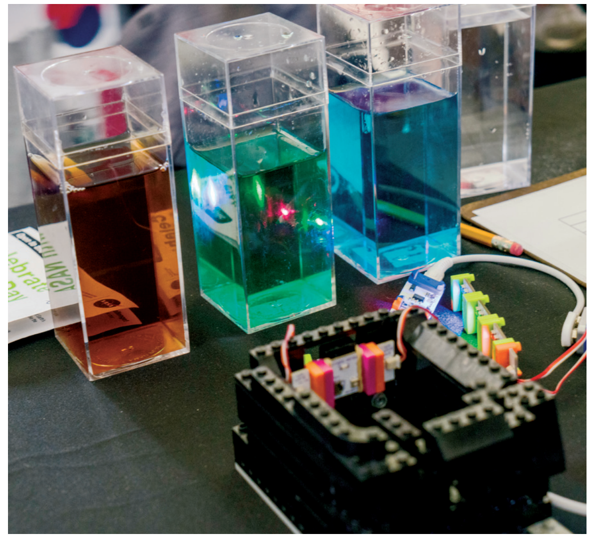
What Color is the Ocean?

National Aeronautics and
Space Administration

Simple Spectrophotometer Activity



Credit: NASA

In this activity, you will use an inexpensive, simple spectrophotometer* to test how light at different visible wavelengths (blue, green, red) is transmitted, or absorbed, through four different colored water samples. Clear water is used as the "control," characterizing the light source and normalizing the other samples. The blue water represents the open ocean water with few plants—conditions you might find far from land in the middle of the ocean. The green water represents productive water with a high concentration of phytoplankton, i.e., a phytoplankton bloom. The tea water represents coastal water or river outflow that contains decaying organic material such as leaves.

**Note that a laboratory spectrophotometer is more sensitive than the one used in this activity.*

Setup and Investigation

1. Prepare four, square containers of water. One container should contain only clear water. For the other three containers: Put one drop of blue food dye in one, one drop of green food dye in another, and some tea (no leaves) in the last. Mix each container well.
2. Build a *light sensor* with battery + power + orange wire + sensor + number display—see *Materials Guide*.
3. Put together a *light source* with power + bright LED. Make sure you have three properly tuned* LED light sources (blue, green, red).

   **Tune one LED light to red (tune up "r" with the littleBits™ screwdriver, tune down "g" and "b"), tune one LED to green (tune up "g," tune down "r" and "b"), and tune one LED to blue (tune up "b," tune down "r" and "g"). Make sure the LED light is not too bright. To do this, adjust the three light sources and/or the sensitivity of the detector so that the light sources put out distinct colors and read up to 98 when transmitted through clear water. Keep the same settings for the entire experiment.*
4. Attach the *light sensor* to one side of the black base and place the blue LED *light source* on the opposite side of the black base. The *light source* should be level with (and shining directly on) the *light sensor* on the opposite side of the black base.
5. Put the clear water sample into the black base and turn on the blue LED light so that the blue light shines through the container of clear water and is received by the *light sensor* on the opposite side. Cover the spectrophotometer (black base, light sensor, and light source) and water sample with a black cloth to minimize background light.
6. Record the value on the light sensor (received by the blue LED light) for clear water in **Table 1**. Remove the blue LED light. Insert the green LED light and record the value on the *light sensor* for clear water in **Table 1**. Remove the green LED light. Insert the red LED light and record the value on the *light sensor* for clear water in **Table 1**. Repeat for all colored water samples (blue, green, tea), completing **Table 1**.
7. Circle the highest sensor value for each colored water sample in **Table 1**. Do you notice a pattern?
8. Calculate the percent of light transmitted for each colored water sample in **Table 2**. To do this, divide each colored water sensor value from **Table 1** by the clear water sensor value for the corresponding light color and multiply that value by 100 to get the percentage of light transmitted. For example, (blue water sensor value for blue LED light) ÷ (clear water sensor value for blue LED light) x 100 = (percentage of blue light transmitted). Calculate and record each percentage in **Table 2**.
9. Plot the values from **Table 2** on the **Graph** for all three colored water samples (blue, green, red) using three corresponding colored pencils (blue, green, red).
10. Discuss the results revealed in **Table 2** and the **Graph**.

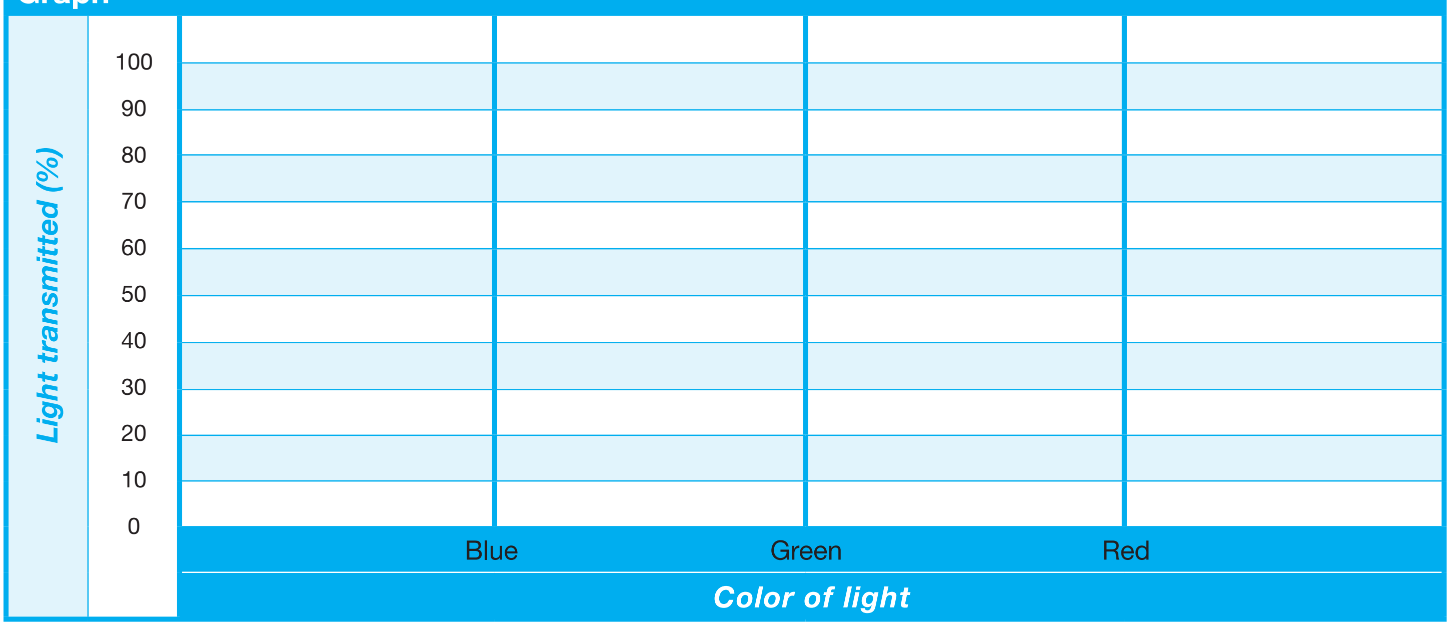
Table 1

Sample	Sensor Value for Blue LED light	Sensor Value for Green LED light	Sensor Value for Red LED light
Clear water			
Blue water			
Green water			
Tea water			

Table 2

Sample	% of Blue light transmitted	% of Green light transmitted	% of Red light transmitted
Clear water	(clear water sensor value for blue LED light) ÷ (clear water sensor value for blue LED light) x 100 = **100**	(clear water sensor value for green LED light) ÷ (clear water sensor value for green LED light) x 100 = **100**	(clear water sensor value for red LED light) ÷ (clear water sensor value for red LED light) x 100 = **100**
Blue water			
Green water			
Tea water			

Graph



Results: The color of the water affects how much light from the light source is transmitted or absorbed before reaching the light sensor. Specifically, the *spectrum* (i.e., graph) for each colored water sample demonstrates that the highest percentage of light transmitted through a medium corresponds most closely to the color of its constituents while the other colors are absorbed. In other words, the blue water transmits the highest amount of blue light and absorbs green and red light. Likewise, the green water spectrum peaks at green and the tea water spectrum peaks at red. These are called *spectral signatures*. While ocean color satellite sensors measure reflected light—not light that is transmitted across a water sample like a spectrophotometer does—scientists are able to remotely sense the same spectral signatures, allowing them to observe and analyze changes in ocean color.

For more information, visit:
www.nasa.gov/earth

NASA Sets the PACE for Advanced Studies of Earth's Changing Climate
http://pace.gsfc.nasa.gov

Reference:

Schollaert Uz, S. 2016. Building intuition for in-water optics and ocean color remote sensing: Spectrophotometer activity with littleBits™. Oceanography 29(1):98–103, ***http://dx.doi.org/10.5670/oceanog.2016.01***