Fundamentals of Color and Appearance

Module 5

Instrumental Color Measurement

Color Science Educational Series

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Module 5:

Instrumental Color Measurement

In Module 2 of this Fundamentals of Color series, we learned that accurate color perception depends on three critical components:

- Light Source
- Object
- Observer

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Building on this foundation, let's now explore how spectrophotometers replicate this Visual Observing Condition using controlled lighting, viewing conditions, and calibrated detectors, to objectively measure and quantify the colors we see.

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They incorporate optical components, such as controlled lighting, grading prisms, and detectors, that simulate the function of the human eyes' cone responses.

Visual Observing Condition	Human Observer	Spectrophotometer
Light Source	Any source of physical light	Controlled light source
Observer	Eye, brain and vocabulary that see's, interprets and communicates color	Optics / Grating / Detectors / Computers that see, analyze, and communicate color
Object	Sample	Sample

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They do this by measuring and analyzing light that is reflected from or transmitted through a sample.

The measured spectral data is then processed by software, analogous to how the brain interprets visual signals, to calculate standardized color values.

This enables consistent, objective communication of color, unaffected by individual perception, ambient lighting, or visual differences.

In this way, spectrophotometers provide a precise and repeatable method for color evaluation, critical for quality control across industries.

Visual Observing Condition	Human Observer	Spectrophotometer
Light Source	Any source of physical light	Controlled light source
Observer	Eye, brain and vocabulary that see's, interprets and communicates color	Optics / Grating / Detectors / Computers that see, analyze, and communicate color
Object	Sample	Sample

Samples are generally classified into three categories:

Opaque, **Translucent**, and **Transparent**.

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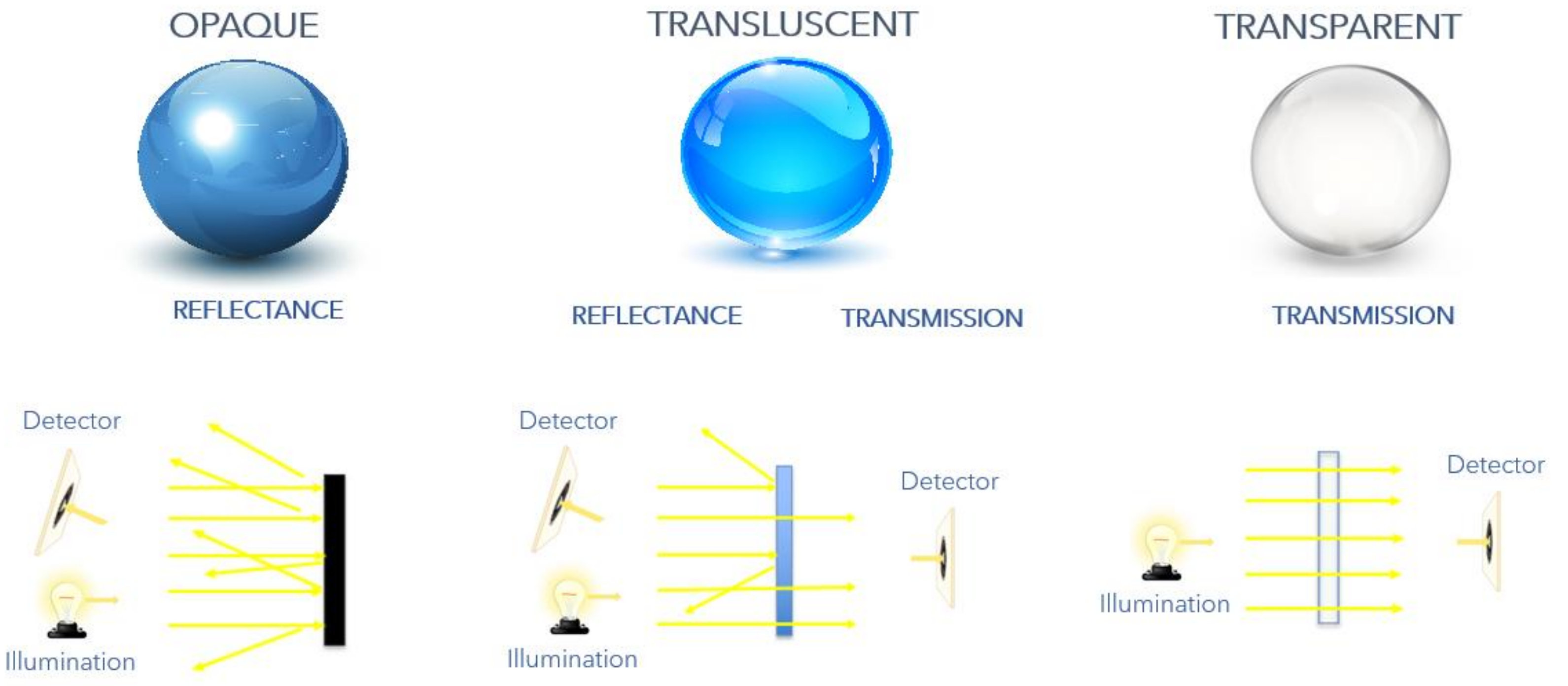
Opaque samples block light completely - no light passes through. Transparent samples allow nearly all light to pass through. Translucent samples fall in between. They both reflect some light off the surface and transmit some light through the material. The degree to which a sample reflects or transmits light determines which measurement method, reflectance or transmission, is best to use to ensure accurate, repeatable color data.



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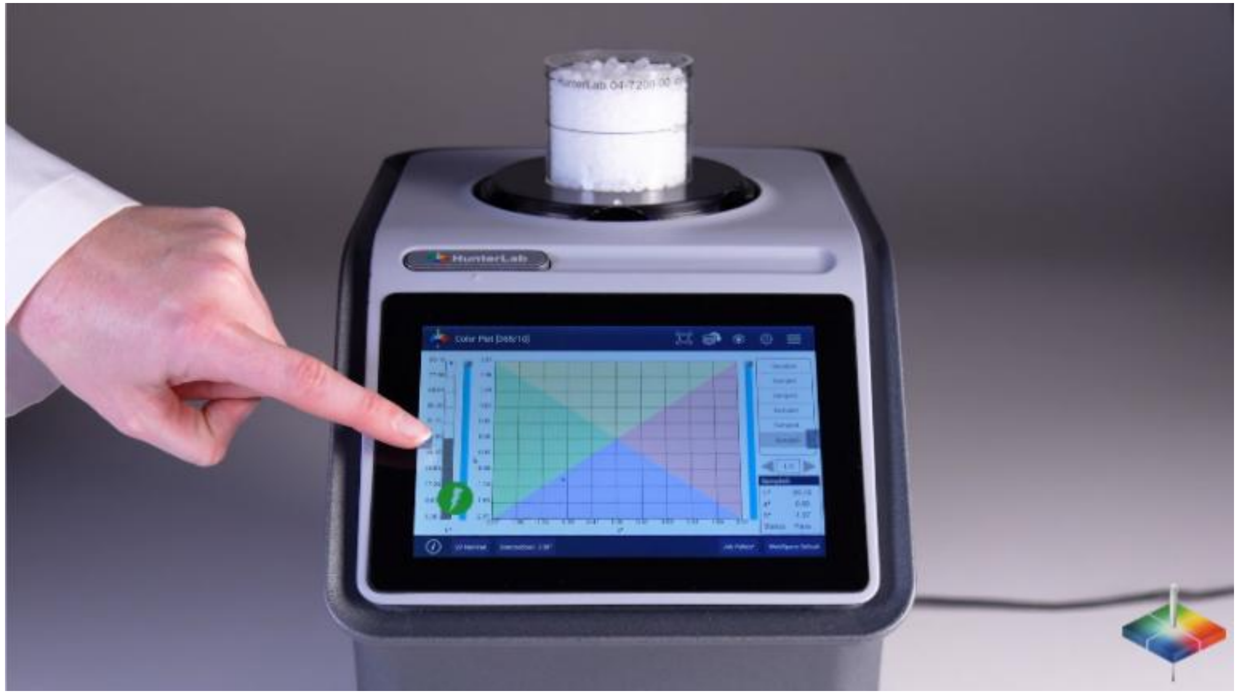
There are two primary types of spectrophotometers used for color measurement: **transmission** and **reflectance**.

Transmission

Reflectance



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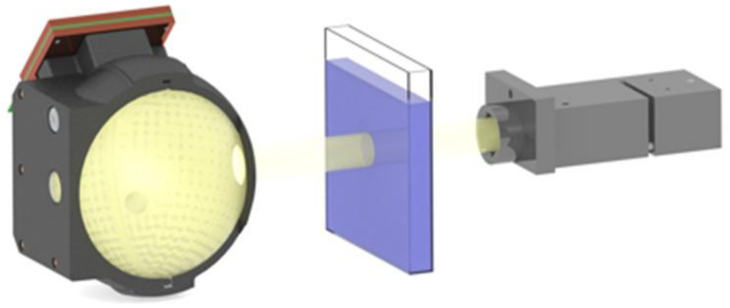
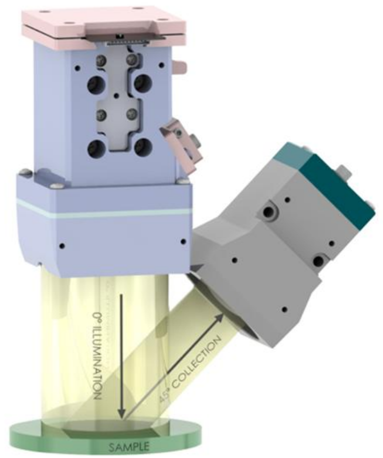
While both types share the same fundamental components, they differ slightly in optical design to accommodate how light interacts with a sample.

These design differences ensure accurate color evaluation based on the specific physical properties of the sample being measured.



Transmission



Reflectance

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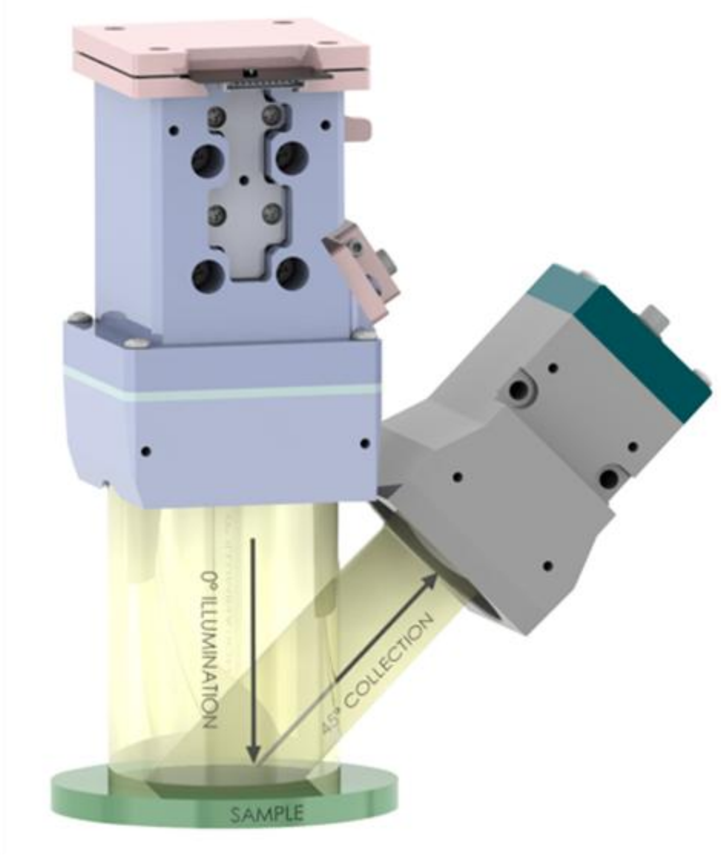
In reflectance measurement, light is directed onto a sample, and the instrument measures the amount of light that is reflected back from the sample to the instrument optics.



Reflectance

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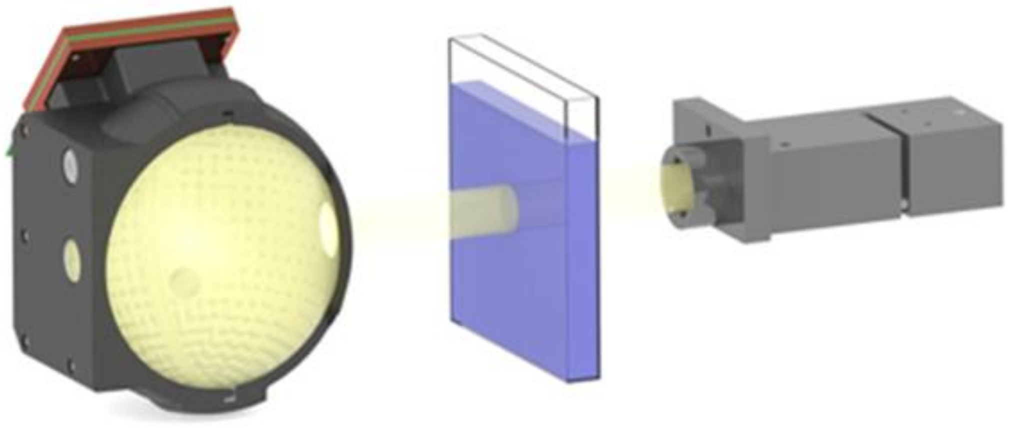
In transmission measurement, light passes through transparent or translucent materials, and the instrument analyzes the amount of light that passes through the sample.



Transmission

To determine whether to use transmission or reflectance measurement, we look at the sample's light transmittance. If the sample transmits 30-percent or less, it is considered too opaque for transmission measurement and should be measured using reflectance instrumentation.

A simple rule of thumb is, if you can see your hand through a sample in a 10-millimeter cuvette, or through a 10-millimeter physical sample, the sample transmits more than 30-percent of light and likely requires transmission measurement.

That said, it's always good practice to test both methods when measuring translucent samples when possible.

The goal is to identify the method that provides the most accurate and repeatable results for your specific sample type.

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As we have just learned, Spectrophotometers work by measuring and quantifying light that is either reflected from, or transmitted through, a sample.

This light is then converted into signals, processed by the instrument, and translated numerically into objective color data, using standardized color scales or color indices.

One commonly used color scale in industry is the **L,a,b** scale.

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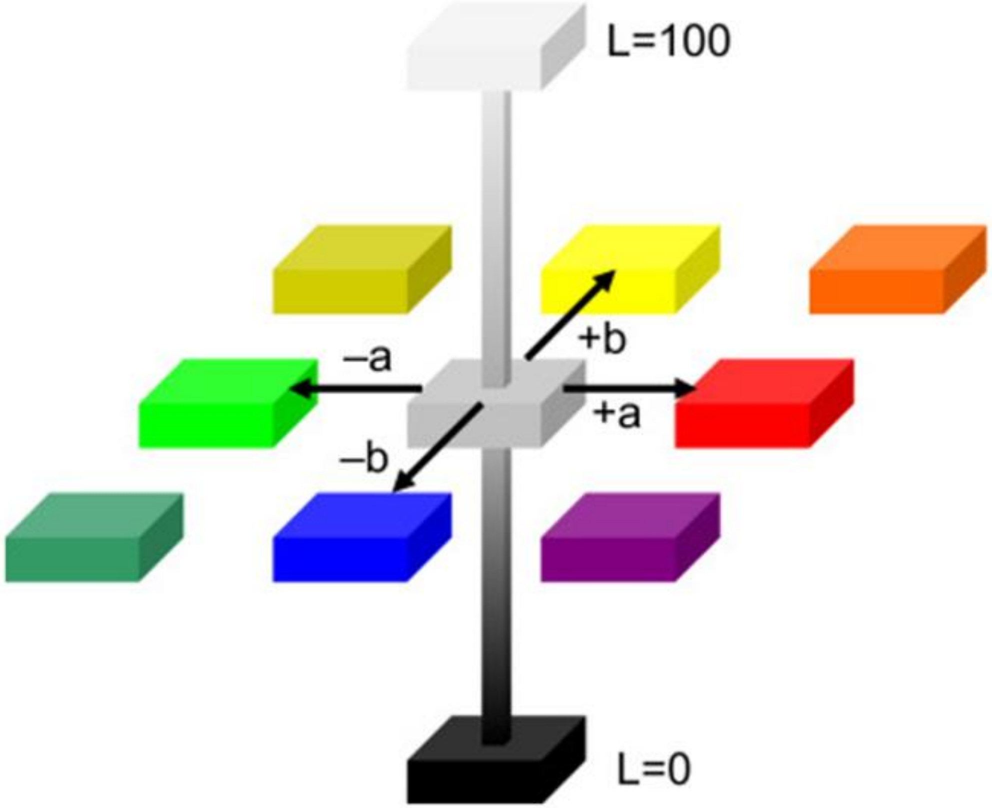
Invented in 1942 by Richard Hunter, the L,a,b color scale quantifies color using three color axis:

- L, from dark to light,

- a, from red to green,

- b, from yellow to blue.

We will discuss color scales and color indices in more detail in later modules.



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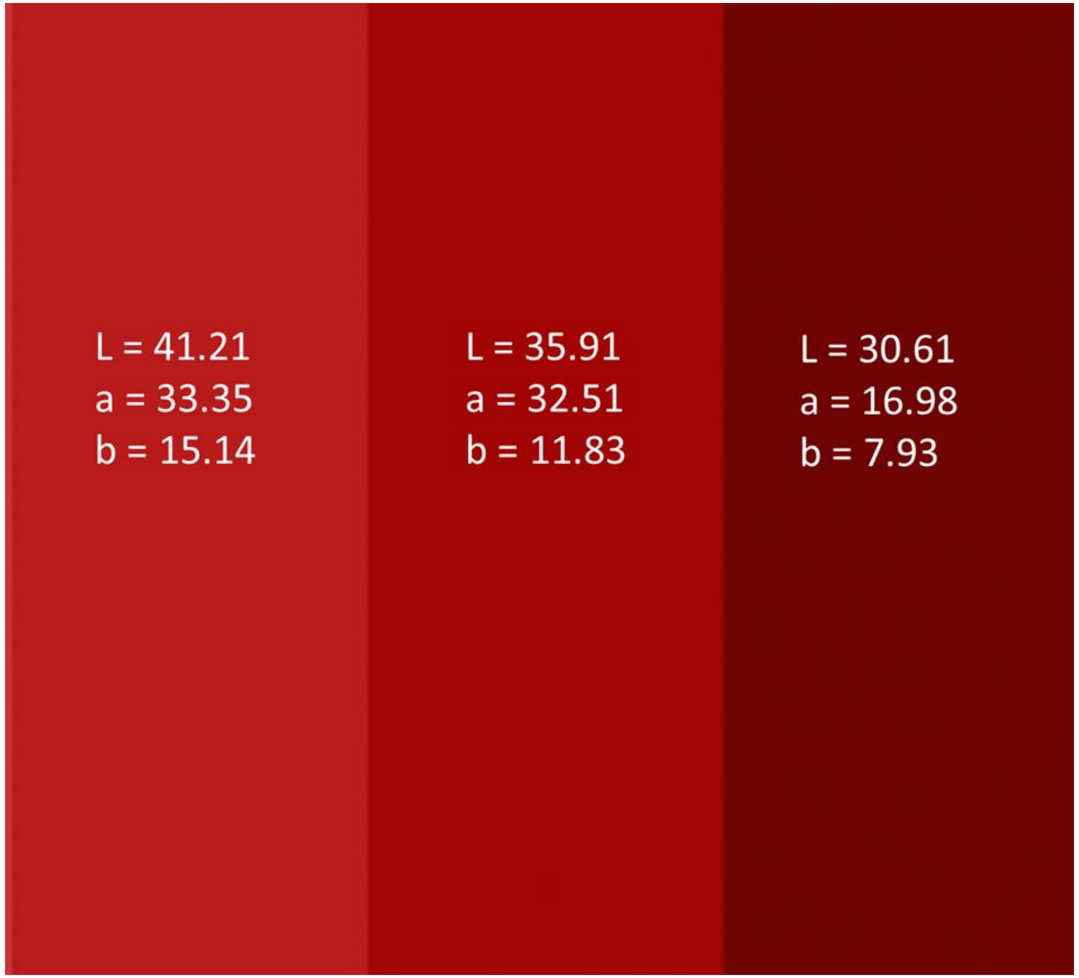
When we measure color using a spectrophotometer, each sample, no matter how similar it may appear visually to any other sample, receives a precise location in L,a,b color space.

This gives every color a specific **color address**, removing human visual color ambiguity and enabling accurate color communication across teams, processes, and locations.



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Thank you for joining us on this journey through color science.

Be sure to watch module 6 in this series, **Light, Illuminant and Observer**, where we will learn the difference between a physical light source and a standard illuminant, how spectral power distribution defines light, and why the concept of the Standard Observer is essential to objective color science.

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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Module 6

Light, Illuminant and Observer

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