

Is Your blue really blue? [Metamerism]

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Grade levels: Grades 6 through 9

Discipline: Physical Science

Objectives: To teach students some fundamentals about color perception, and to explain the phenomenon called "metamerism".

Students will learn the three basic components of color perception: light source, illuminated colored object, and the light detector.

Background: As Chevreul stated in 1854, "The art of the tapestry weaver is based upon the principle of mixing colours, and on the principle of their simultaneous contrast".

It is a common, though sometimes an unpleasant discovery, that colors appear identical under one light source but fail to match under another. This may be familiar to you from mixing paints [trying to match paints during automobile repairs, coordinating clothes, etc.]. Why is this so?

Observing color requires three things: a source of light, a "colored" object that the light illuminates, and a detector.

Common light sources include fluorescent, incandescent, ultraviolet, and sunlight. These different light source have different spectral distributions. Spectral distribution is defined as the curve that illustrates the intensity of light emitted by the source at each wavelength.

Dyes and pigments create the color in objects such as textiles, paints, etc. Different dyes and pigments have different spectral reflectance curves. The spectral

reflectance curve shows the fraction of the light reflected at each wavelength from the material. Color perception is a combination of the spectral reflectance of the dye or pigment, and the spectral distribution of the light source.

Metamerism: Two colored objects made from two different dyes or pigments may look the same under one light source, but different under another light source. This is what is known as metamerism. Two different colors may appear to be exactly matched simply because the combination of spectral reflectance and source distribution is fortuitously matched! However, this pair will not be a perfect color match when viewed with another light source. The combination of spectral reflectance with the spectral distribution of the second light source will be different, thus the colors will be perceived as mismatched [see enclosed figure]. The pair of colors are said to exhibit metamerism. Pairs of colored objects having the same spectral reflectance curves and therefore the same color perception for all light sources are nonmetameric and form an invariant pair.

The final component necessary for color perception is a detector.

The human eye has a thin membrane, the retina, which contains the light sensitive cells. The retina has two major components: the rods and cones. The cones are sensitive to colors. There are three types of cones in the human eye, each contains a different photopigment with peak response to a particular part of the visible spectrum. Thus, by differential transmission of nerve impulses upon stimulation, the cones are able to encode information about the spectral content of the image so that the observer experiences the sensation of color. Each individual has a different spectral sensitivity.

There is only one practical method to detect metameric matches - view the samples under more than one light source. This is what the laboratory involves!

Management tips: Use the Macbeth Daylighting Metamerism Test Kit #3 - "Do these colors match or mismatch?" obtained through Macbeth - A division of Kollmorgen Company
Little Britain Road
P. O. Box 230
Newburgh, New York 12550
1-800-431-4952

Materials: Macbeth Daylighting Metamersim Test Kit #3
incandescent bulb [light source]
fluorescent bulb [light source]
ultraviolet bulb [light source]
ultraviolet safety glasses

Vocabulary: graph dye
spectra colorant
spectral reflectance pigment
ultraviolet radiation light
color spectrum
incandescent metamerism
fluorescent invariant pair

Procedures: 1. Students will work in groups of four or five.
2. Observe the Macbeth Daylighting Card under classroom light. Record your observations.
3. Observe your Macbeth Daylighting Card under an incandescent light source. Record your observations.
4. Place the card under a fluorescent light source. Record your observations.
5. Place the card under an ultraviolet light source. Record your observations.
6. Hold the card under direct sunlight and record your findings.

Questions: 1. How do the samples on the card compare to each other under different light sources?
2. How can you detect a metameric match?
3. How can this test kit aid in everyday situations?

References: Principles of Color Technology; Second Edition, Fred W. Bellmeyer. Jr. and Max Saltzman, A. Wiley - Interscience Publications; John Wiley and Sons, New York, 1981.

The Photonics Dictionary, TM Book 4 39th International Edition, 1993, Larien Publishing Company Inc., Pittsfield, MA 01202-4949.