Fundamentals of Color and Appearance

Module 3

Color Attributes and Color Systems

Color Science Educational Series

Fundamentals of Color and Appearance

Module 3:

Color Attributes and Color Systems

Between 1750 and the early 1900s, artists, scientists, and designers across the world worked to develop structured systems for organizing color.

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Their goal was to make color easier to understand, describe, and reproduce, whether for artistic expression or for ensuring consistency in manufacturing and design.

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These early color systems aimed to bring order to what had long been a subjective and inconsistent process of visual color assessment.

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They led to the creation of physical color charts and descriptive notation systems, enabling people to express and compare color values with greater precision, laying the groundwork for the scientific and objective color measurement technologies that would follow in the 20th century.

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One of the most significant breakthroughs came with the **Munsell Color System**, initially introduced by Albert Henry Munsell in 1905 with the publication A Color Notation.

This was followed by the Atlas of the Munsell Color System in 1915, which provided a visual representation of the system.

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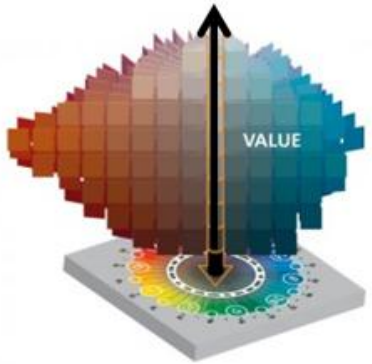
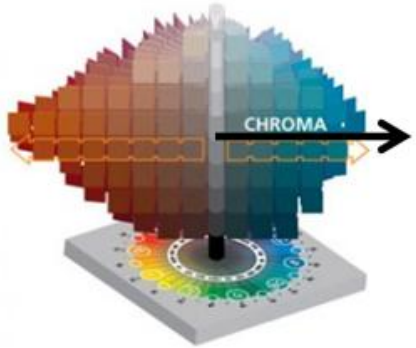
The Munsell Color System describes colors based on three independent dimensions:

- Hue, the color itself.
- Value, the lightness of a color.
- Chroma, the color intensity or saturation of a color.

Hue



Value



Chroma

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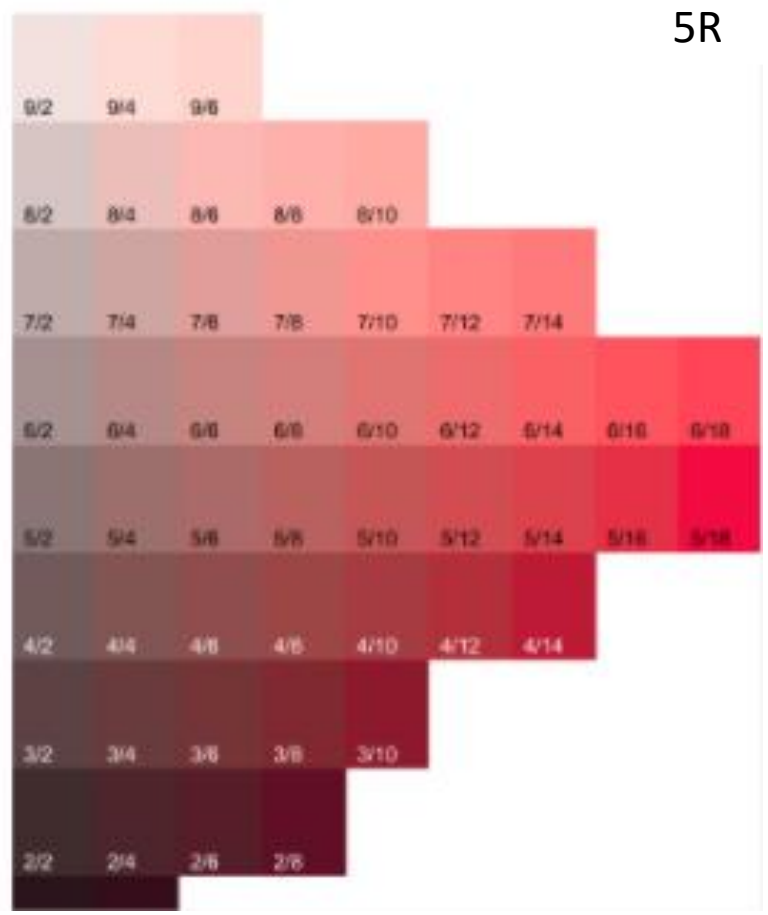
In the Munsell system, a color is identified with a notation like 5R 7 2:

- The designation 5R is the Hue, or the color red.
- The designation 7 is the Value, or lightness of the color.
- The designation 2 is the Chroma, or intensity of the color.



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These notations are used to locate specific colors on Munsell color charts, making communication about color clearer and more consistent.

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While several earlier color order systems placed colors into a three-dimensional solid of one form or another, Munsell was the first to provide a way to visually and numerically represent colors in a standardized and systematic manner.

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Another approach is the **Natural Color System**, or **NCS**, introduced in 1979 by the Scandinavian Color Institute, now NCS Color AB, Sweden.

It is based on the psychological perception of color, aligning with how humans naturally see and describe color, and was developed from the Swedish physicist Anders Hard and influenced by the early work of Ewald Hering on opponent color theory.

This system focuses on how we perceive colors and includes several components

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It first identifies six elementary colors that humans interpret as pure.

These colors are White, Black, or saturation, Yellow, Red, Blue, and Green.

1. NCS COLOR

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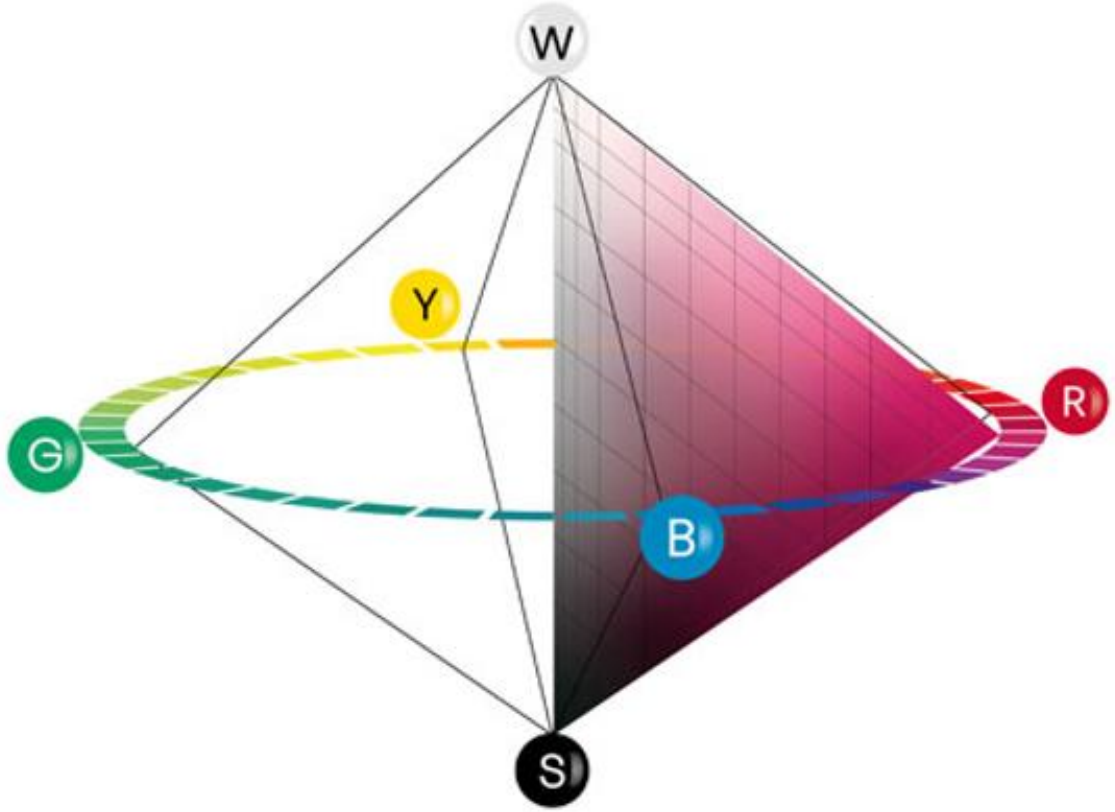
Next is a 3D color space where every perceivable surface color is mapped.

2. NCS COLOR SPACE

NCS Natural Color System®



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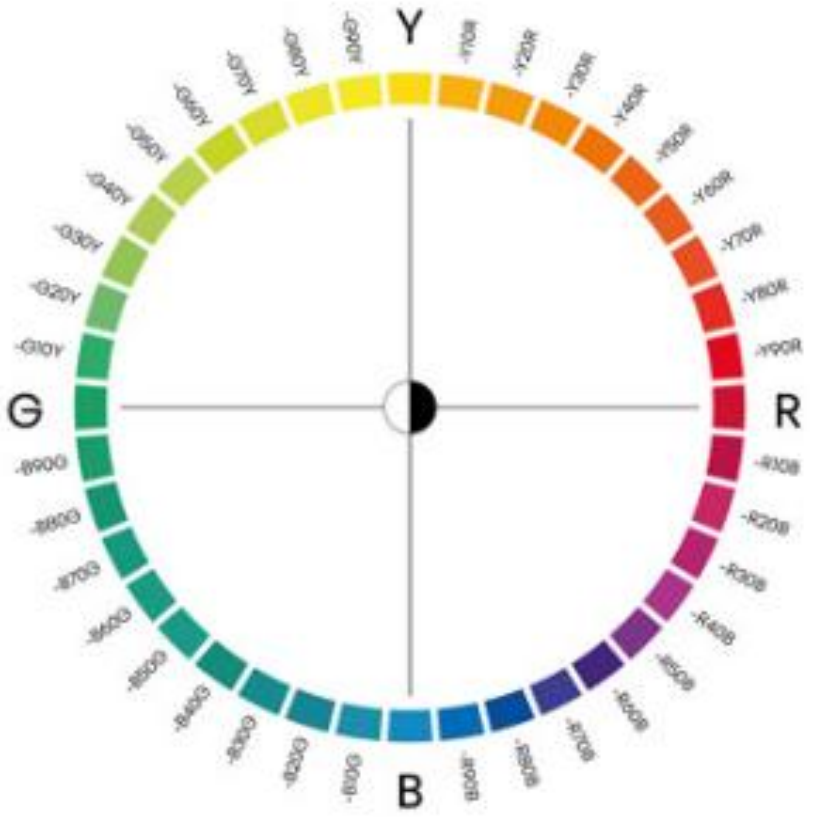
A color circle shows relationships between hues.

3. NCS COLOR CIRCLE

Natural Color System®



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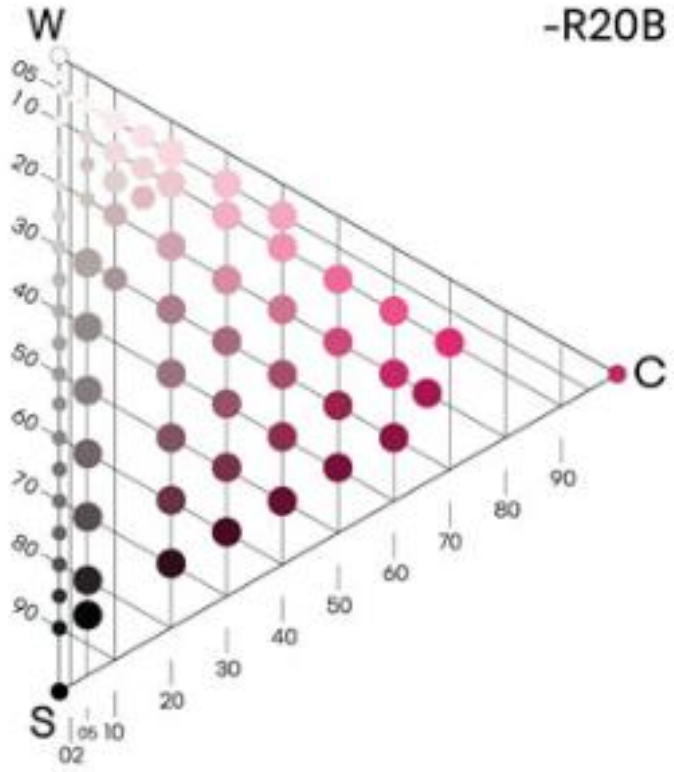
A color triangle indicating levels of whiteness, blackness, and chromaticity.

4. NCS COLOR TRIANGLE

Natural Color System®



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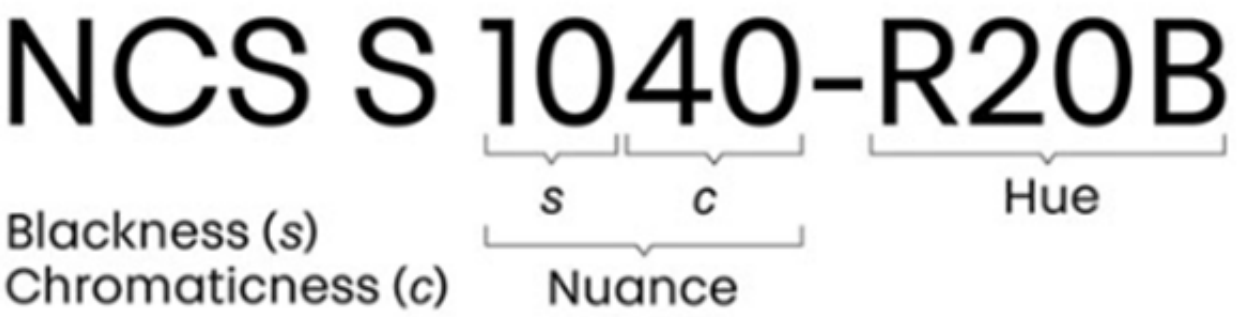
And a notation system, like NCS, S, 1040, R20B, to express these color values more precisely

5. NCS NOTATION

NCS
Natural Color System®



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In 1947, the Optical Society of America, now known as OPTICA, introduced the OSA Uniform Color Space.

Previously created color order systems, such as the Munsell color system, failed to represent perceptual uniformity in all directions.

OSA-UCS

(Optical Society of America Uniform Color Space)

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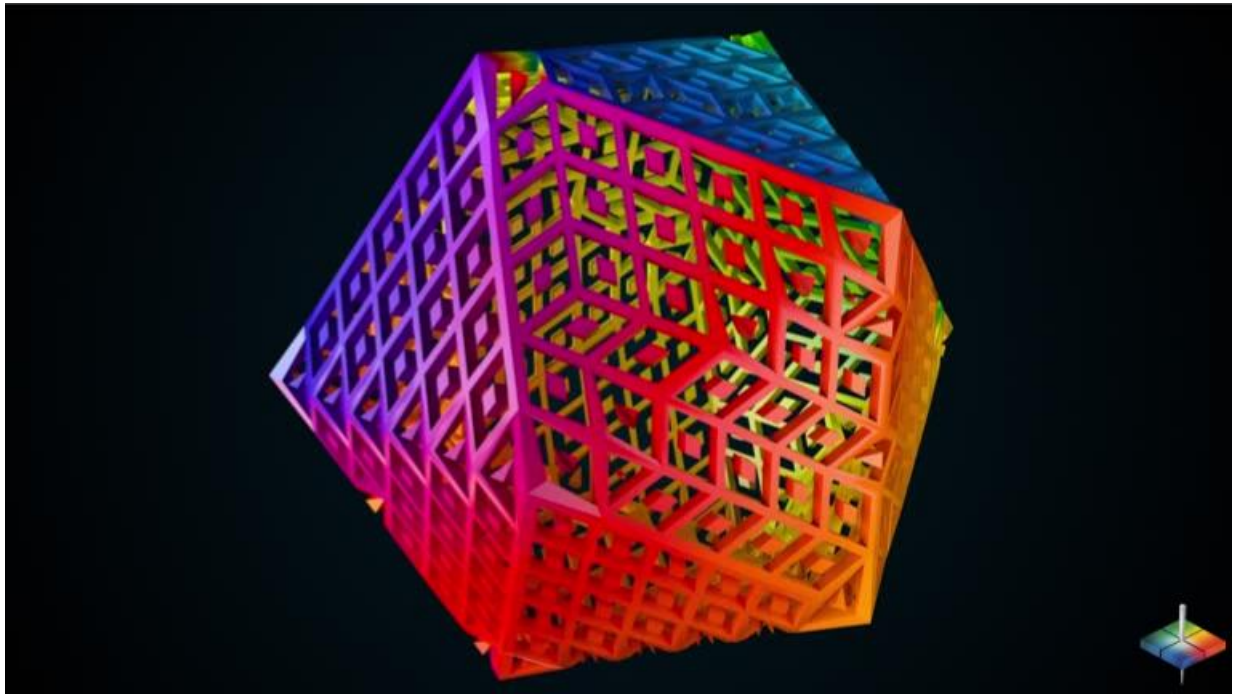
The committee decided that to accurately represent uniform color differences in all directions, a new shape of three-dimensional Cartesian geometry would need to be used.

The OSA system uses a rhombohedral lattice based on a cuboctahedron.

This shape allowed for even spacing and precise mapping of color differences in 3D Cartesian space.



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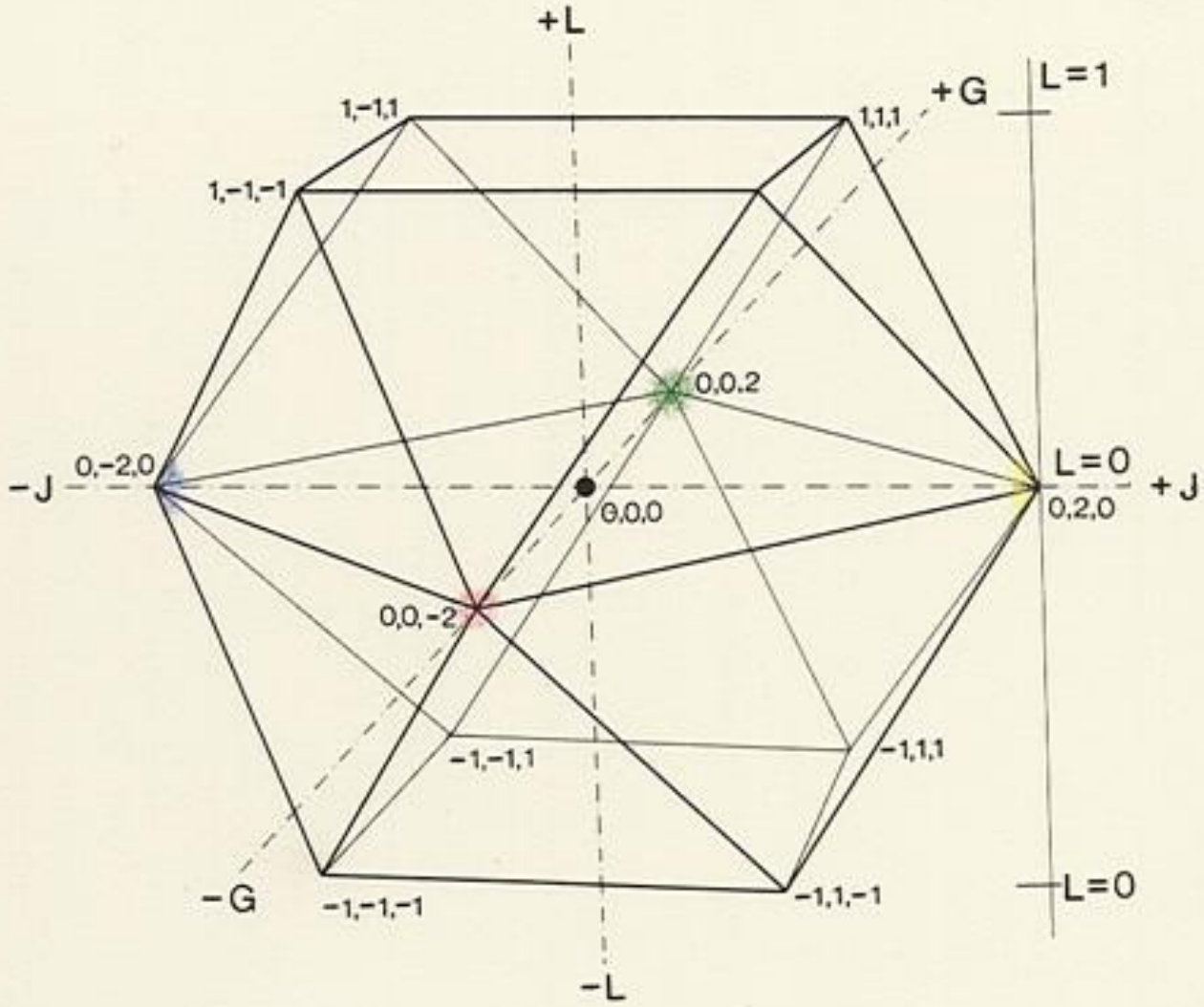

OSA-UCS

(Optical Society of America Uniform Color Space)

Lightness (L) - Lighter shades have positive values and darker shades have negative values.

Jaune (j) - Yellow-blue chromatic dimension, varying from positive values appearing more yellowish to negative values appearing more blueish.

Green (g) - Green-red chromatic axis varies from more greenish positive values to more pinkish negative values.

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OSA-UCS

(Optical Society of America Uniform Color Space)

While no longer in use today, this system was yet another effort to improve on earlier color systems and remains an important milestone in the evolution of color science

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The most scientifically rigorous system came in 1931, when the International Commission on Illumination introduced the CIE 1931 color space.

The CIE, or International Commission on Illumination, is the international authority on light, illumination, and color, responsible for defining and publishing all standard illuminants used in color assessment and color measurement.

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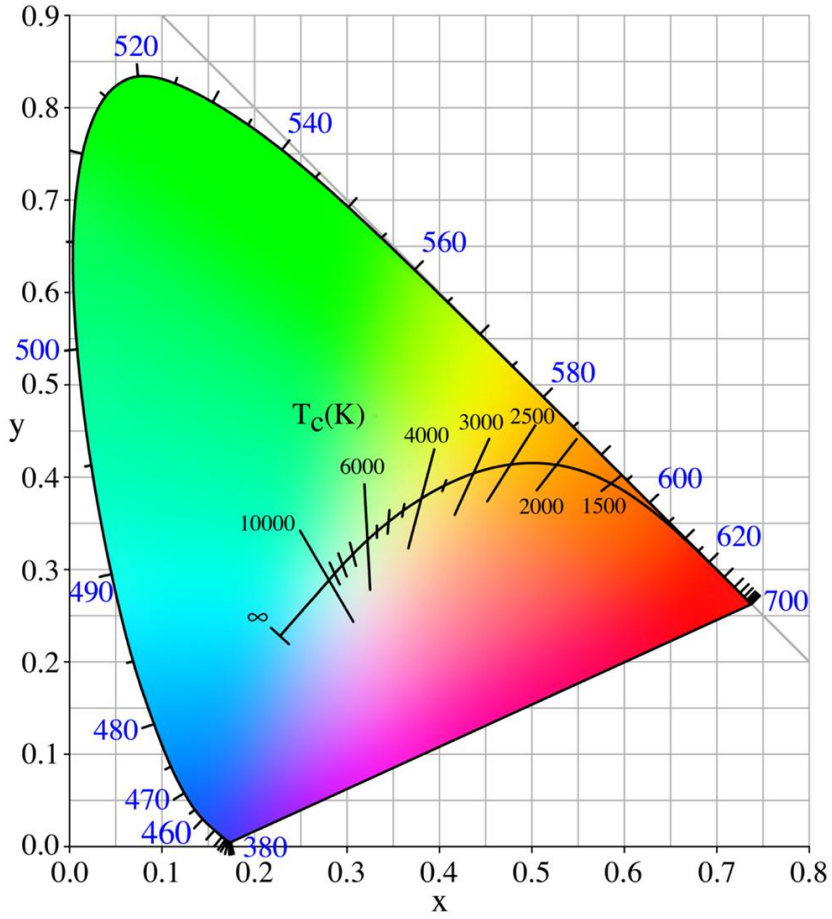
The CIE XYZ color space underpins Standard Observers and Standard Illuminants as the foundation for the development of all color scales and indices used in color measurement today.

These were the first systems to link light wavelengths directly to human vision responses.

We will discuss CIE in much more detail in later modules.



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The Hunter L,a,b color space was developed by Richard S. Hunter and introduced in 1942. It is based on the opponent color theory, representing color using three axes:

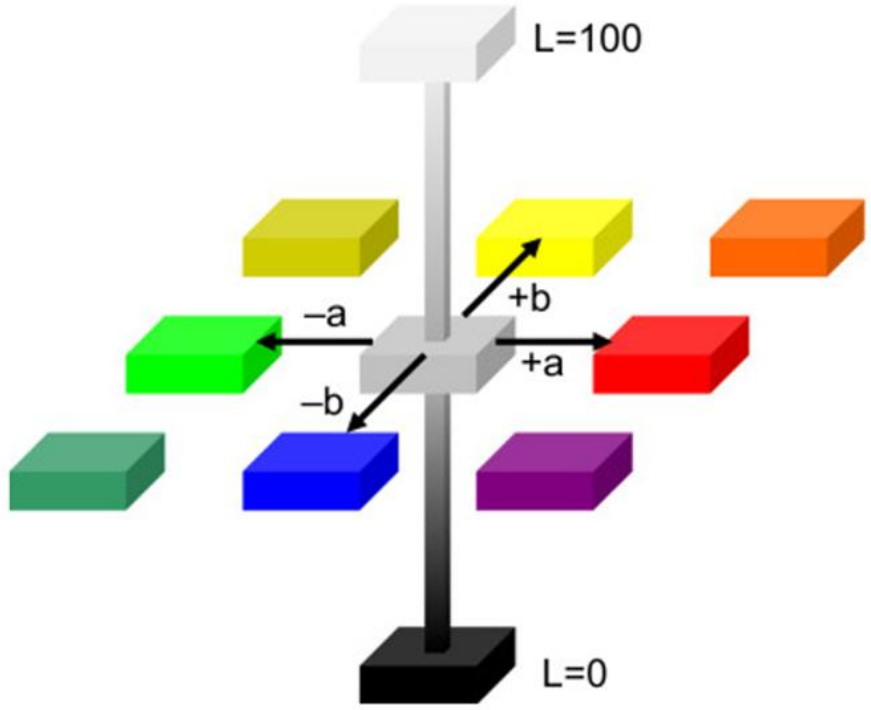
L, for light to dark

a, for red to green

b, for yellow to blue

It was designed to be more perceptually uniform than the CIEXYZ color space, meaning that equal distances on the scale correspond to roughly equal perceived color differences.

This scale was a precursor to the CIELAB color space, which was later developed by the CIE in 1976.



Hunter L, a, b

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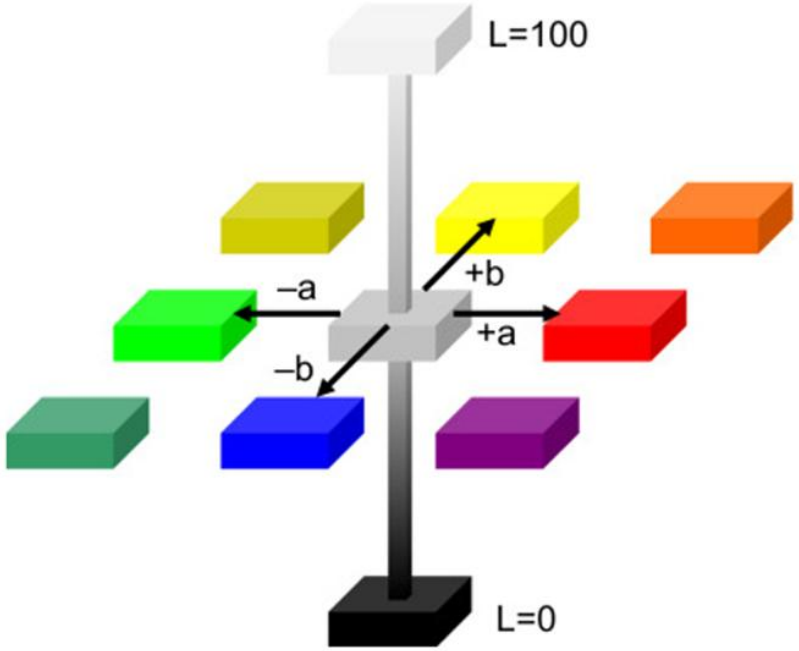
CIELAB built upon earlier work, including the Hunter Lab color space, and represents colors using the same three Hunter color coordinates L, a, and b.

The CIELAB color space was formally recommended and adopted as an international standard in 1976.

To differentiate the two models, CIELAB is always denoted with asterisk's following the L, a and b color coordinates.



Hunter L, a, b

CIE L*,a*,b*

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Color systems are the essential first step in bridging the gap between subjective visual color assessment and objective instrumental color measurement, providing a common language to communicate color.

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These color systems offer standardized frameworks that translate visual impressions into measurable values, allowing industries to move beyond inconsistent visual evaluations toward precise, repeatable, and globally understood color communication.

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By defining color through numerical coordinates and structured dimensions, color systems enable improved color specification, reproduction, and quality control across applications, and form the foundation for modern color science and measurement technologies.

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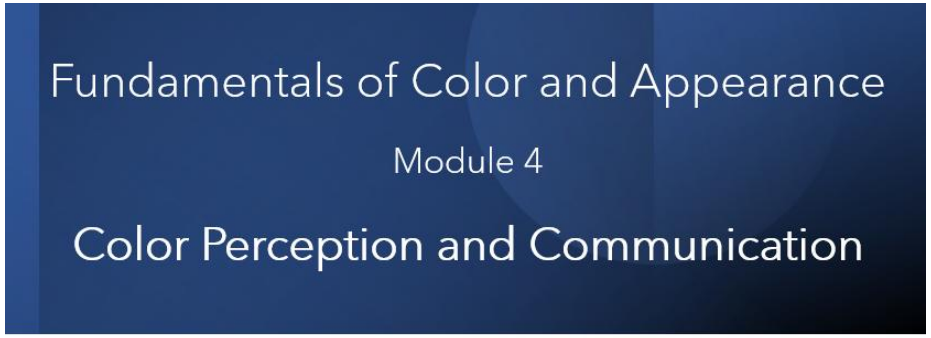
Thank you for joining us in this exploration of color science.

Be sure to watch module 4, **Color Perception and Communication**, where we explore why visual color assessment and communication of color is inherently unreliable, influenced by personal vocabulary, environmental conditions, and differences in individual vision.

And be sure to visit **hunterlab.com** to learn more about how our solutions can help you achieve color confidence, every time, or to schedule a consultation with one of our color experts.



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