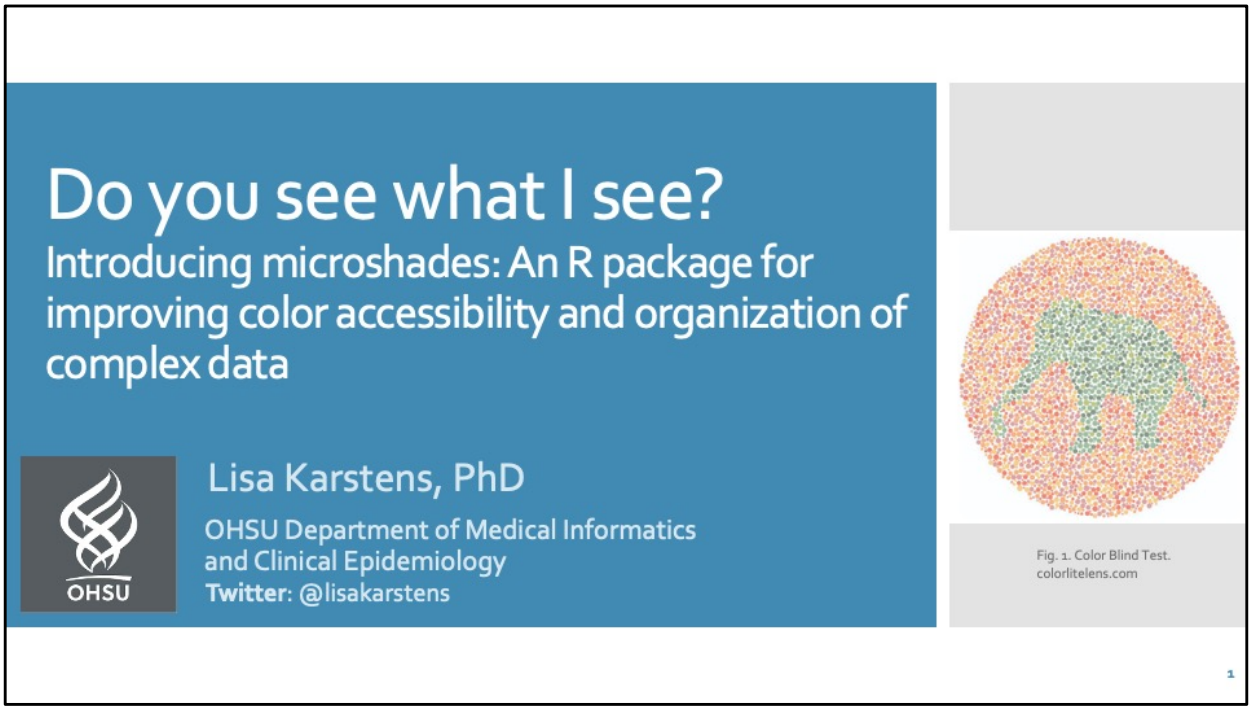
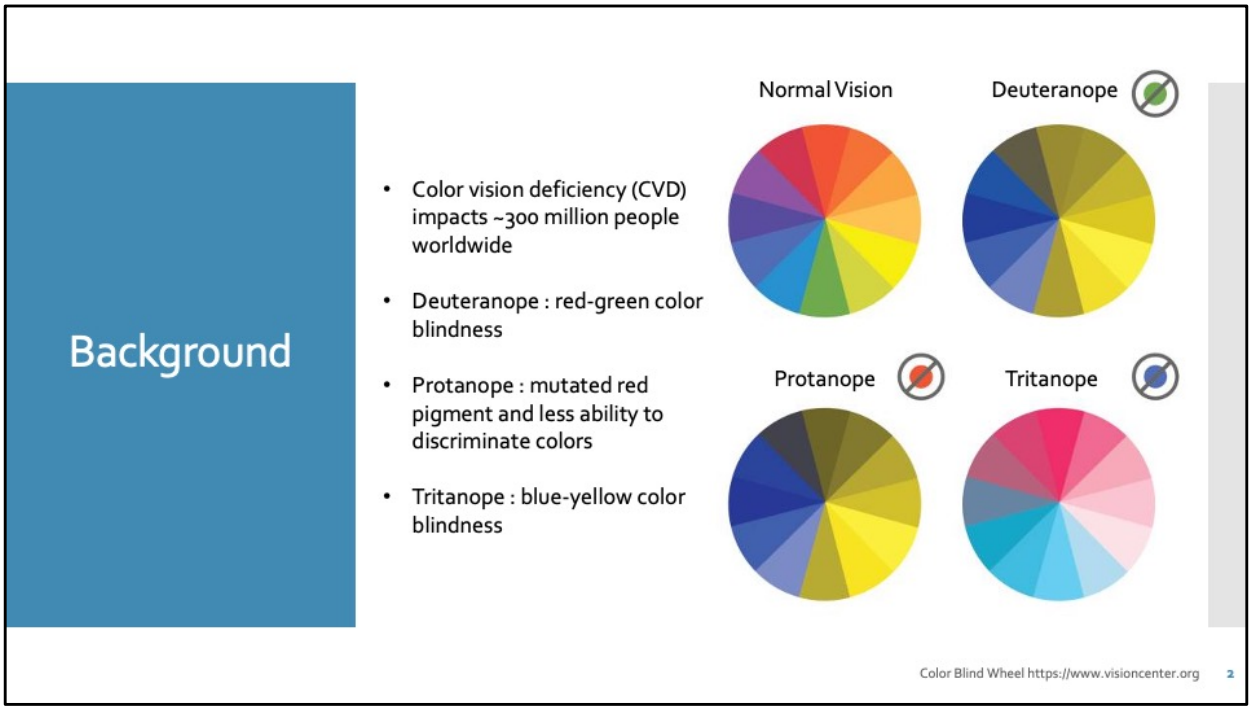


Thank you for joining me today! Do you see what I see? In this picture I see an elephant, but not all people can. I'd like to introduce microshades, an R package for improving color accessibility and organization of complex data.

Image Credit: https://bit.ly/ColorBlind_Test

Alt-text of image: An image of a circle created with smaller circles of varying colors, including several reds, oranges, and yellows. Within the circle is an elephant made of similar small green circles. This elephant is not visible to individuals with red-green colorblindness.



Our main motivation for this project was to create a color palette that is accessible to individuals that experience Color vision Deficiency, otherwise known as CVD or colorblindness. CVD impacts roughly 300 million people worldwide, which is comparable to the current US population. CVD refers to partial but not complete colorblindness and diminishes the ability to distinguish certain colors. The three different types of CVD.

Deuteranope : This is the most common type of CVD, also know as "red-green color blindness”

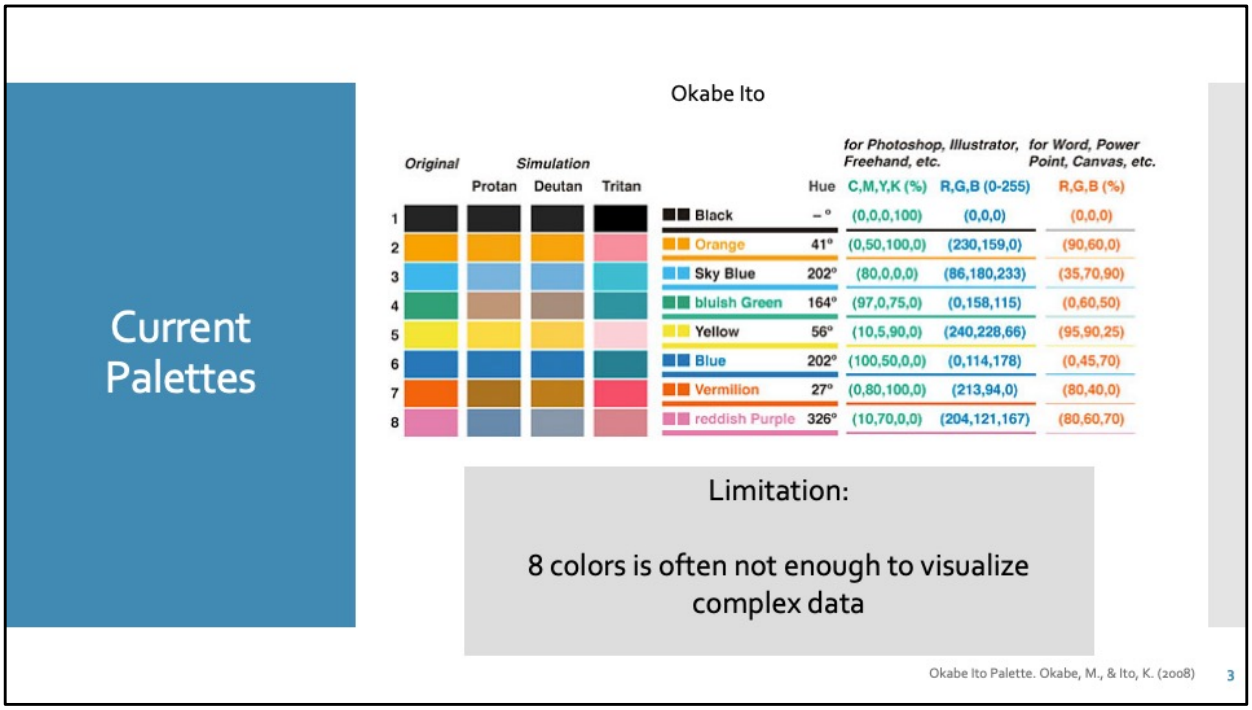
Protanope : Less common than Deuteranope, described as mutated red pigment and less ability to discriminate colors

Tritanope : Relatively Rare, also known as "blue-yellow color blindness"

The goals/intentions for this project : Improve accessibility of figures – Considering the high prevalence of CVD in the world

Image credit: https://bit.ly/Color_Blind_Def

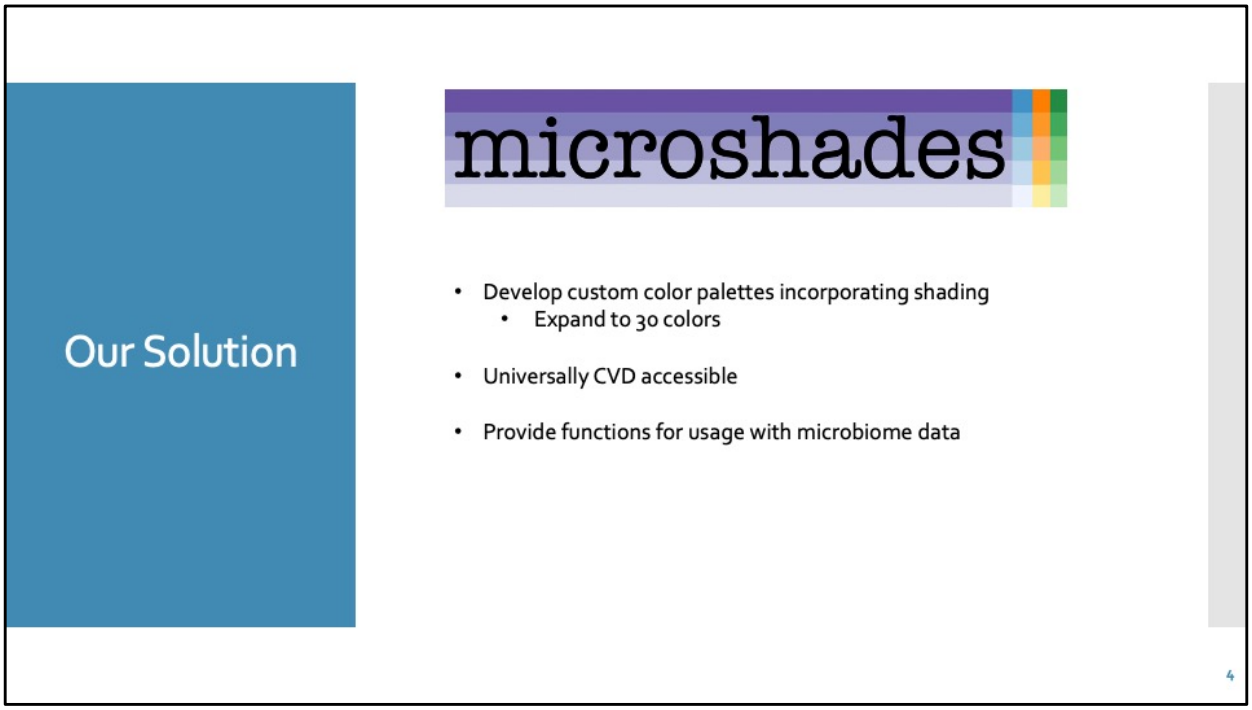
Alt-text of image: 4 color wheels are displayed. The first is a standard color wheel with 12 colors spanning the rainbow. The second is a simulation of how the color wheel looks to someone with deuteranope (red-green) colorblindness. The third is how the color wheel looks to individuals with protanope (red colorblindness) and the last one is how the color wheel looks to people with tritanope (blue-yellow) colorblindness.



One of the current leading accessible palettes is the Okabe Ito color palette, which you can see, when run in cvd simulations is universally cvd friendly. This is great; however, this palette is limited to 8 colors, which is not sufficient for visualizing complex data.

Image source: https://bit.ly/Okabe_Ito

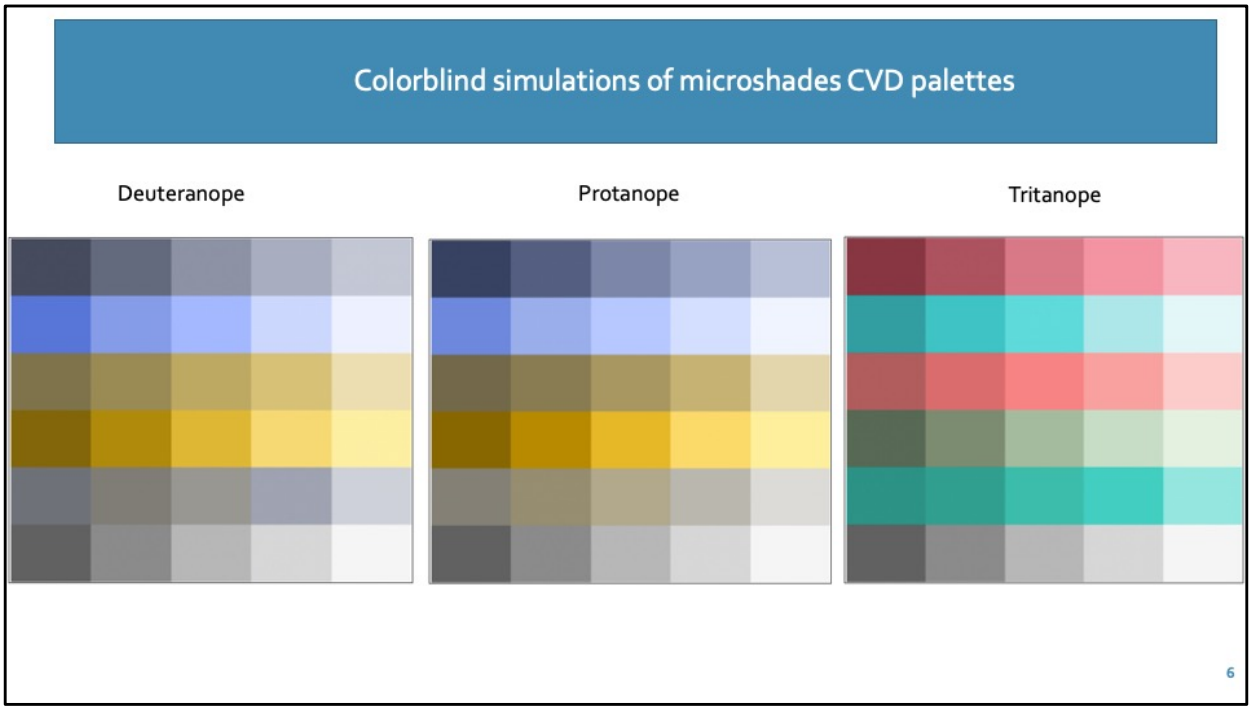
Alt-text of image: A grid of the Okabe Ito color palette is displayed as a column of 8 distinct colors. The following three columns display the colors with cvd simulators demonstrating that the colors are distinct to individuals with different forms of colorblindness. This is followed by the names of the colors and common CMYK and RGB codes.



Our solution was to develop an R package that incorporates shading to expand the number of colors available to 30, with the goal of continued universal CVD accessibility. Our lab also works with complex microbiome data, so we wanted to make sure that we could use these colors with our data and created functions in this package that would apply microshades palettes and assist in additional data organization.

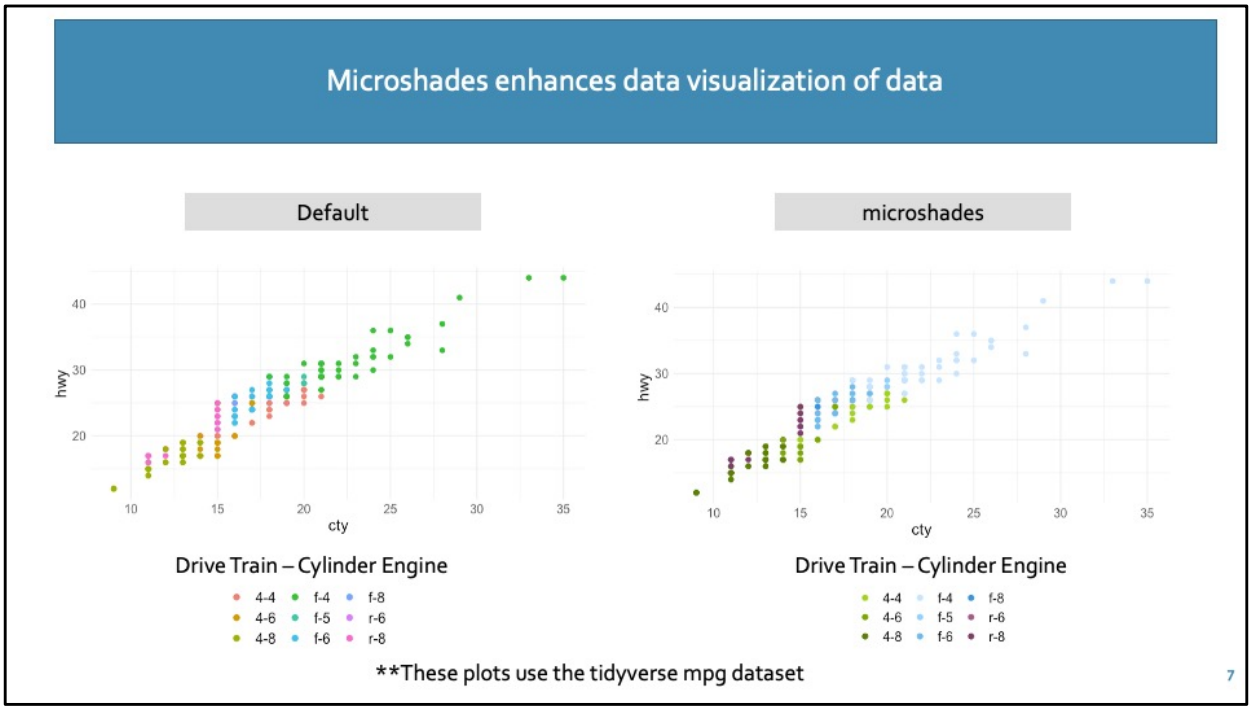
We developed two microshades palettes, however for the purpose of this talk I would like to focus on the universally CVD friendly palettes. This palette includes 6 base colors, with different shading applied, to result in a total of 30 colors.

Alt-text of image: The microshades color palette is revealed. The image consists of 6 rectangles each a different base color or hue, each with 5 shaded squares.



This next slide shows the microshades cvd palettes under each type of cvd simulation. The colors are distinct, and therefore universally accessible

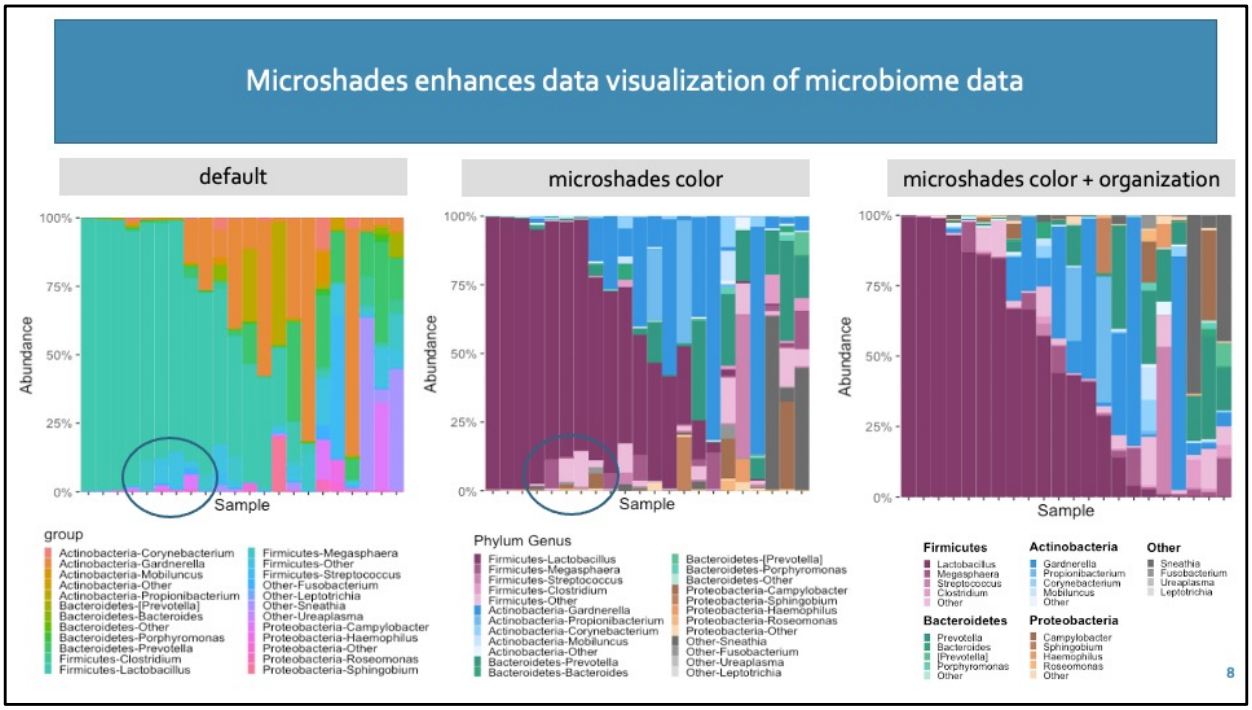
Alt-text of image: The microshades palette is displayed with a simulation of how it looks to individuals with deuteranope. The microshades palette is displayed with a simulation of how it looks to individuals with protanope. The microshades palette is displayed with a simulation of how it looks to individuals with Tritanope.



Microshades palettes are easily accessed with our package and can be applied to any plot. This plot examines cars fuel efficiency on the hwy vs city in terms of mpg. The points on the plot represent a car with a particular type of drive train and cylinder engine. This first plot uses a default coloring system, which provides no meaningful order to the coloring.

This next plot uses microshades colors and organization, Each drive train is a different color, and the number of cylinder engine is represented by a shade of the drive train color. With this color organization, we are able to visualize that FWD cars tend to have the highest city and hwy mpg. Additionally, cars with fewer cylinders tend to be the most fuel efficient. This color organization is not only accessible to all, but is additionally helpful in noticing trends

Alt-text of image: A scatter plot is displayed with default coloring from ggplot. The same scatter plot is displayed with the microshades palette applied. The application of the microshades palette makes colors accessible to those with CVD and also shows additional patterns not obvious before.

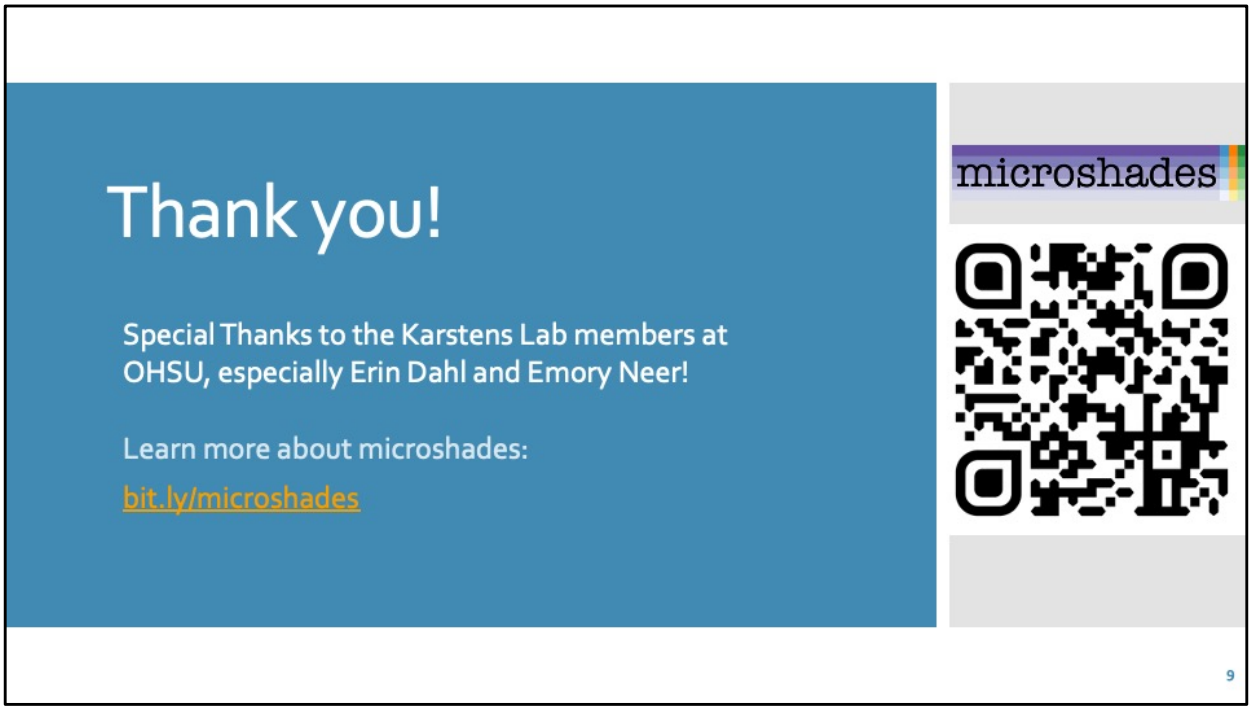


Another example of microshades in action is this microbiome data example, containing relative abundance data for various samples. In this plot, the color represents different bacteria in each sample, and colors are determined by the default ggplot color scheme. The next plot contains the same relative abundance data, with the same sample order. This plot uses the accessible microshades cvd_palettes . The colors are organized and better represent the Phylum-Genus classification of bacteria found in the samples. If you look at the Firmicute samples circled, you can tell the cvd colors drastically improve the distinguishability of the colors. This last plot uses the microshades cvd accessible colors and microshades organizational functions, so the layout of the data further improves the visibility of trends. Microshades was also used to generate a custom legend that further shows the organization of the data.

As you can see, there are many benefits of using microshades, and the small change of using a palette that is CVD accessible will make your work interpretable to all.

Alt-text of image: A stacked barplot is displayed with default coloring from ggplot. The barplot is displayed with the microshades palette applied. The application of the microshades palette makes colors accessible to those with CVD and also shows

additional patterns not obvious before, which are circled. The barplot is displayed with the microshades palette and data organization applied.



Thank you for joining my presentation, please visit our website bit.ly/microshades to learn more about how you can use microshades!