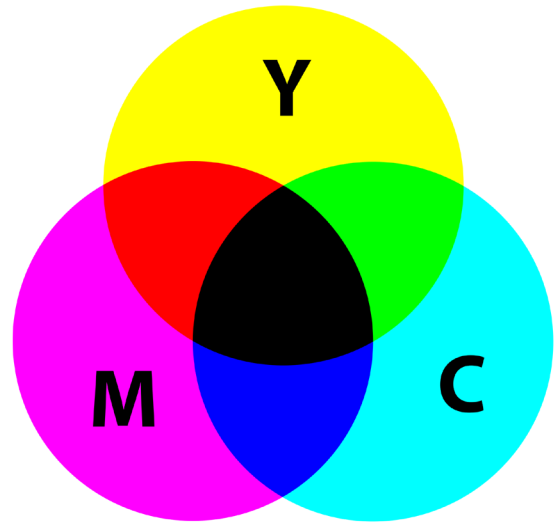
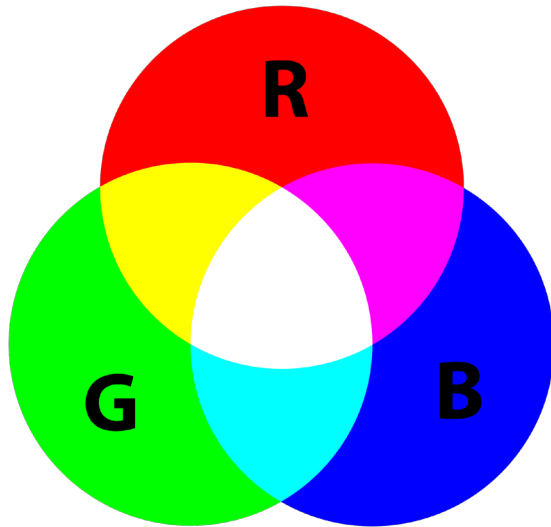


Additive vs. Subtractive Color



Additive Color

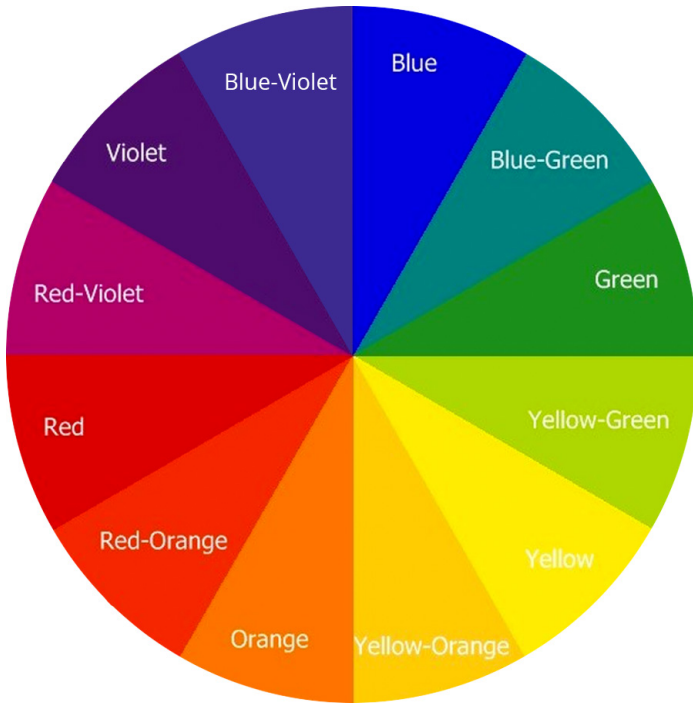
- Light, human vision, and digital screens.
- Colors create white when combined in equal measure.
- Springs from Isaac Newton's experimentations with prisms and light.
- Theory models the way human vision sees color rather than all color.
- Many things are outside our vision light spectrum: longer than red (infrared), and shorter than violet (ultraviolet).
- First experiments done by photographer James Clerk Maxwell in 1861 .



Subtractive Color

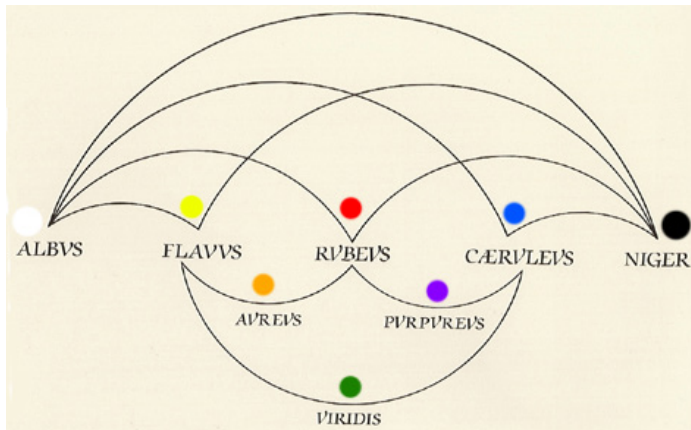
- Paints, pigments, dyes, and inks.
- CMYK model
- Colors create black when combined in equal measure.

Red, Yellow, Blue Primary Model

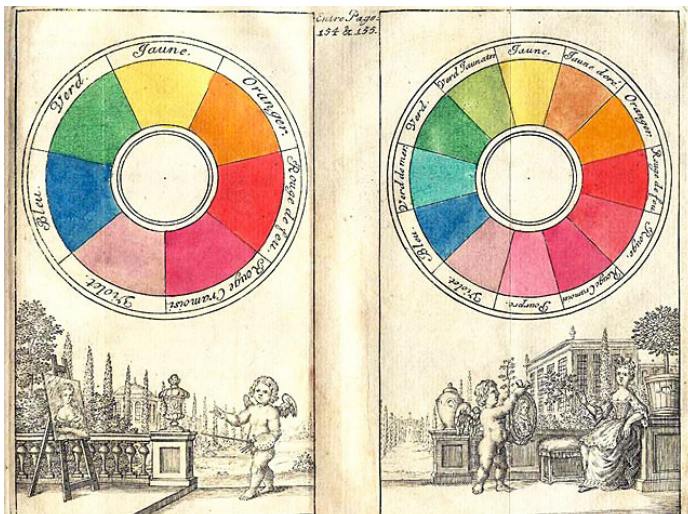


- Earlier theoretical construct which attempted to help us understand color.
- Still the foundation most color theory classes.
- In practice, can sometimes create muddy secondary or tertiary colors.
- Primary colors: red, yellow, blue.
- Secondary colors: orange, green, and violet
- Tertiary colors: red-orange, yellow-orange, yellow-green, blue-green, blue-violet, red-violet.
- Complementary colors: directly across from each other. When placed next to each other they appear brighter. When mixed together they become more neutral.
- Analogous colors: colors that are next to each other. Have visual harmony.

History of Primary Color System & Color Wheel



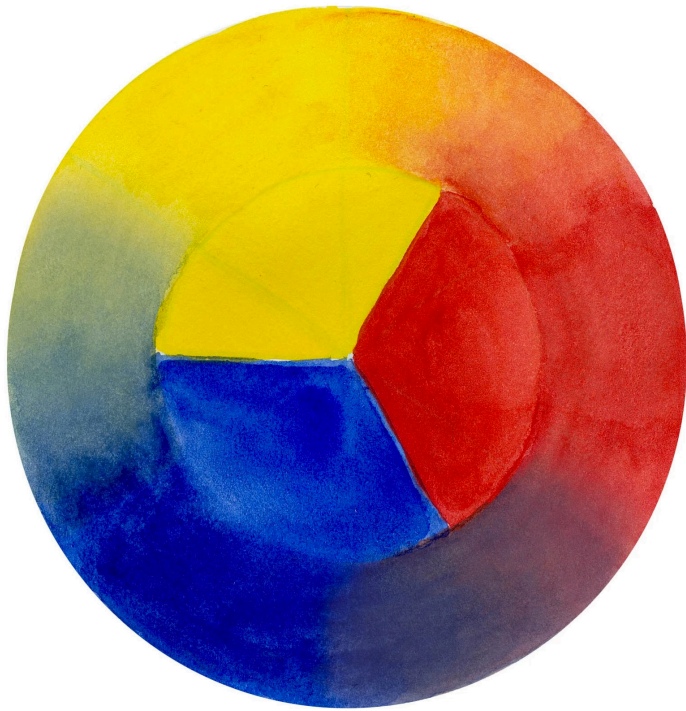
- The idea that painters can mix all colours except three can be traced back to Aristotle in his *Meteorologica* (c. 350 B.C.). [Aristotle was talking about RGB though.]
- Yellow, red and blue are placed between white and black in a linear scale mentioned in a commentary on the *Timaeus* of Plato from the 4th-5th century CE.
- The same scale also appears in the first visual representation of the concept of primary colours, a diagram in Francois D'Aguilon's *Opticorum Libri Sex* of 1613 (top left)



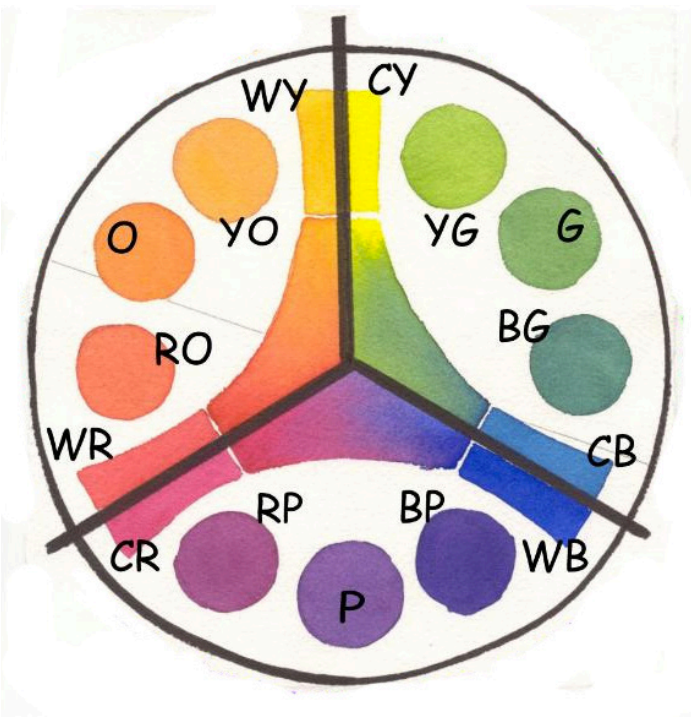
- Robert Boyle (1664) introduced the term "primary colour" in English.
- The earliest color wheel is often attributed to Isaac Newton in the mid 1600s. (Research first reported in 1672.) In 1705, as part of publishing *Optiks*, he named ROYGBIV as the colors he saw in refracted light (rainbows).
- The earliest surviving color wheels (bottom-left) are hand-painted colour circles from the 1708 edition of the *Traite de la peinture en miniature*, by an anonymous French artist. They, unlike early primary color discussions, keep with Isaac Newton and include Indigo as a 7th color.

Split Primary System

- There was a very early acknowledgement that a strong primary red and a strong primary blue do not necessarily make a beautiful purple. Francois D'Aguilon's *Opticorum Libri Sex*, focuses primarily on a primary color mixing system, but notes that while the 5 colors (he was including black and white) can mix an enormous amount colors, some colors can achieve greater splendor when they are not mixed.
- The split primary system was designed to counter the limitations of the primary system and address the muddy secondary and tertiary colors. (See the muddy colors to the left.)



- The split primary mixing system calls for a warm and a cool version of each primary.
- Now most frequently: cadmium red (warm) and alizarin crimson (cool), cadmium yellow (warm), lemon yellow (cool), ultramarine/cobalt/ (cool) and cerulean blue (warm).
- Can be replicated using period pigments: Vermillion (warm), madder/carmine (cool), Naples yellow medium (warm), lead yellow (cool), azurite (warm), and ultramarine (cool).



Mineral vs. Organic Pigments

Mineral/Inorganic/Granular Pigments

- Generally from minerals, clay, metal,
- Low dyeing strength
- Good light-fastness
- Opaque
- Never dissolve all the way



Period Examples:

- Red Ochre (prehistory)
- Yellow Ochre (prehistory)
- Lime white (prehistory)
- Malachite (from Egyptian antiquity)
- Orpiment (from Egyptian antiquity)
- Azurite (from Egyptian antiquity-)
- Red Lead (from Greek/Roman antiquity)
- Vermillion (8th c. -)
- Lead white (from Greek antiquity)
- Ultramarine (12th c.)
- Lead tin yellow (13th c. -)
- Naples Yellow (16th c. -)
- Venetian Red

Modern Examples:

- Cerulean Blue
- Cadmium Red
- Cadmium Yellow
- Cobalt Blue
- Oxide of Chromium

Organic/Staining Pigments

- Generally from plants, bugs, & other organics
- High dyeing strength. Staining.
- Poor light-fastness
- Transparent
- Fully water-soluble.



Period Examples:

- Carbon Black (prehistory)
- Bone Black (prehistory)
- Umber (prehistory)
- Madder Lake (from Egyptian antiquity)
- Carmine Lake (from Egyptian antiquity)
- Indigo (from Egyptian antiquity)
- Green Earth (from Greek antiquity)
- Verdigris (from Greek antiquity)
- Indian Yellow (15th c.-19th c.)
- Copper resinate (15th-17th c.)

Modern Examples:

- Alizarin Crimson
- Lemon Yellow
- Permanent Rose/Opera Rose
- Viridian
- Prussian Blue

Modern synthetics have really made things difficult. Their formulas can vary wildly and the same color can be both a stain and a granular pigment across competing brands. The source of a pigment is only a general rule for its categorization and is not reliable. When in doubt, play with it and make your own decision.

Realities of Color Mixing

So inorganic pigments are light-fast, come in a range of colors (including ultramarine), and are super opaque (so they can paint right over mistakes. What's not to like right?

Well for starters: inorganic pigments don't play well with others. Because they never dissolve fully in the medium, in our case water, they have a tendency to settle out. When two inorganic pigments are mixed, whichever has heavier particulate will sink to the bottom.

They can also retain a gritty texture. Take for example, ultramarine blue, which turns gray when it's ground too finely. (Ultramarine is almost always the heaviest pigment on a palette) This makes them unsuitable for covering large expanses of space. Working in miniature like we do on manuscripts, this is a minimal problem, but it's a headache when attempting watercolor washes.

Inorganic pigments either need to be laid down straight (alone) or stirred frequently. Avoid watering them down too heavily because they become less controllable.

Meanwhile stains are alarmingly permanent. If you drip a drop of madder where you don't want it, expect that pink spot to be there forever. Inorganic pigments don't soak into the paper in the same way, and so have some flexibility for correction if the issue is dealt with quickly.

Compensating for a Single-Binder



In period, manuscript paints were mixed with either gum arabic or glair as a binder. The two bring out very different qualities when bound with pigments. Paints made with glair tend to be lighter and brighter, than corresponding gum arabic paints.

What to do then? Modern gouaches like modern watercolors are bound with gum arabic.

The answer: compensate with zinc/mixing white.

Zinc white/mixing white: is a transparent white that will make a color lighter and brighter without making it pastel and dull. It can be used to emulate the brightness of glair based paints. The mixture will be fairly transparent though, and as a top layer should be used with very little water.