It's Time to Teach the Correct Primary Colors.

Larry and Wendy Woolf

When asked what are the primary colors, most of us would answer, "That's easy. The primary colors are red, yellow, and blue." We are sure of the answer because we were taught this in school, have read it in books, and have studied color theory based on this model. However, if we begin to investigate this issue and look at a variety of different sources for our answer, we find conflict and confusion.
For example, after such an investigation we came across the following statements:

• "The primary colors of paints, pigments, etc. are red, yellow, blue." (Webster's New World Dictionary)
• . . . The correct colors used by printers . . .are cyan, magenta, and yellow." (Journal of Chemical Education)
• "The primary process colors are: Yellow, Red (Magenta), and Blue (Cyan). (Color Printing Manual)
• . . . In painting or printing, the primaries are often said to be red, yellow, and blue. Here we are loosely speaking of magenta, yellow, and cyan." (Conceptual Physics - Hewitt)

Depending on the source, one might find that the primary colors of pigment are red, yellow and blue--or cyan, magenta and yellow--or red (magenta), yellow and cyan (blue). And what are these colors, anyway? Our society has agreed that there are distinct colors corresponding to the color names blue, cyan, yellow, red, green, and magenta. To see these colors, go to <http://www.sci-ed-ga.org/modules/materialscience/color/materials.html> and look at the color of the slides in item #21.

There is no dispute about the primary colors of light. They are red, green and blue. (Put a drop of water on your TV screen or computer to easily demonstrate this). So why can't anyone agree on the primary colors of paints and pigments?

Luckily, there is one area of color theory agreed upon by everyone--the definition of 'primary colors.' By using this definition we can find a path to enlightenment and clarity.

The definition of a primary color is:

1) a primary color cannot be produced by mixing two colors together.
2) The primary colors are combined to produce all hues.

Using the above definition of primary colors, let's see if red, yellow and blue are, indeed, primary colors. We know that yellow paint cannot be formed by combining other pigments. That's intuitive. But how about red and blue? A few quick experiments with color printing can prove that blue is made from equal amounts of cyan and magenta and red is made from equal amounts of yellow and magenta. So by our definition, red and blue *cannot* be primary colors because they can be made by mixing other pigments. When we mix red, blue, and yellow, we get a very limited number of dark colors. (This

can be especially frustrating for elementary art educators using tempera paint to teach color mixing). On the other hand, mixing cyan, magenta, and yellow gives us a huge range of colors. For proof, take a look at color printed pages, such as a magazine, a colored page in a newspaper, or your own color printer. All of these use mixtures of cyan, magenta, and yellow to make all of the other colors. The correct primary colors of pigment are, therefore, cyan, magenta, and yellow and not red, yellow, and blue. The correct secondary colors, made by mixing the primaries, are red, green, and blue. (Green is made by mixing cyan and yellow.)

By now you might be thinking, "that's fine for printing and photography, but it's different for paint." The truth is, however, that color theory is the same for printing, photography, *and* paint. Confusion arises from the fact that people call cyan either light or sky blue or turquoise even though it should be regarded as a distinct color. And magenta is sometimes considered a purple-red or a dark red when it is not. Magenta is a color distinct from red or purple. So where can you get true cyan and magenta paint? It is difficult, but we have found that Pthalo blue comes very close to a true cyan. It makes beautiful blues and purples when mixed with Quinacridone magenta, the closest paint to a true magenta. However, even these paint colors vary from company to company. When using these two colors in combination with a true yellow, such as cadmium-yellow-light or Hansa yellow, one can make a huge variety of colors, including blue and red. Try it and then compare the colors you make to those when you mix red (cadmium red), blue (ultramarine or cobalt), and yellow. (Note: *Golden Paints* makes primary magenta, primary yellow, and primary cyan paint, available at most stores.)

Many groups already recognize the correct primary colors of paint. The New York State standards for visual arts states that the primary colors of pigment are cyan, magenta, and yellow. The Inter-Society Color Council (ISCC) is the principal professional society in the field of color, encompassing the arts, sciences, and industry. They agree that cyan, magenta and yellow are the primary colors of pigment, which in combination can form all hues. The most recent draft of the revised California science framework also states this.

We must stop teaching color theory based on a false set of primary colors. We shouldn't be afraid to spread the truth even though most of the literature is wrong. This in itself is an important lesson to teach students.

What if Columbus had been afraid to tell the truth? We still might believe the Earth was flat! Oops ... bad analogy. It turns out that neither Columbus nor his contemporaries believed the earth was flat. Yet this illusion persists today, firmly established with the help of the media, textbooks, teachers, and even noted historians. Shades of the primary colors of paint!

It is time for color to be taught consistently throughout all subject areas. It's time to tear down the walls of the Color Tower of Babel and teach the truth about color, that the primary colors of paint are cyan, magenta, and yellow.

Larry Woolf is a PhD physicist at General Atomics in San Diego and has given many education outreach workshops on color theory to chemistry, physics, and art teachers. Wendy Woolf is an art and science educator. She also is a painter.

For additional information and a correct color wheel, see www.sci-ed-ga.org and click on Presentations, or Educational Materials, or Education Modules/It's a Colorful Life. See also the article "Confusing Color Concepts Clarified," L. D. Woolf, The Physics Teacher magazine, volume 37, number 4, April 1999.

Additional information added June 17, 2003.
Here are some resources for purchasing primary cyan, magenta, and yellow paints - both oils and water colors:

Watercolor paints:

Primary Magenta	PV19
Primary Cyan	PB15:3
Primary Yellow	PY97

Oil Paints:

Primary Cyan	Classico 400
Primary Magenta	Classico 256
Primary Yellow	Classico 116