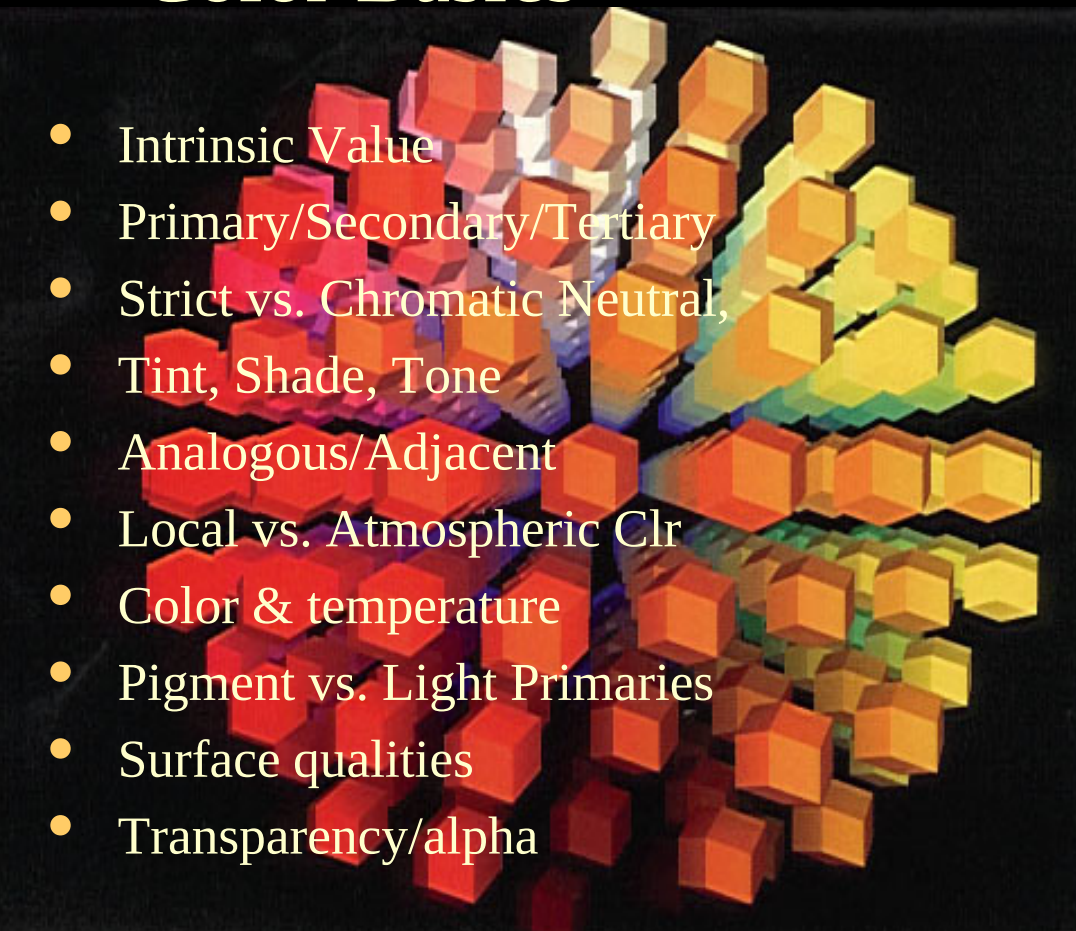
Color Theory

- Color Basics



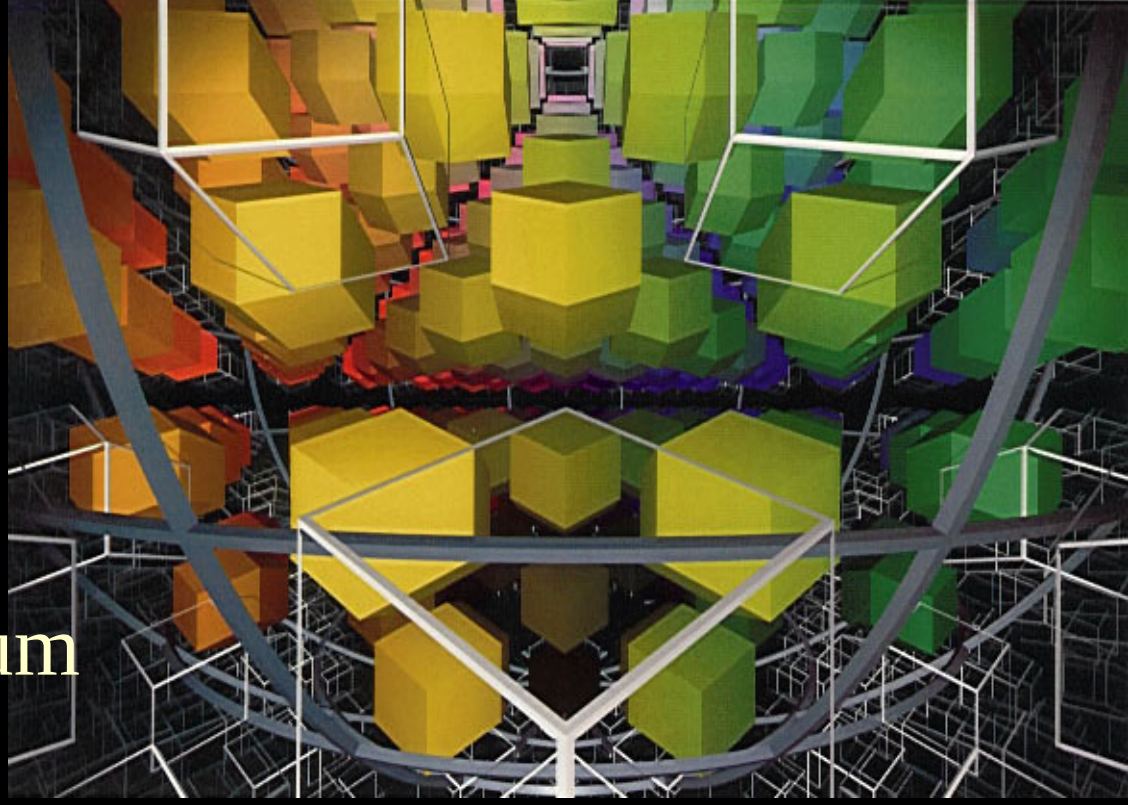
- Intrinsic Value
- Primary/Secondary/Tertiary
- Strict vs. Chromatic Neutral,
- Tint, Shade, Tone
- Analogous/Adjacent
- Local vs. Atmospheric Clr
- Color & temperature
- Pigment vs. Light Primaries
- Surface qualities
- Transparency/alpha

Three dimensions of color

- Just as a point is space can be defined by is position in the three special dimensions (height, width, depth) , color also has its own three dimensions. Any single color can be described by its three dimensions.

- **Hue**
- **Chroma**
- **Value**

Basic terms & concepts:

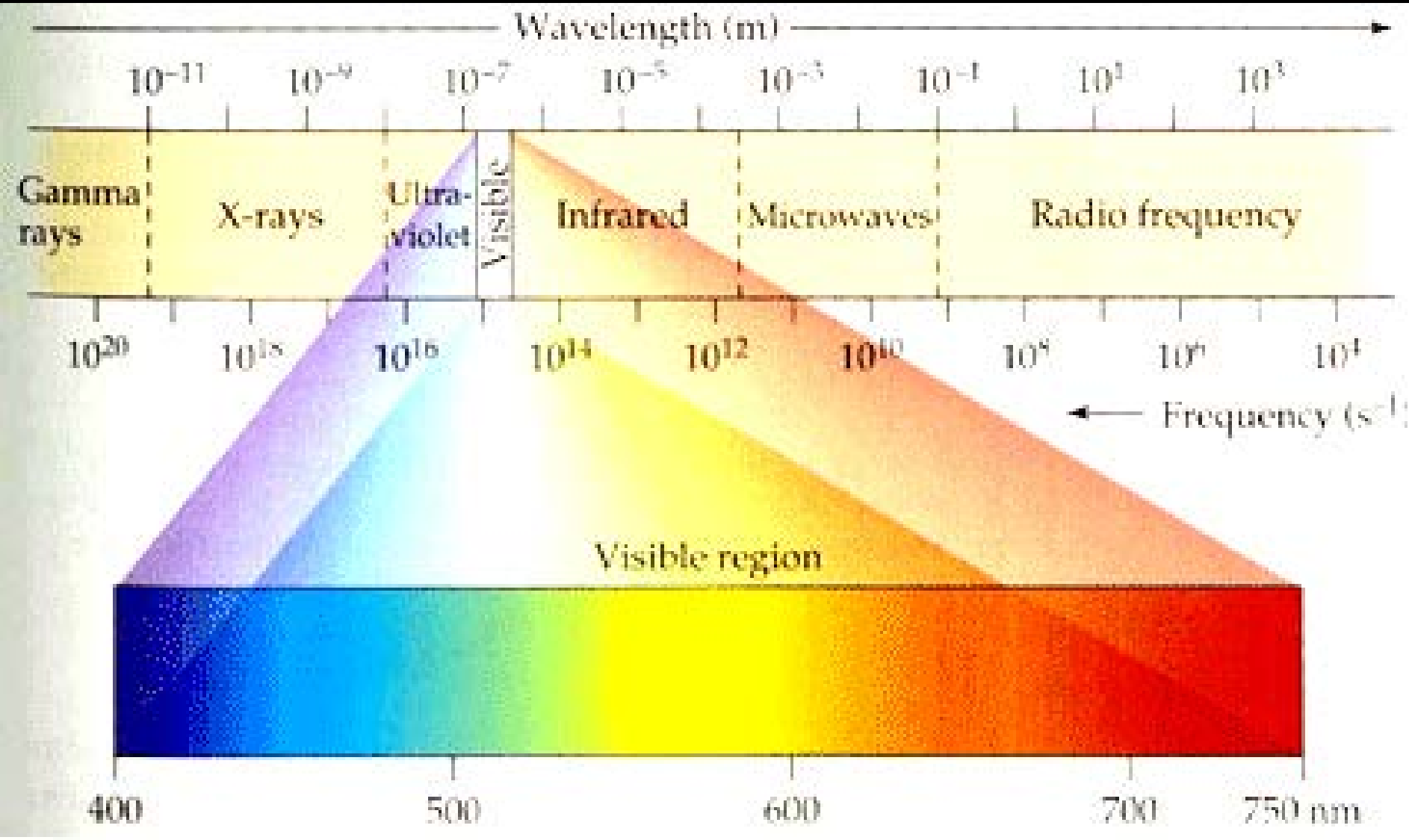


- Color as light
- The visible spectrum
- wavelengths
- White light
- Reflection, Transmission, Absorption, Refraction
- Additive Color vs. Subtractive Color
- Light Primaries vs. Pigment Primaries

Color as Light

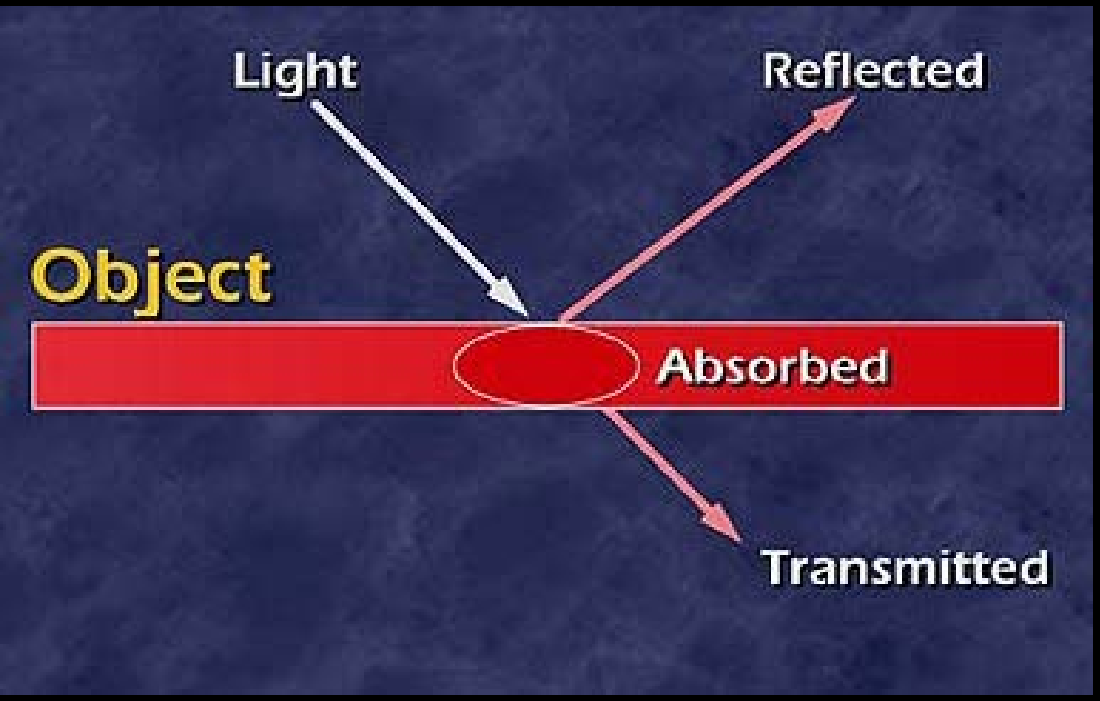
- Every color you have ever seen was due to colored light.
- Your eye sees *only light* – never the surface, never a pigment, paint or dye, and never the object.
- The nerves at the back of our eye are photo-sensors – they respond to light.
- Since we see light, but we most often mix pigment – in paint, or ink, or dyes – *we must understand both color as light and color as pigment. That is, we must understand additive color (light) and subtractive color (pigment)*

Visible light spectrum

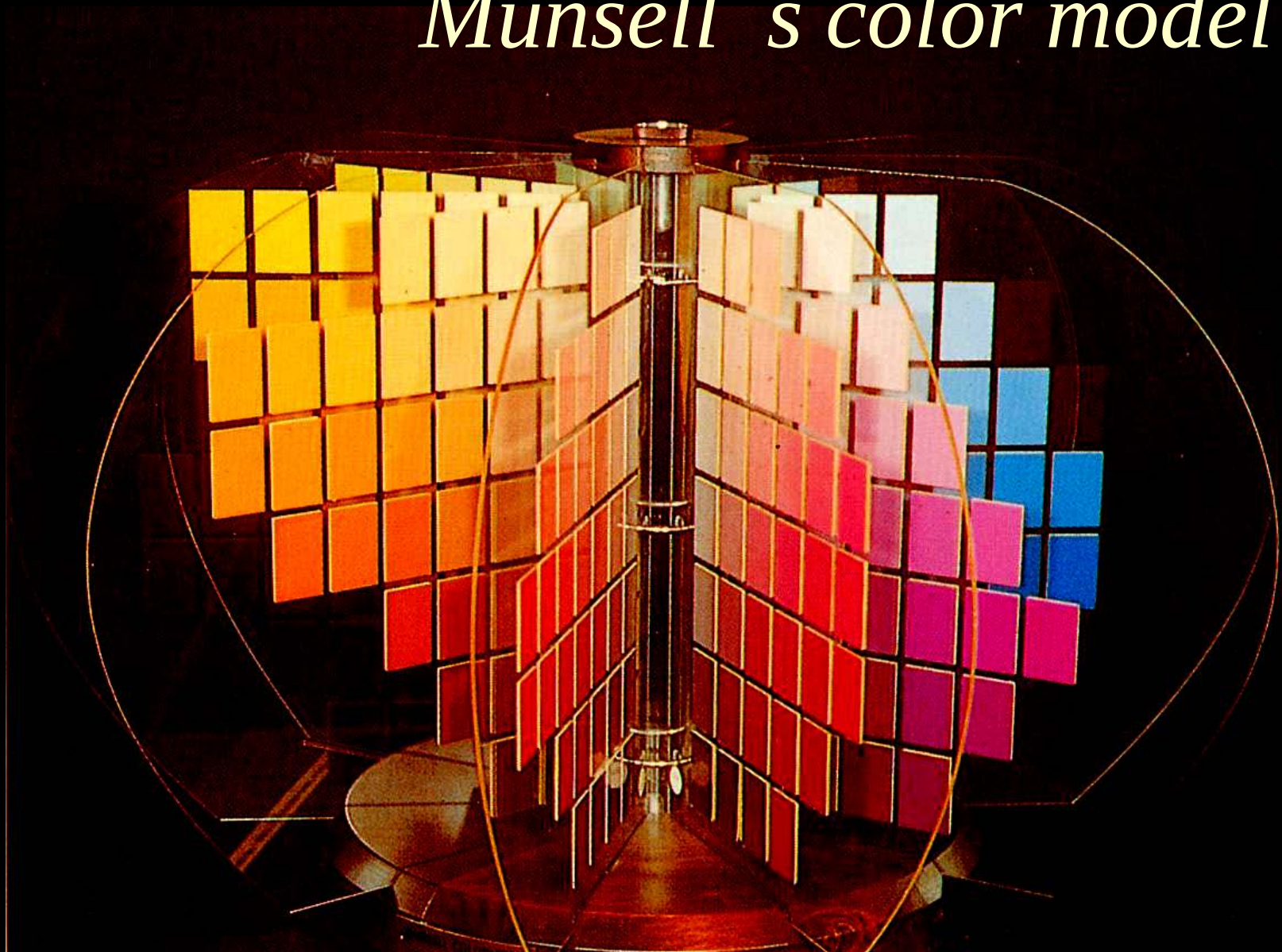


White-Light to Colored objects/surfaces:

- Absorption is the main way that materials become “colored” —subtracting some colors from white light, and either reflecting or transmitting “colored” light.



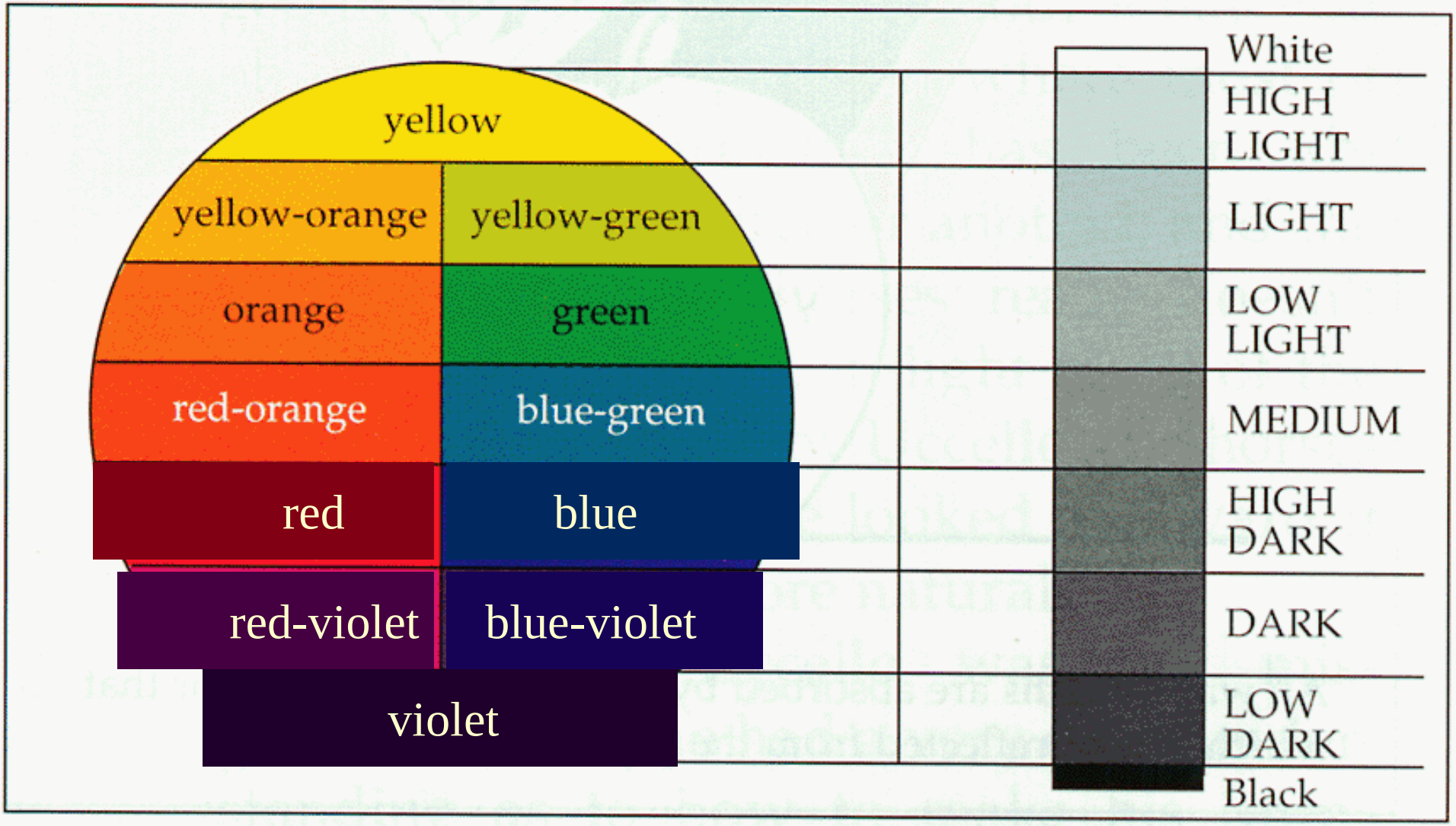
Three dimensions of color - Munsell ’s color model



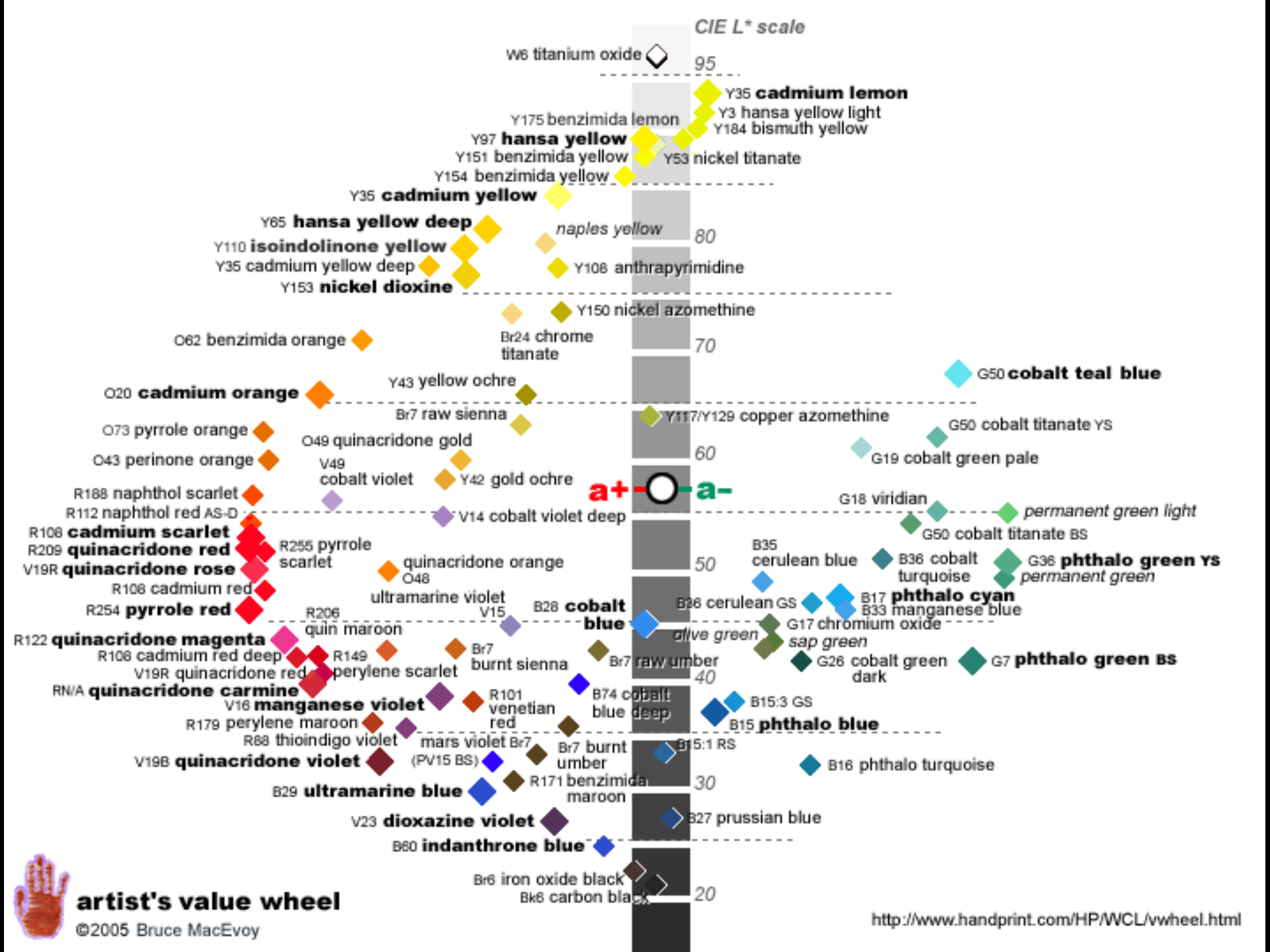
Intrinsic Value or Natural Value

- Every hue has its own intrinsic value. This is **the value of the undiluted hue at full chroma**.
- In practical terms, think of the "strait from the tube" color – yellow is very light in value, violet is very dark in value, blue and red are middle values.

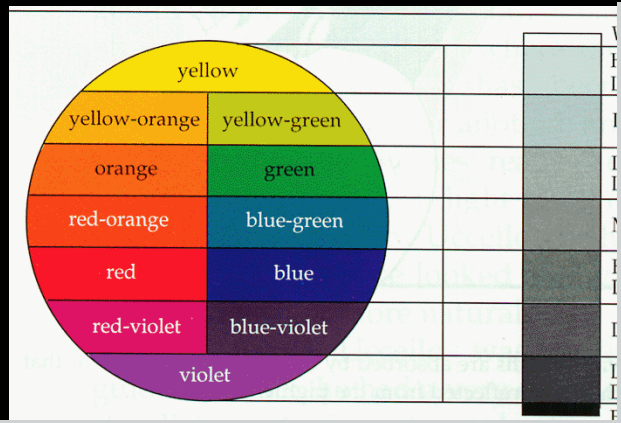
Intrinsic Value or Natural Value

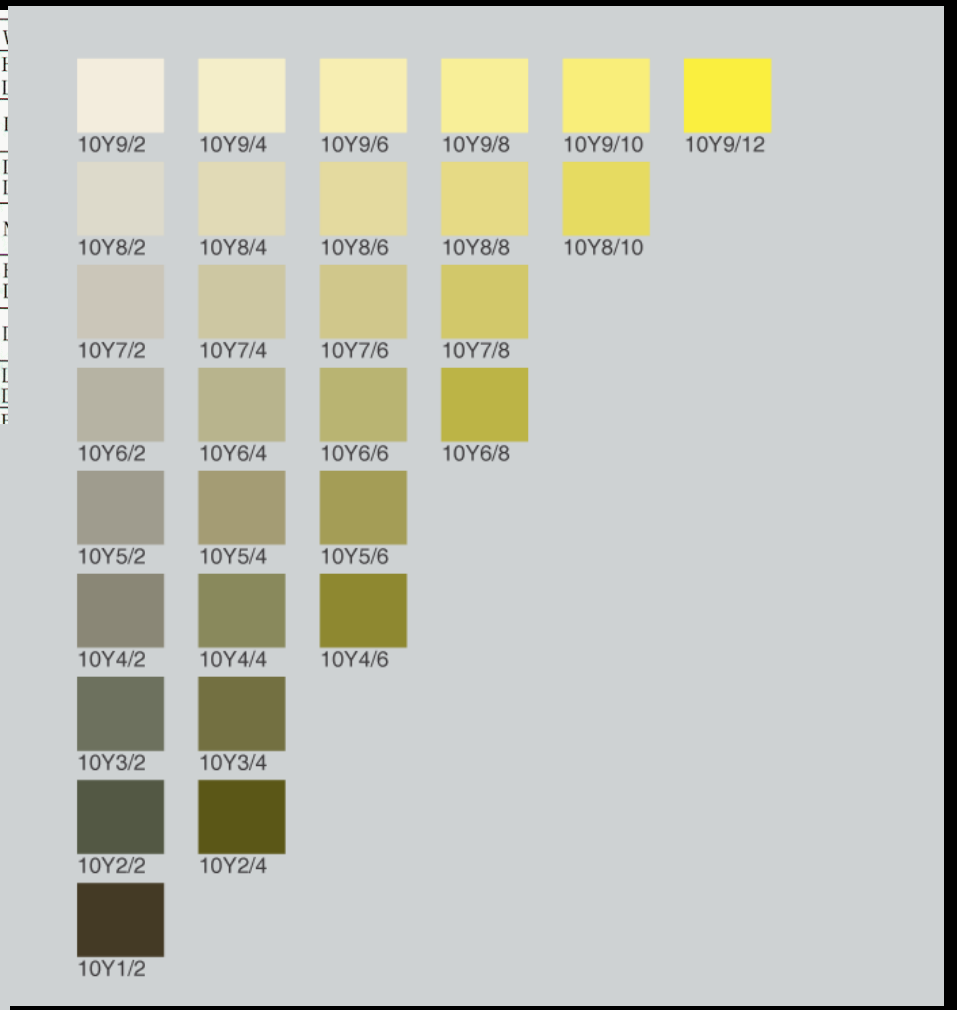


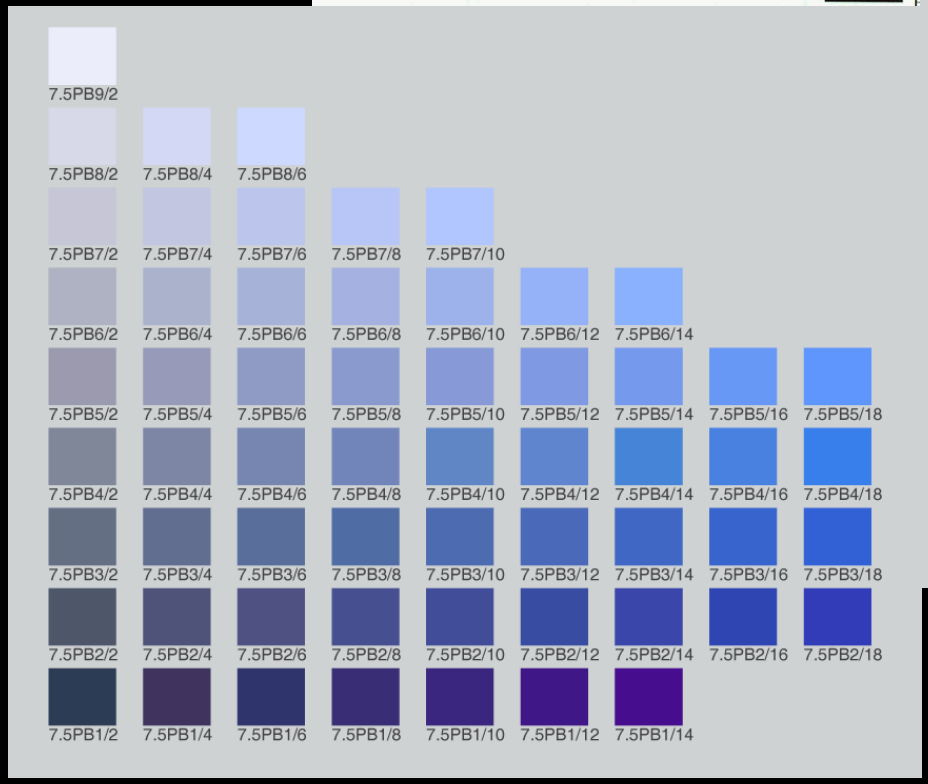
Color and Value


CIE L* scale
W6 titanium oxide
95
Y35 cadmium lemon
Y3 hansa yellow light
Y184 bismuth yellow
Y175 benzimida lemon
Y97 hansa yellow
Y151 benzimida yellow
Y53 nickel titanate
Y154 benzimida yellow
Y35 cadmium yellow
Y65 hansa yellow deep
naples yellow
80
Y110 isoindolinone yellow
Y35 cadmium yellow deep
Y108 anthrapyrimidine
Y153 nickel dioxine
Y150 nickel azomethine
O62 benzimida orange
Br24 chrome titanate
70
G50 cobalt teal blue
Y43 yellow ochre
O20 cadmium orange
Br7 raw sienna
Y117/Y129 copper azomethine
G50 cobalt titanate YS
O73 pyrrole orange
O49 quinacridone gold
G19 cobalt green pale
60
O43 perinone orange
V49 cobalt violet
Y42 gold ochre
a+
a-
R188 naphthol scarlet
G18 viridian
permanent green light
R112 naphthol red AS-D
V14 cobalt violet deep
G50 cobalt titanate BS
R108 cadmium scarlet
R209 quinacridone red
R255 pyrrole scarlet
B35 cerulean blue
B36 cobalt turquoise
G36 phthalo green YS
permanent green
V19R quinacridone rose
quinacridone orange O48
50
R108 cadmium red
ultramarine violet
B26 cerulean GS
B17 phthalo cyan
B33 manganese blue
R254 pyrrole red
R206 quin maroon
V15
B28 cobalt blue
G17 chromium oxide
R122 quinacridone magenta
olive green
sap green
R108 cadmium red deep
R149 perylene scarlet
Br7 burnt sienna
Br7 raw umber
G26 cobalt green dark
G7 phthalo green BS
V19R quinacridone red
40
RN/A quinacridone carmine
B74 cobalt blue deep
V16 manganese violet
R101 venetian red
B15:3 GS
R179 perylene maroon
B15 phthalo blue
R88 thioindigo violet
mars violet (PV15 BS)
Br7 burnt umber
B15:1 RS
V19B quinacridone violet
B16 phthalo turquoise
30
B29 ultramarine blue
R171 benzimida maroon
V23 dioxazine violet
B27 prussian blue
B60 indanthrone blue
Br6 iron oxide black
Bk6 carbon black
20
artist's value wheel
©2005 Bruce MacEvoy
http://www.handprint.com/HP/WCL/vwheel.html

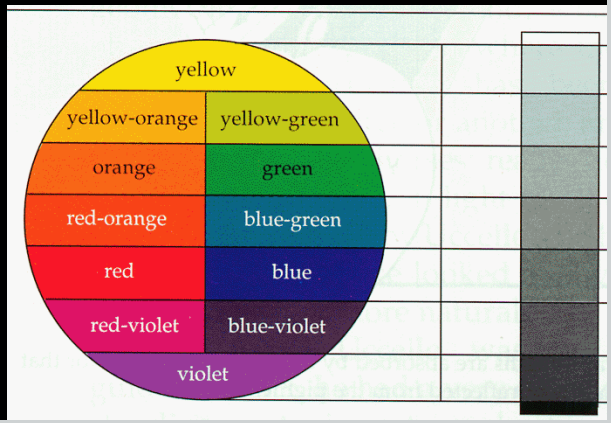
Intrinsic Value: each hue has its own "native territory" of value.

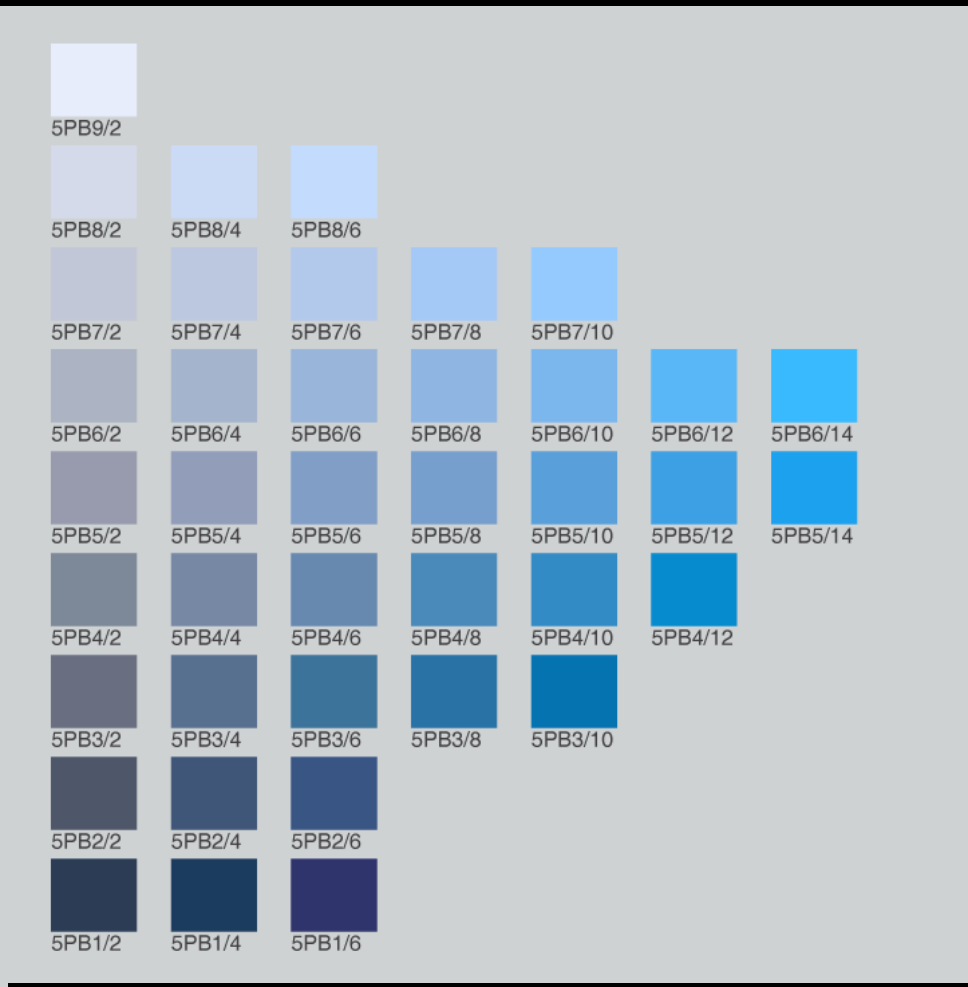


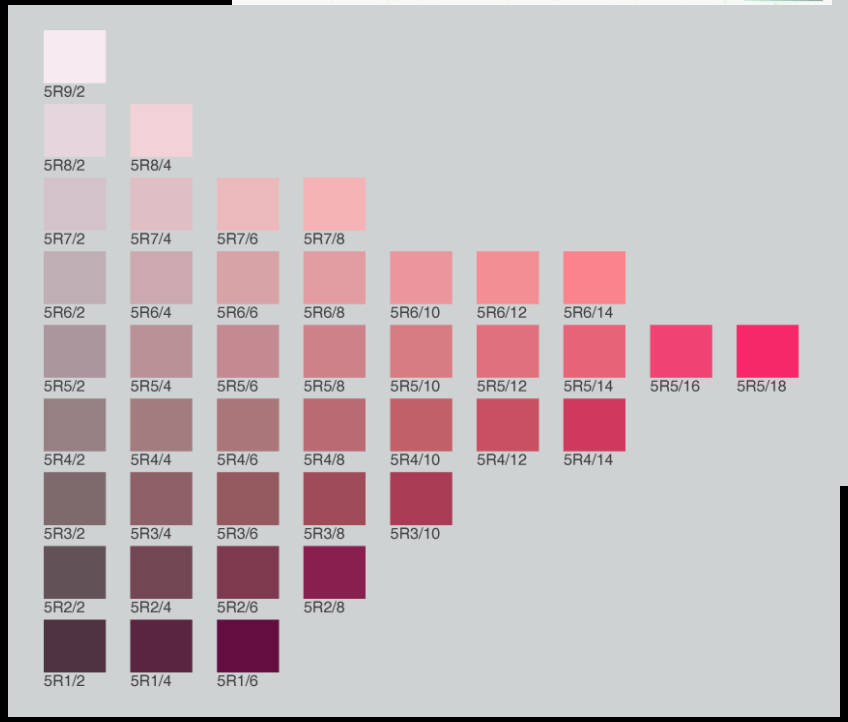




Intrinsic Value: each hue has its own "native territory" of value.

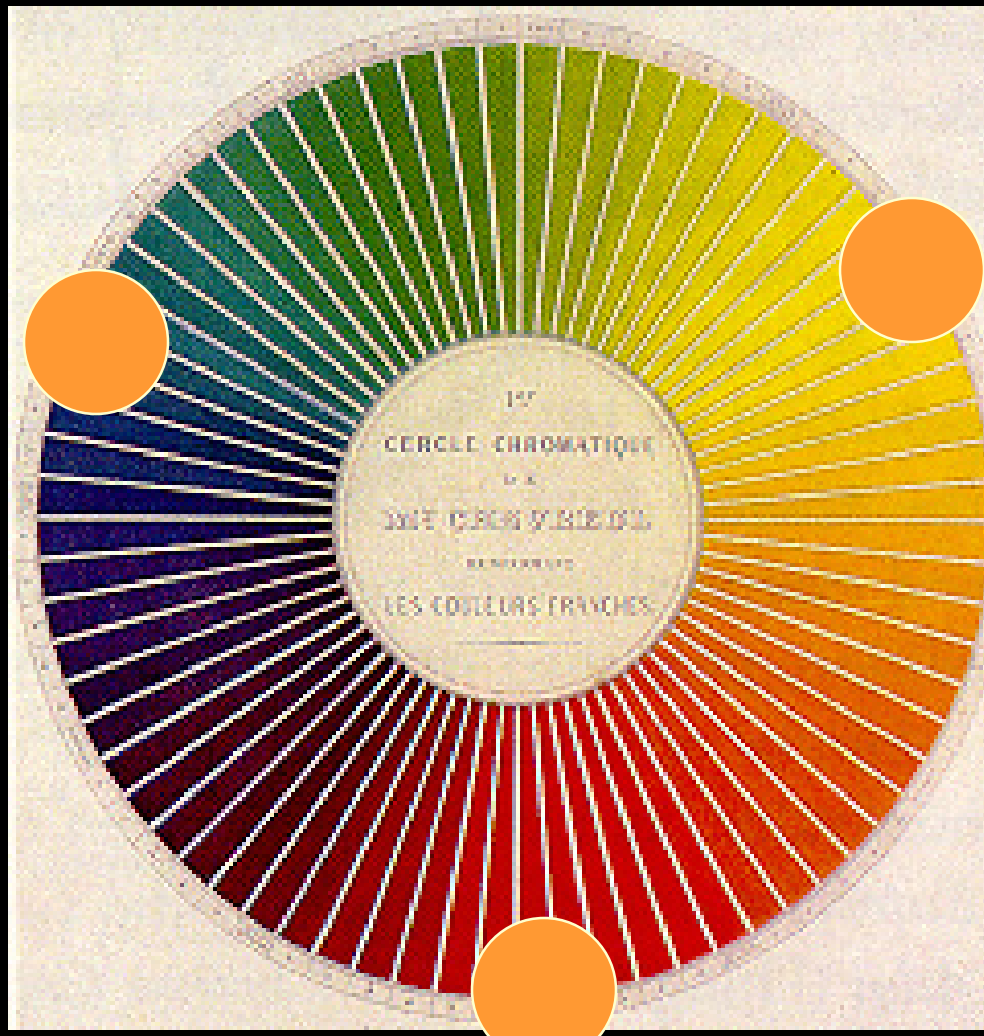






Subtractive Primaries, Secondaries, Tertiaries

- **Primaries (3)**
- **R, Y, B**
- Secondaries
- Tertiaries

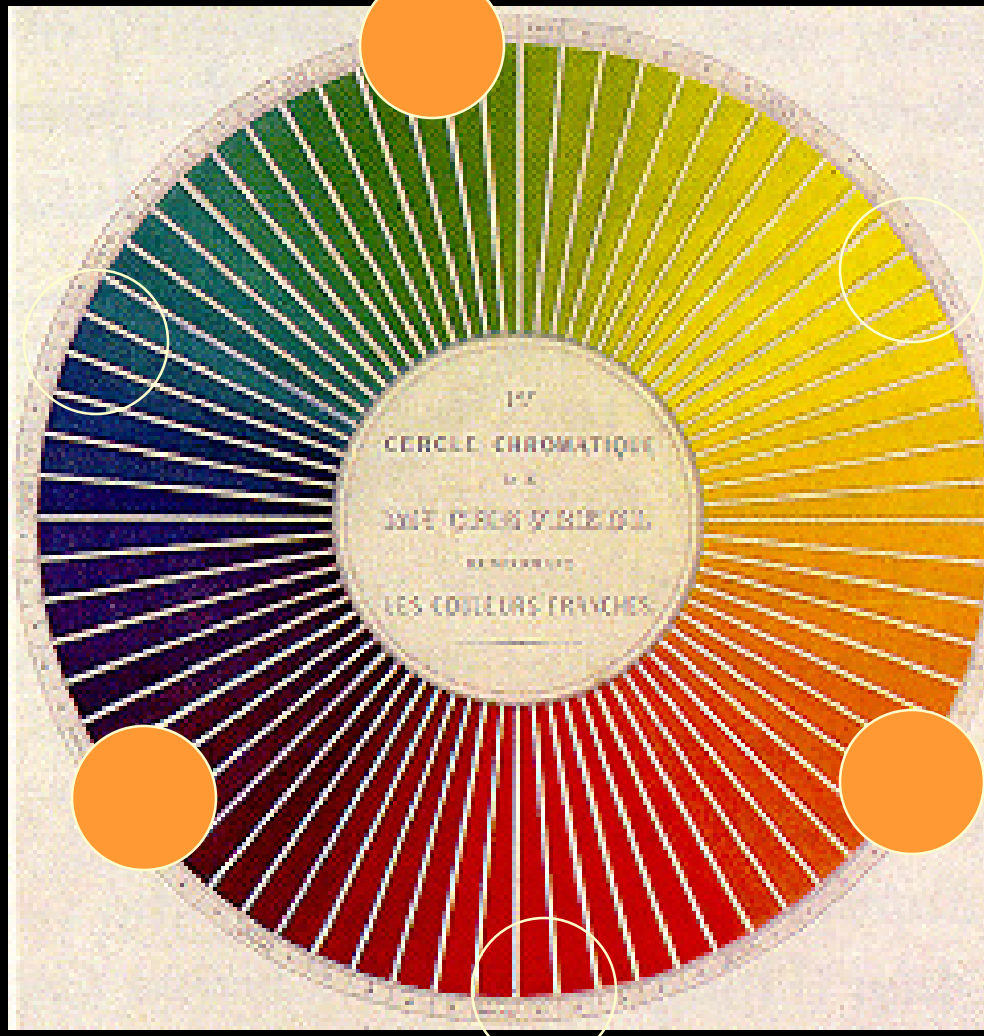


Secondary Color

- In theory, a hue that is mixed by equal proportions of two (adjacent) primary colors.
- In traditional color mixing, there are three secondary colors – however, there will be as many secondary colors in a color model as there are primary colors.

Subtractive Primaries, Secondaries, Tertiaries

- Primaries
- **Secondaries (3)**
- **G, O, V**
- Tertiaries

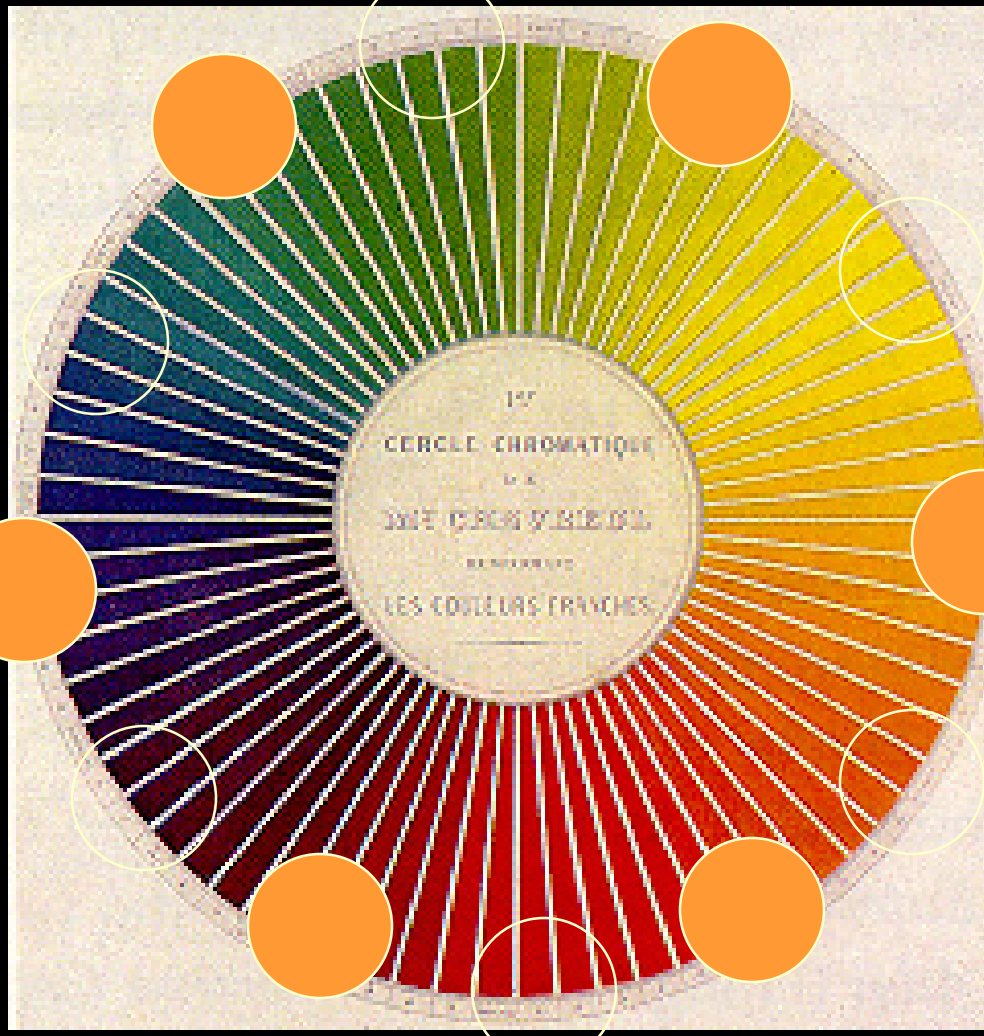


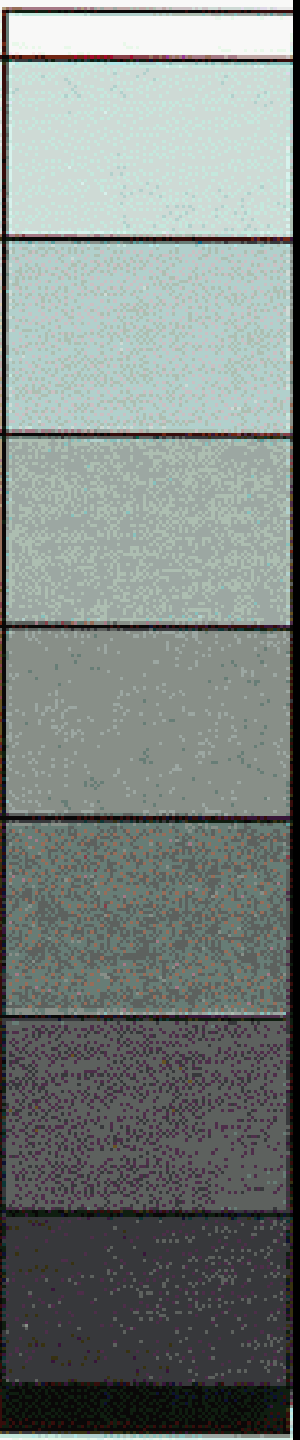
Tertiary Color

- In theory, a hue that is mixed by equal proportions of a primary color and an adjacent secondary color.
- In traditional color mixing, there are six tertiary colors – however, there will be as many tertiary colors in a color model as there are primary AND secondary colors, combined.

Subtractive Primaries, Secondaries, Tertiaries

- Primaries
- Secondaries
- **Tertiaries (6)**
- **YO, RO, RV,**
- **BV, BG, YG**





Neutral Color

- A neutral is a color that has no chroma – so it has no discernable hue at all.
- **True neutrals** are black, white and the grays.
- In practice, we refer to many colors as neutrals when their chroma is quite low – browns, along with warm and cool grays are usually called neutrals though, *strictly* speaking, they are **near-neutrals**.

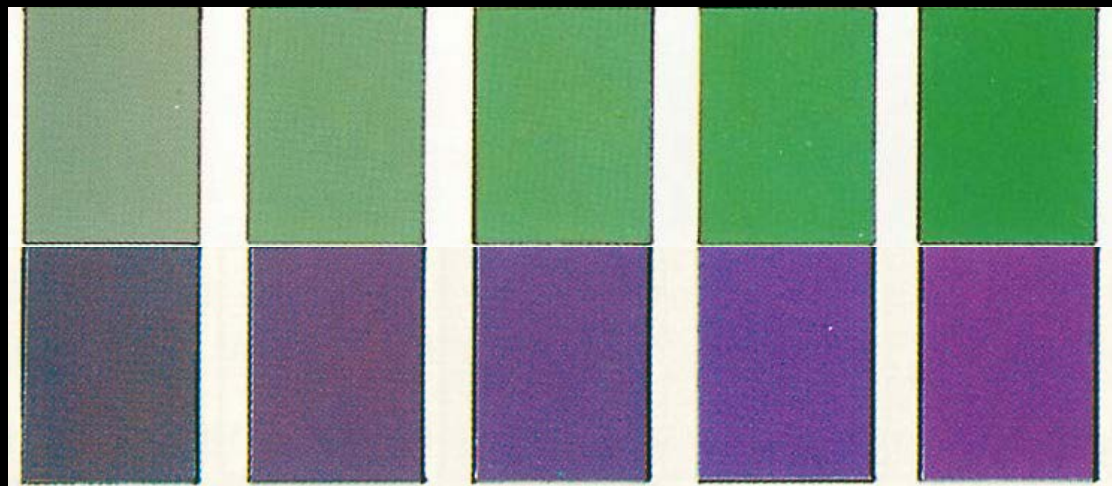
Strict vs. Near Neutrals (Chromatic Neutrals)

- We will speak of “**strict neutrals**” or “**true neutrals**” when referring to **grays** that have *no hue* whatsoever.

- But when speaking of “neutrals”, we will often include “**near neutrals**”, the **browns** and **near-grays**.

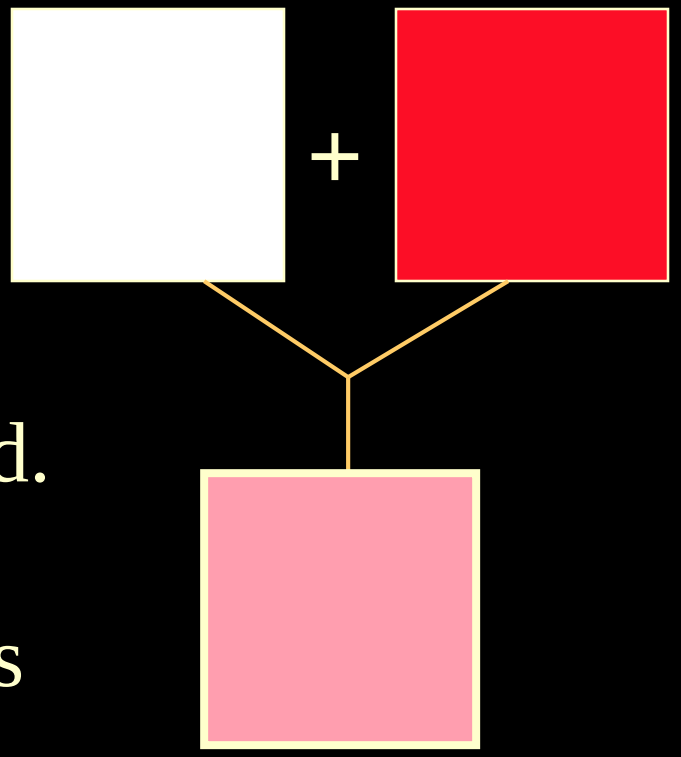
Neutrals vs. ***Chromatic Hues***

- True **Neutrals** have *no* chroma, or zero-Chroma.
  Near-neutrals have very little chroma.
- **Chromatic hues** are the opposite —they have higher chroma (more “color”, higher saturation, a more apparent hue)

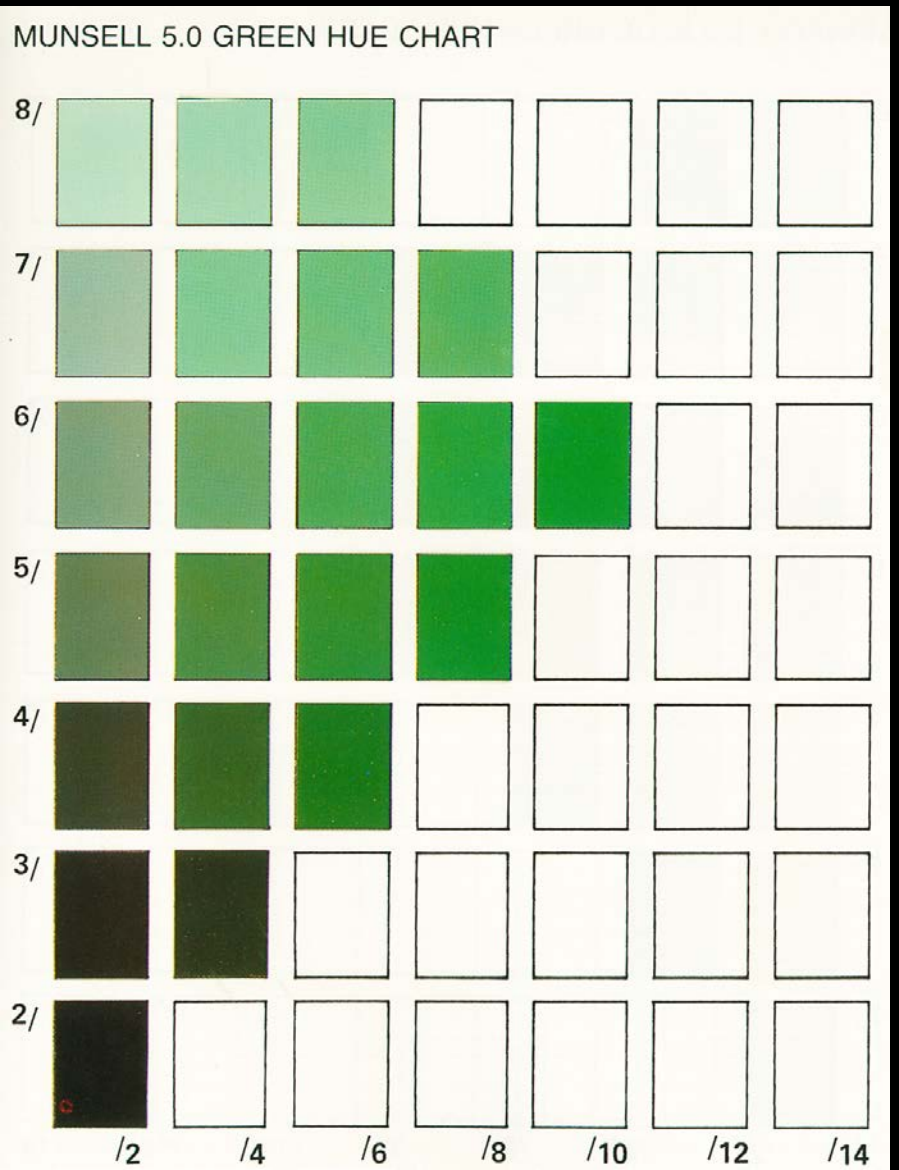


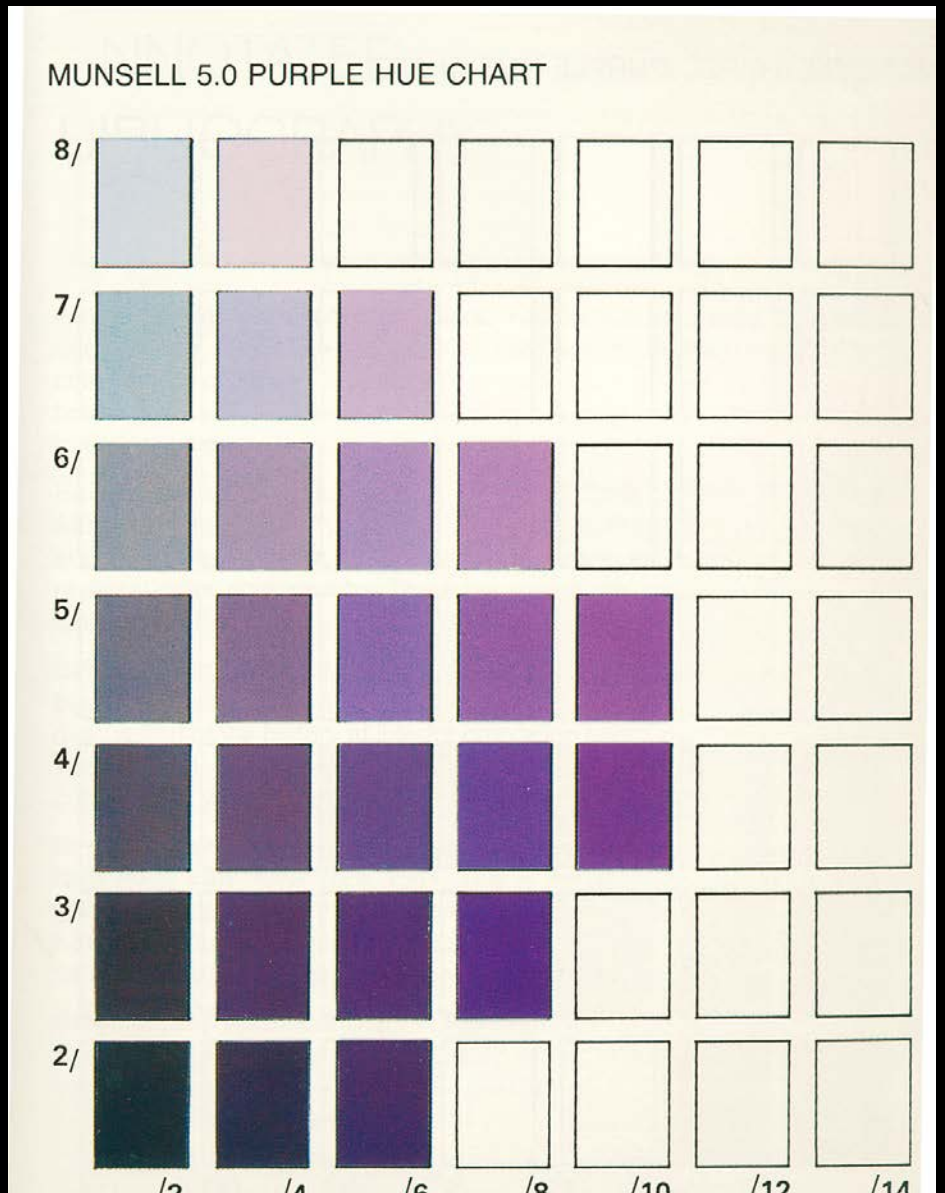
Tint

- **A high-value form of a hue.**
- In practice, a tint is a color that has had white added to it.
- For instance, pink is a tint of red. A pure, primary red might be mixed with white. The result is a “light red” —a tint of red.



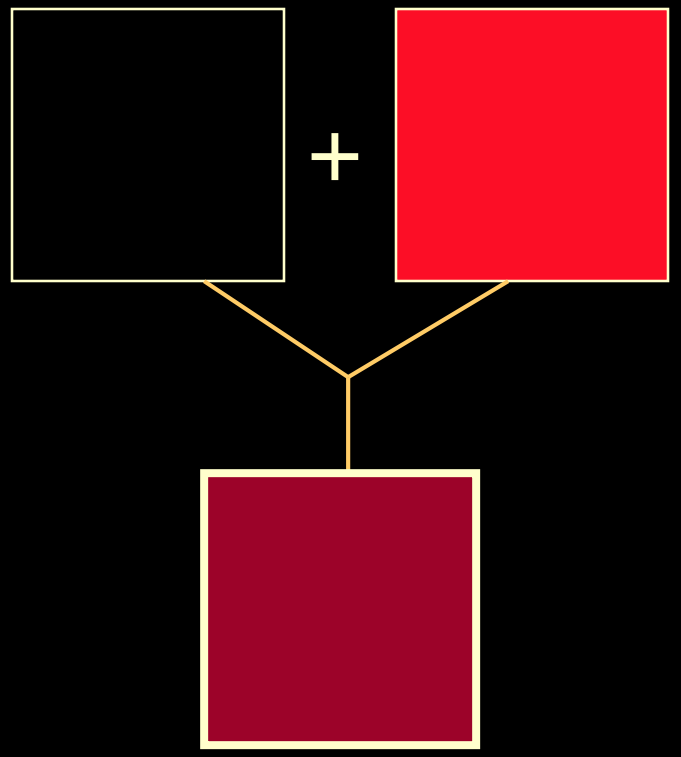
Constant Hue Charts





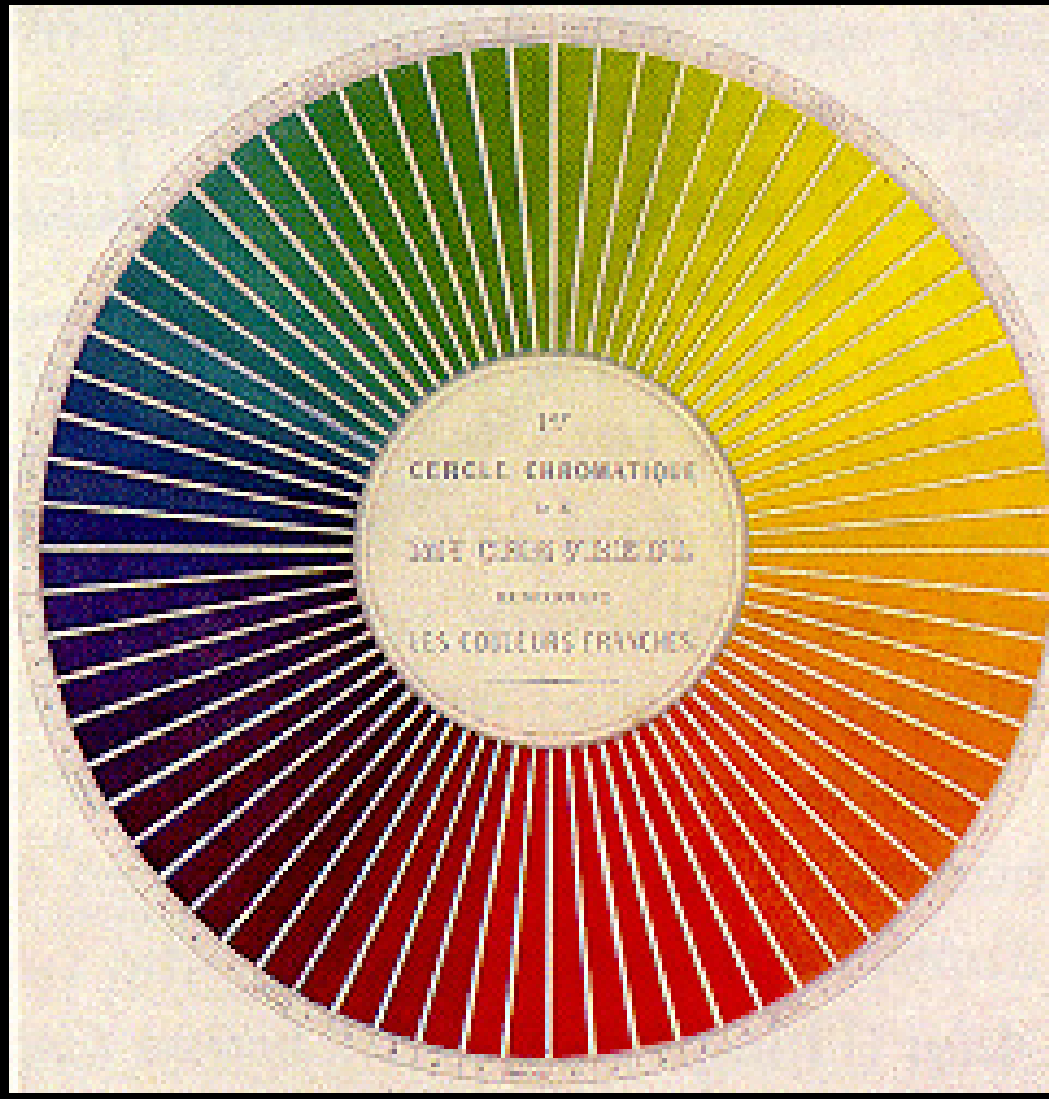
Shade

- **A low-value form of a hue.**
- In practice, a color that has had black added to it.
- Maroon is a shade of red —a pure, primary red might be mixed with black (or dark brown, or dark gray). The result is a “dark red” —a shade of red.



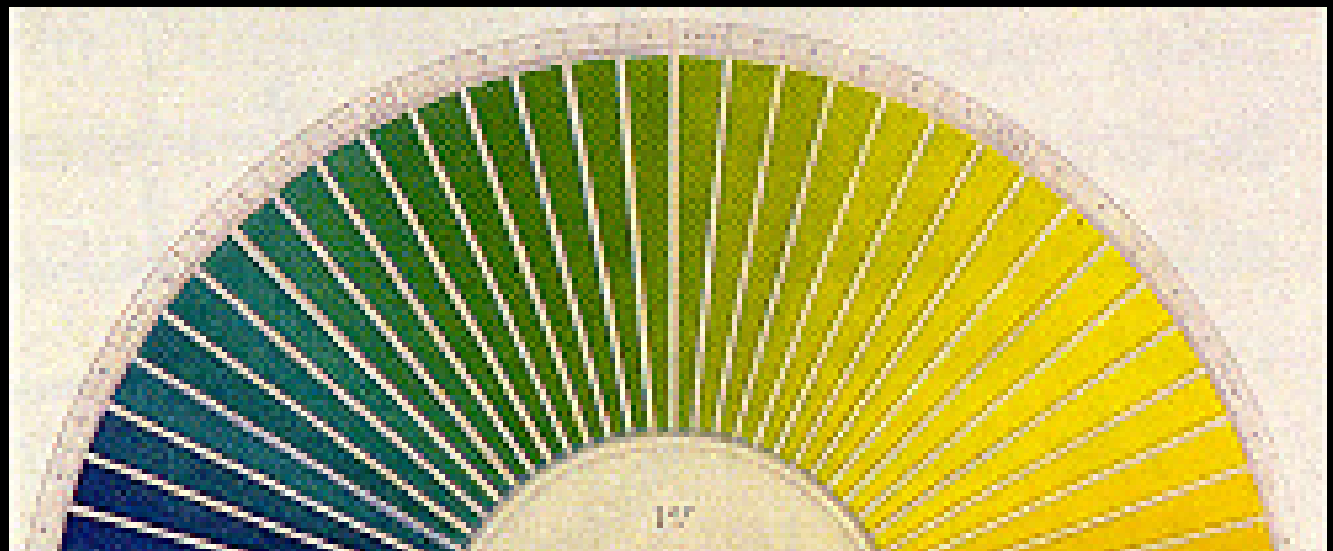
Warm and Cool Colors

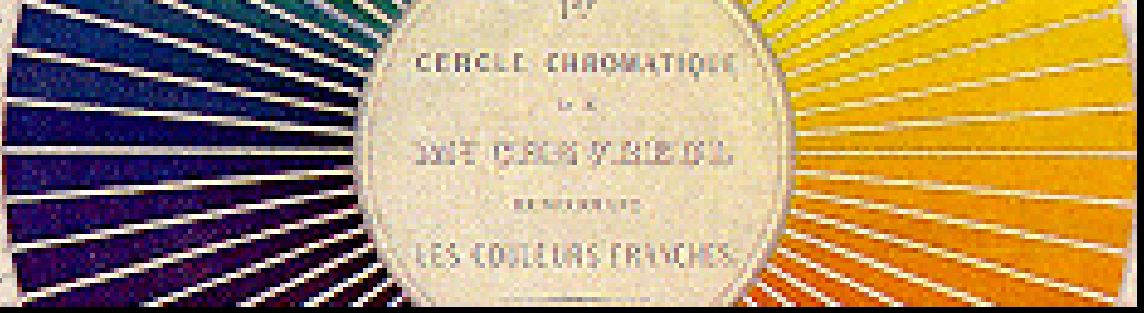
- Warms: reds, yellows, oranges -- fire colors.
- Cool: blues, violets, some greens.
- Note that *every* color is warm *compared to* some colors and cool compared to others.
- Temperature is relative to surroundings.



Adjacent (or Analogous)

- Hues that are near each other on a color wheel.
- Colors that are similar in hue.
- Colors that have some dominant hue in common.





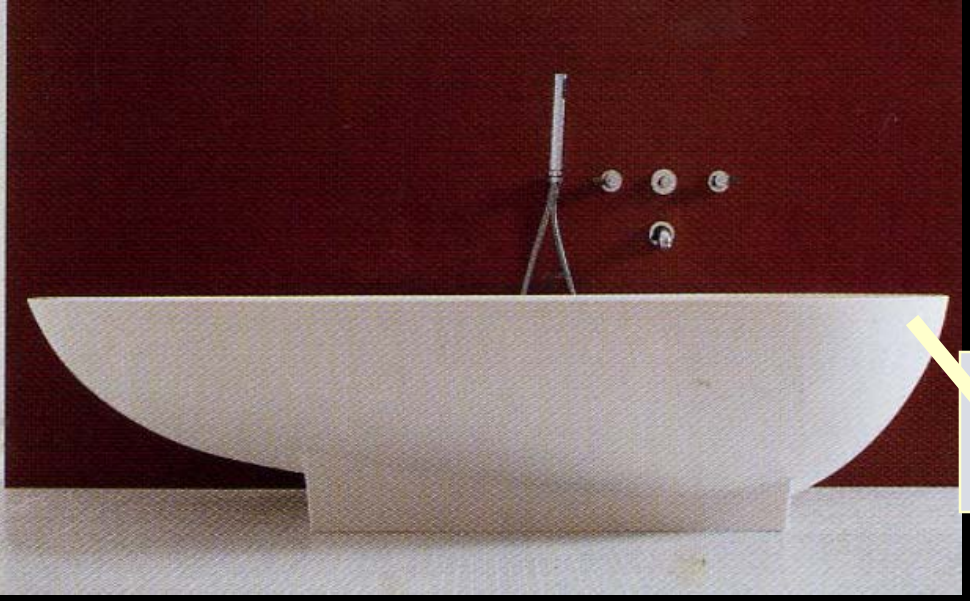
Complementary

- Hues that are opposite each other on a color wheel.
- Note that there are several color wheels or color models. Precise complementary pairs differ according to the color model.
- In general, complementary hues are as “different” as hues can be -- and so offer a powerful visual contrast for design purposes.

Local Color vs. Atmospheric Color

- **Local Color** is the color of a surface, material, fabric, or light source under ideal white light and undisturbed viewing conditions.

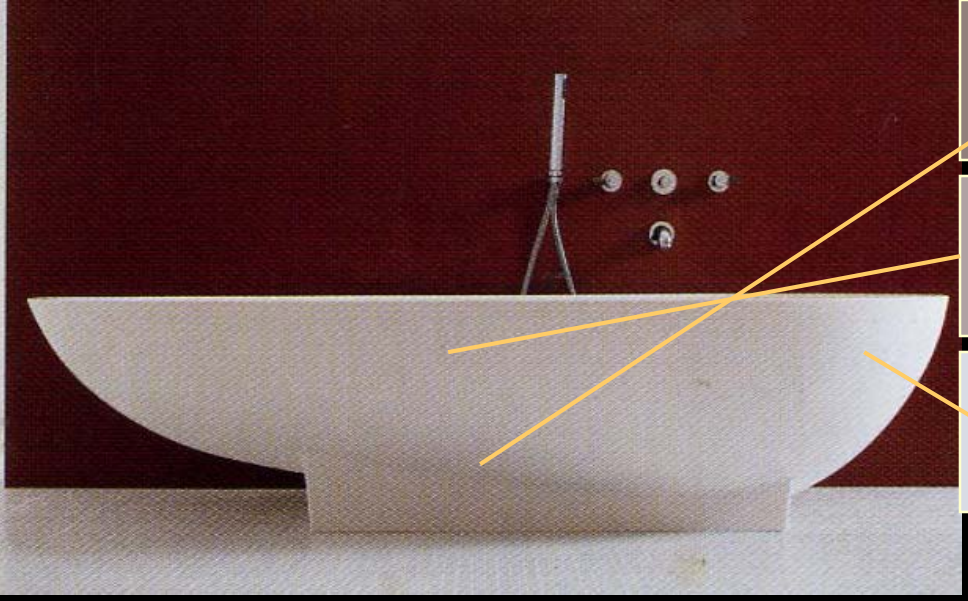
- **Atmospheric Color** is the color that a surface, material, etc. *appears* to be due to lighting conditions, atmospheric mist and dust, and distance.



Local Color

- surface color.

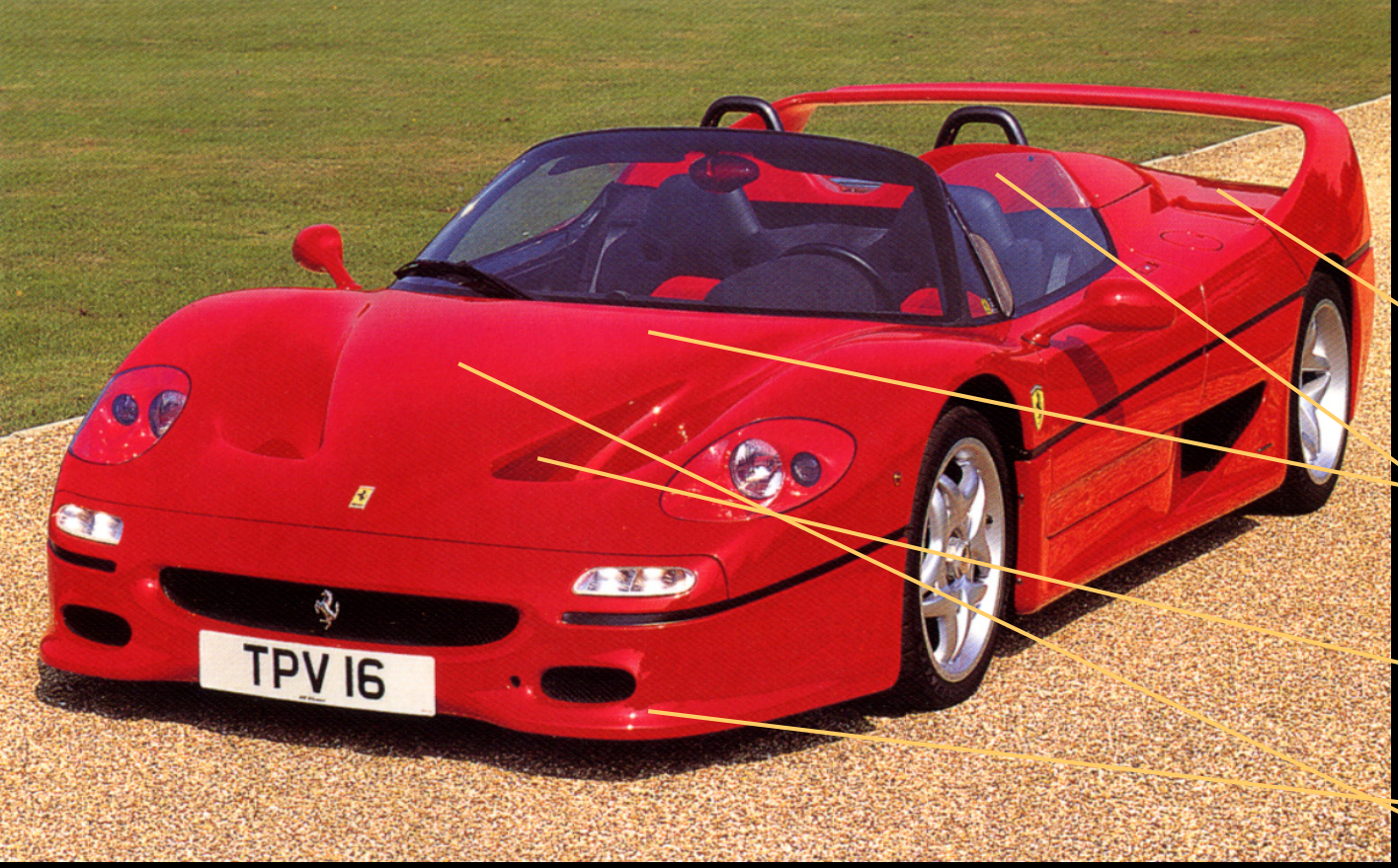
- The *local color* of this bathtub is *White*.
- This is the color that a surface is under perfectly balanced white light, with no glare, no shadows, and no mist, fog or smoke obscuring our view.
- Local color is the color of the surface itself undisturbed by atmosphere and irregular lighting..



Atmospheric Color:

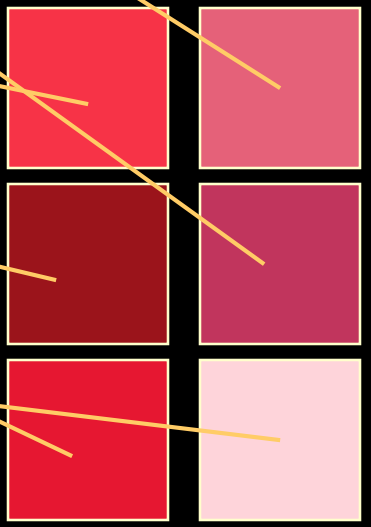
Local Color altered by light/shadow, etc.

- For the interior designer, especially, local color (swatches and paint samples, for instance) are only a part of the color planning – lighting is the other essential component of color design.
-
- **Lighting conditions always alter the appearance of local color.**



Atmospheric Color:

Local Color altered by light/shadow, etc.



- Question: What color is the Ferrari?
- Answer: lots of colors.
  (modeling/angles of surfaces with respect to light source, and reflected sky/environment influence color.)

- What is the *local color* of the Ferrari?
- Answer: Red. (hue: Red, value: middle/5, chroma: high)

Atmospheric Color

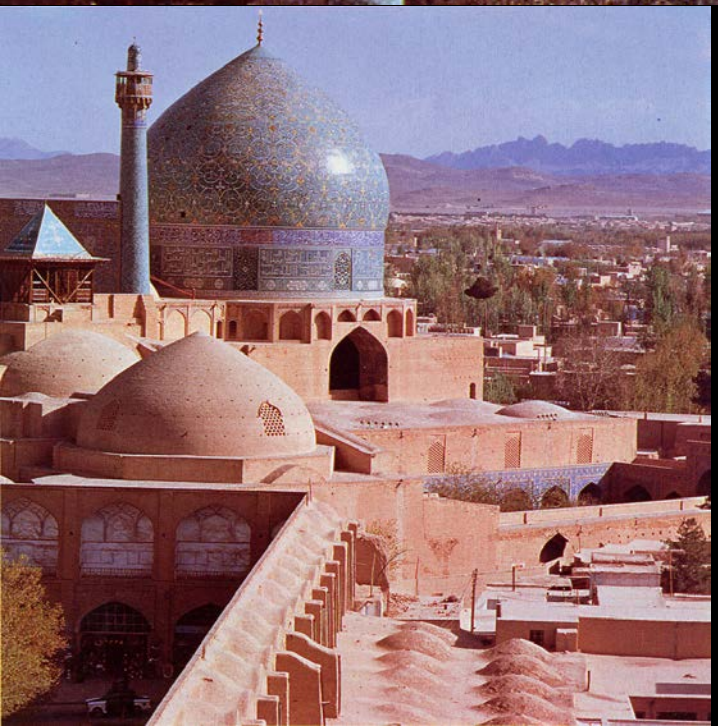
- **The color a surface *appears to be* when lighting, shadows, fog or mist and other moderating factors are taken into account.**

Atmospheric Color

- In practice, all color that you and I see is “atmospheric” – in that every color we perceive depends on the conditions we see it in…
  We see the effects of light sources, shadows, glare, dust, moisture, reflections, etc.

- …*however*, we paint, apply and specify *local colors*!

Atmospheric Color



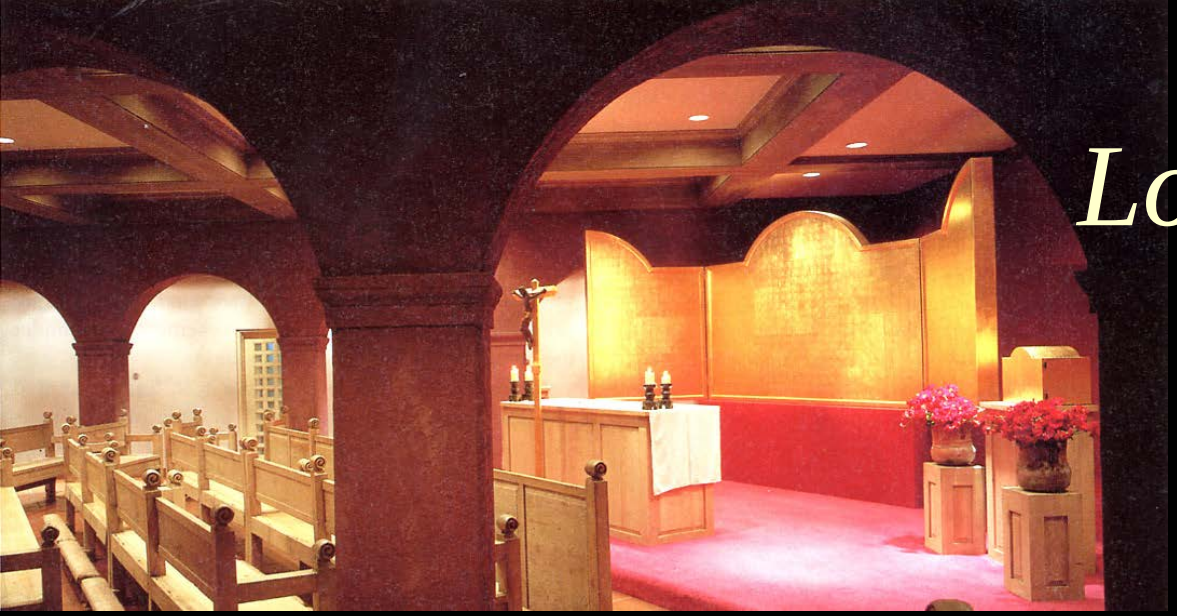
- Dust and moisture *between the viewer and the subject, scatter sunlight, cause distant surfaces to be closer to "sky color" -- which is fully due to sunlight scattered by dust, moisture, gases and pollutants.*

Atmospheric Color

Bierstadt *The Haying*

Atmospheric perspective, also called **Aerial perspective**, is a reliable technique artists use to *create an illusion of depth or distance*.

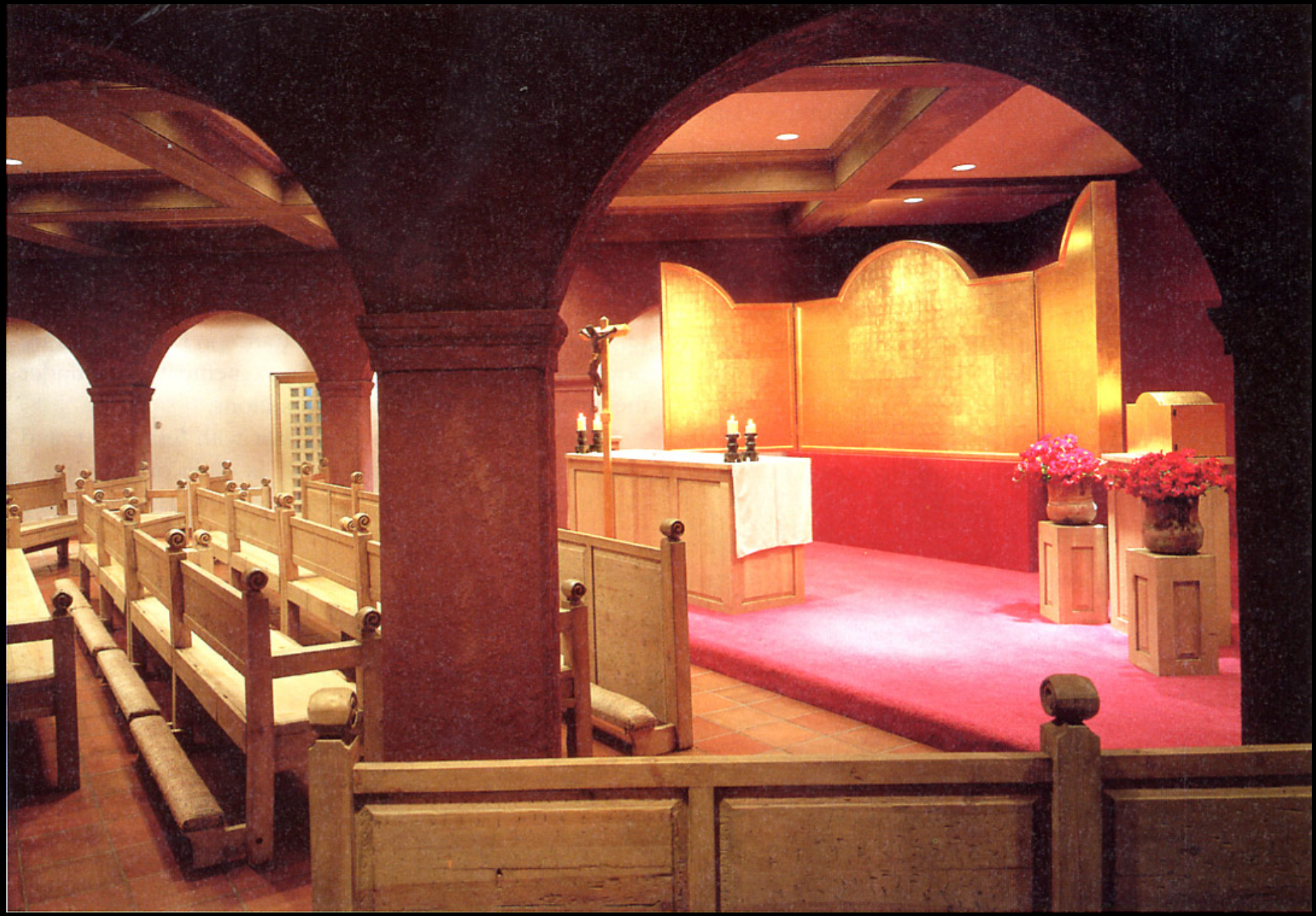
Colors of distant objects are lower in chroma, usually lighter in value and more bluish in hue.



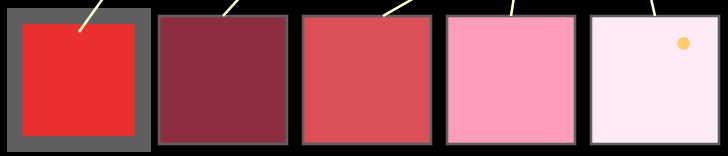
Local Color vs. Atmospheric Color

- Architects, Interior Designers and stage designers, especially, must distinguish between the *colors that are specified*, and the *colors that the viewer sees*.
- **Light, shadow, and surface characteristics alter color dramatically**, generally expanding the range of color in the design.

Emmanuel chapel p. 161



Emmanuel chapel p. 161



Local colors (paint, carpet, wood…) are altered by lighting and surface qualities.

In Interiors and Architecture, we specify local colors, but plan atmospheric colors.

Color as Pigment

- A pigment is any material used to ***provide the actual color*** to a paint, a dye, an ink or other colored medium. Pigment is the ***colored matter*** within the substance we color with.
- Each ***pigment absorbs certain colors*** of light and reflects other colors.
- The characteristics of ***selective absorption and reflection determine the color*** of the pigment.

Paint, Dye and Ink

- The media we apply color with have three basic ingredients.
- Pigment
- Binder
- Solvent

Paint, Dye and Ink

- Pigment
  - The coloring agent – the actual colored substance. Note that there are many kinds of pigments with distinctive characteristics.
  - Pigments vary in coloring power, opacity, light-fastness, and permanence.

Paint, Dye and Ink

- Binder
  - Binder is the “glue” that enables pigments to adhere and stay where you put them.
  - Each medium has is own binder. (linseed oil, glcyerine, acrylic polymer, etc.) In general, the various media are distinguised primarily by their binder.
  - Note that not all pigments are use with all binders/media -- the binder and solvent can chemically react with some pigments.

Paint, Dye and Ink

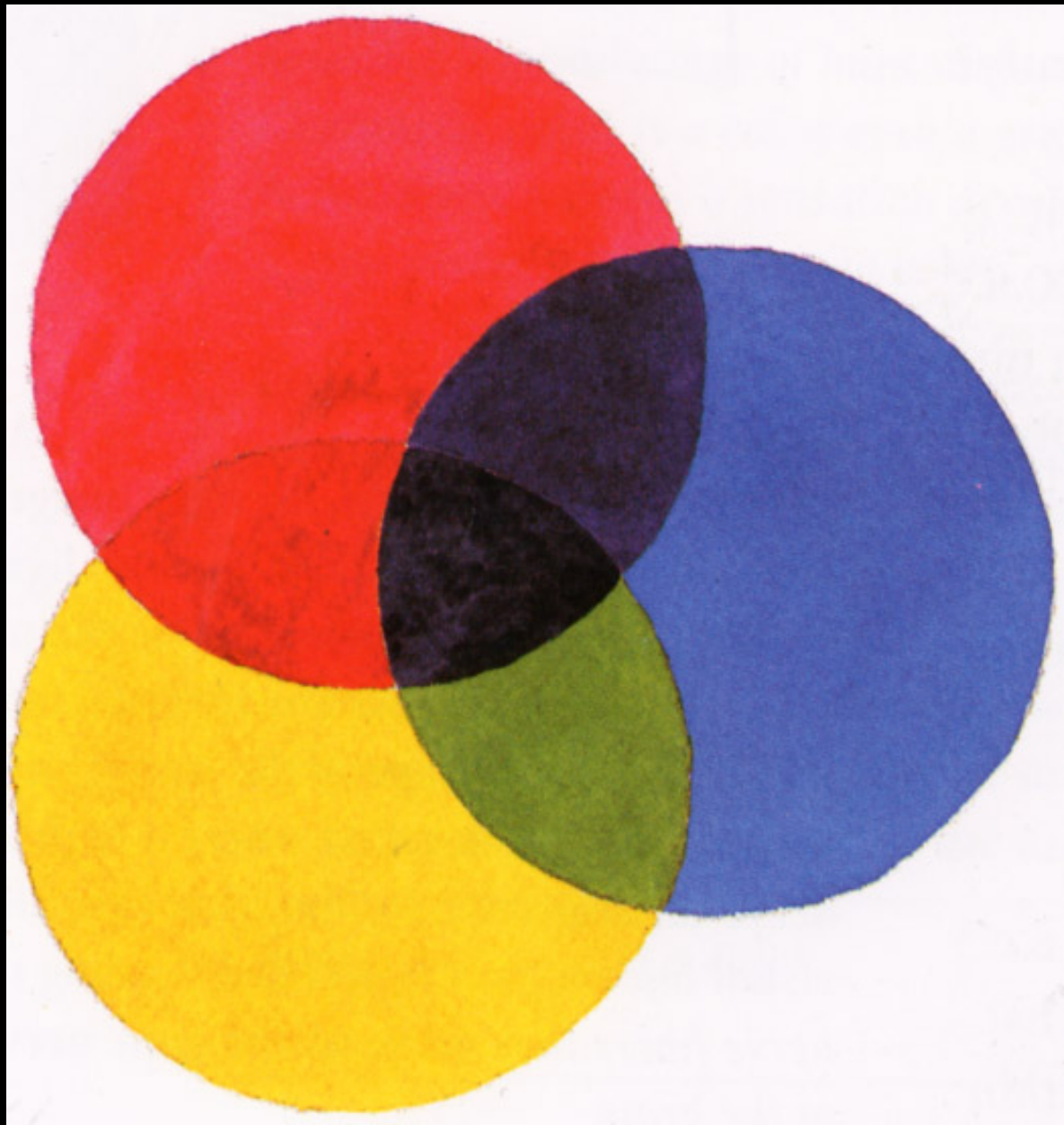
- Solvent
  - The solvent keeps the paint moist and fluid until it dries. In watercolors, tempera and acrylics, water is the solvent. In oil paint, turpentine provides liquidity.
  - The pigment must be able to suspend or float in the solvent and binder.

Subtracting Colors by Adding Pigments

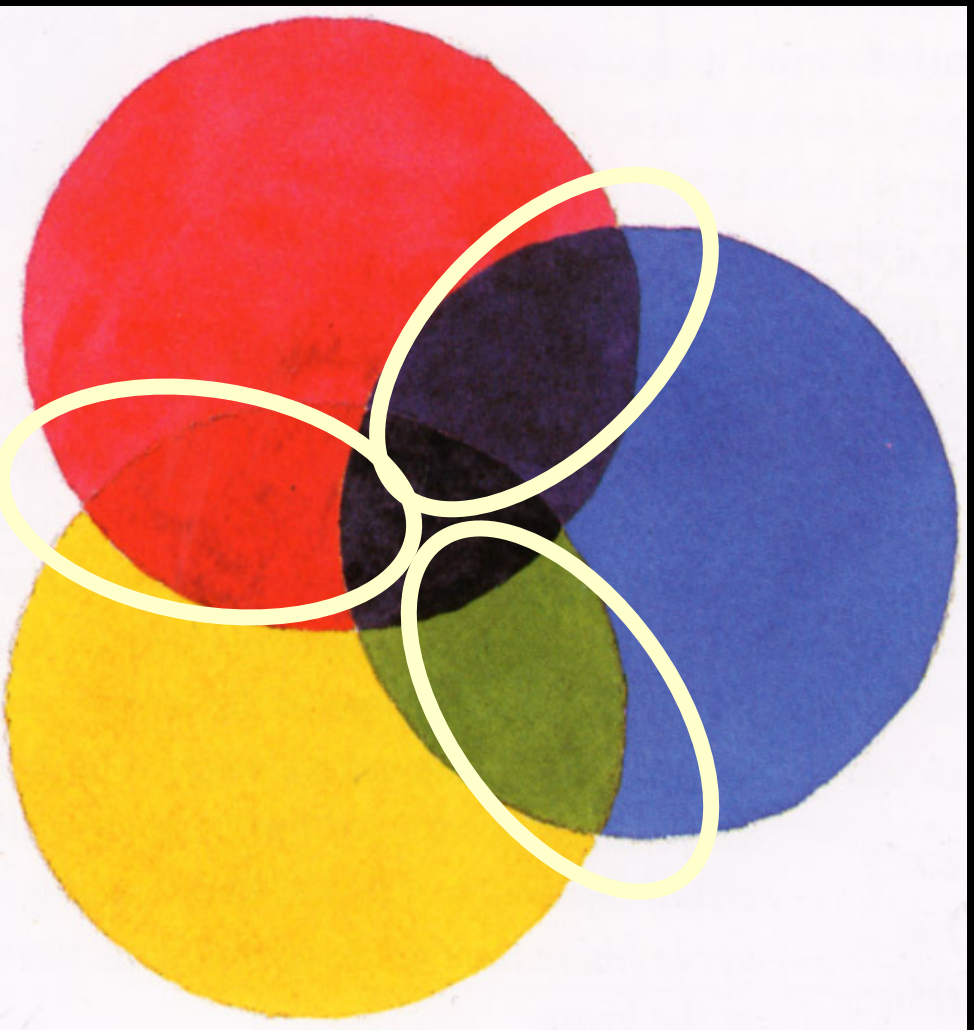
- Whenever we mix two pigments together, the colors absorbed (subtracted) by each color continue to be absorbed – and so, less light reflects and a new hue results.
- So, ***the resulting color is a bit darker*** in value than might be expected.

The traditional Subtractive primaries

- Red
- Yellow
- Blue



Pigment Primaries & Secondaries



- Secondaries
- Orange
- Violet
- Green
- As color/pigment is added, we get closer to black. (each added color subtracts FROM reflected light.)

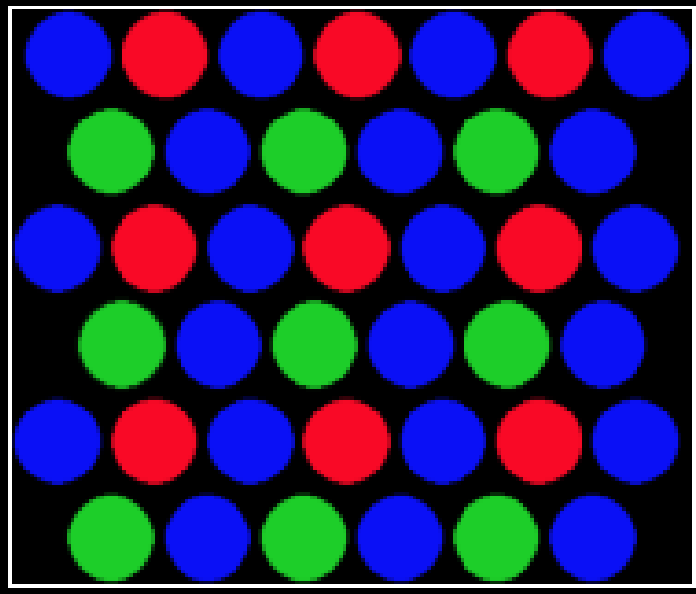
The traditional Subtractive primaries

- Mixed together, they should create black *theoretically*.
- In practice a dark muddy gray usually results.

Light/Additive Primary Colors

- The primaries for light-color mixing and pigment-color mixing are NOT the same.
- Red
- Green
- Blue

The Additive Primaries RGB



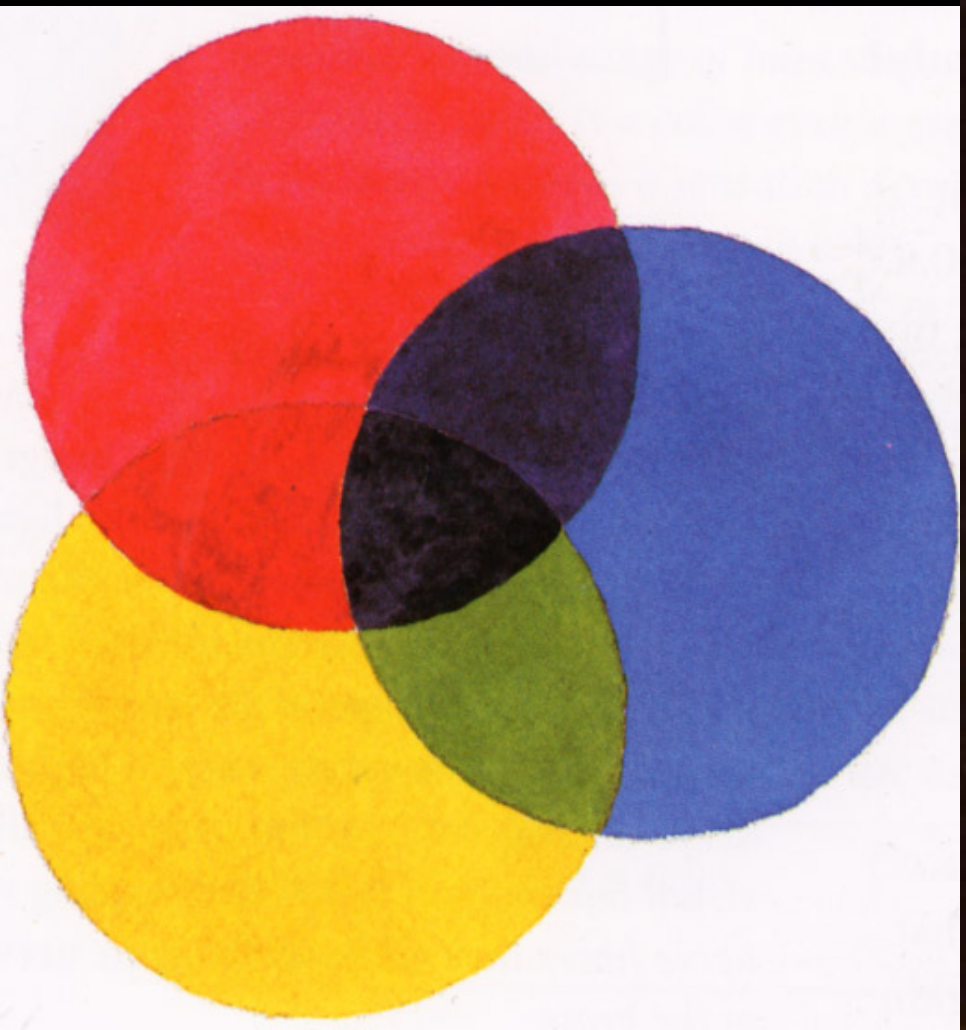
- Red
- Green
- Blue
- Colors of the phosphors on a television or computer monitor (RGB).
- When combined (all are glowing) these light primaries produce white - even though they don’t overlap (optical mixing).
- The absence of light is black – darkness.

Light & Primaries & Secondaries

- *Secondaries*
  - Yellow
  - Magenta
  - Cyan

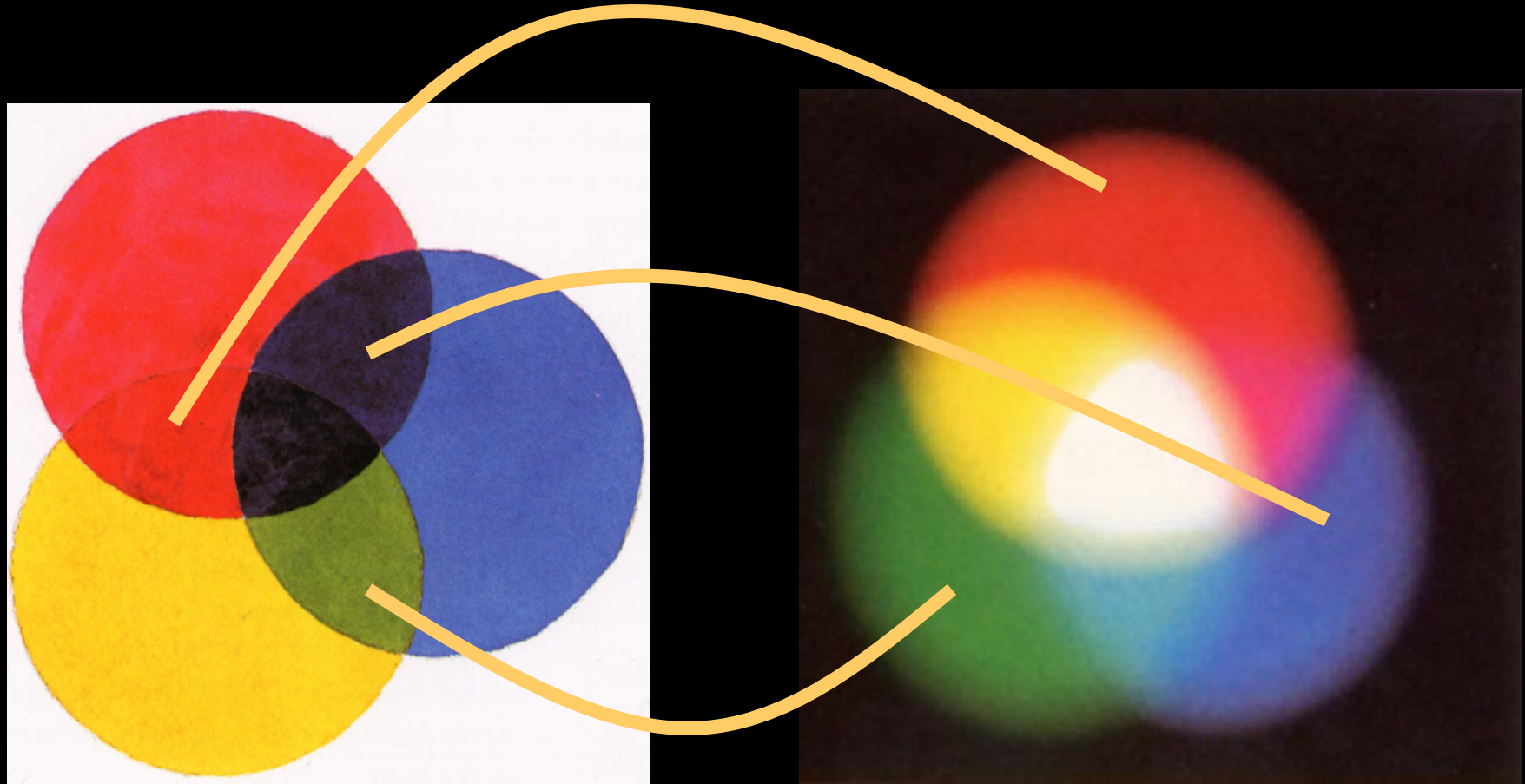
- (note - these are the **primary inks/colors in CMYK printing**)
- As color/lights are added, the result is closer to white

Pigment vs. Light Primaries & Secondaries



Pigment vs. Light Primaries & Secondaries

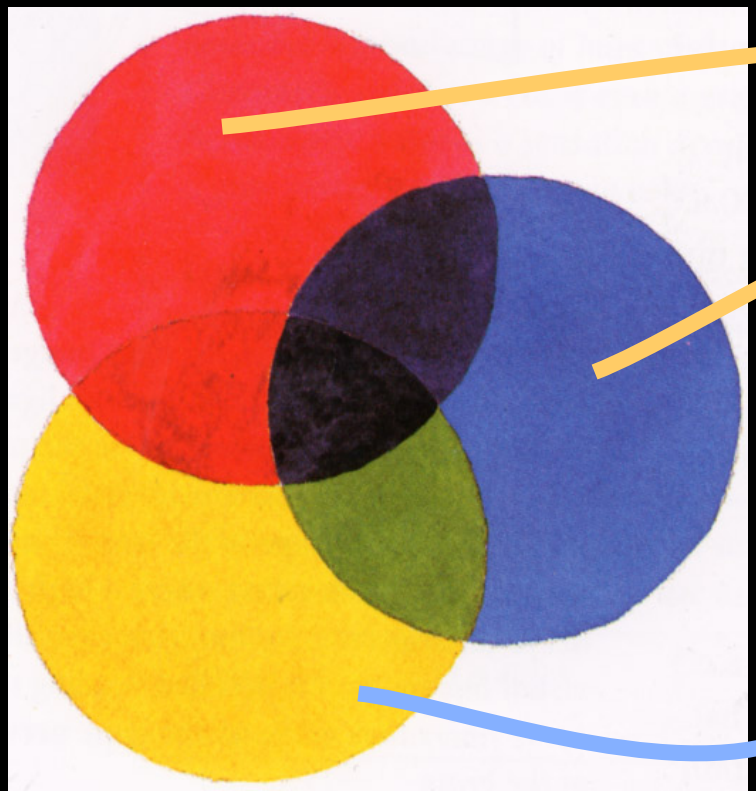
Light (additive) primaries are *very* similar to pigment (subtractive) secondaries.



Pigment vs. Light Primaries & Secondaries

Pigment (subtractive) primaries are *very* similar to light (additive) secondaries.

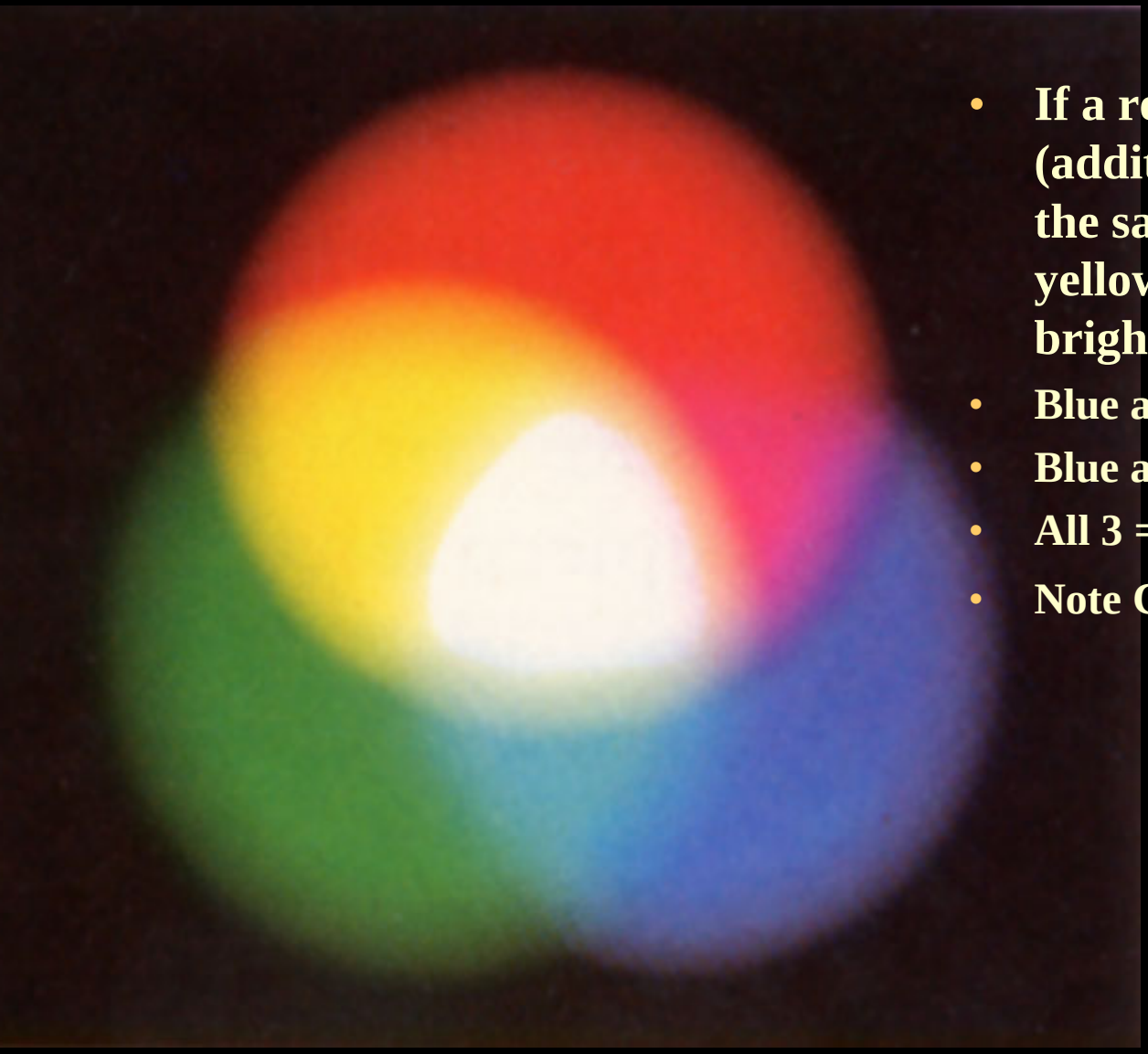
In fact, the most true and reliable pigment primaries may be derived from light-secondaries. (e.g. **CMY**K)



Adding Color by Adding Light

- **Whenever two colored lights are shined on the same spot, a new color is created. If a red light and a green light (additive primaries) shine on the same spot, they "add up" to yellow – a much lighter and brighter color.**

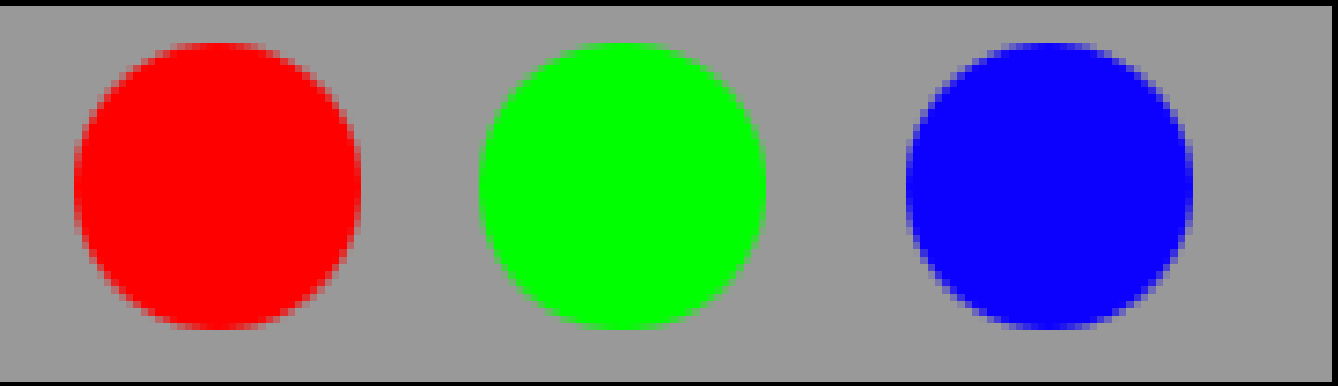
Adding Color by Adding Light

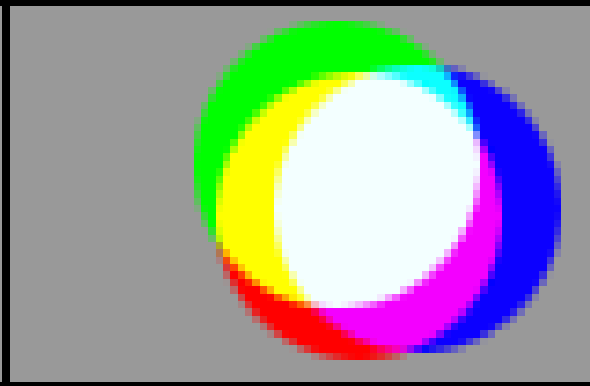


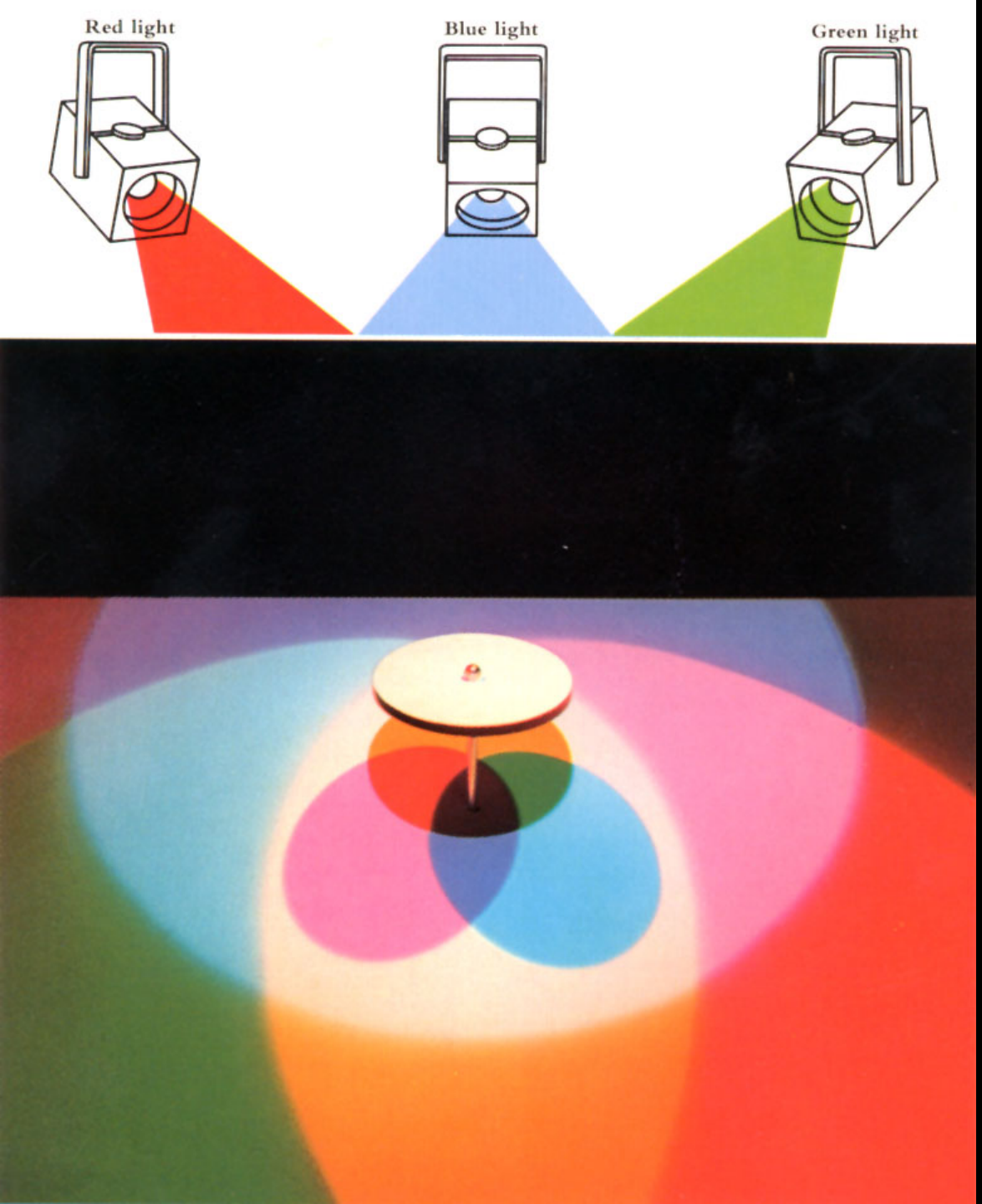
- **If a red light and a green light (additive primaries) shine on the same spot, they “add up” to yellow – a much lighter and brighter color.**
- **Blue and Red = Magenta**
- **Blue and Green = Cyan.**
- **All 3 = white.**
- **Note CMYK**

Adding Color by Adding Light

- When all colored lights are “added up”, or combined, the result is white light.
- This is the opposite of what we usually see a prism do – though a prism can be positioned to rejoin colored light into white.







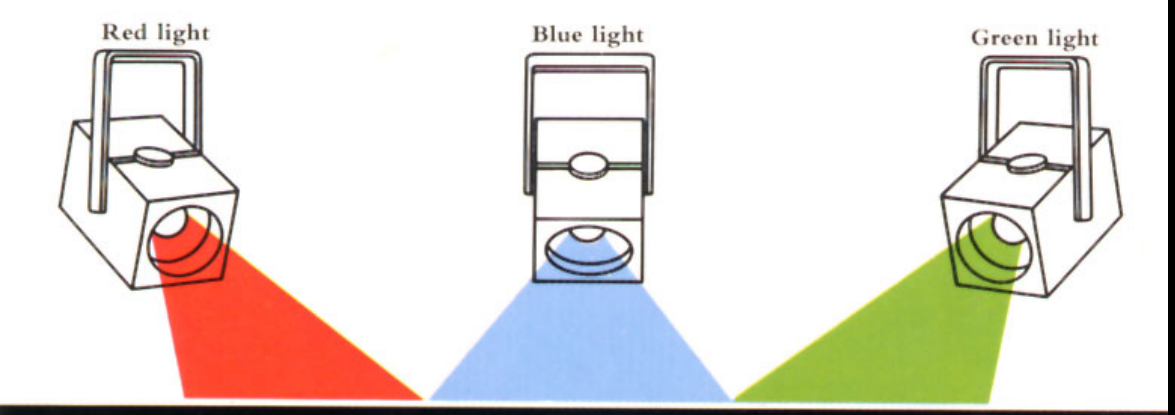
Adding Color by Adding Light

- **Note the color of partially shaded areas -- which colors of light are illuminating those spots?**

*We always work with **both** additive and subtractive color*

- Because we most often select and mix ***pigmented*** colors under paricular ***lighting*** conditions, we must pay attention to ***both additive and subtractive*** models of color and light.
- Perceived color is a product of ***both*** phenomena.

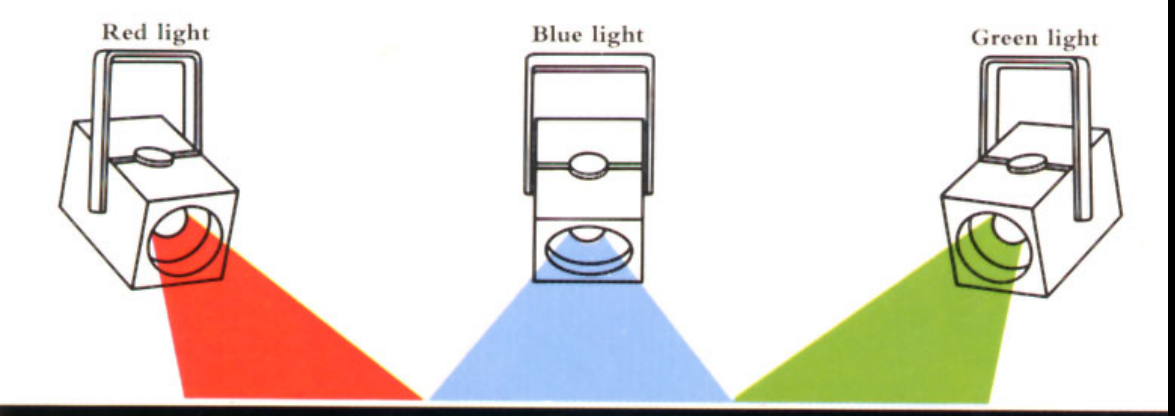
finis



The color we see

the color of illumination

ALL color depends on light.
If no there is no illumination, there IS no color.



The color we see

light sources vary in color

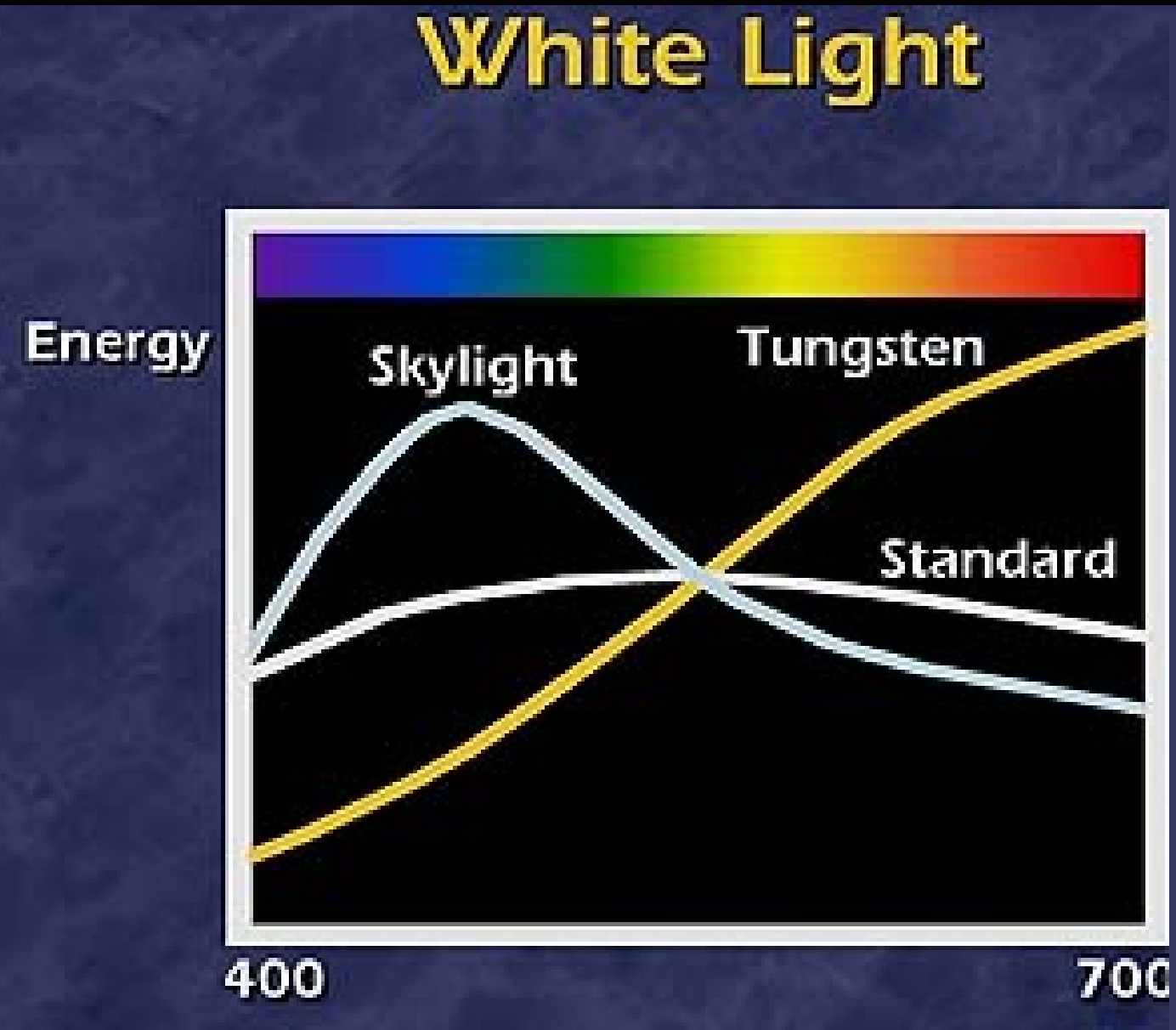
additive color (light)
RGB primaries

Light Sources

- Our perception of color is always altered by the colors of the light (or lights) that illuminate the objects we see.
- Ambient light is rarely color-balanced (true white), but is, instead, shifted toward one hue or another – that is, the illumination itself has a color.
- The color of illumination alters the appearance of the local color; lighting changes perceived color.

Common Light Sources

Dominant Hue of Light Sources



Most light sources project many colors of light.

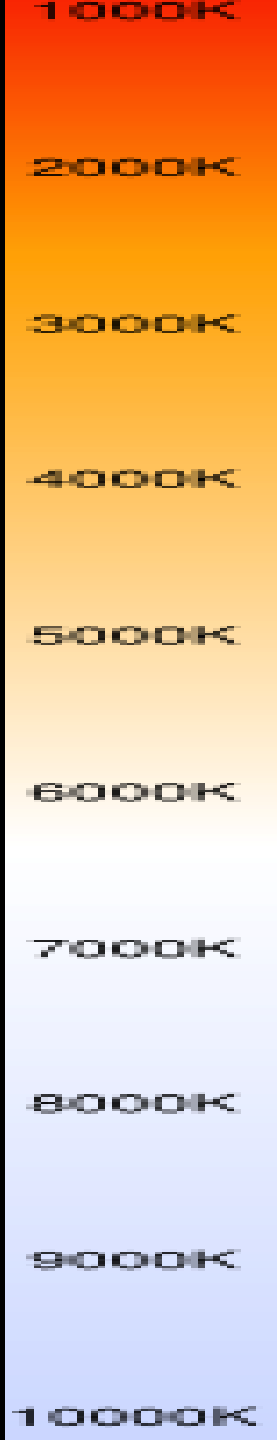
But one color/hue will dominate.

What color is White?

Kelvin temperature/ratings

- Some typical color temperatures are:

1500 K	Candlelight
2680 K	40 W incandescent lamp
3000 K	200 W incandescent lamp
3200 K	Sunrise/sunset
3400 K	Tungsten lamp
3400 K	1 hour from dusk/dawn
5000-4500 K	Xenon lamp/light arc
5500 K	Sunny daylight around noon
5500-5600 K	Electronic photo flash
6500-7500 K	Overcast sky
9000-12000 K	Blue sky



www.schorsch.com/kbase/glossary/cct.html

What color is White?

Kelvin temperature/ratings

- Standard unit for color temperature is Kelvin (K).

- Technically, color temperature refers to the temperature to which one would have to heat a theoretical "black body" source to produce light of the same visual color.

www.schorsch.com/kbase/glossary/cct.html

Black Bodies

- *In physics, a black body is an object that absorbs all electromagnetic radiation that falls onto it. No radiation passes through it and none is reflected.*
- *…the amount and wavelength (color) of electromagnetic radiation they emit is directly related to their temperature.*
- Black bodies below around 700 K (430 ° C) produce very little radiation at visible wavelengths and appear black (hence the name). Black bodies above this temperature however, produce radiation at visible wavelengths starting at red, going through orange, yellow, and white before ending up at blue as the temperature increases.

en.wikipedia.org/wiki/Black_body

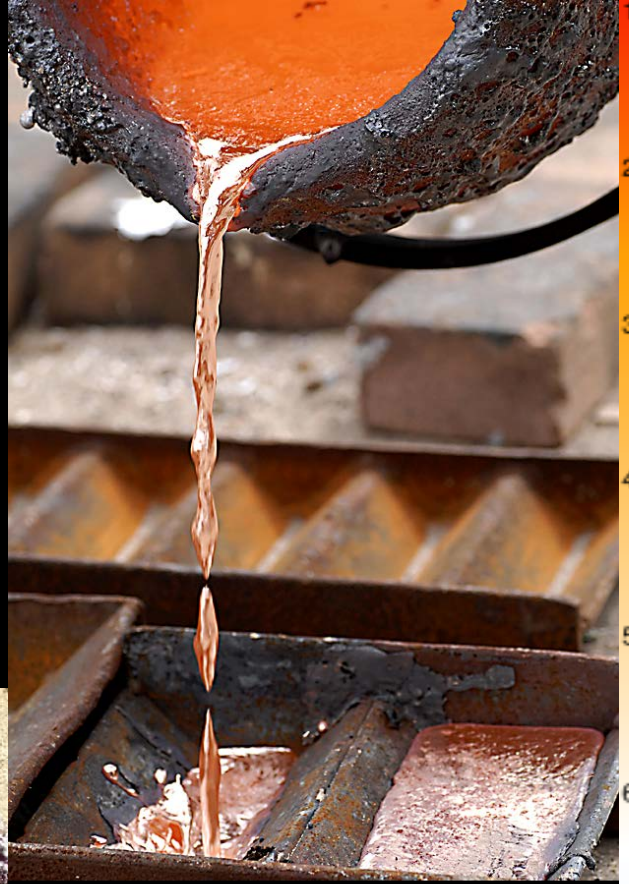
Temperature by Color

- *Molten bronze at ~2200 deg F.*
- *Foundry workers can "read" the temperature of molten metals by the color.*

http://www.flickr.com/photos/alixking/469178023/

Temperature by Color

- *Foundry workers "read" the temperature of molten metals by the color.*



http://www.flickr.com/photos/alixking/469178023/

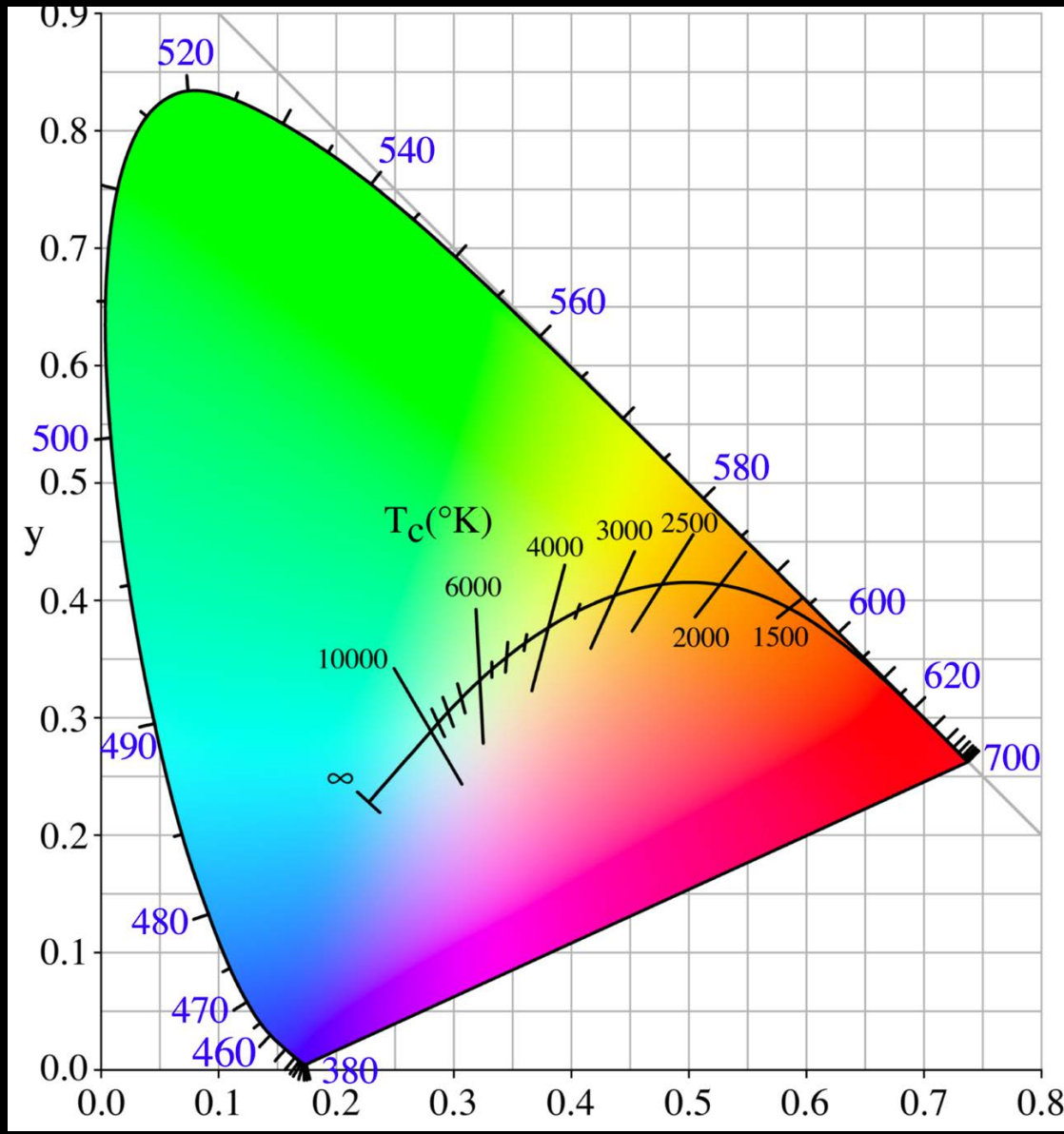
Kelvin Color Temperature, Black Bodies & Your Monitor

This is a C.I.E. Chromaticity Diagram — it is one of the most widely used color models used for measuring and specifying color in many contexts — such as the color of white in your computer monitor.

Astronomers also use it to measure the temperature of “black bodies” – depending on how hot something is, it will radiate energy at a particular wavelength.

In case you’re wondering…
Kelvin= (Fahrenheit + 459) x 5/9
273K = 32F

Kelvin = Celsius + 273



Lighting Temperature & Kelvin

Illumination: 2800˚ Kelvin

(warm light)

Illumination: 4700˚ Kelvin

(cool light)

Lighting Temperature & Kelvin

Illumination: 2800˚ Kelvin

(warm light)

Illumination: 4700˚ Kelvin

(cool light)

Lighting Temperature & Kelvin

Illumination: 2950˚ Kelvin

(warm light)

Illumination: 4700˚ Kelvin

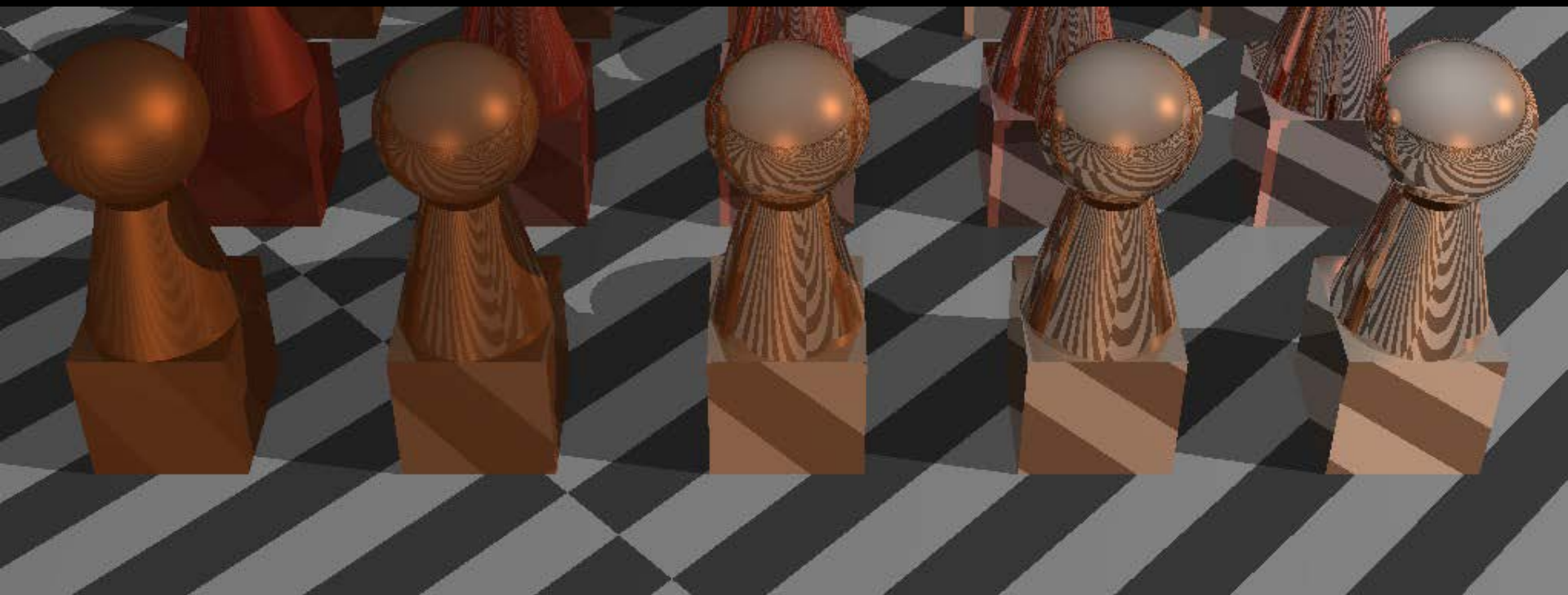
(cool light)

Suffused/Aggregate Color

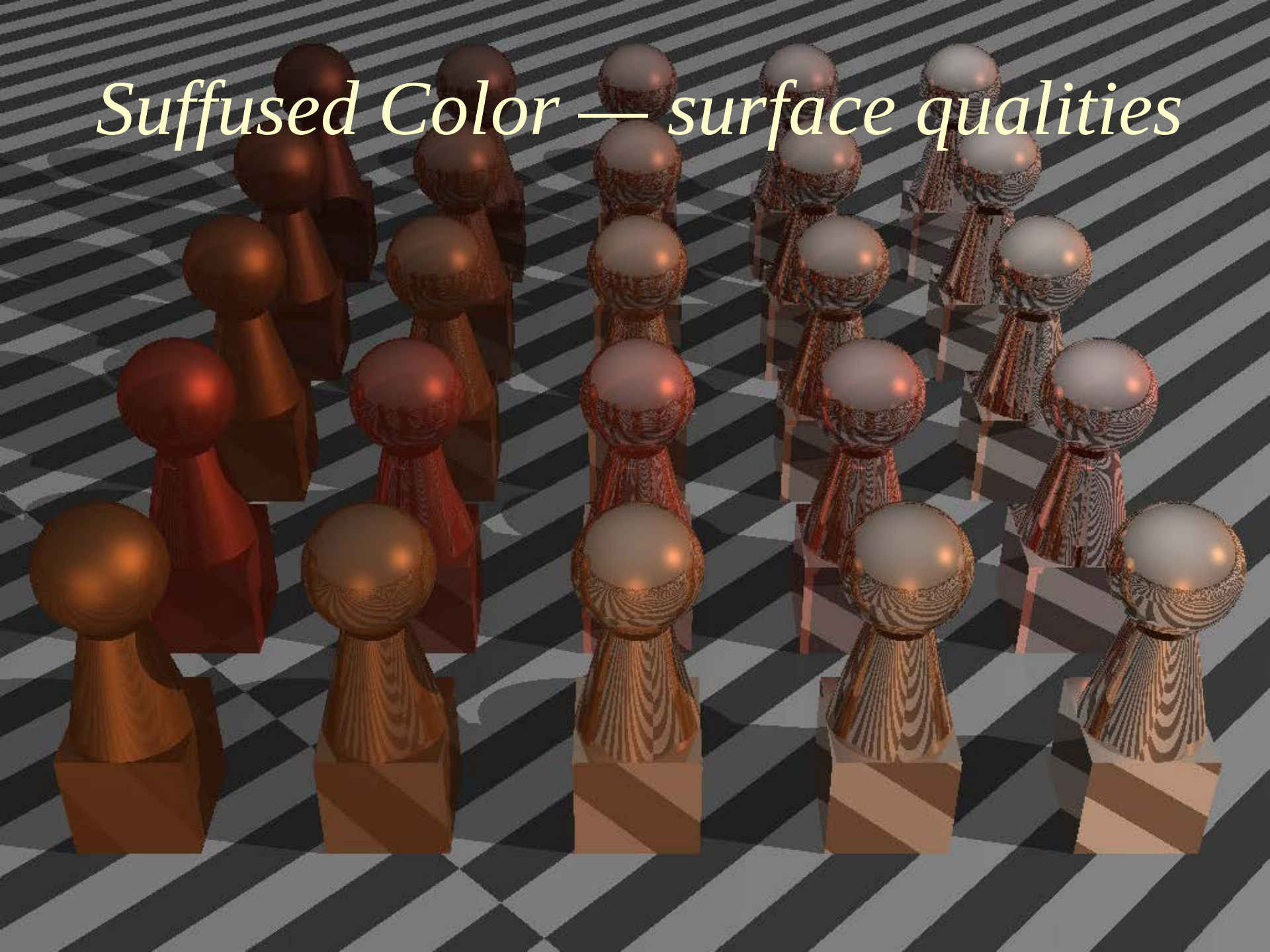
- Most surfaces and even many paints, have several colors in them. Fabrics often have several colors.
- Artists sometimes choose to not fully mix their paints, but let several colors remain visible.
- In short, most surfaces we see have several colors present in varied proportions. The designer must consider the overall color, as well as the impact of the constituent colors.

Suffused Color — surface qualities

- Local color is altered by the character of the surface -- is it rough, is it smooth, is it matte, is it glossy?



Suffused Color — surface qualities



Suffused Color — surface qualities

- Different surfaces reflect light differently, and since color is a by-product of light, different surfaces of the same color produce a different variety of colors.
- Consider wood finishes, metal surfaces.

Aggregate Color

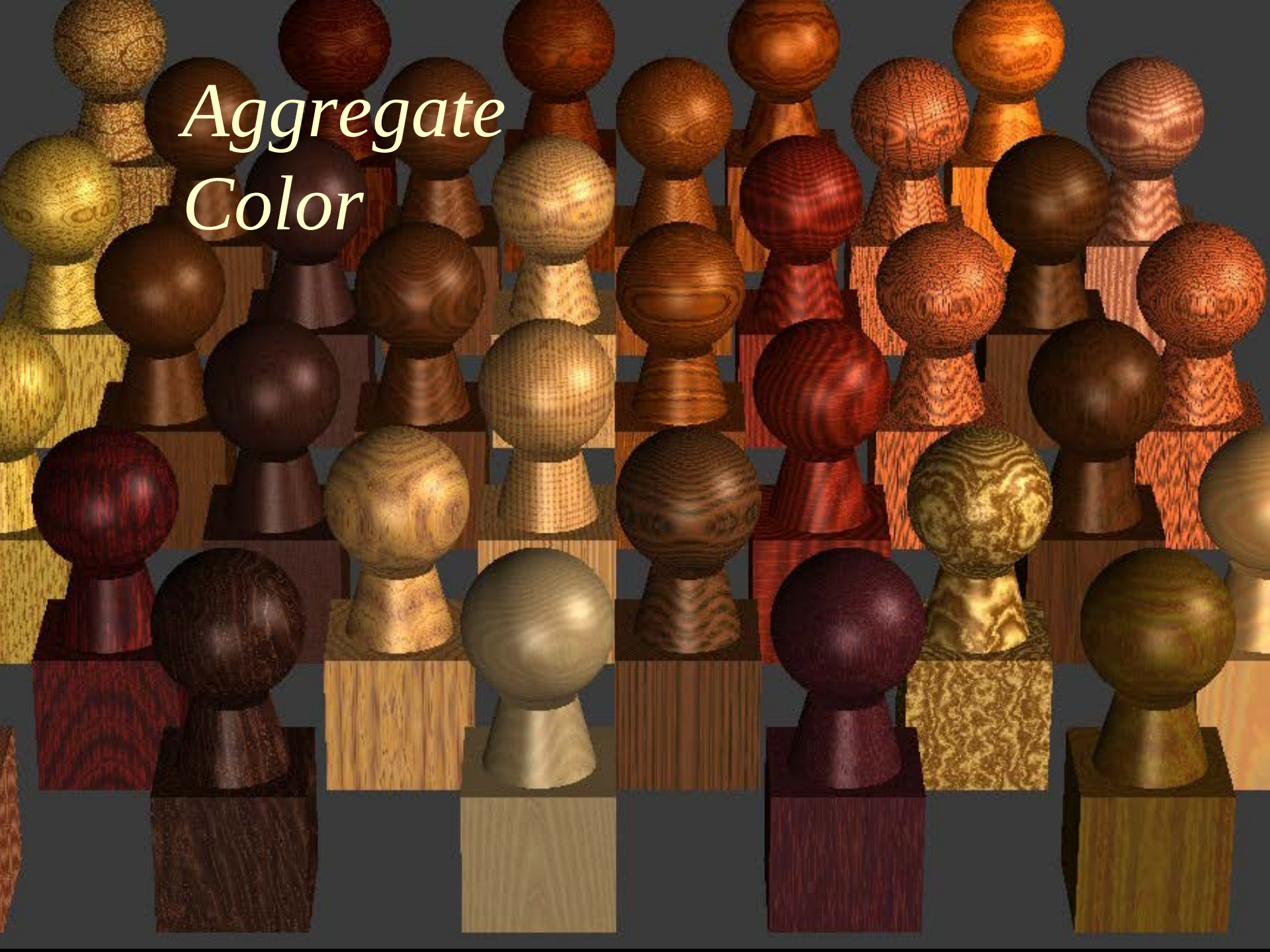
- Many colors are “in” most surfaces and materials.
- The designer must consider the overall color – the color “chord” – as well as the individual colors present.

Aggregate Color

- Each color is relates to those around it.
- At different distances, the impact of an aggregate color changes -- far away the details blend into a single color impression.

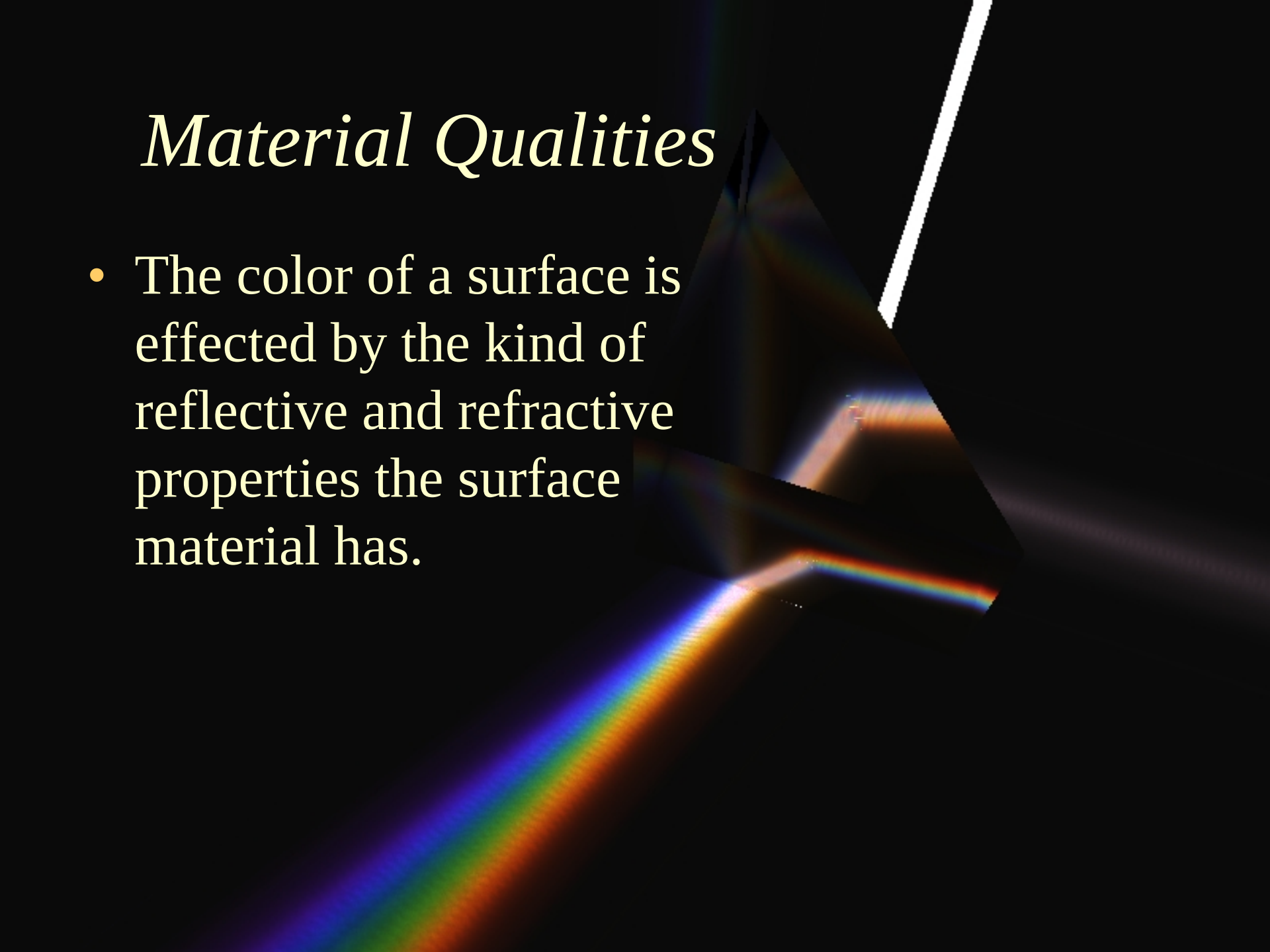
Aggregate Color

- Wood, marble and granite, for instance, often have several distinct colors – sometimes in very fine textures so that the constituent colors don’t fully show themselves except on close inspection.


Aggregate
Color

Material Qualities

- The color of a surface is effected by the kind of reflective and refractive properties the surface material has.

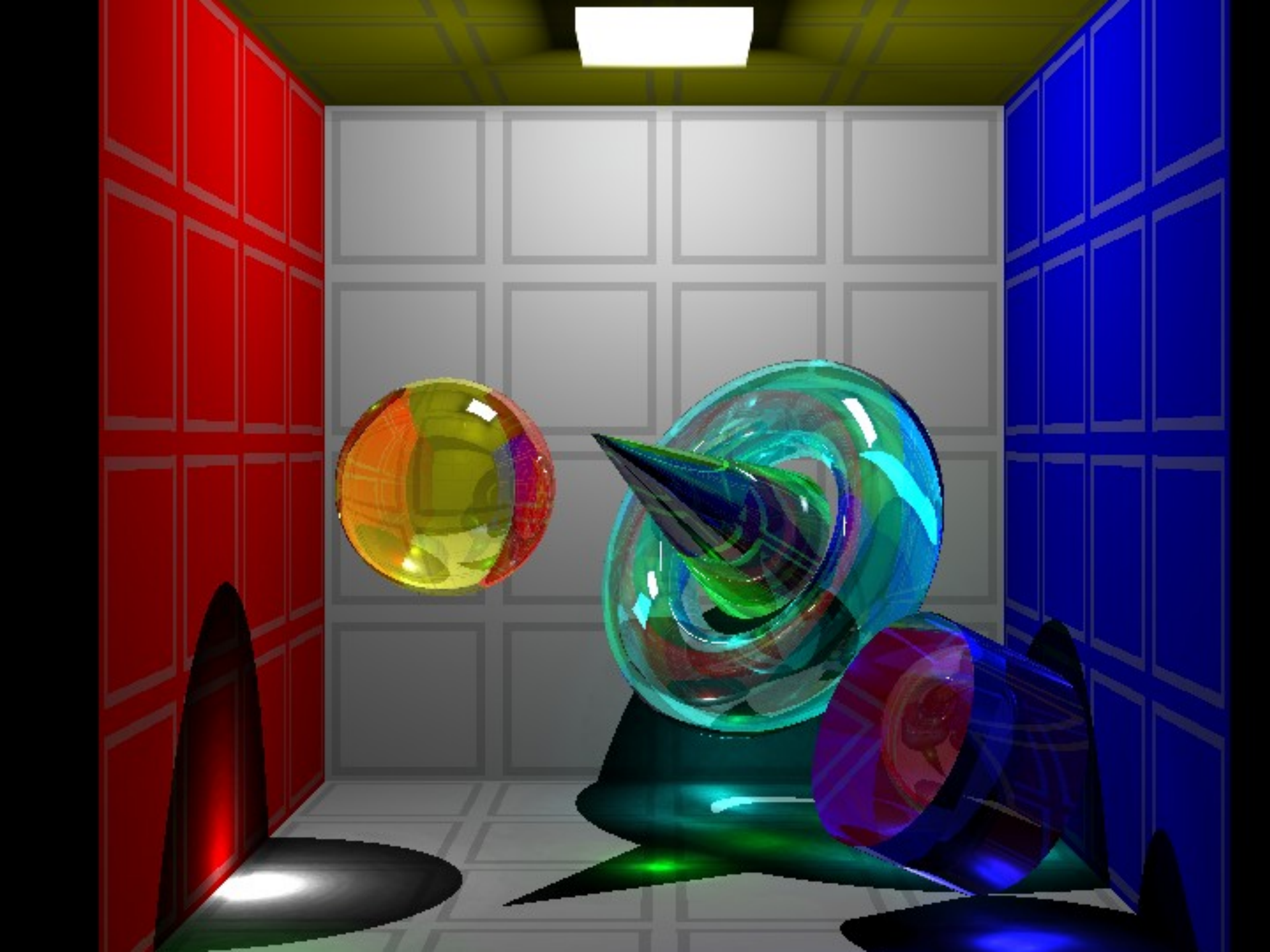


Material Qualities

- Polished metal, for instance, is highly reflective – gold may have a local color of yellow-orange, but the viewer always sees that yellow color mixed with reflections of whatever else in nearby.

Material Qualities

- Plastics and glass will transmit light through the surface, as well as reflecting light off of the surface.
- This combination reflection, diffusion, refraction, and absorption enables glass to be fascinating material.



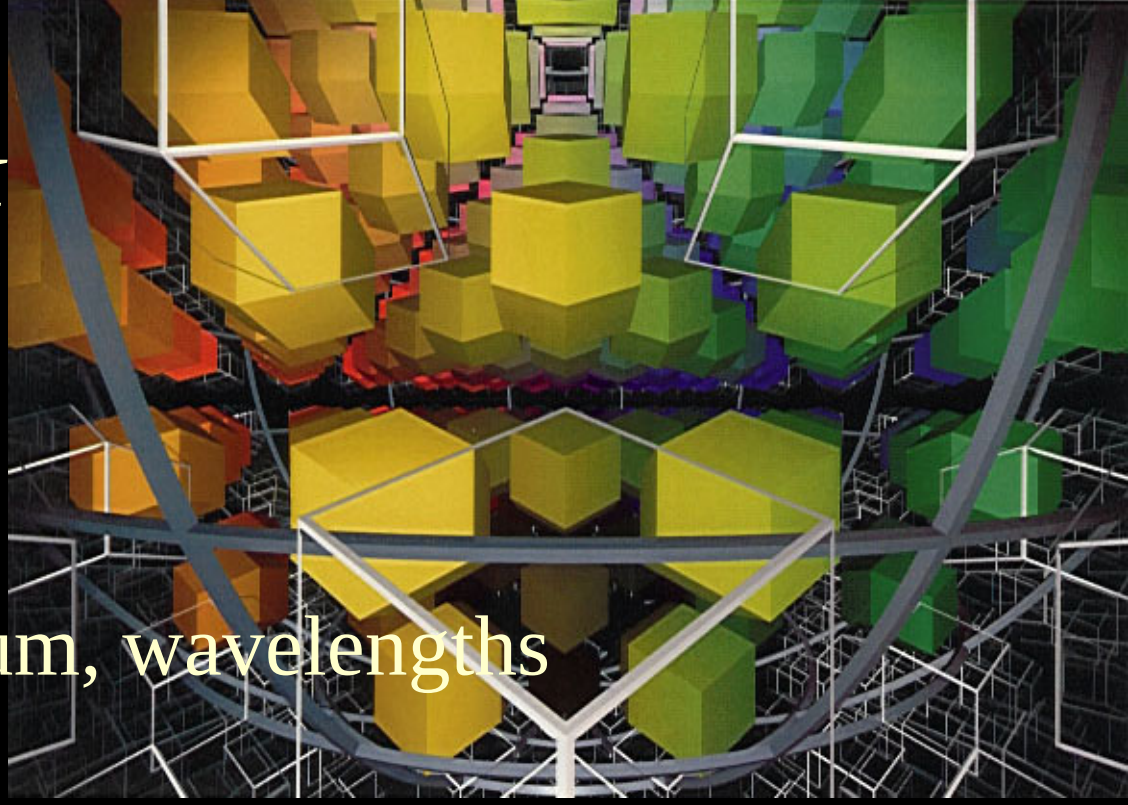
Deep color -- layered and suspended pigments

- Pearls and pearlescent paint both reflect and refract light – echoing the colors nearby, while softening the colors and contrasts.
- Glass and gloss varnishes or laquer’s transmit light and refract it – light is bent and, to some extent, divided into constituent colors.

Surface Qualities

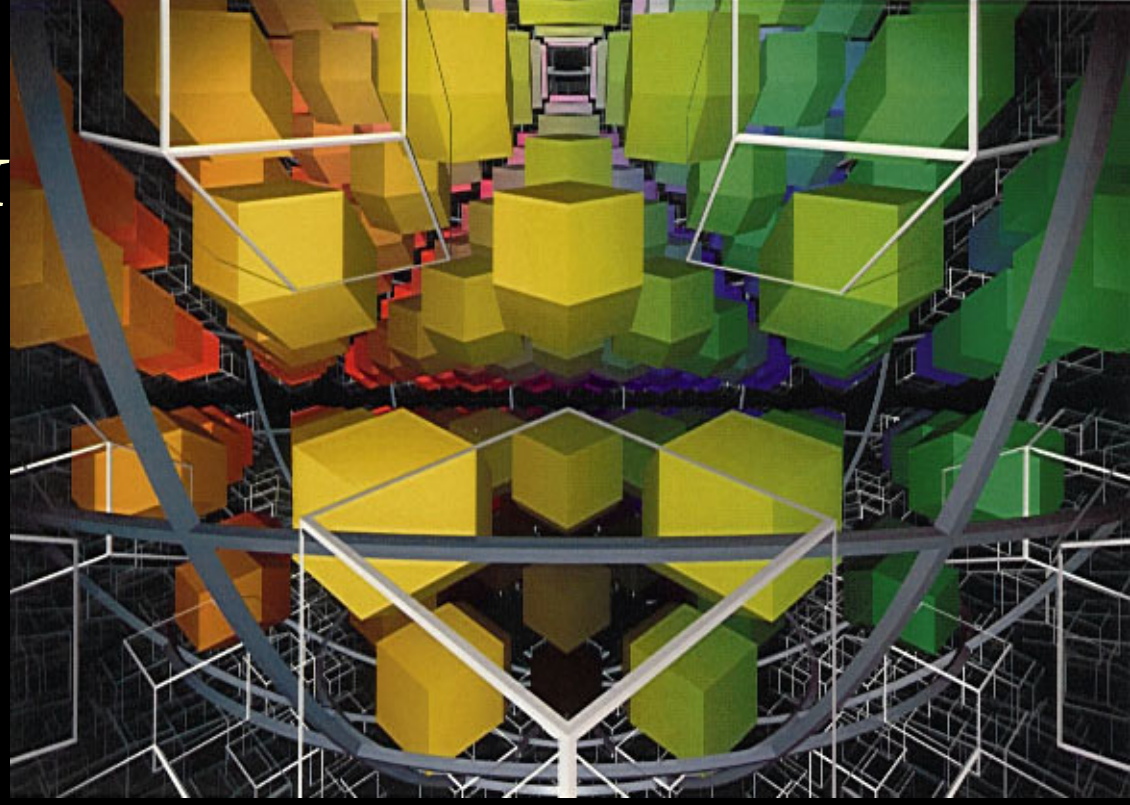
- Local color and lighting alone do not determine the final color of an object. A surface color may well reflect other colors from nearby objects.
- Glass often has a polished surface that reflects light (and so colors), but also transmit and refracts much of the light.

Color terms & concepts:



- Color as light
- The visible spectrum, wavelengths
- White light
- Reflection, Transmission, Absorption, Refraction
- Additive Color vs. Subtractive Color
- Light Primaries vs. Pigment Primaries

Color terms & concepts:



Intrinsic value,

binder,

local color,

aggregate color, atmospheric color,

Complementary, Analogous,

Warm, Cool,

Neutrals and Near Neutrals