

Best Color Palettes for Scientific Figures and Data Visualizations

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Choosing the right colors for your data visualizations improves audience comprehension and makes your work accessible to people with color blindness. Color is also an important element of designing scientific graphs and data visualizations because it is a powerful storytelling tool.

Below is a comprehensive guide that will help you create your own effective scientific color palettes and provides resources to help you apply the selected colors in different data visualization platforms.

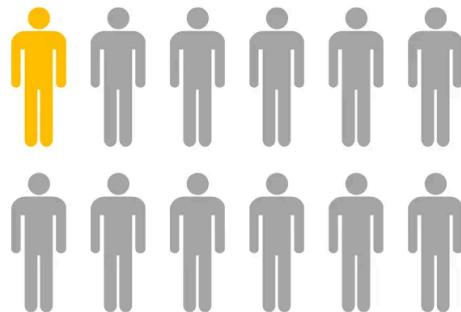
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What is a Color Palette and Why Should I Care?

A color palette is a set of colors that you use within a visual. For scientific purposes, carefully selected color palette can be a powerful tool that helps you tell your scientific story. For example, the use of blue and red on a heat map makes the audience think hot (increase) or cold (decrease), the use of green and brown on a map can tell a story of rainfall impact or vegetation density.

Vision Deficiencies (CVD), also known as color blindness. Approximately 1 in 12 men and 1 in 200 women experience different forms of CVD, so it is a common occurrence that requires understanding which color combinations are hard for people to distinguish.



1 in 12 Men



1 in 200 Women

The percentage of people with Color Vision Deficiency (CVD) in the world

How to Find the Best Scientific Color Combinations

Choosing opposing colors on the color wheel are some of the best color combinations.

These colors can help people understand your data story and are also the most accessible for people with color blindness and other color perception difficulties. However, it is important to note that you should not feel limited by only using these options.

Choose colors from opposite sides of the color wheel for a color blind person to better understand your data story.



Use Color Saturation and Lightness to Create Contrast

You can use any combination of colors as long as they are highly contrasting, even if they are different shades of the same color. The three main color characteristics are hue, saturation, and lightness. You can adjust any three of these characteristics to create an effective scientific color palette using any colors that best represents your dataset.

	HEX	RGB	HSL
 Hue	#c1272d	rgb(193,39,45)	hsl(357.66,66.38%)
 Saturation (0 - 100)	#e7bcfc	rgb(231,188,188)	hsl(0.47,25%,82.1)
 Lightness (0 - 100)	#8d1f17	rgb(141,31,23)	hsl(4.07,95%,32.1)

Color characteristics and color code examples

In order to test which colors are best for your scientific project and keep them uniform across different platforms, you need to know that every color is defined by different kinds of codes. The three main color codes that you need to know for scientific publications and presentations are “hex”, “rgb”, and “hsl”, which are a six-digit codes that you can use to identify the exact colors that you want. These color codes are consistent across design tools such as Adobe Illustrator, Excel, PowerPoint, Prism, Google Slides, websites platforms, etc. You may also need to know the CMYK or grayscale codes for different graphing and data visualization tools.

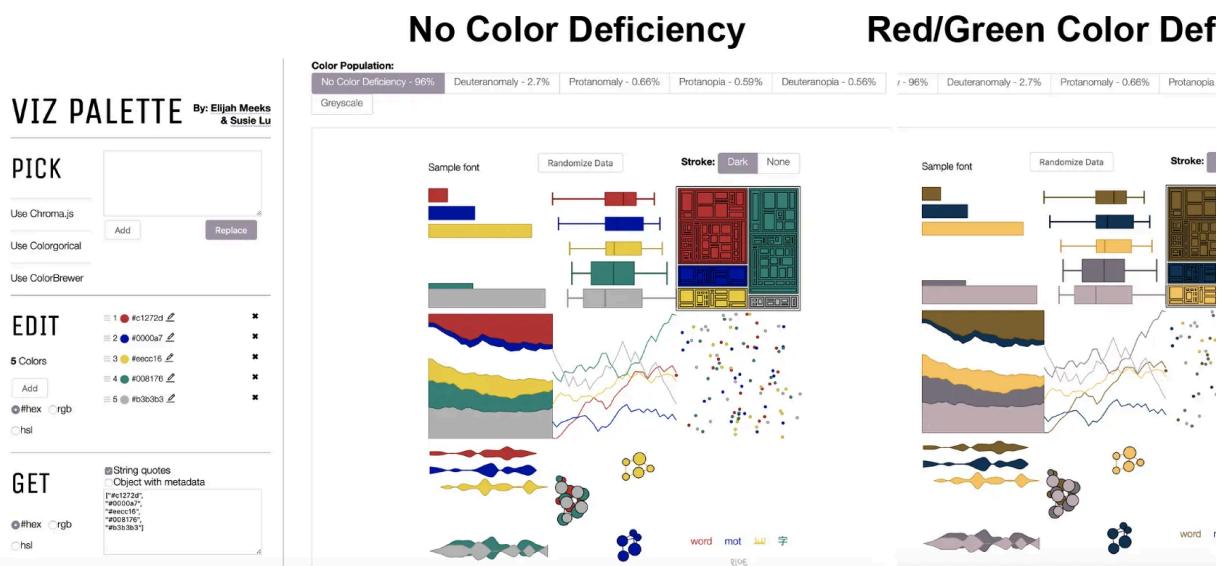
To find different color codes, I recommend that you use the tools below:

- **Toptal Color Plate Tool** - Use this color tool to create, visualize, and download color palettes based on monochrome, analogic, complementary, triad, and quad HEX code color palette: <https://www.toptal.com/designers/colourcode>.
- **Google Color Picker** - Online tool where you can use a color slider to find the HEX, RGB, CMYK, and HSL color codes: <https://g.co/kgs/qDGrn3rn3>.
- **Image Color Picker** - Online tool where you can upload an image or provide a URL and get the RGB Color, HEX Color and HSL Color codes from the image: <https://imagecolorpicker.com/en>.

Use the Viz Palette Tool to Test for Color Accessibility

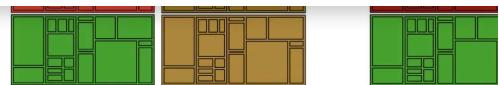
After you choose a potential color palette for your scientific graphs, posters, or presentations, we recommend that you check whether your colors are accessible to people with all types of color blindness using a fantastic tool called "Viz Palette" by Elijah Meeks & Susie Lu: <https://projects.susielu.com/viz-palette>.

The Viz Palette tool allows you to enter the HEX, RGB, or HSL color codes in the Edit section, then test how people with different types of CVD will see the colors. The example below shows how the tool allows you to see what a set of colors looks like to a person with red/green color blindness and also shows the gray scale view. If your chosen color palette is not full, you can make adjustments to some of the color's hue, saturation, and lightness until it meets the tools requirements for the fewest color conflicts.



Viz Palette by Elijah Meeks & Susie Lu: <https://projects.susielu.com/viz-palette>

color conflicts for people with color blindness. However, if it is important to your data story, you can use red and green colors together as long as you apply different saturation and lightness to increase the contrast. (See example where high contrasting red and green colors can be used together without a conflict).



Accessible Color Palettes for Charts Graphs

The best color palettes for data visualizations are accessible to a wide audience and [data storytelling](#). The examples below provide color combinations and hex codes for bar charts, line graphs, and pie charts that work well for scientific publications. These include hex codes and provide options for sequential, qualitative and divergent color

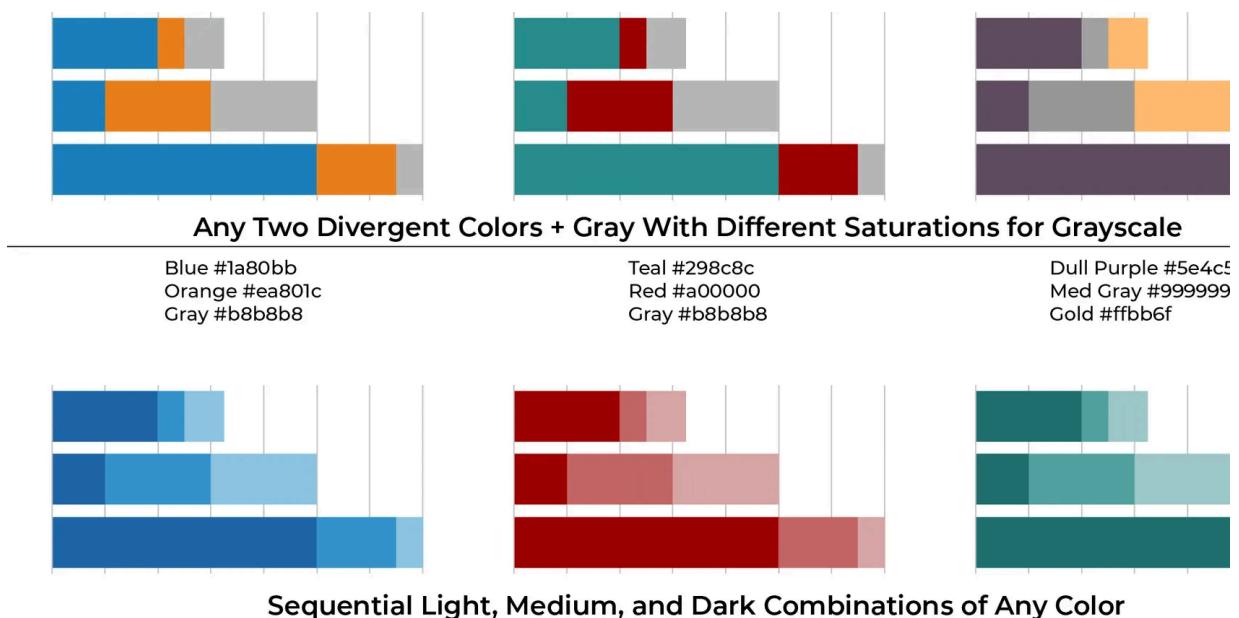
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Two Color Combinations for Bar Graphs



Bar graph color palette examples

Three Color Combinations for Bar Graphs



Stacked bar chart color palette examples



Any Four Divergent Colors with Different Saturations for Grayscale

Blue #0000a2
Red #bc272d

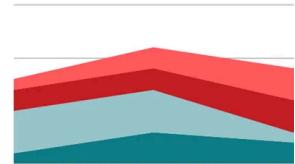
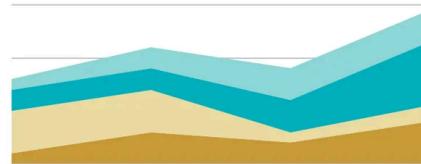
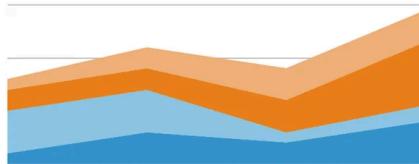
Yellow #e9c716
Teal #50ad9f

Purple #4a2377
Blue #8cc5e3

Pink #f55f74
Teal #0d7d87

Red #d31f11
Orange #f47a00

Light T
Dark T



Sequential Light and Dark Pairs of Any Two Divergent Colors

Med Blue #3594cc
Light Blue #8cc5e3

Med Orange #ea801c
Light Orange #f0b077

Med Brown #c99b38
Light Brown #eddca5

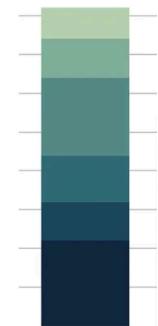
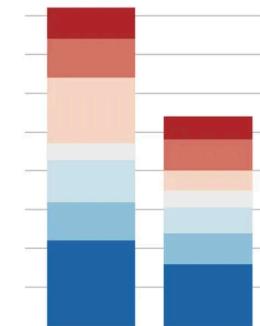
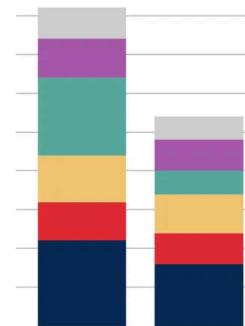
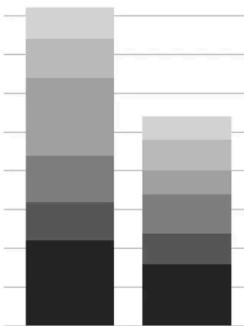
Med Teal #00b0be
Light Teal #8fd7d7

Dark Teal #0d7d87
Light Teal #99c6cc

Dark
Light

Line graph color palette examples

Six Color Combinations for Charts



Any Six Contrasting Colors with Different Saturations

Grayscale

G1 #262626
G2 #595959
G3 #7f7f7f
G4 #a1a1a1
G5 #bababa
G6 #d4d4d4

Qualitative

Gray #cecece
Purple #a559aa
Teal #59a89c
Gold #f0c571
Red #e02b35
Dark Blue #082a54

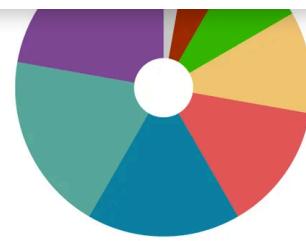
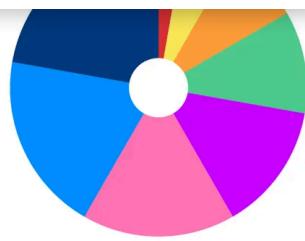
Divergent (Heat maps)

Dark Blue #2066a8
Med Blue #8ec1da
Light Blue #cde1ec
Gray #eddede
Light Red #f6d6c2
Med Red #d47264
Dark Red #ae282c

Seque

Teal 1 #b
Teal 2 #8
Teal 3 #f
Teal 4 #:
Teal 5 #1
Teal 6 #:

Color palette examples for six variables



Any Eight Contrasting Colors

Grayscale

G1 #0d0d0d
G2 #262626
G3 #595959
G4 #7f7f7f
G5 #a1a1a1
G6 #bababa
G7 #d4d4d4
G8 #eddeded

Bright

Dark Blue #003a7d
Med Blue #008dff
Pink #ff73b6
Purple #c701ff
Green #4ecb8d
Orange #ff9d3a
Yellow #f9e858
Red #d83034

Muted

Gray #c8c8c8
Gold #ffcc51
Teal #59a89c
Blue #0b81a2
Red #e25759
Dark Red #9d2c00
Purple #7e4794
Green #36b700

Alterna

Light Blue
Med Blue
Light Pink
Med Pink
Light Green
Med Green
Light Orange
Med Orange

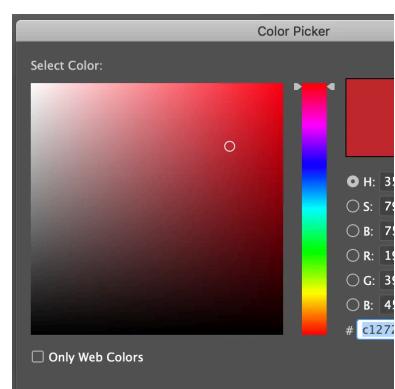
Pie chart color palette examples

Color Guides for Data Visualization Platforms

Data visualization platforms have different options for applying color and using the color palette. Below are resources to help you apply the best colors for graphing platforms such as Adobe Illustrator, Excel, R, Tableau, MATLAB, and Map Generators.

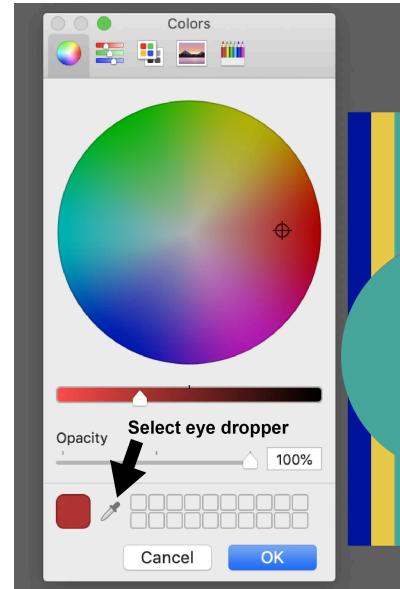
Color Palettes in Adobe Illustrator

- Color palettes in Adobe Illustrator are called swatches and can be used to make your scientific publications, figures, and posters have professional color consistency.
- The main tool is called the Color Picker where you can enter the exact HEX code or choose any color from the sliders.



Color Palette Tools in Microsoft Excel and PowerPoint

- There are many different versions of Microsoft Excel and PowerPoint, but most of them have an "eye dropper" tool in the color formatting section that allows you to select any color that is available on your screen. This is helpful if you want pull colors from an example image, such as your institution's logo, an example color palette image, or an image with your predefined HEX code colors.
- Some versions of Microsoft will also allow you to directly enter the HEX code in the color formatting settings.
- To find which color tools are available for your version of the software, select the graph, text, or shape element that you want to change using "CTRL + Click" or the Right Click on your mouse and select the color formatting options from the menu options that appear.



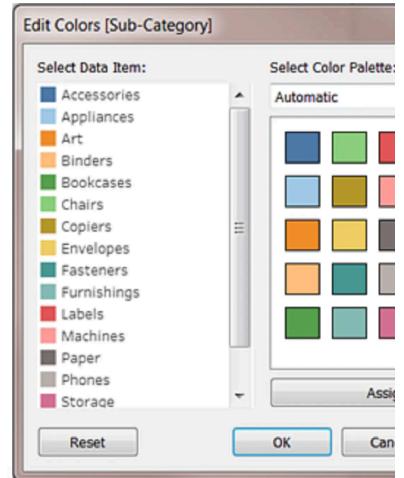
Resource:

- <https://github.com/EmilHvitfeldt/r-color-palettes>
- To learn how to apply color in R, I recommend using the open resources available from the University of British Columbia:
https://www.stat.ubc.ca/~jenny/STAT545A/block15_colorMappingBase.html

burlywood4	cadetblue	cadetblue1	cadetblue2
cadetblue4	chartreuse	chartreuse1	chartreuse2
chartreuse4	chocolate	chocolate1	chocolate2
chocolate4	coral	coral1	coral2
coral4	cornflowerblue	cornsilk	cornsilk1
cornsilk3	cornsilk4	cyan	cyan1
cyan3	cyan4	darkblue	darkblue1
darkgoldenrod1	darkgoldenrod2	darkgoldenrod3	darkgoldenrod4
darkgreen	darkgrey	darkkhaki	darkkhaki1
darkolivegreen1	darkolivegreen2	darkolivegreen3	darkolivegreen4
darkorange1	darkorange2	darkorange3	darkorange4
darkorchid1	darkorchid2	darkorchid3	darkorchid4
darksalmon	darkseagreen	darkseagreen1	darkseagreen2
darkseagreen4	darkslateblue	darkslategray	darkslategray1
darkslategray3	darkslategray4	darkslategray	darkslategray1
deeppink	deeppink1	deeppink2	deeppink3
deepskyblue	deepskyblue1	deepskyblue2	deepskyblue3

Colors Palettes in Tableau

- To learn how to apply color to data visualizations in Tableau, visit the Tableau Help Center pages:
https://help.tableau.com/current/pro/desktop/en-us/viewparts_marks_markproperties_color.htm



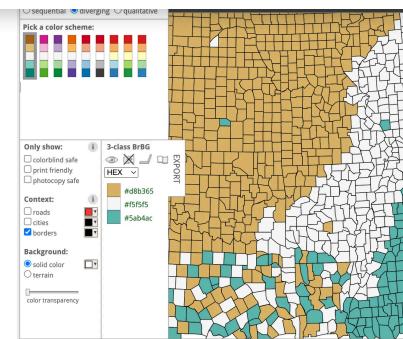
Color Palettes in MATLAB

- MATLab uses RGB values and a color picker code (`c = uisetcolor`) to define colors.
- Below are two resources that can help you select the right MATLab color palettes for your graphs and visualizations:
 - <https://www.mathworks.com/help/matlab/ref/uisetcolor.html>
 - <http://math.loyola.edu/~loberbro/matlab/html/colorsInMatlab.html>



Color Palettes for Maps and Cartography

- The best tool for testing color palettes for maps and cartography data is the Color Brewer by Cynthia Brewer, Mark Harrower and The Pennsylvania State University:
<https://colorbrewer2.org/#type=sequential&scheme=BuGn&n=3>



Color Palettes for Scientific Poster Backgrounds

- Use this resource article to learn more about good research poster design:
<https://www.simplifiedsciencepublishing.com/resources/free-research-poster-t-and-tutorials>

Tool to Translate a Color into Any Format

- Use this Color Hex tool to find all of the color codes from a HEX color code such HSL, CMYK, and many others: <https://www.rapidtables.com/convert/color/index.html>
- This may be helpful if you need to translate your desired colors to a software or platform that uses a less common color code.

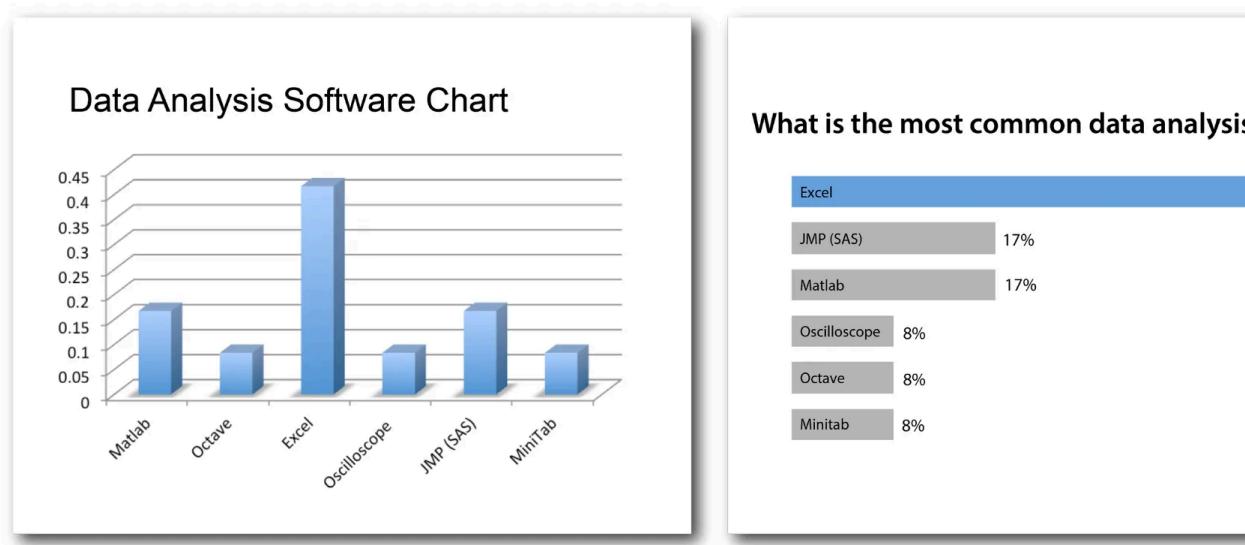
How to Use Color to Tell your Scientific Story

attention.

For example, the graphs below both use the same data, but the graph on the right changes the order, improves formatting, and selectively uses color to draw your eye to the most important information. After you create any data visualization, you should ask yourself whether you have highlighted the main point of your scientific story, and if not, consider revising your colors.

Read these articles to learn more scientific story design tips and tricks:

- [Scientific Data Visualization Tools and Techniques](#)
- [Data Storytelling: How to Tell a Great Data Story in 4 Steps](#)

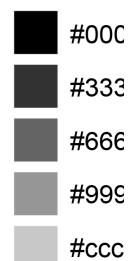


Before and after graph color design improvement example

Grayscale is a Good Default Option

Although color can be used as an effective tool to tell your data story, it is also important to note that grayscale colors are still a great way to represent your data. The key to using grayscale in scientific research is to make sure that there is approximately a 15-30% difference in saturation between the colors used (e.g. shades of gray). Most default color guides

Grayscale with saturation difference



Science Color Palette Summary

All of the tools described in this article can help you find and apply the right colors for visualizations and scientific figures. Now that you have all of the resources you need, use the simple process below to create your own scientific color palette:

How to Choose the Best Scientific Color Palette:

- **Step 1.** Choose a color palette that looks good to you and best represents your audience.
- **Step 2.** Test the colors in the Viz Palette tool to see how they will affect a colorblind audience.
- **Step 3.** Adjust color, hue and saturation in the Viz Palette until there are no color differences between the data series.
- **Step 4.** Apply the final colors to your data visualization platform, scientific paper and graphs that highlights the main point of your data.

References:

- Statistic of number of people with CVD from <https://www.colourblindawareness.org/color-blindness/>

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