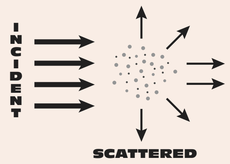
LIGHT MATTERS

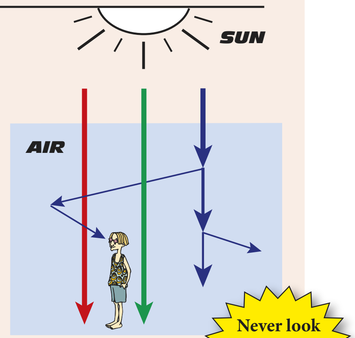
MOLECULES AND SMALL PARTICLES SCATTER LIGHT

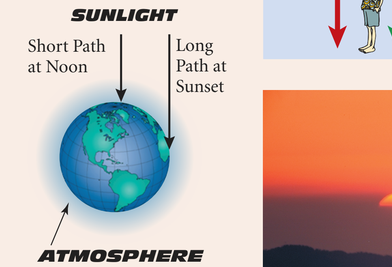


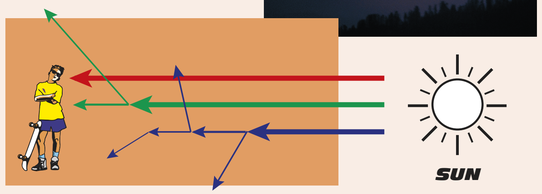
Air molecules and particles smaller than the wavelengths of visible light preferentially scatter shorter wavelength visible light:

violet > blue > green > red.

When sunlight passes through the atmosphere, the shorter wavelength components are preferentially scattered. So when we look *away from the sun*, we see the blue sky. When we look *toward the sun*, we see unscattered light. Why isn't the sky violet? See the details section below for a hint and reference 3 for a complete explanation.







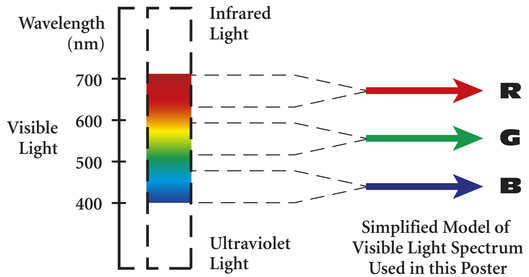
Sunlight passes through a longer length of atmosphere at sunset than at noon, which leads to increased scattering. When we look *toward the sun* at sunset, we see the unscattered light that is enriched in light of longer wavelengths. This results in a yellow or orange or even red sun.

Some Details and Clarifications

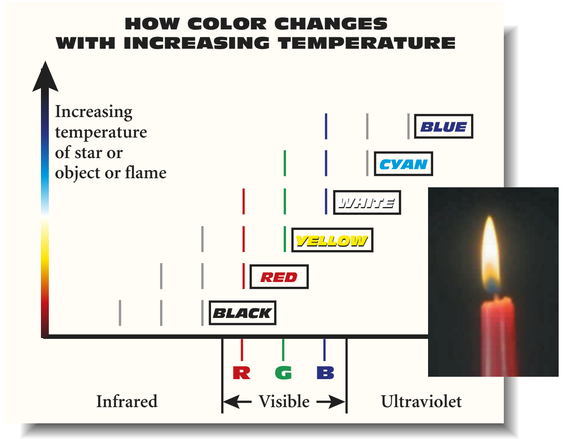
- Light is not colored. Color is a human visual response that depends on the spectrum of visible light entering our eyes - the color that we observe then depends on the responsivity of the long, middle, and short wavelength sensitive cones in our eyes and the processing of these signals by the brain.
- The color of an object seen by reflected light depends on both the light spectrum illuminating the object as well as the reflectance spectrum of the object. This is why the color of clothes changes with illumination conditions.
- Light of a single wavelength corresponds to a definite perceived color. Most perceived colors can be evoked by a large number of different light spectra entering our eyes.
- For further details about and limitations of the explanations given in this poster, consult the references.

Created by: Dr. Lawrence Woolf, General Atomics
Graphic Artist: Virginia Degutis Wolfe
For additional information: www.sci-ed-ga.org

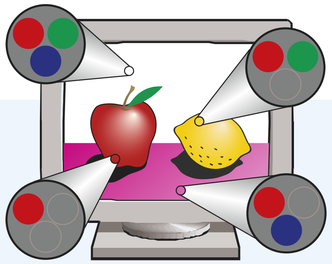
LIGHT EMISSION



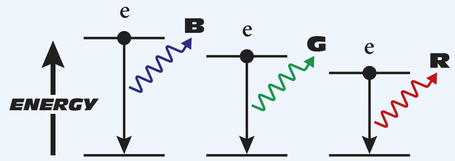
Simplified Model of Visible Light Spectrum Used in this Poster



Objects emit light over a wide continuous range of wavelengths. At each temperature, this range can be approximated by three separated wavelengths. The rules for additive color mixing can then be used to predict how the color of hot objects changes with increasing temperature.



A computer monitor uses **R**, **G**, **B** phosphors to generate colors.

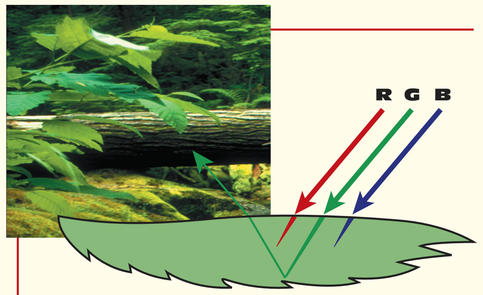


In these phosphors, the energy lost by an excited electron (e) results in light emitted with that energy.

References

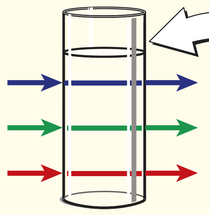
1. Clouds in a Glass of Beer, Craig F. Bohren, John Wiley & Sons, 1987.
2. What Light Through Yonder Window Breaks, Craig F. Bohren, John Wiley & Sons, 1991.
3. "Colors of the Sky," C.F. Bohren and A. B. Fraser, The Physics Teacher, May 1985, pp. 267-272.
4. "Confusing Color Concepts Clarified," L. D. Woolf, The Physics Teacher, April 1999, pp. 204-206.
5. Light and Color in Nature and Art, S. J. Williamson and H. Z. Cummins, John Wiley & Sons, 1983.

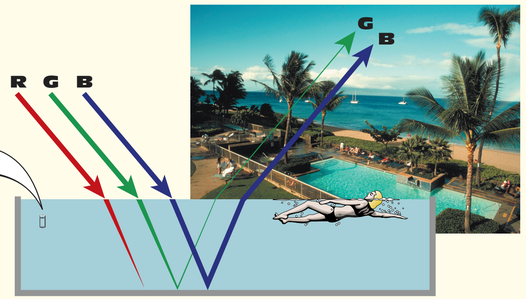
ABSORPTION



Leaves are dark green because they absorb almost all of the red and blue part of the visible spectrum and much of the green; they reflect a small portion of the green. Much of the absorbed light is used for photosynthesis; the remaining absorbed light heats the plant.

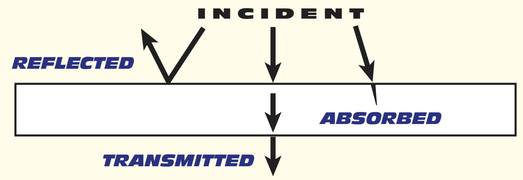
Water in a glass does not appear colored because the short path of light through the glass of water results in almost no light absorption.



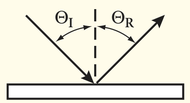


Deep water appears blue because absorption of visible light by water is gradual as well as selective: greatest at the red end of the spectrum, least at the violet and blue end.

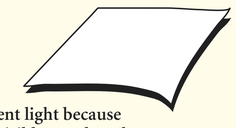
BULK MATTER REFLECTS, TRANSMITS, AND ABSORBS LIGHT



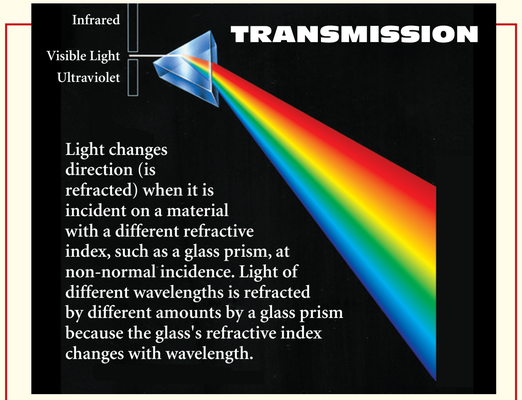
REFLECTION



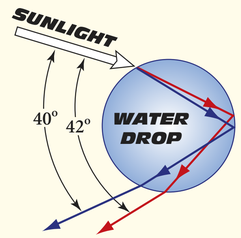
The smooth surface of a mirror reflects a ray of light so that the angle of incidence (Θ_I) = angle of reflection (Θ_R).



The surface of a white piece of paper diffusely reflects the incident light because the surface is optically rough at visible wavelengths.



Light changes direction (is refracted) when it is incident on a material with a different refractive index, such as a glass prism, at non-normal incidence. Light of different wavelengths is refracted by different amounts by a glass prism because the glass's refractive index changes with wavelength.



Part of the incident light undergoes refraction as it enters a water drop, then reflection at the back surface, then refraction as it exits the drop. The index of refraction of water is different for different wavelengths, causing the incident sunlight to separate into a rainbow of colors. Only shown are the rays corresponding to the angle at which scattering is a maximum. See Reference 1, chapter 21 for further details.

SCIENCES EDUCATION FOUNDATION
GENERAL ATOMICS