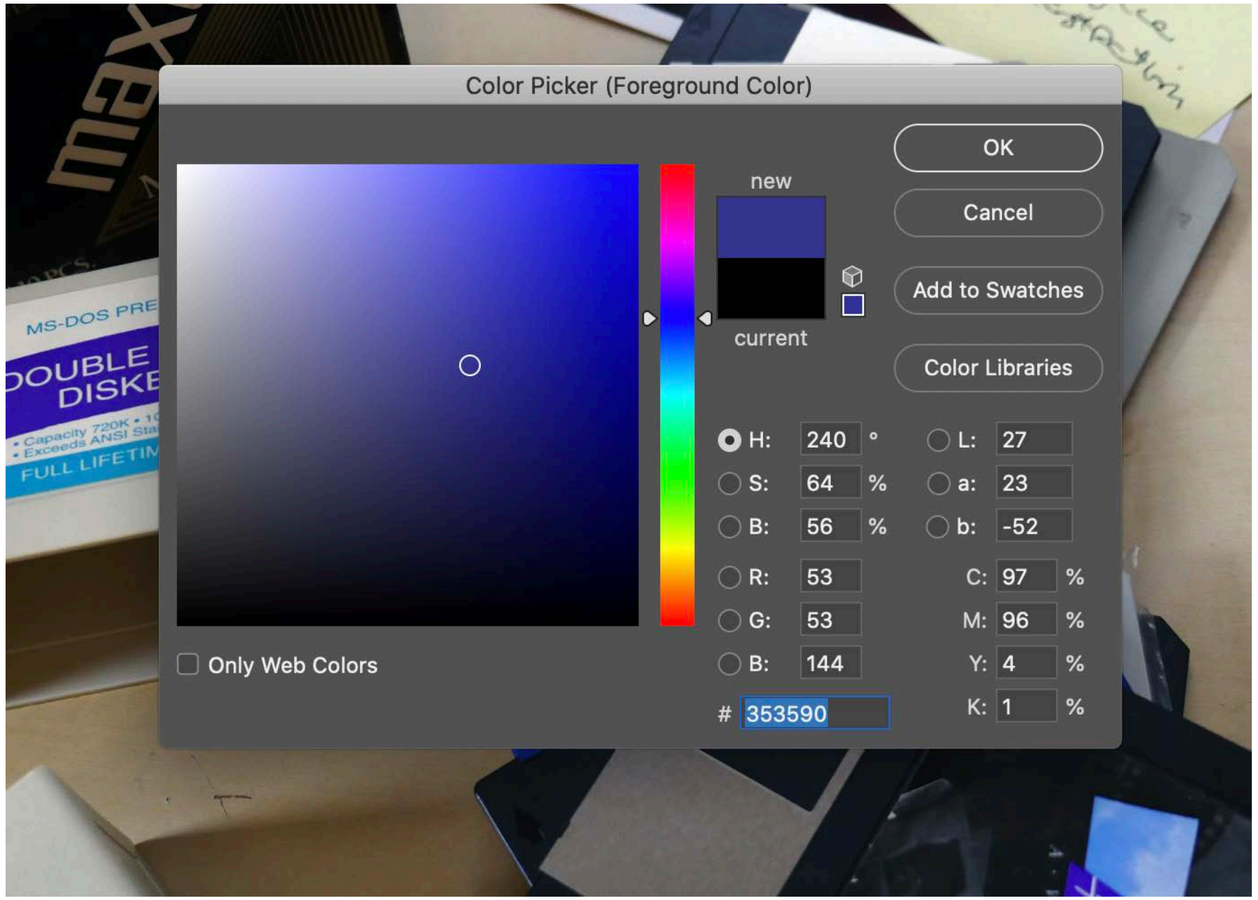
Video systems incorporate a separate B&W signal (luminance) as well as the three color signals. The idea here was to make broadcast TV signals back-compatible with black and white sets.

COLOR SPACE = YUV
Y = Green + Luminance
R = Red
B = Blue

COLOR SPACE = RGB
R = Red
G = Green
B = Blue

The Digital Image

To create the digital image, the idea of three separate color signals was retained from analog media.



In this Photoshop dialog box you can see a variety of color systems for print, web use.

Bit Depth

In imaging, the *size* of the individual becomes very important, as unlike audio, the sample rate, or number of samples per second, is fixed. That size is measured in number of bits per sample.

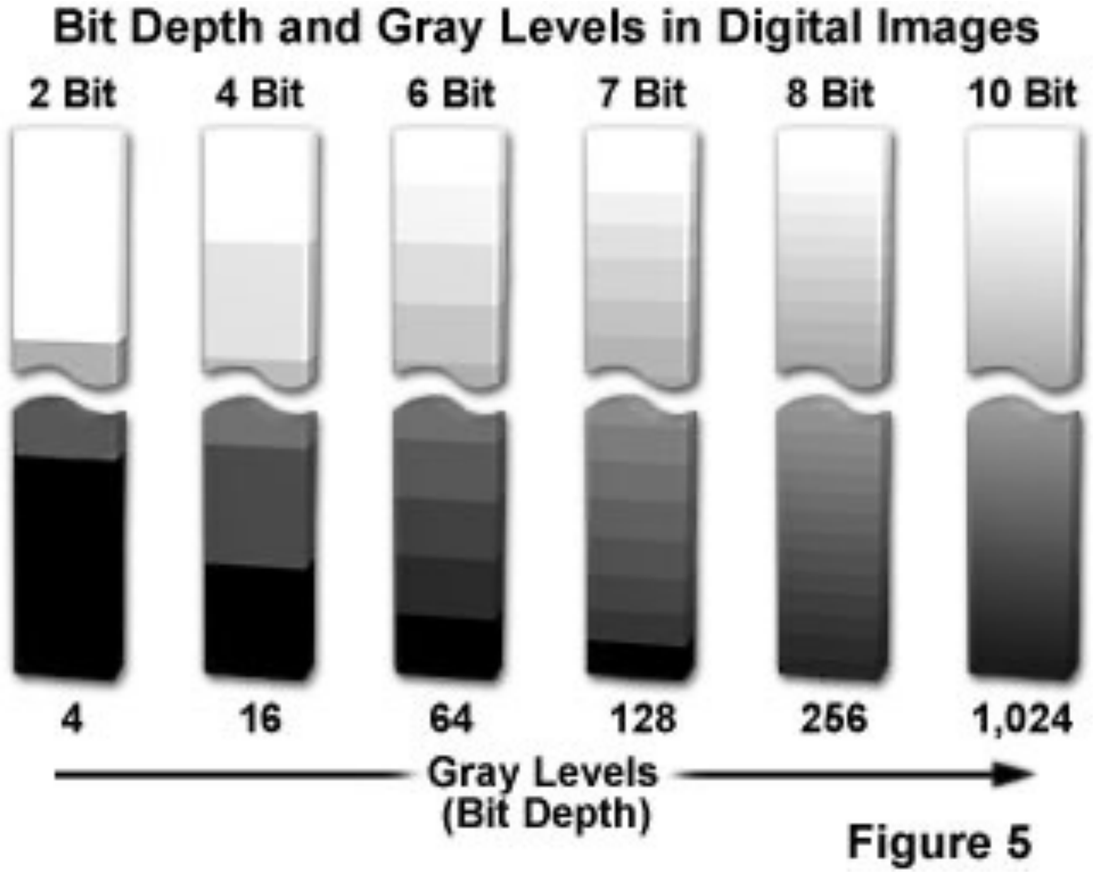


Figure 5

Digital Color

CONCEPT: Color Depth or 'bit depth'

Early color computers could handle only **8 bit** color.

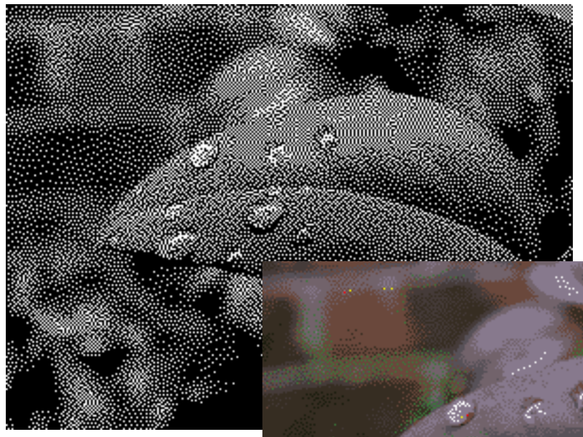
2x2x2x2x2x2x2x2

How many colors?

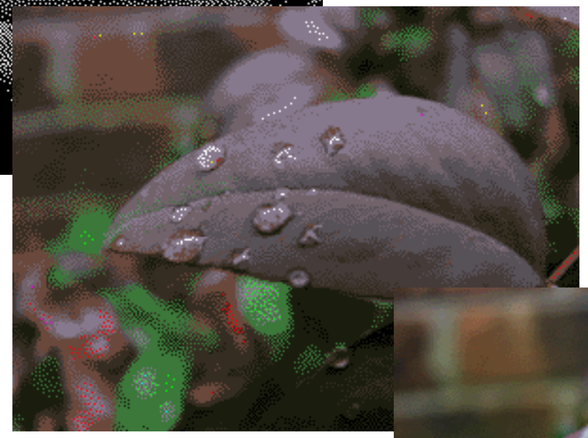
Bit Depth refers to the **size** of the number that constitutes a digital sample as opposed to the **frequency** or ‘sample rate’. These numbers are binary, so a 4-bit number gives you 16 choices, and an 8-bit gives you 256.

10001111000001111111011101010

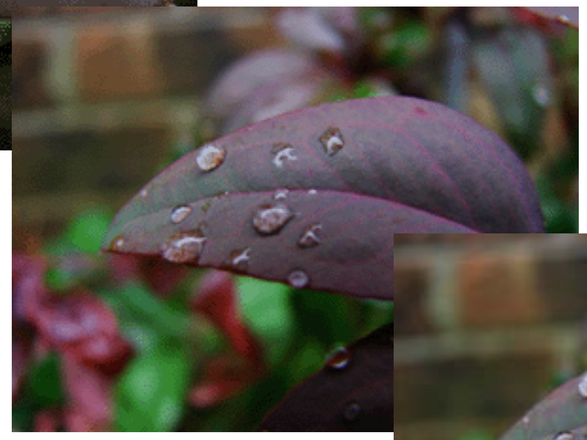
1 bit

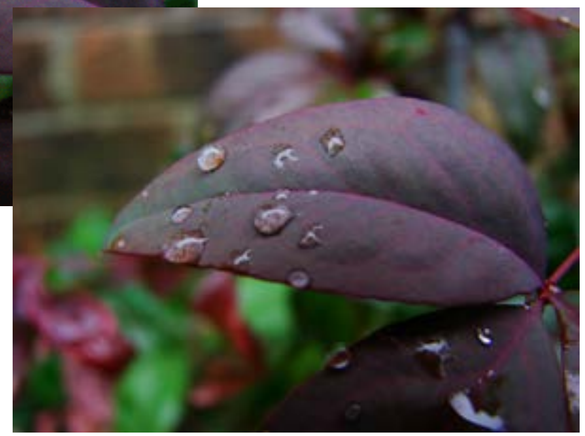


4 bit



8 bit



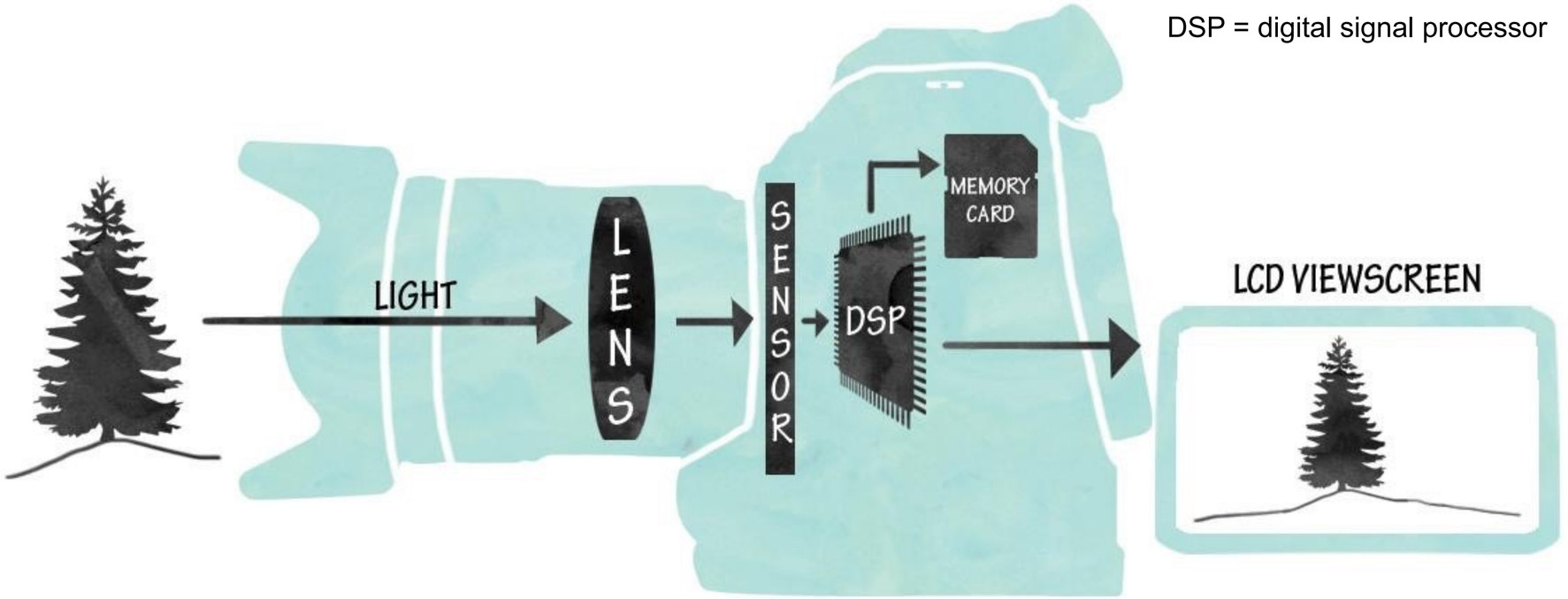


24 bit = 256 x 256 x256

24 bit color has 8 bits for each color ‘channel’
256 x 256 x256

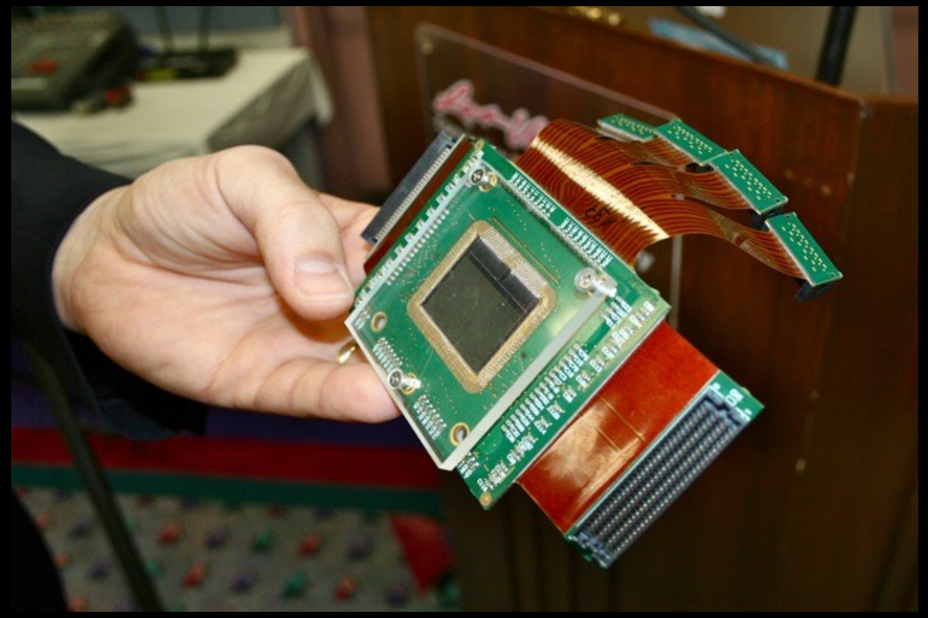
Hybrid Video Cameras & DSLRs

DSP = digital signal processor



In these cameras the form factor and and imaging area of still film cameras has been combined with the capabilities of digital video.

THE CMOS CHIP



CMOS sensor in ARRI Alexa sees 3168 x 1782 pixels
but uses only center section of 3072 x 1728

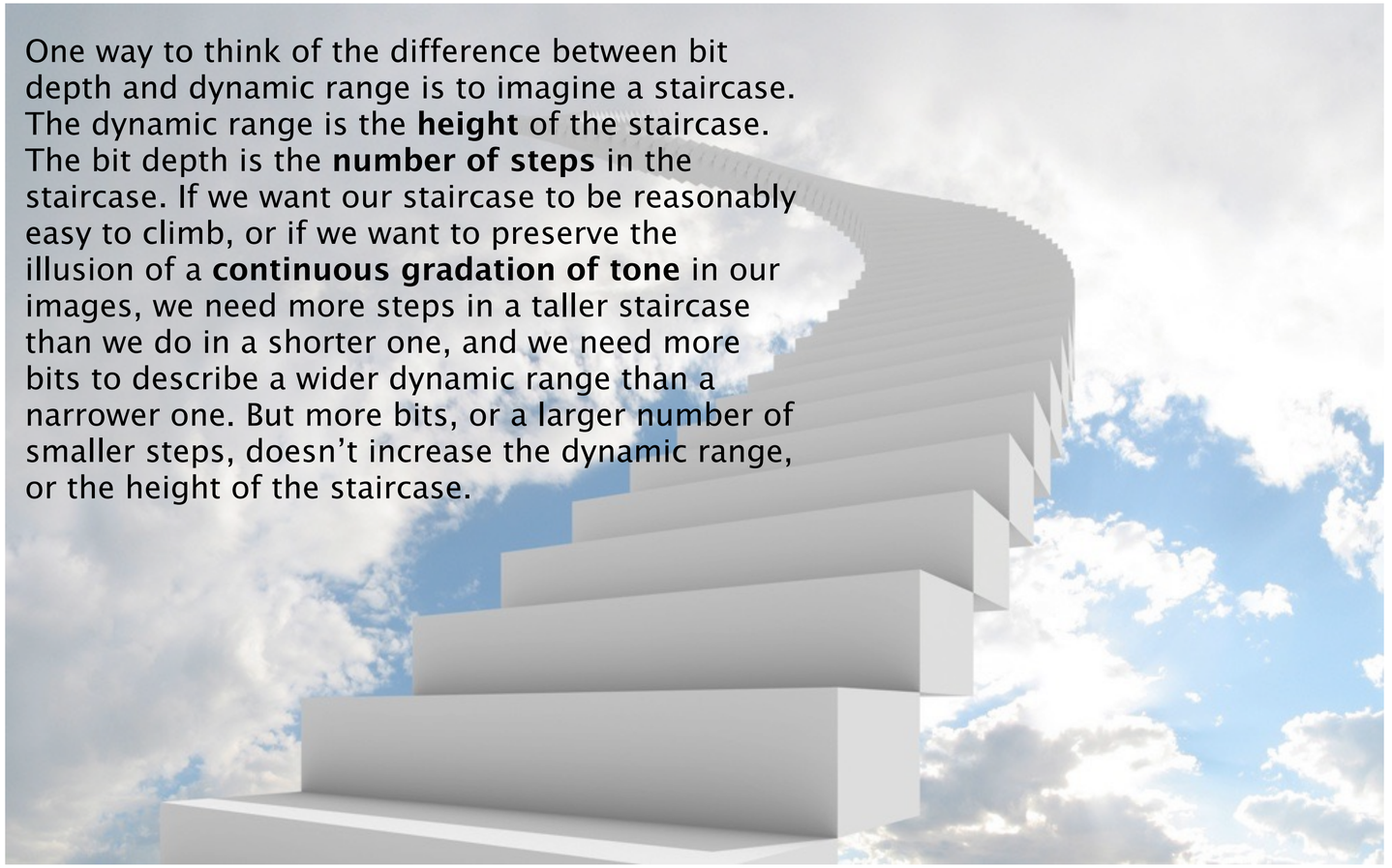
Dynamic Range

Dynamic range in digital cameras is an analog limitation of the sensor.

The ***brightest*** scene information the camera can capture is limited by the capacity of the sensor element. At some point the element can no longer accept any more photons—a condition called **saturation**—and any photons arriving after saturation are not counted.

The ***darkest*** shade a camera can capture is determined by the more subjective point at which the noise inherent in the system overwhelms the very weak signal generated by the small number of photons that hit the sensor.

Bit Depth vs Dynamic Range



One way to think of the difference between bit depth and dynamic range is to imagine a staircase. The dynamic range is the **height** of the staircase. The bit depth is the **number of steps** in the staircase. If we want our staircase to be reasonably easy to climb, or if we want to preserve the illusion of a **continuous gradation of tone** in our images, we need more steps in a taller staircase than we do in a shorter one, and we need more bits to describe a wider dynamic range than a narrower one. But more bits, or a larger number of smaller steps, doesn't increase the dynamic range, or the height of the staircase.