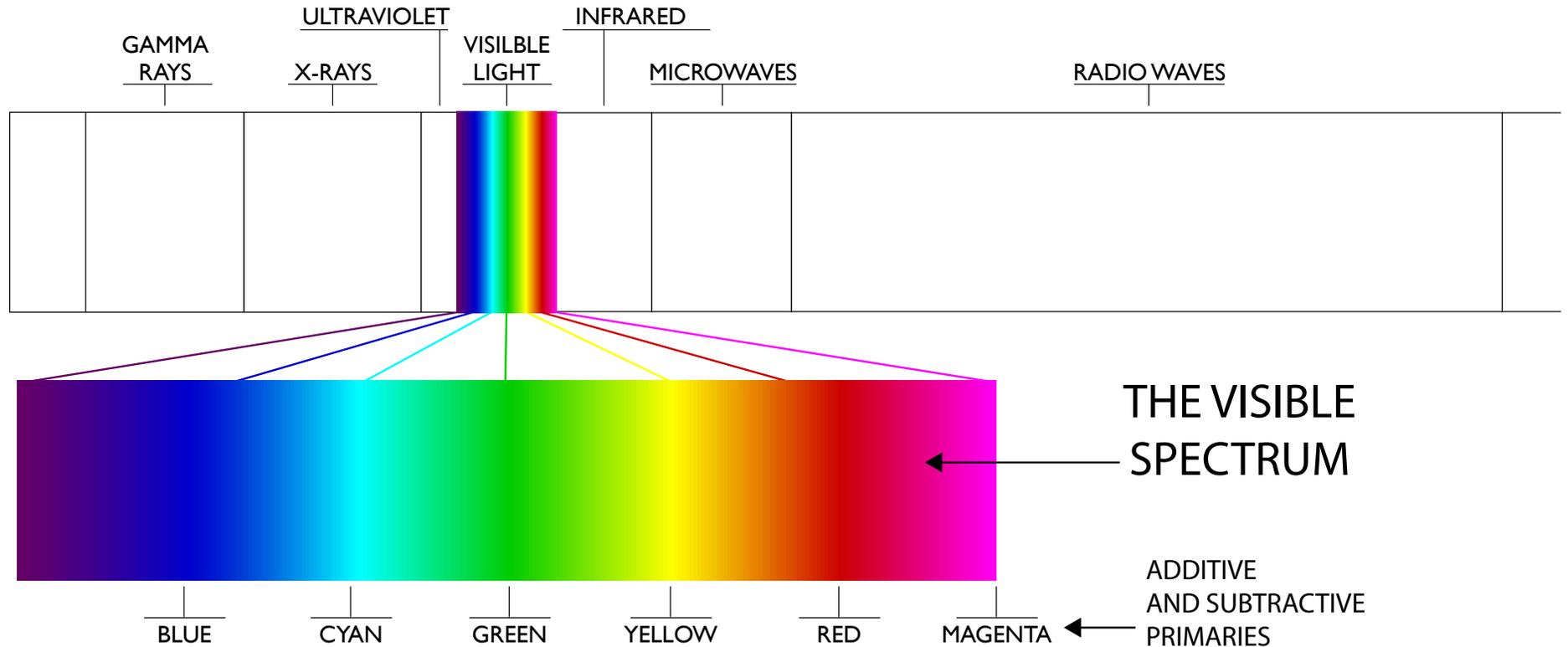


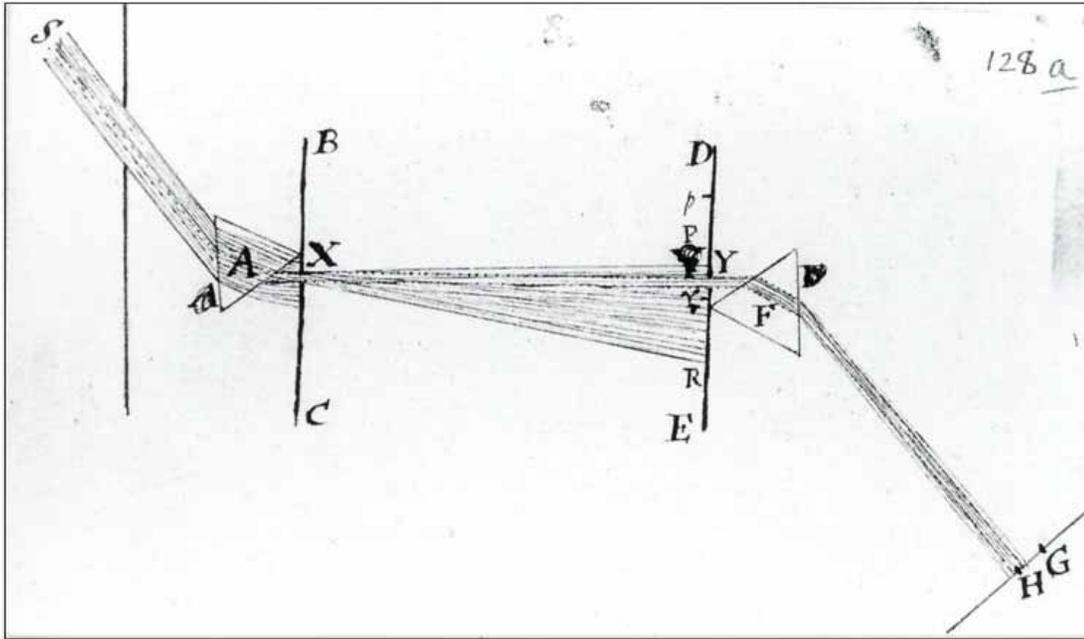
Our senses don't deceive us;
our judgment does.

— Johann Wolfgang von Goethe



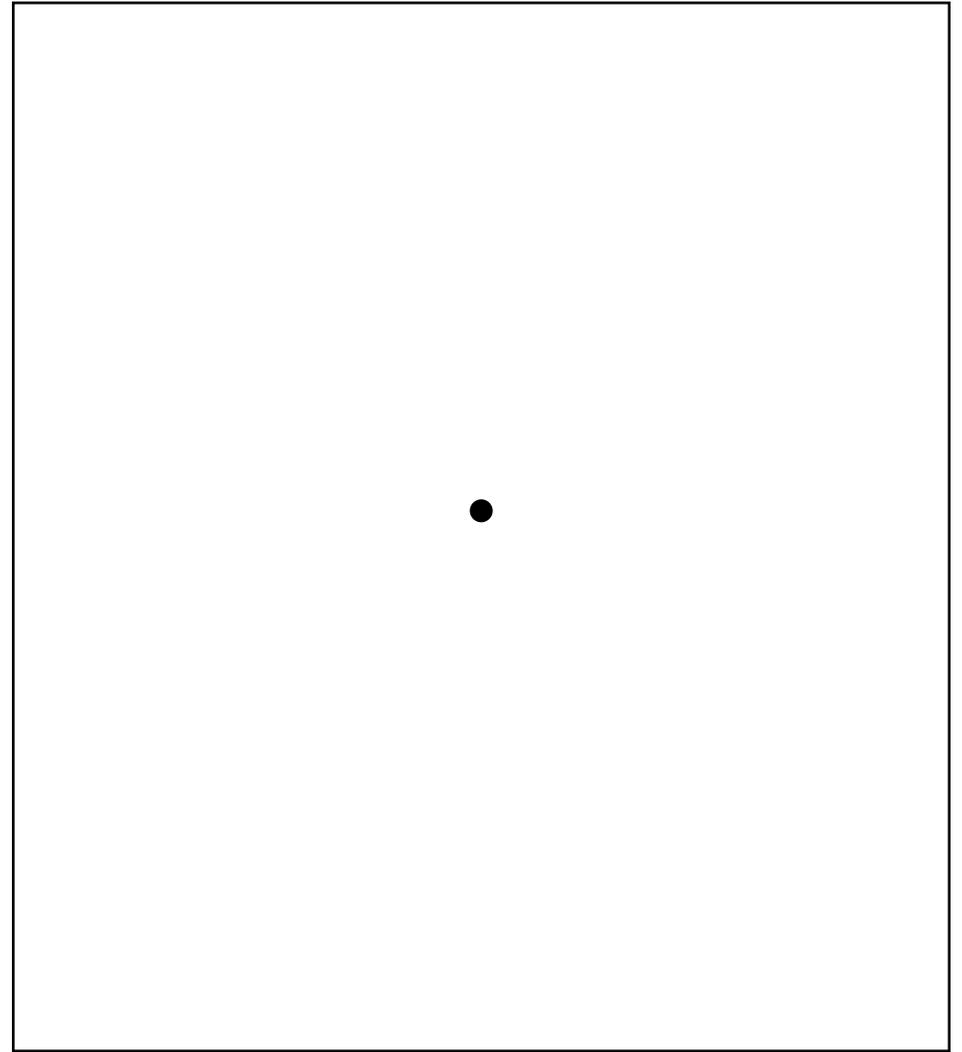
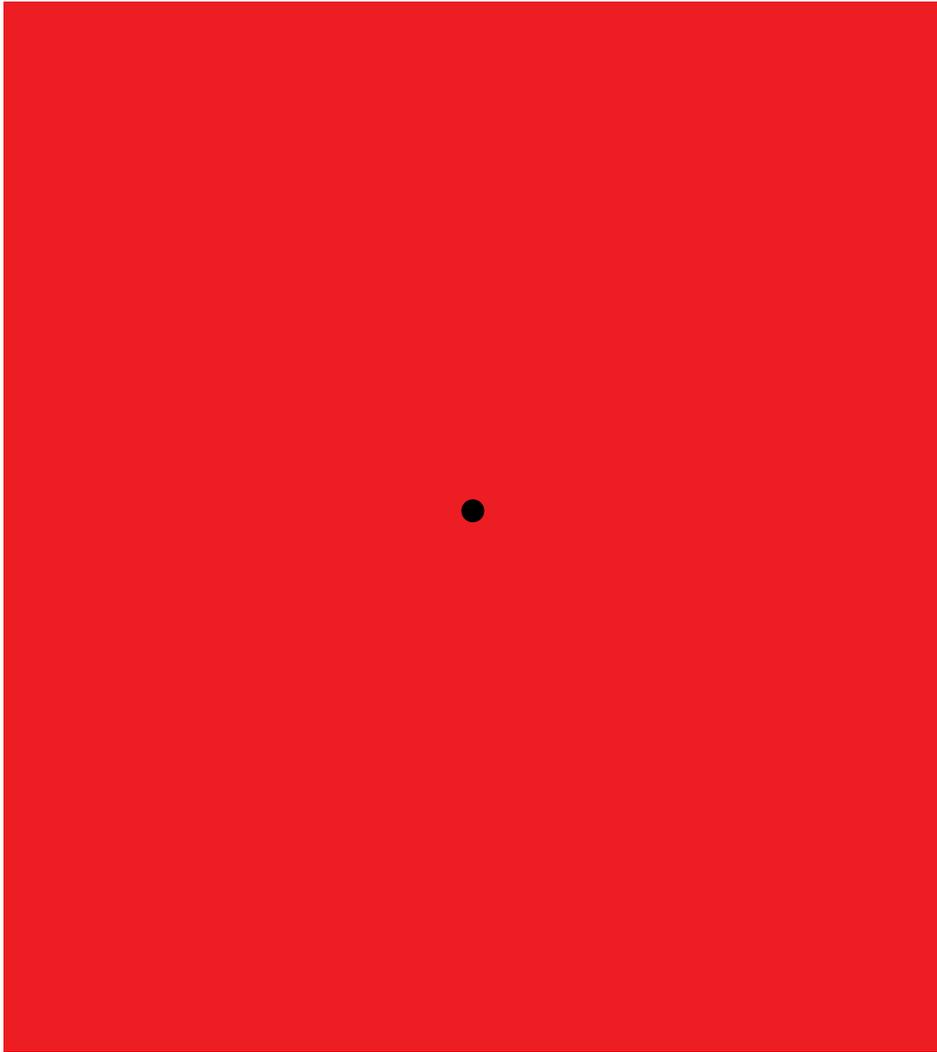
The visible spectrum...

- ... is the part that we can see of the **electro-magnetic spectrum**.
- The visible spectrum contains millions of colors of varying wavelengths.
- Light from the sun contains all of these colors. A prism splits these colors into the familiar rainbow.

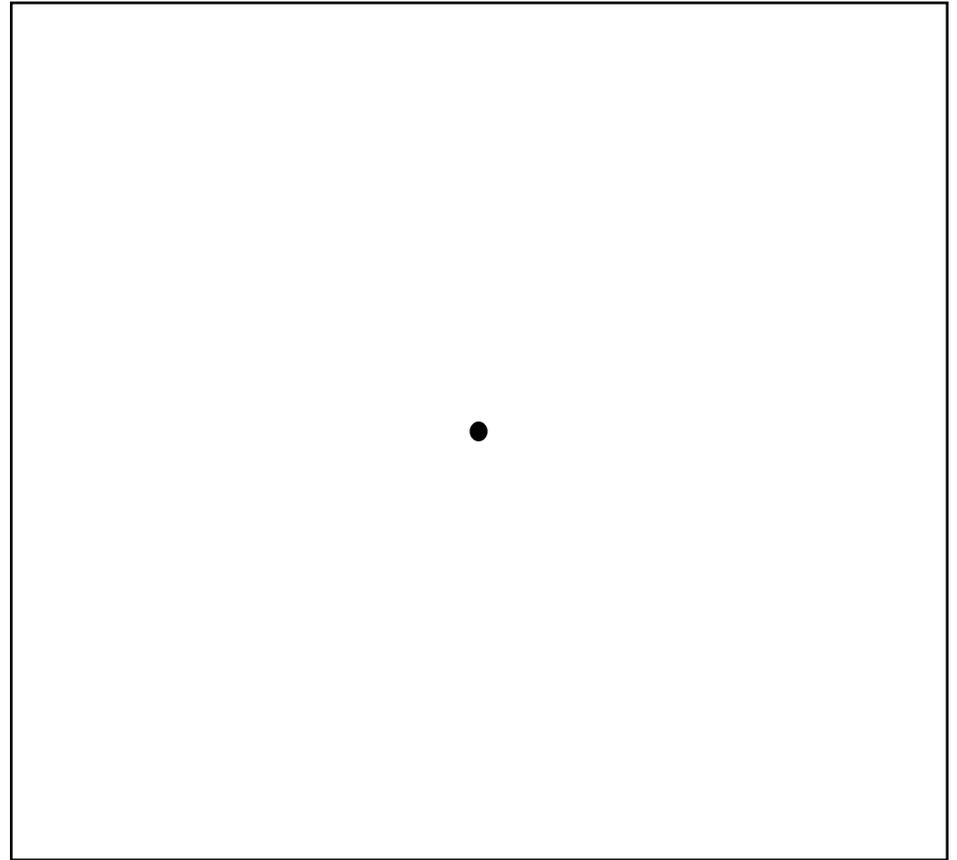
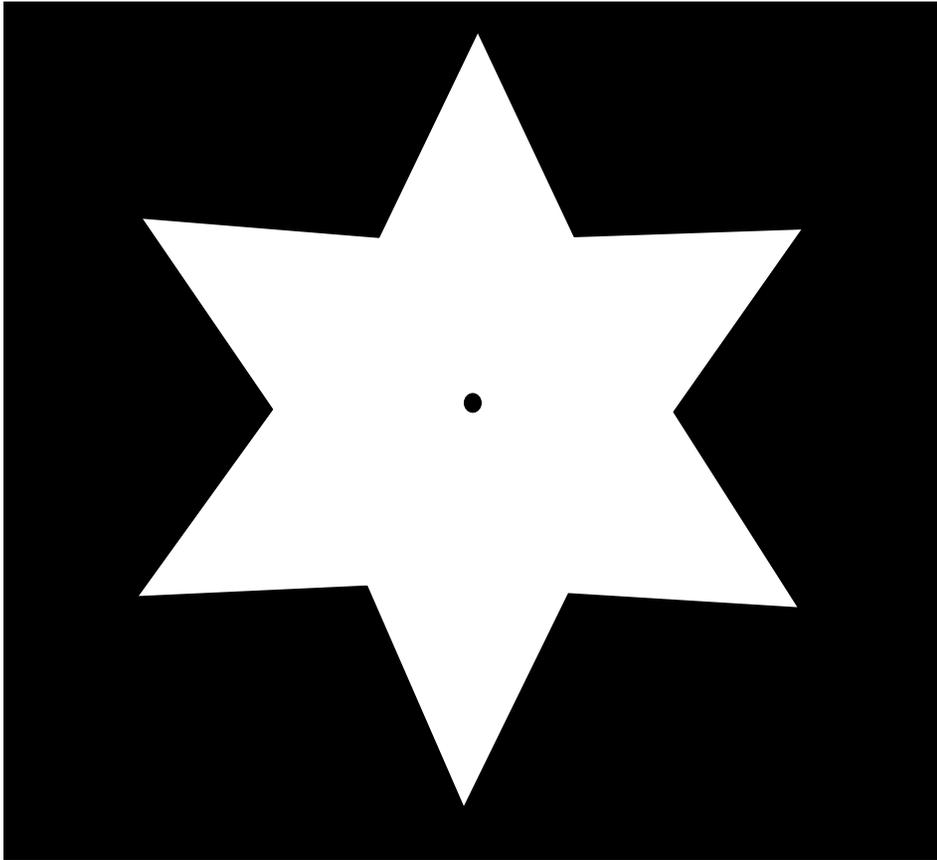


- Sir Isaac Newton (1642-1726) was the first to understand the visible spectrum.
- He refracted white light with a prism, resolving it into its component colors, then used another prism to reverse the process.



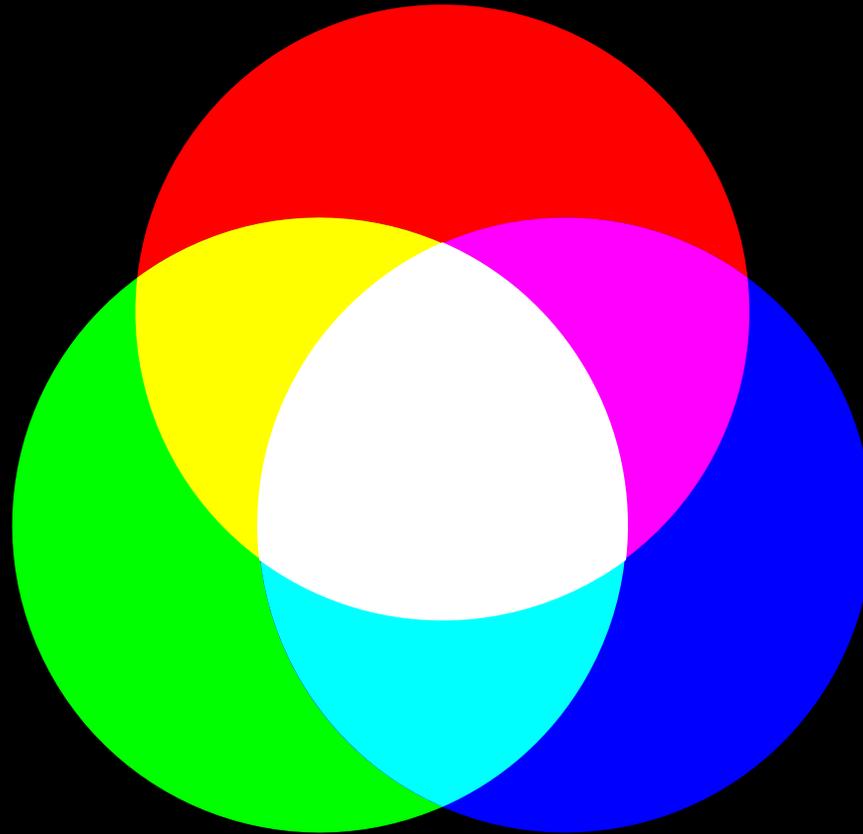


The eye has receptors **sensitive to** the primary colors **red, green and blue**. Stare at the dot in the middle of the red square for 30 seconds, then shift quickly and stare at the dot in the white square. What color do you see? Red stays on the retina as an after-image of its **complementary color**, cyan blue.



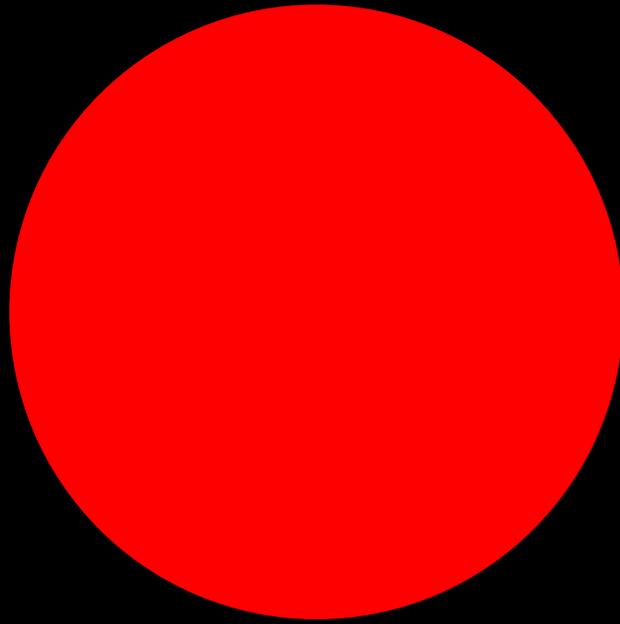
Now stare at the dot in the middle of the white star for 30 seconds, then shift to the dot in the white square. What do you see?

- After-images are due to rods and cones in the eye becoming sensitized. Rods and cones are photoreceptors on the retina.
- The rods, about 120 million, are not sensitive to color.
- The 6 to 7 million cones are color sensitive. They are concentrated in the macula, a spot in the center of the retina.

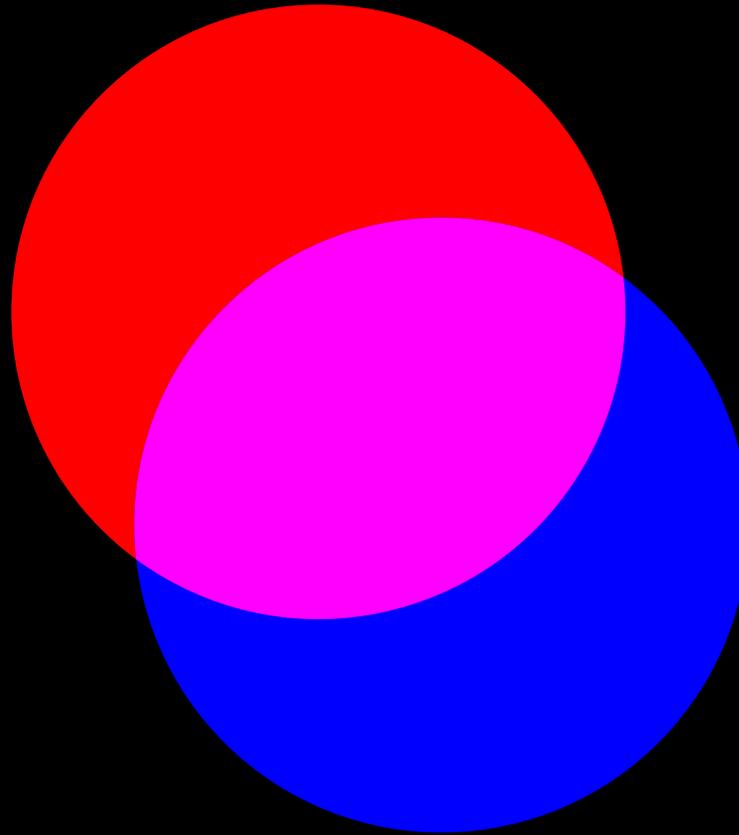


Additive color

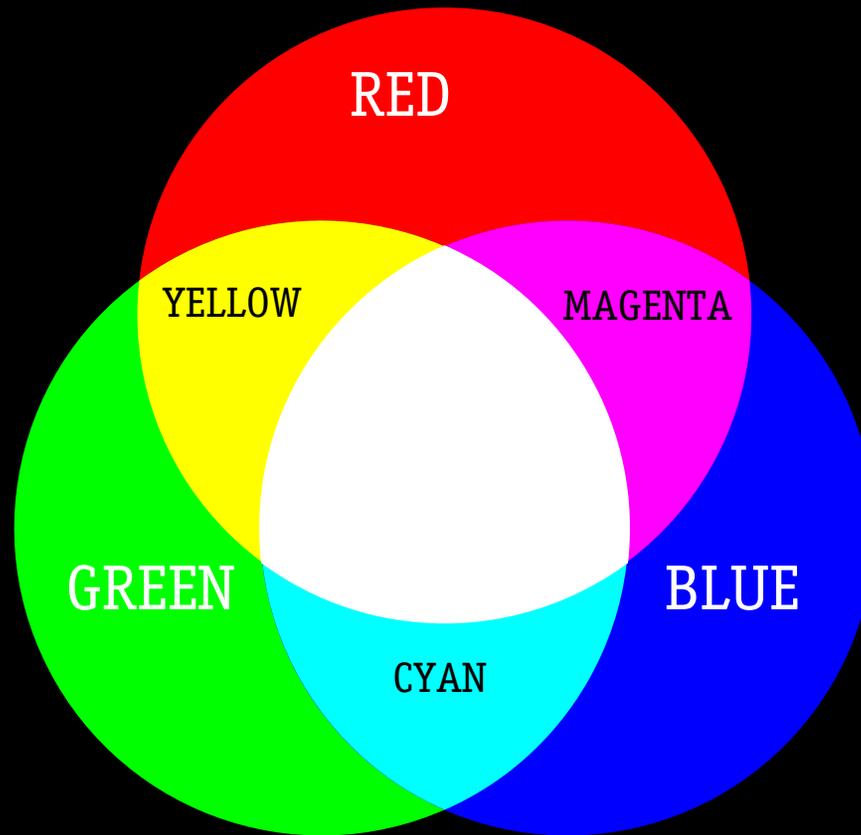
- The receptors in the eye are sensitive to the primary colors red, green and blue.
- These are called the **additive primaries**, or projected-color primaries.



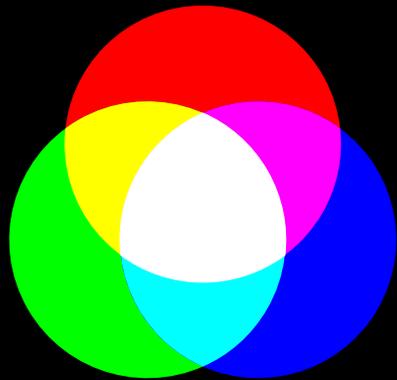
Additive primaries (red, green and blue) are used to reproduce color on a TV screen, in color film and on a computer screen.



Red, green and blue (RGB) are called additive primaries because as each color is added to a black screen, they blend to form lighter colors.

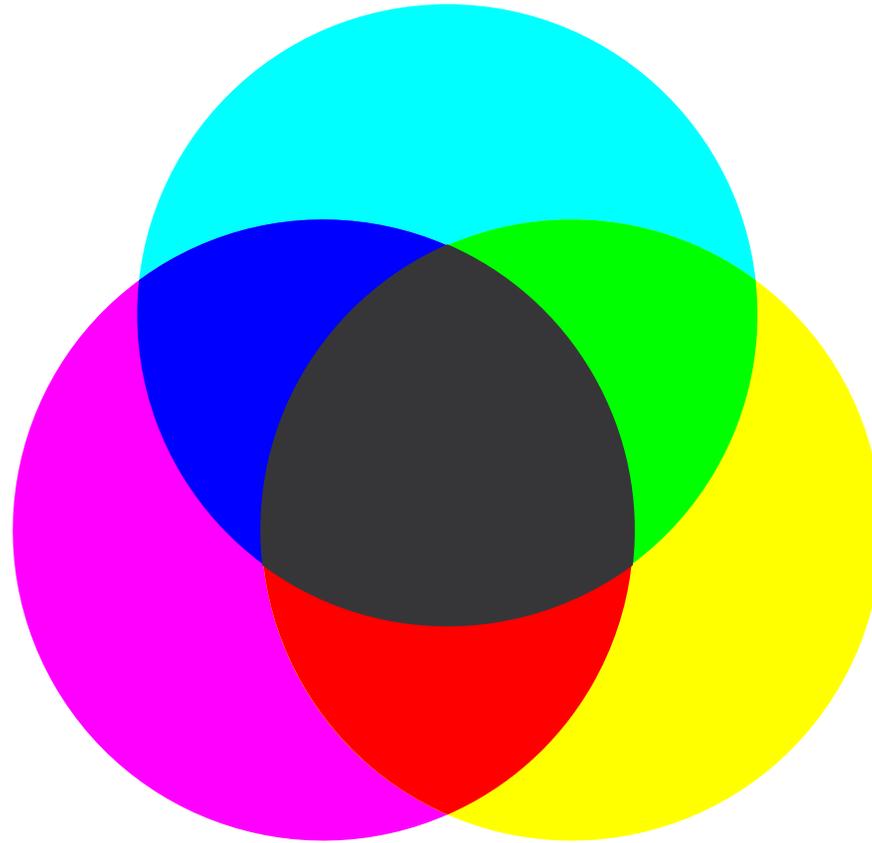


Where RGB overlap, **complementary colors** form. When we stared at the red square, we developed an after-image. When we switched to the white square, we saw that after-image as cyan, the complementary of red.



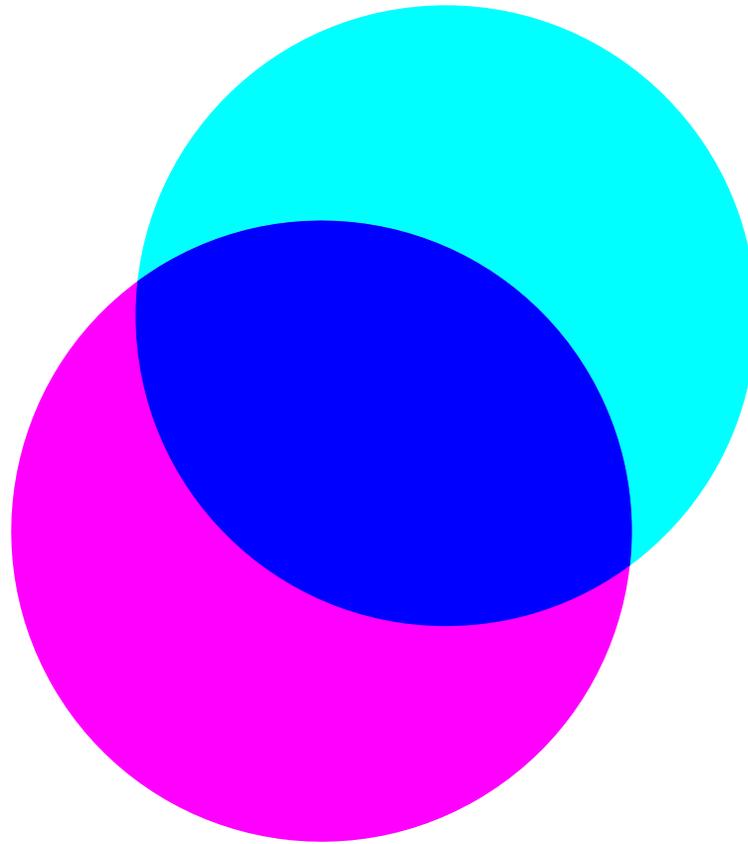
Projected color

With additive color, the three primaries of red, green and blue are projected one on top of the other to form a **composite image**. Where all three are present, such as the background, the result is white.

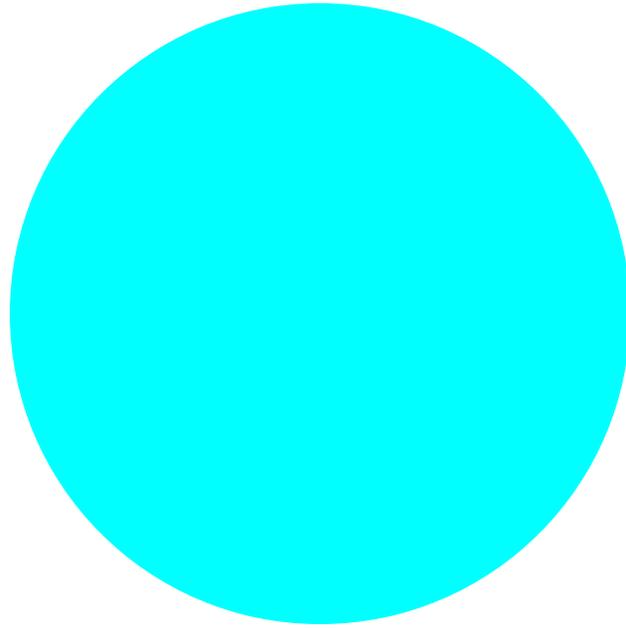


Subtractive color

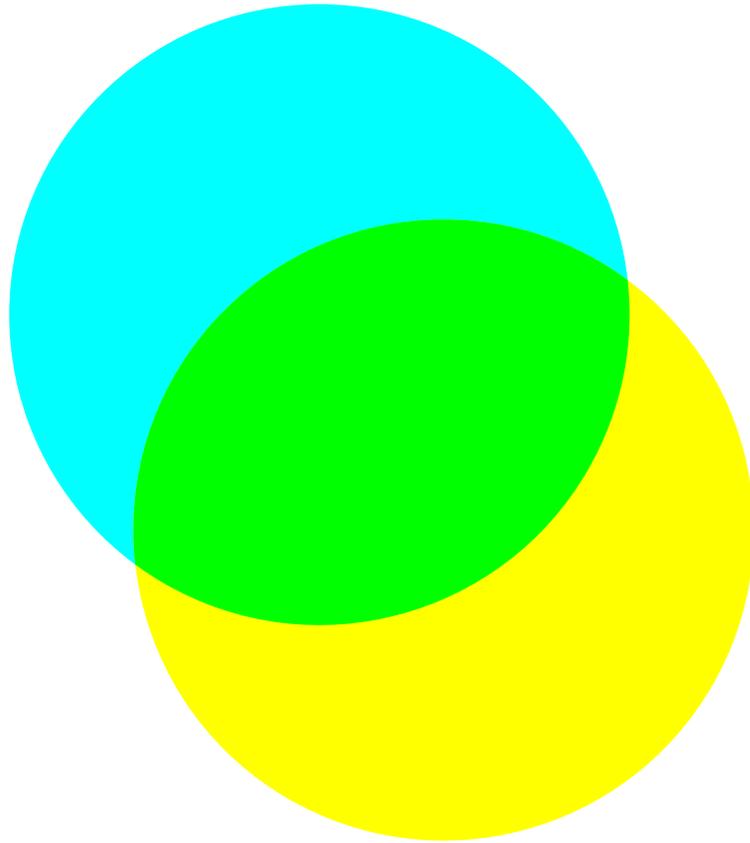
- Cyan, magenta and yellow for the **subtractive primaries**. These are complementary colors to red, green and blue.
- These subtractive primaries, along with black, are used in printing in what is known as the **four-color process**. The shorthand for this is CMYK, with “K” standing for black.



- With subtractive color, as we subtract color, we get closer to the white of the page.
- Where no ink is present, we see white, or as close to white as the paper gets.



- Because the paper is never pure white, and because the inks are never pure cyan, magenta and yellow, the colors can look dull without black to add shadow and detail.
- Subtractive color sometimes is called **reflected color** because it is used in printing, where the ink on the page absorbs colors of some wavelengths and reflects others.

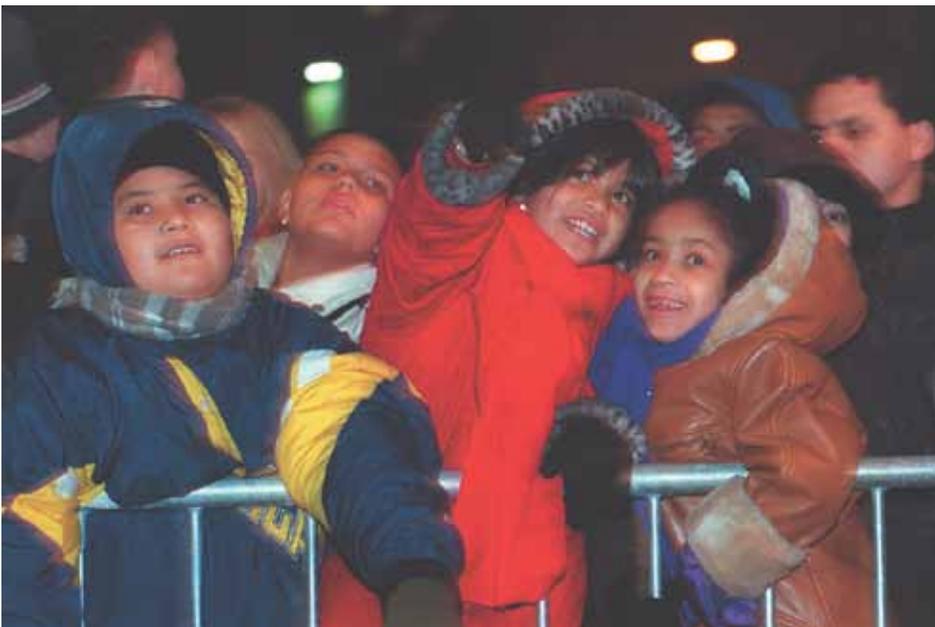


- Remember that in additive color, as we add more and more red, green and blue light, we approach white.
- With subtractive color, it's the other way. As we subtract cyan, magenta, yellow and black ink, we get closer to white.



A color separation

Before a color picture can be printed, it is **separated** into its CMYK. Digital pictures are stored in separate channels for each primary. With this separation, the white is produced by an absence of ink in any of the four colors.

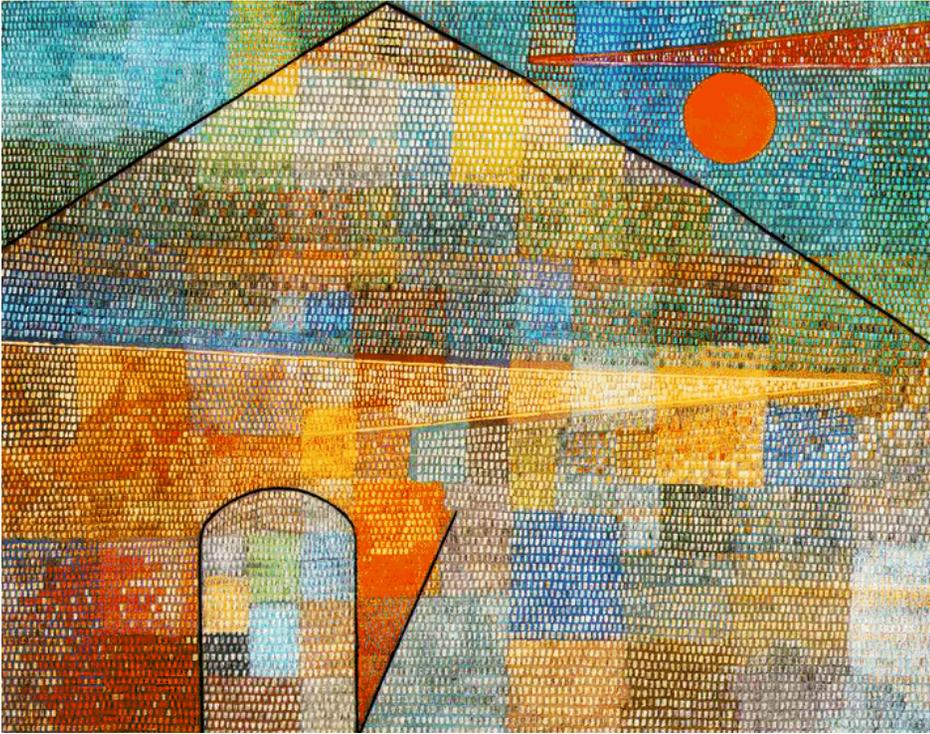


Black undercolor

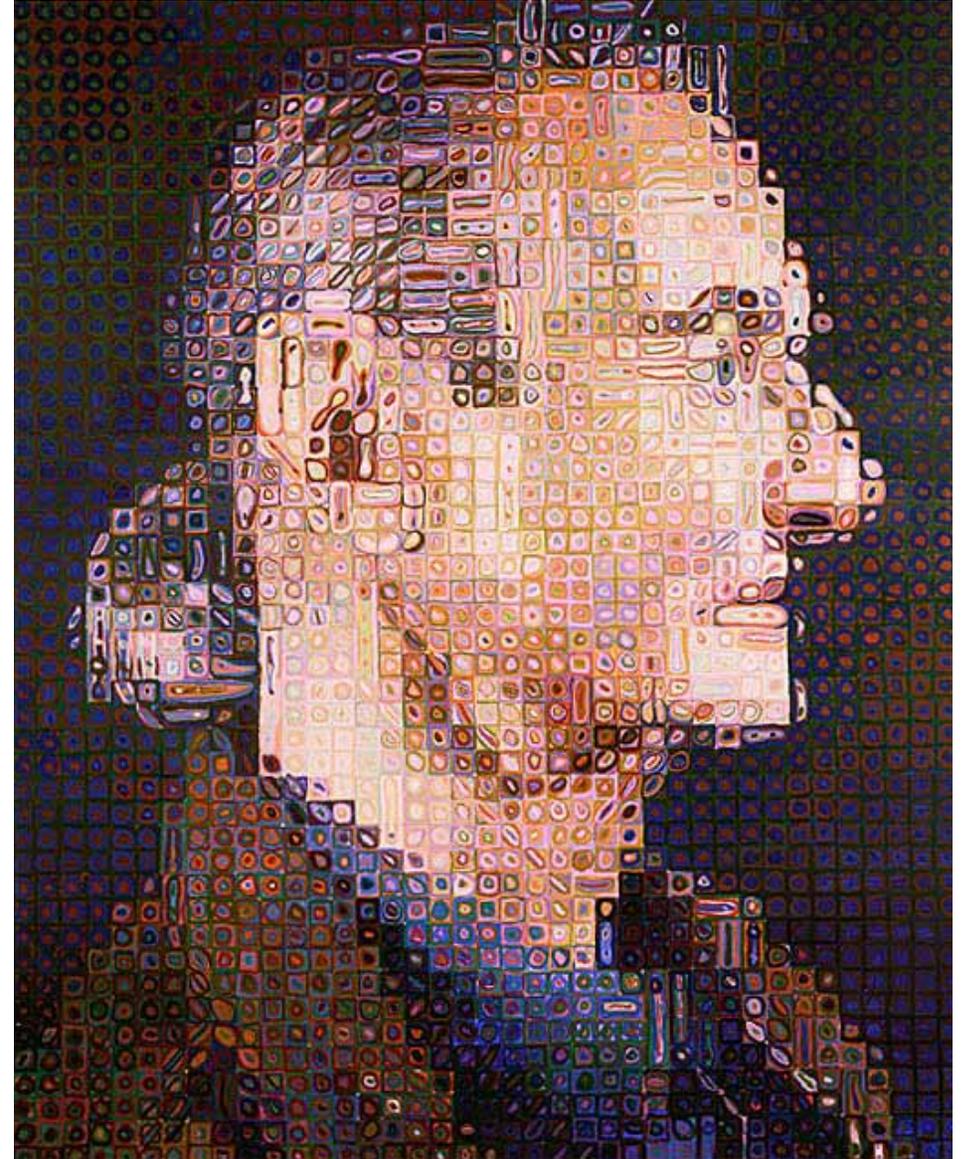
- Black ink is necessary because no ink is pure in color and no paper is a pure white.
- The black ink provides contrast and saves money because less colored ink is needed to make the black and gray tones.
- The picture to the left has no **black undercolor**.

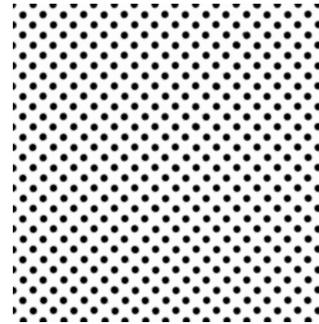
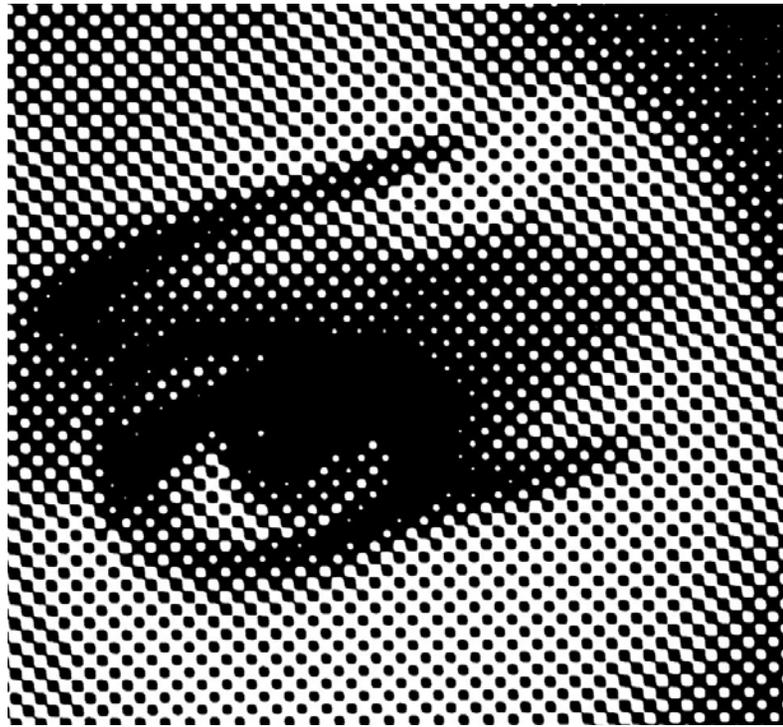


- The colors in additive or subtractive color are not “mixed” but rather presented individually. The eye does the “mixing,” creating an illusion of color similar to that of French artist George Seurat.
- Seurat portrayed the play of light by using tiny brushstrokes of contrasting colors. The style became known as *pointillism*.
- He created huge compositions with tiny, detached strokes of pure color too small to be distinguished when looking at the entire work; it made his paintings shimmer with brilliance.

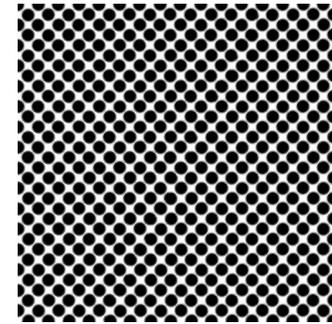


- Other artists have used similar techniques, believing that the colors seen by the eye appear more pure and vibrant than those created by mixing paint.
- Paul Klee used a mosaic technique (above), while Chuck Close uses small squares, each a tiny abstract painting, to produce an overall image.

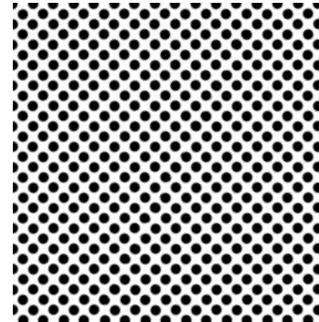




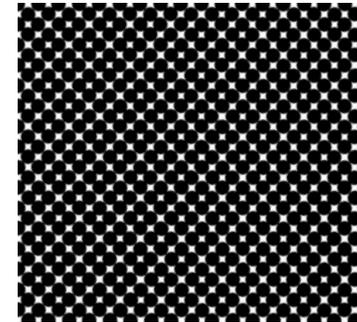
20% DOT PATTERN



60% DOT PATTERN



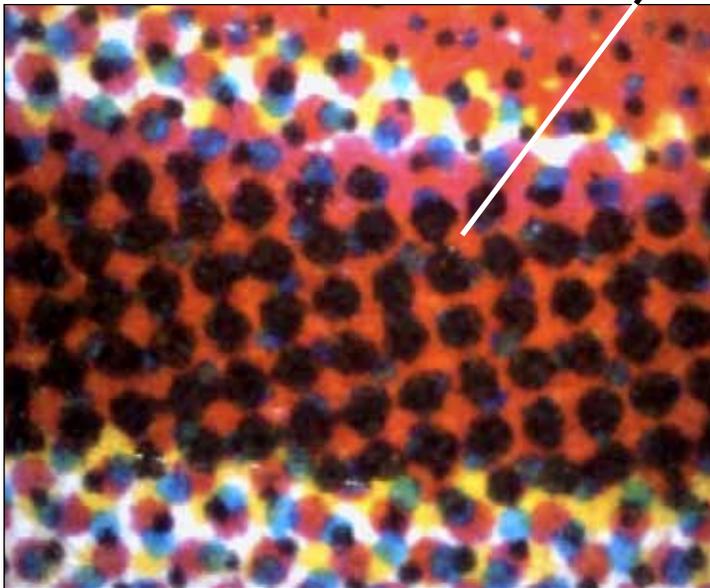
40% DOT PATTERN



80% DOT PATTERN

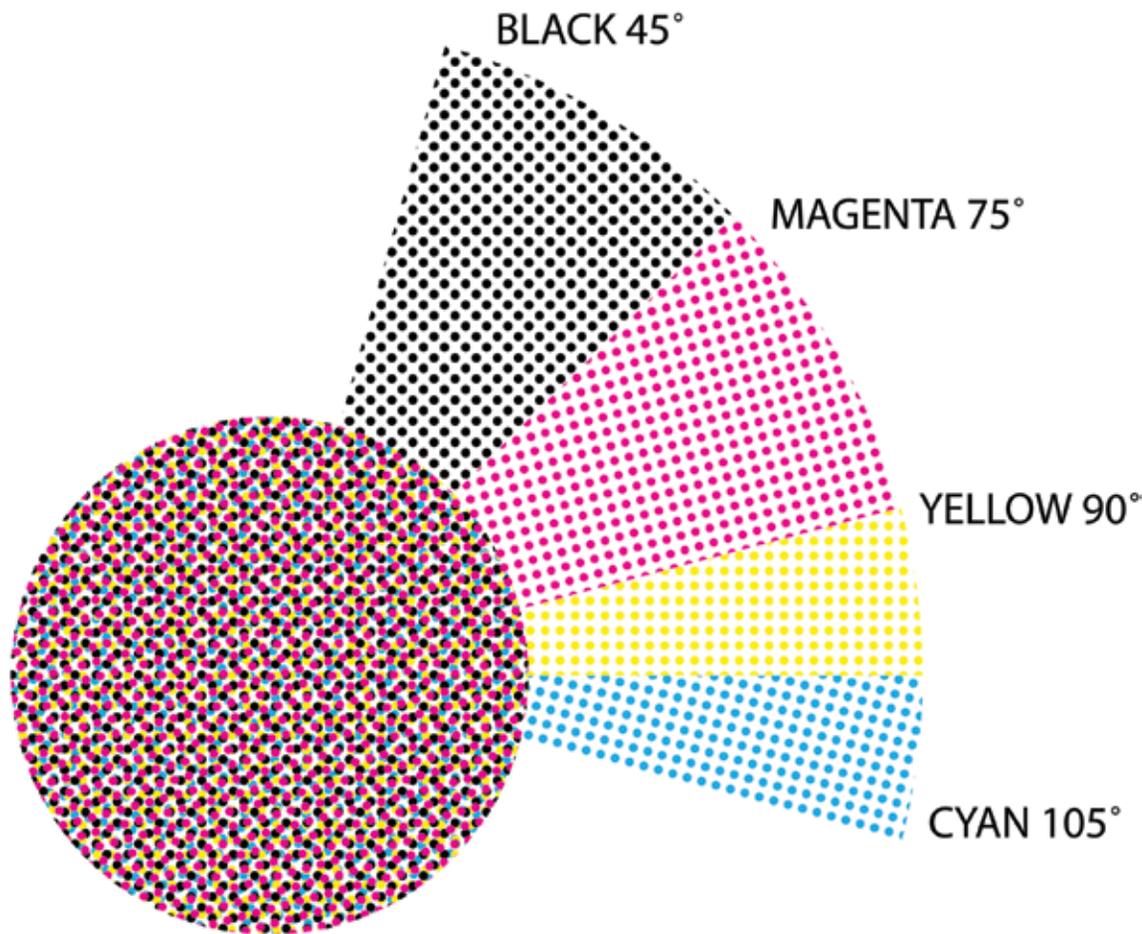
The grayscale halftone

- Black and white printing uses two tones: The white of the paper and the black of the ink. To simulate gray tones, printers use the **halftone process**.
- A computer algorithm analyzes the gray tones in a photograph and substitutes tiny dots of black to simulate the gray tone.
- The black dots vary in size, approaching complete coverage (100%) or dwindling to no coverage (0%). When the dots are very small, the eye sees gray that is almost white.

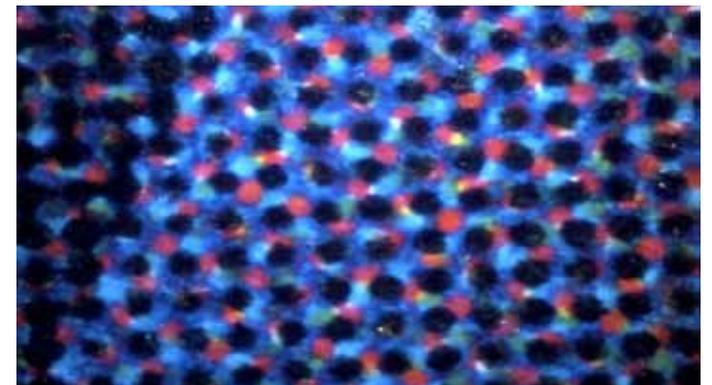
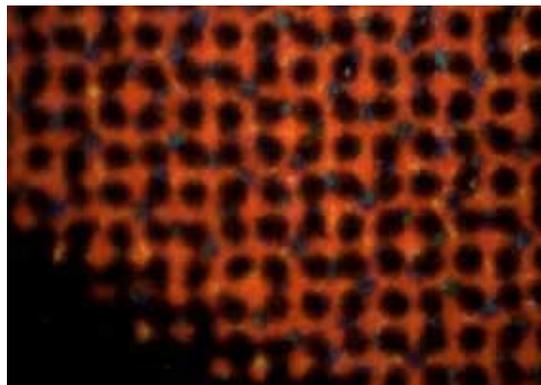
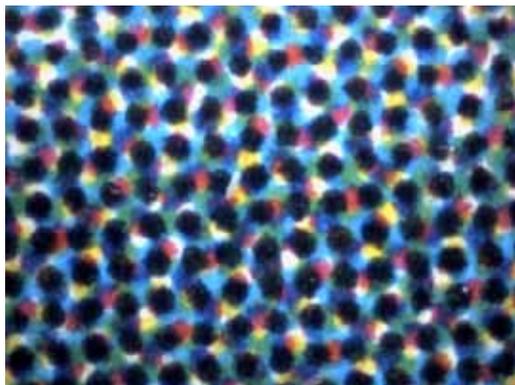


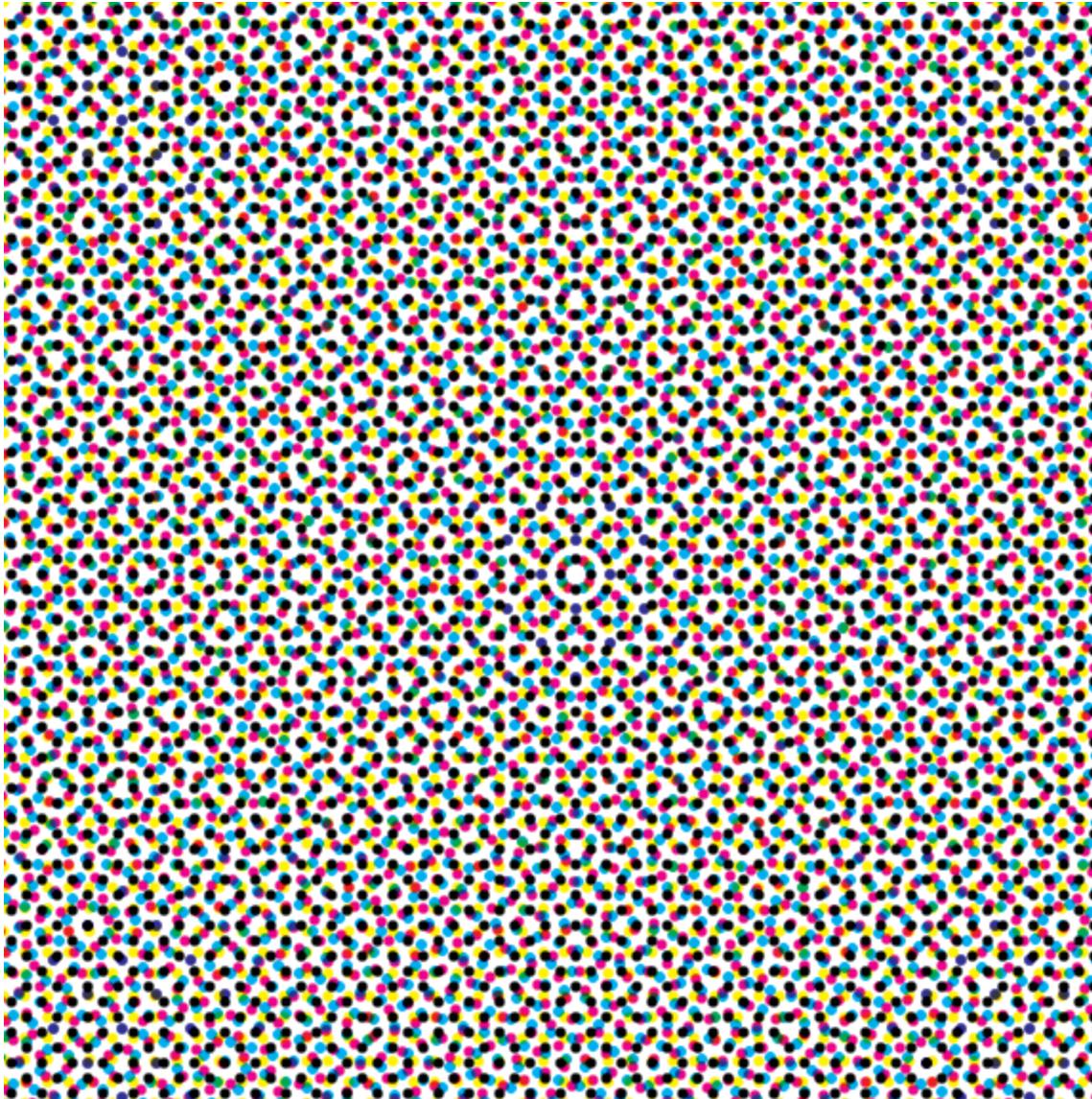
The color halftone

- In a color halftone, the image is **separated** into cyan, magenta, yellow and black.
- Each of the four images in the **separation** is converted into a halftone.
- As with black and white, the **density** of each of the colors is measured by the percentage the dots cover.



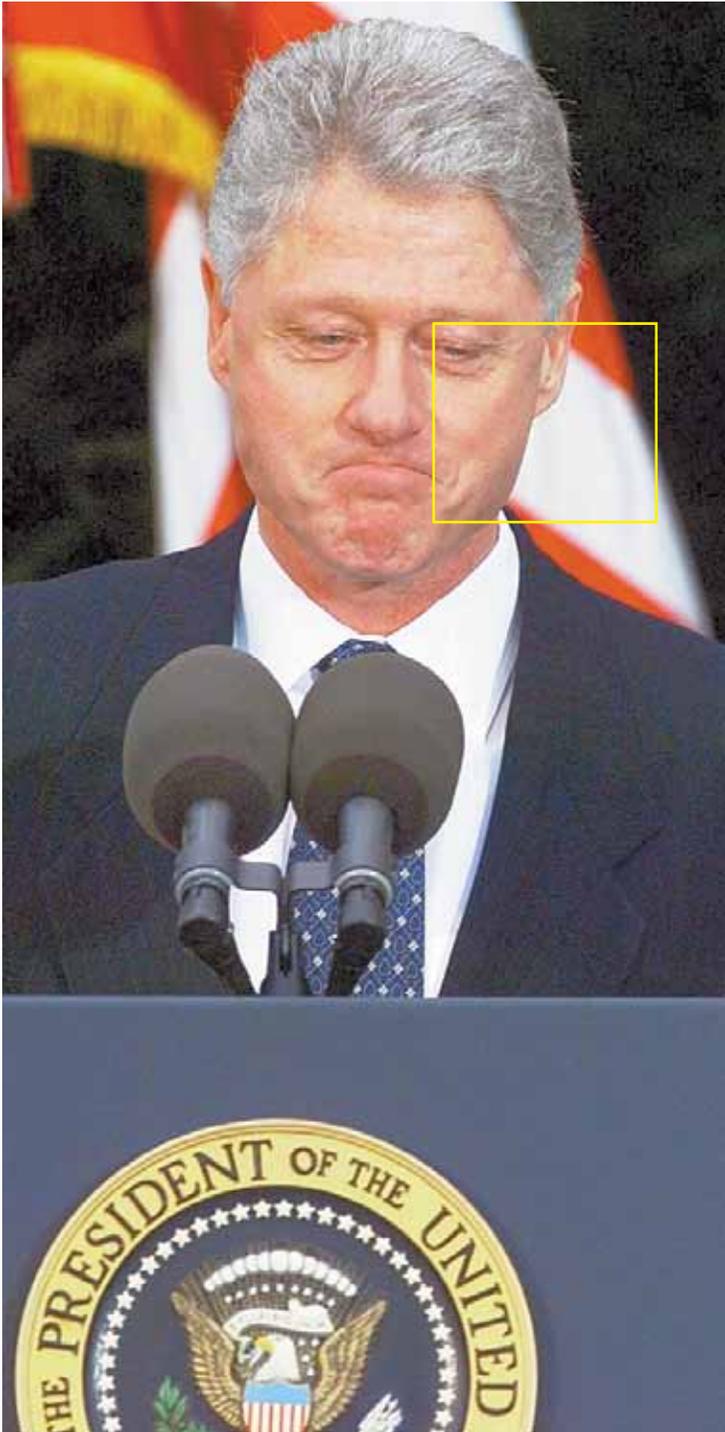
- Each CMYK color is printed separately one atop another.
- Each color of the halftone is printed at a different angle so that the dots do not overlap.
- Where the colors come together, “rosettes” form in a characteristic circular pattern.





- In this halftone sample, each of the four colors (CMYK) is printed with uniform 20-percent dots.
- In both color models, when all primaries are in equal amounts, a shade of gray is produced.





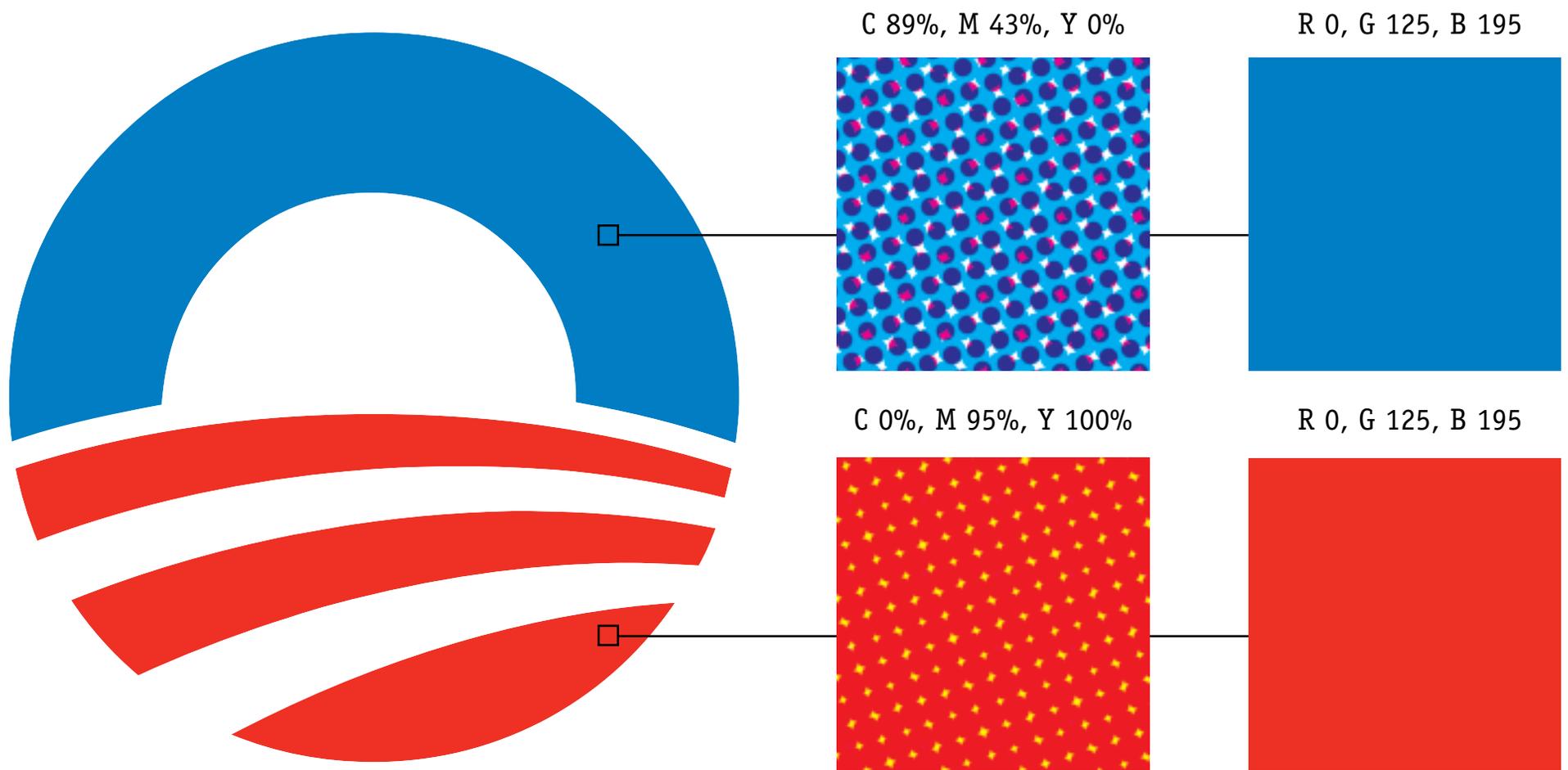
PRINTED HALFTONE



DIGITAL IMAGE

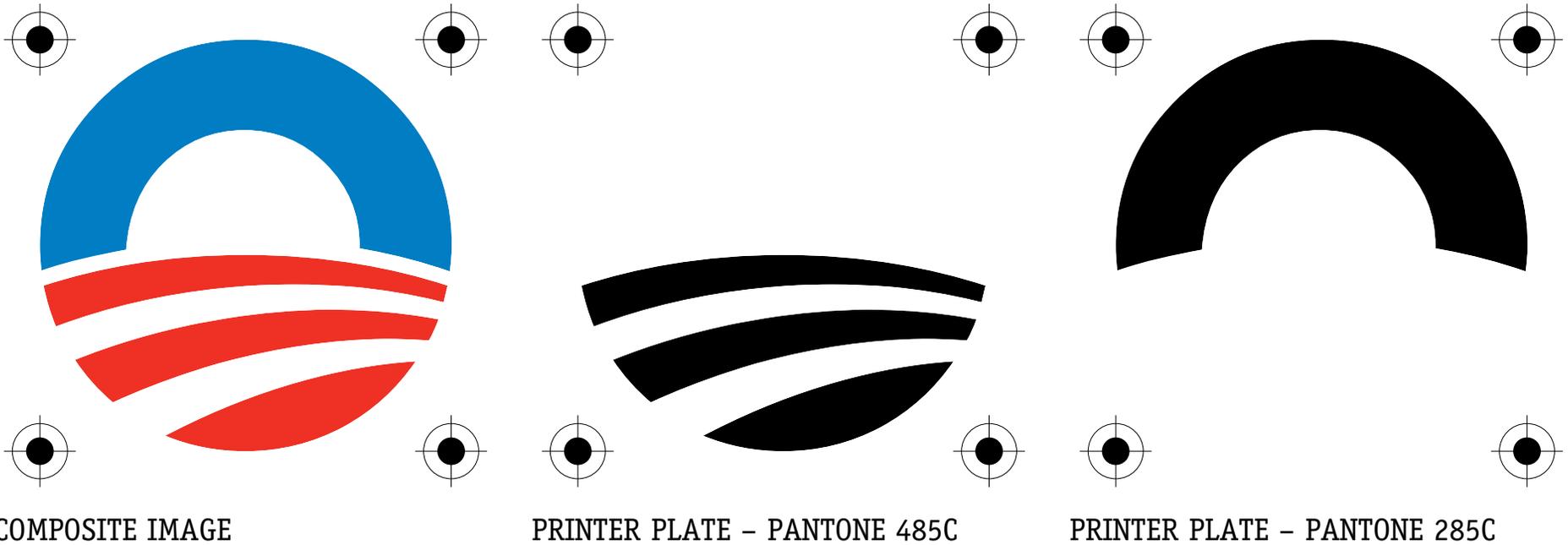
Photographic color

- In a photograph, even areas that look smooth and uniform in color will have small variations in dot size.
- Variations in dot size give the photo a 3D texture by adding depth of shadow and tone.
- In a digital photo, these variations can be seen by enlarging the photo until the pixels are visible.



Flat color

- For illustrations, color is applied in uniform percentages over large areas, producing **flat color**.
- The CMYK dots are even in size and are evenly spaced.
- In a digital images, pixels are uniform in color.



Spot color

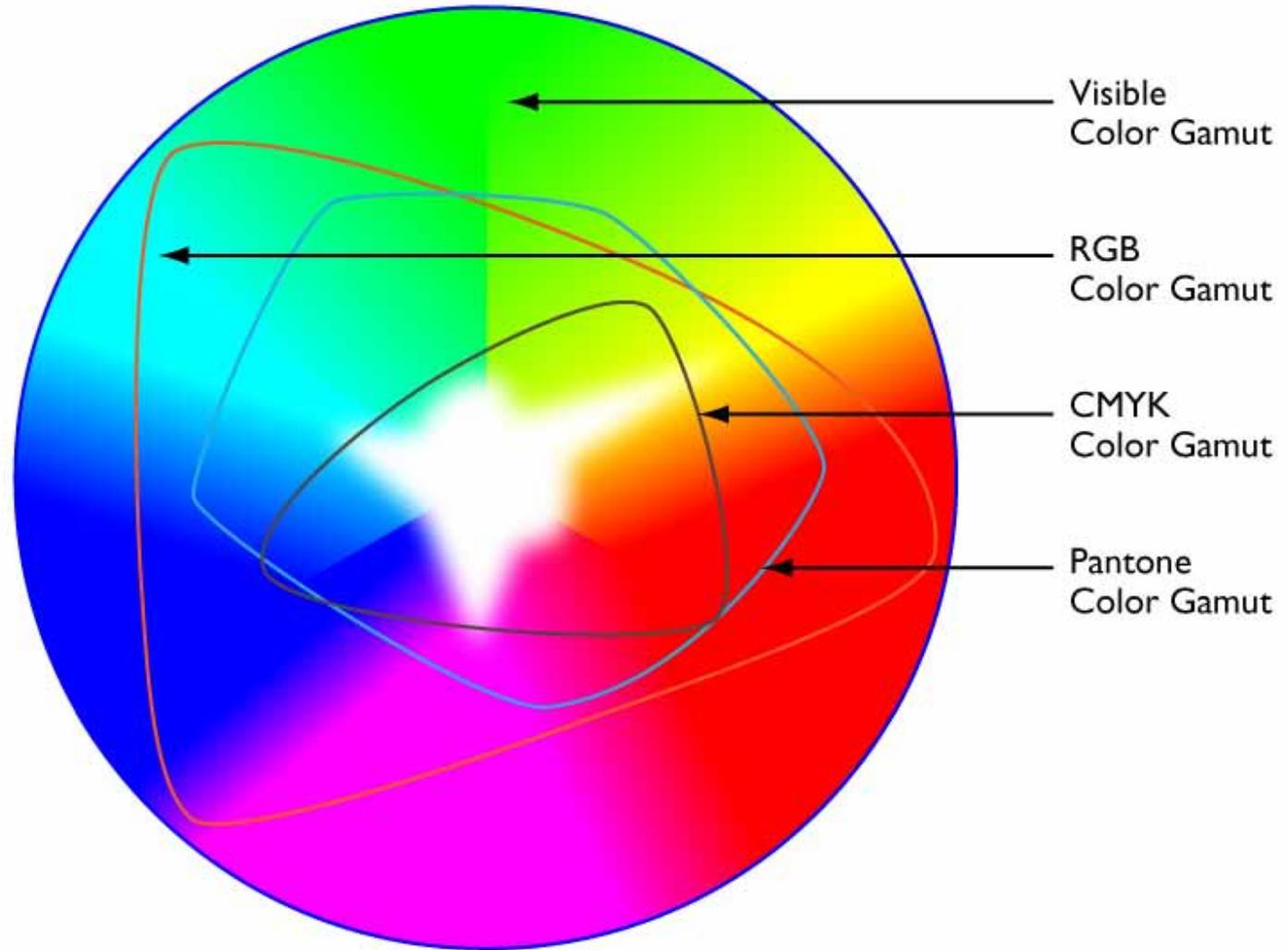
- Inks can be mixed like paint using a color matching system such as Pantone. The mixed ink can be used in flat-color illustrations.
- Using one or two **spot colors** saves money over four-color process.
- Spot colors are specified on the printing order.
- The printer looks up Pantone formula and mixes the ink.
- “C” stands for coated paper.

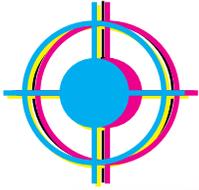


A printer mixes ink from a Pantone lookup chart.

Gamut

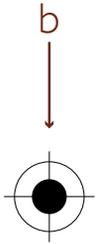
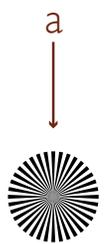
- A **color gamut** is a subset of colors that can be accurately represented within a given color space or by an output device.
- The additive gamut (RGB) and the subtractive gamut (CMYK) are radically different.
- Also, different monitors and printers vary in the gamut they can reproduce.



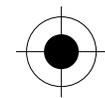
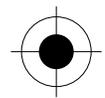
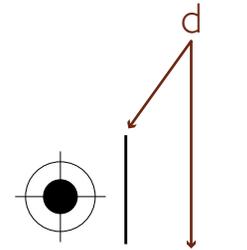


Registration

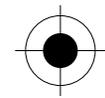
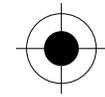
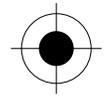
- When the paper goes through four press units, one for each color, it must be aligned exactly or the picture quality will suffer.
- The picture to the left is **'out of register.'**
- The press operator can adjust the position of each plate in with precision adjustment gears while the press is running at low speed. Pages are printed with color targets and density patches to aid in the process.



DAISY.TIF 200lpi 12/19/2008 4:39:20 PM
 PROCESS CYAN MAGENTA YELLOW BLACK



PRINTER'S MARKS
 a. star target
 b. registration mark
 c. page information
 d. trim marks
 e. color bar
 f. tint bar

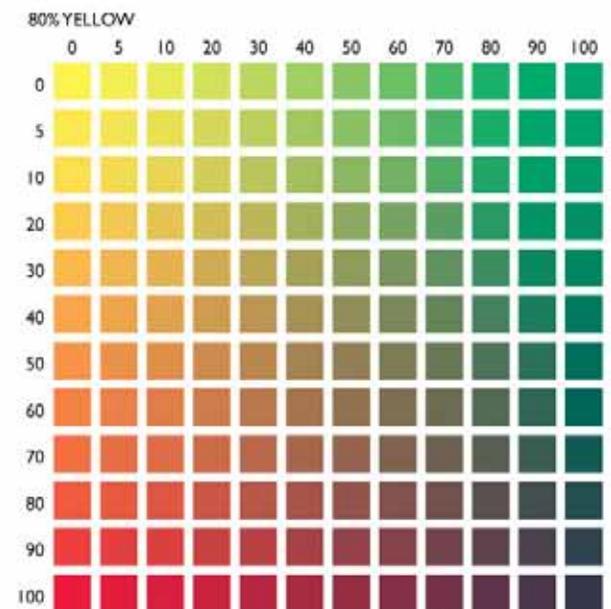
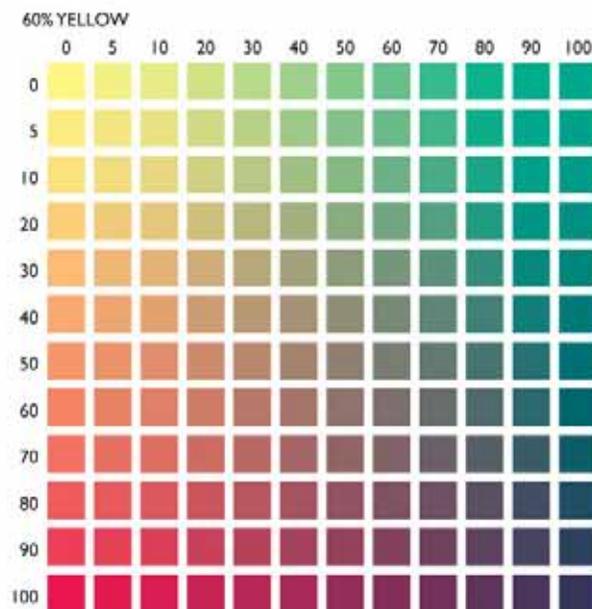
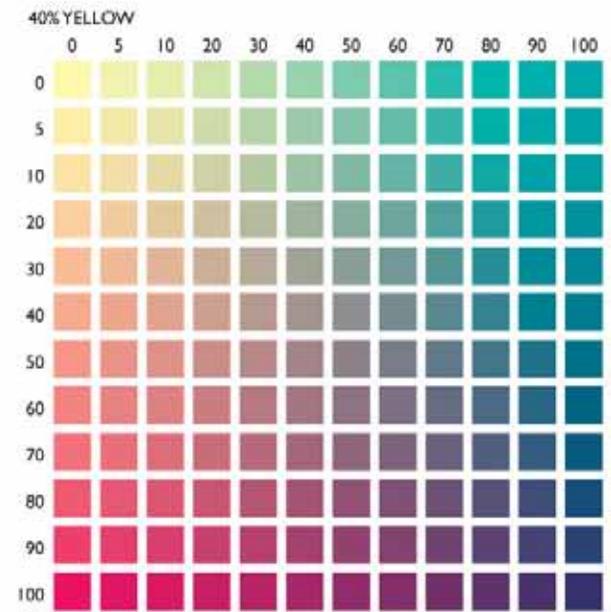
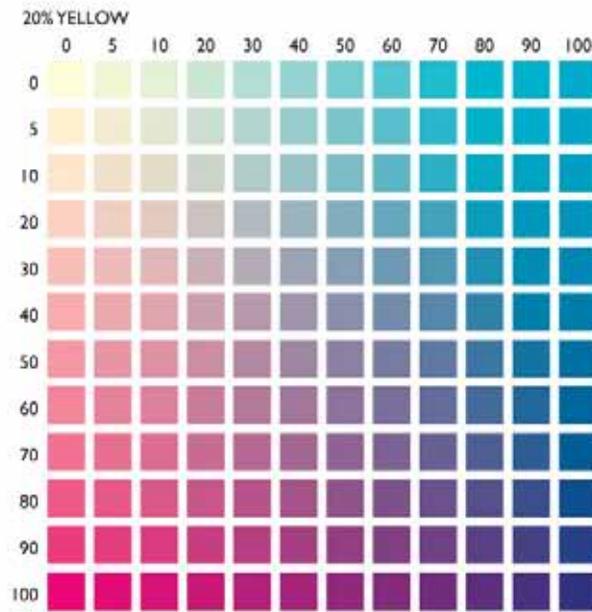




- Virtually every kind of printing, where ink is applied to paper, uses the four-color process. This includes giant web presses and ink-jet printers.
- All of these devices work the same way: Each of the four colors is applied separately in turn.
- Our eyes “mix” the colors.

Look-up charts

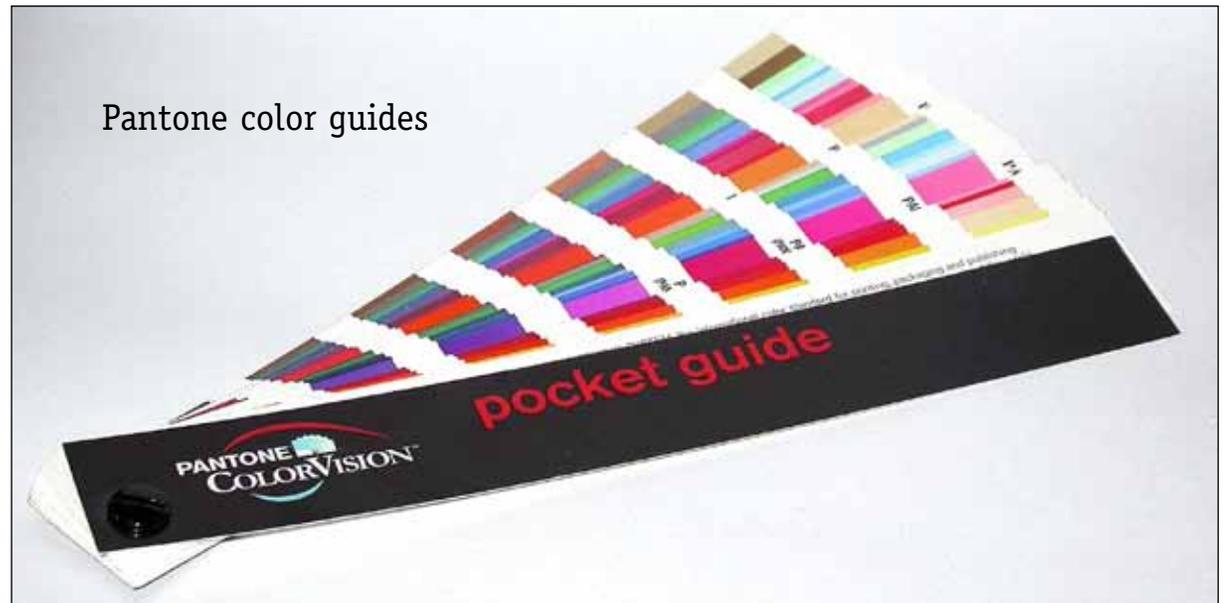
- For a specific flat CMYK colors, designers turn to a lookup chart.
- It's made up of squares with increasing percents of cyan, magenta and yellow. Sometimes black is added.
- These charts start with 20, 40, 60 and 80 percent yellow upper left.
- Cyan and magenta are added down and right, 10% at a time.



- Color lookup charts are printed on coated or uncoated paper, often on the press used for publication.

Pantone, DIC color

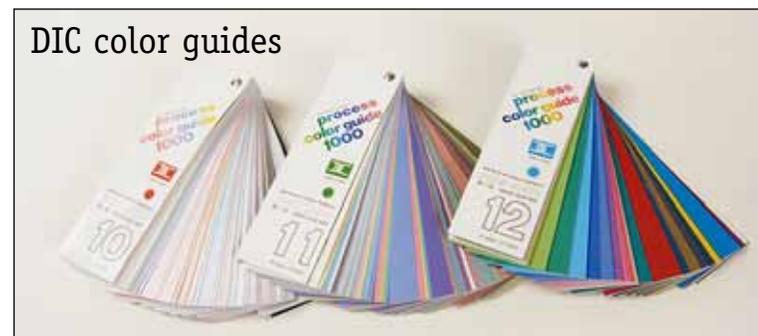
- Several companies offer color guides similar to the color chips found in paint stores. These include Pantone Color Matching and DIC, a Japanese company.
- The designer uses color guides to specify a spot or process color by number.
- Pantone is widely accepted by printers in the United States.



Pantone 021 CVU
(uncoated paper)



DIC 2527p



Pantone 021 converted
to process: 61% magenta
80% yellow



#663399	#BA5537
#502A77	#7791B6
#07004E	#C9B850
#746E9C	#822F5B
#000033	#DF9A71
#93A657	#4F0F0F
#948A71	#6139AB
#3A4C8A	#666666

The color palette

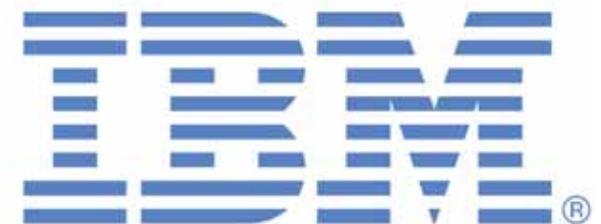
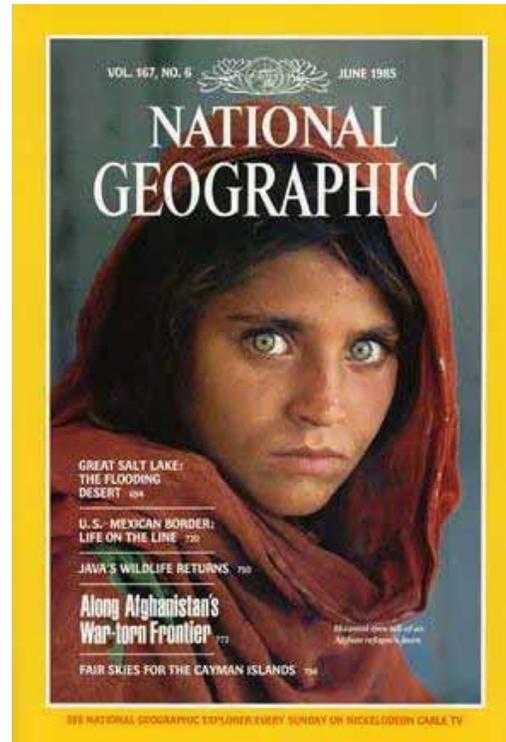
- Designers never work with an unlimited number of colors. They build a palette of the colors they hope will be identified with the publication or product.
- In advertising, the color palette is important because it becomes tied closely with product identification. Colors are chosen for personality and for how well they work together.



Color palette and identity

- Choose your color palettes carefully, then use those colors consistently.
- Color is so closely tied to identity that a company such as IBM can come to be known as “Big Blue.”
- The yellow square around the National Geographic cover has become a trademark all by itself.
- The best color palettes have meaning beyond consistency. These palettes are chosen for mood, to convey meaning.

Choose your color palette carefully!



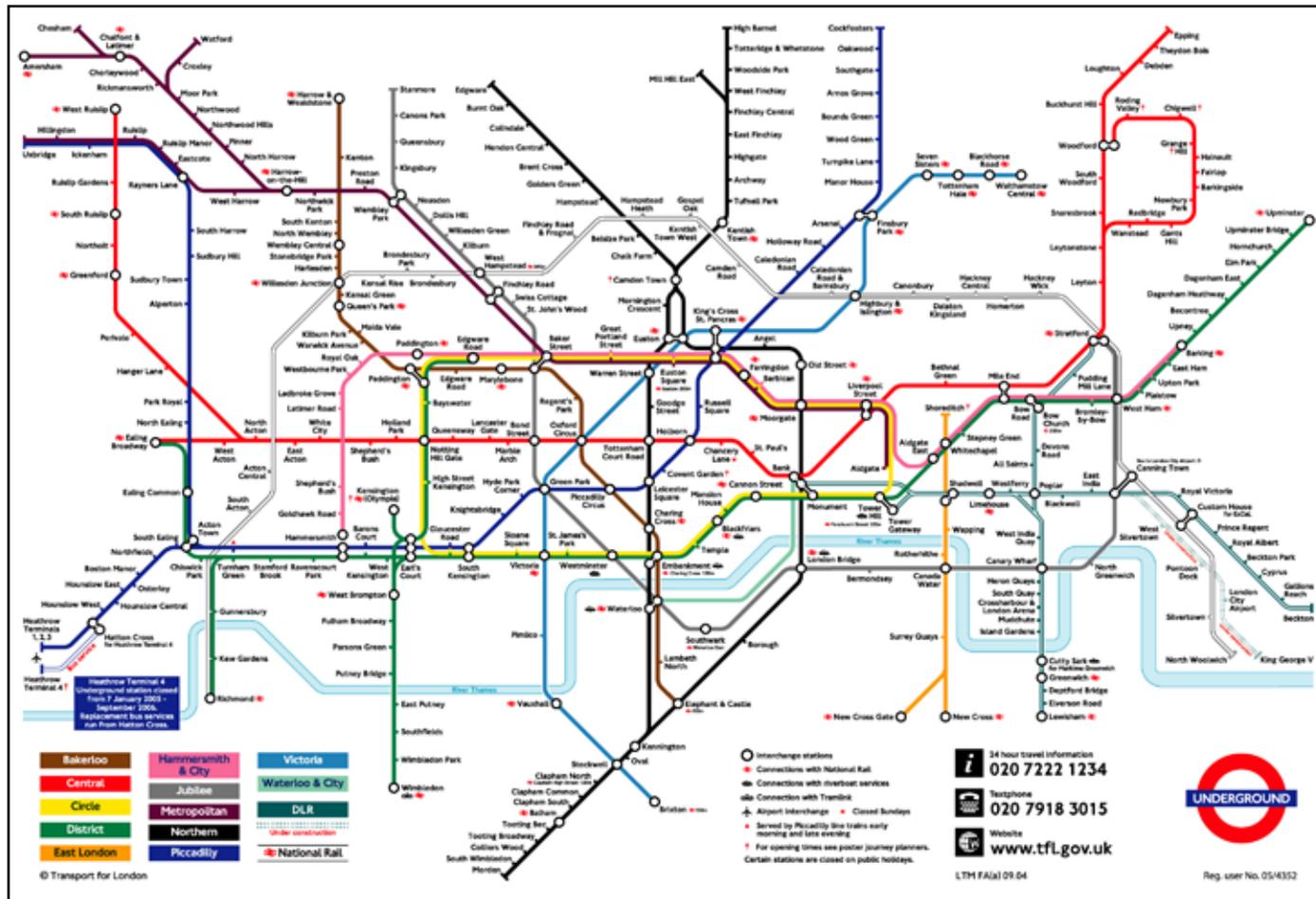
#663399	#BA5537
#502A77	#7791B6
#07004E	#C9B850
#746E9C	#822F5B
#000033	#DF9A71
#93A657	#4F0F0F
#948A71	#6139AB
#3A4C8A	#666666

The University of St. Thomas specified this palette of colors that are allowed on its web pages.



McDonald's color palette hasn't changed in 50 years.

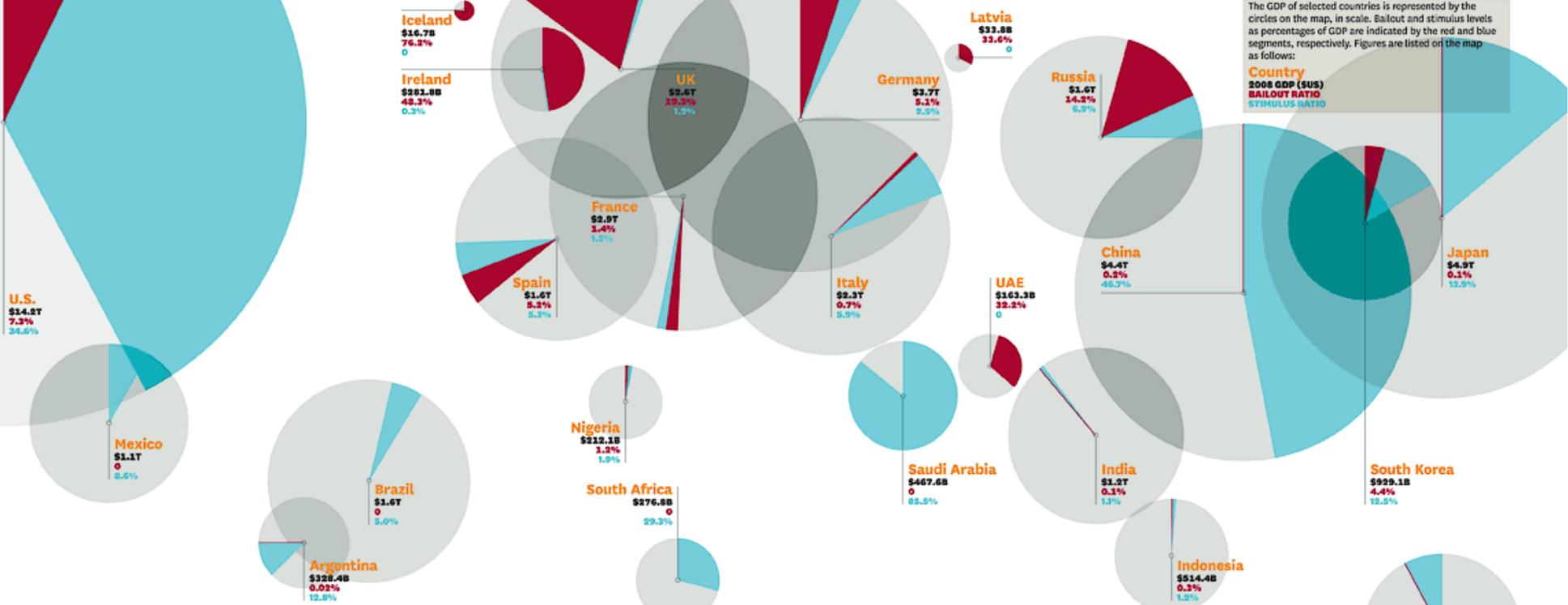




Color as information

Color provides layers of information, organizing complex graphics into something that is easy to follow. This London subway map uses colors coordinated with various train routes.

Vision Statement



How to Read This Chart
 The GDP of selected countries is represented by the circles on the map, in scale. Bailout and stimulus levels as percentages of GDP are indicated by the red and blue segments, respectively. Figures are listed on the map as follows:
Country
2008 GDP (\$US)
BAILOUT RATIO
STIMULUS RATIO

A Map to Healthy—and Ailing—Markets

The economic crisis will influence business long into recovery. As strategists target global investments, they need to understand the effects of bailout and stimulus programs. Calculating these interventions as percentages of GDP helps identify which economies will be stressed and which will have the resources to bounce back.

Bailout
 A high bailout-to-GDP ratio—a large slice of red in the pie—usually indicates financial stress and instability that will extend the economy's recovery time. Countries with the highest bailout percentages are mostly in the West, where the crisis originated. (Three-quarters of all bailout money was allocated in Western nations and accounts for 7.8% of their combined GDP.) Others, like the

United Arab Emirates, were deeply invested in Western financial markets and real estate. For instance, despite similar conservative stances regarding leverage, the UAE and Saudi Arabia experienced markedly different recessions because the UAE did not strictly enforce its policies. Countries with high percentages not pictured here include Hungary (20.6%), Qatar (17.9%), and Norway (12.5%).

Stimulus
 The stimulus-to-GDP ratio is more complicated. A high percentage of stimulus—a large slice of blue—indicates that the country is deeply affected by the recession but also willing and able to drive recovery through public policy. Although Eastern economies didn't use much bailout money, they received 40% of all stimulus funds—amounting to a 20.6% stimulus-to-GDP ratio (\$3.7T), compared

with Western economies' 14.0% ratio (\$5.7T). Given the scope of global trade and the West's demand for Eastern goods and services, the recession reached beyond Western financial markets. This was a global economy in action: The source of the trouble was local; its effect, worldwide. Eastern nations including China and Japan have invested substantial funds in aviation, shipbuilding, textiles, and

petrochemicals. South Korea has chosen to prop up small and midsize businesses and, like China, to invest more heavily than the U.S. in green projects such as solar energy and clean transportation.

TOTAL BAILOUT
\$3.6T
5.73% OF WORLD GDP
\$515 BAILOUT PER CAPITA

TOTAL STIMULUS
\$9.4T
15.39% OF WORLD GDP
\$1,382 STIMULUS PER CAPITA

Grail Research is a strategic research firm based in Cambridge, Massachusetts. The design firm de Luxe & Associates is based in Sydney.

HBR Reprint F1001E

Another example of color as information