Activity 4: Data visualization 2: Customizing plots

Jan. 14th, 2026, Calvin Munson

Walt and Luis

Overview

Welcome! Today's activity is all about the basics of customizing plots. We will continue using `ggplot2` and will use two built-in datasets for this activity (no reading in data is necessary today!).

You will submit two outputs for this activity:

1. A **PDF** of a rendered Quarto document with all of your R code (see below). Please include all of the code that appears in this document, in addition to adding your own code in the "Q#" sections.

If you have trouble submitting as a PDF, please ask Calvin or Malin for help. If we still can't solve it, you can submit the .qmd file instead.

2. A plot and research question from the final section

A note about submitting code:

As a general practice, it is good to **use headers to denote which section of the homework** you are in and **add in your own comments about what each line is actually doing** - this is excellent practice for organizing your own big R scripts in the future. A common way that you will code for the first few years of your coding career will consist of you revisiting old R scripts and copying/pasting code and/or adapting that code to your current problems. I promise you, your future self will be thrilled with your current self if you take the extra few minutes to 1) organize your code in a nice way and 2) provide detailed comments about what each line is doing (as well as what questions you have about it).

Also, don't be afraid to use lots of blank lines! It is MUCH nicer for your future self to look at code that has a few blank lines in between sections of code than a bajillion lines in a row of straight code.

For the remaining activities, please put headers (either as comments in the code or as Quarto headers) to denote which question you are answering (e.g. "Q1:") and precede your code with comments that describe what that code does.

1) Penguins!

Figure 1: Gentoo penguin

Setting up

First, let's load our packages. You should already have the `here` and `ggplot2` packages installed; read them in from the library in your code. Also install and read in the `palmerpenguins` package, which contains built-in data - you may recognize this from Malin's ggplot lecture!

#installing packages and librarying them

```r
#install.packages("palmerpenguins")
library(ggplot2)
library(here)
library(palmerpenguins)
```

We just installed a package which has data built into it. We are going to go ahead and store the `penguins` data frame as a data object anyway (not technically necessary because it's already built-in, but this reinforces storing dataframes).

```r
# Read in the palmer penguins data
penguins <- penguins
```

Next, let's navigate to the help page of this dataset. Doing so provides information on the dataset and its various columns. We can learn that this dataset "includes measurements for penguin species, island in Palmer Archipelago, size (flipper length, body mass, bill dimensions), and sex". Read on to learn about each column in the dataset.

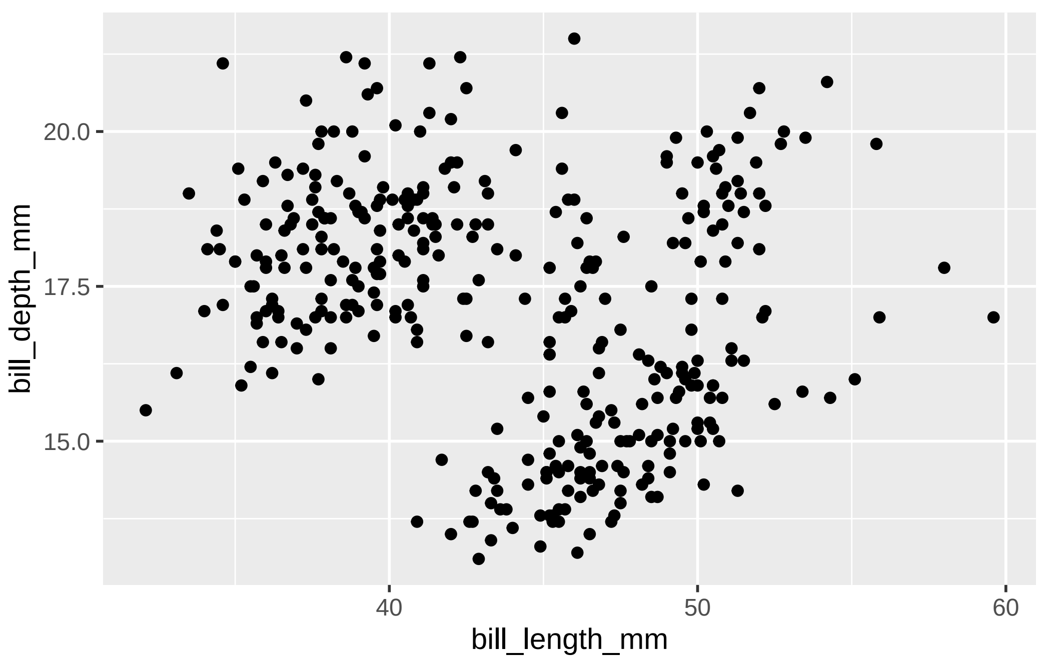
```r
# Putting a "?" in front of a function (or built-in dataset) will automatically bring up its
?penguins
```

Start with a question

Let's start by forming a research question. Let's ask: *How are bill length and bill depth associated, and how does this vary by species of penguin?*

Let's create a basic graph to begin. Plotting `bill_length_mm` on the x-axis and `bill_depth_mm` on the y-axis.

```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point()
```



Q1.1: Do you see a relationship?

Does it look like there is a relationship between these variables? Describe the relationship.

There might be multiple linear relationships that may be lost in the noise, co-varites may be sex or species.

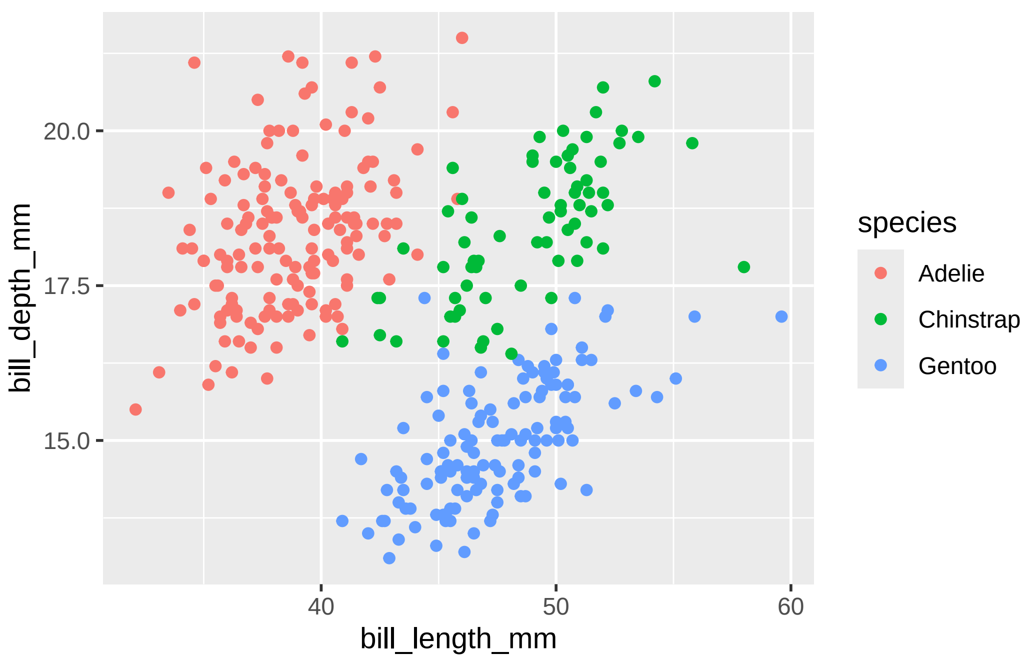
Q1.2: Color the points by species of penguin

That previous graph only addresses part of our question: we asked not only "how are bill length and bill depth associated", but also "**how does this vary by species of penguin**?"

To address the second part of our question:

1. Change the aesthetics of this plot to color the points by the species of penguin and
2. Interpret the graph by describing the relationship you see and if this new visualization changes your answer to Q1.1. # created new graph with the new "color = species" command, to highlight clusters based on species

```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(color = species))
```



The take-home message here is to be thorough with how you look at your data! If you ignore certain variables, you might miss important patterns (this is also crucial when deciding what statistical models we should run on our data, but more on that in a few weeks!).

Ok, now let's jump into some fun data visualization and learn about how to customize our plots!

Scales for aesthetics

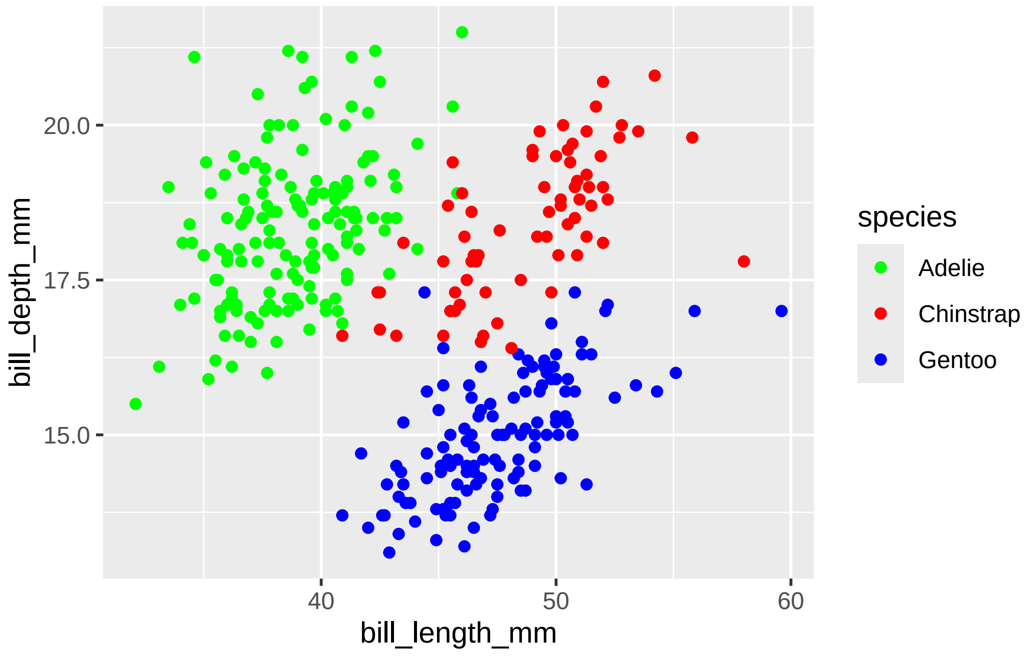
We can manually modify the appearance of the aesthetics of our ggplot graph (e.g. the `color`, `shape`, opacity (aka `alpha`), `x`, `y`, etc) by using a series of functions called `scale_*_**()` where the first * is replaced by the aesthetic we are modifying (e.g. color), and the second translates to the kind of prepacked or manual set of values that we want to use. Often it will be `scale_*_manual()` if we want to manually chose the values instead of using premade ones.

Monday's Seaside Chat provided some practice with modifying the scales of the color aesthetics using `scale_color_manual()` and `scale_color_brewer()`.

Q1.3: Add your favorite colors to your graph

Using your new color skills, modify the `scale_color_*` code below to include a new color selection!

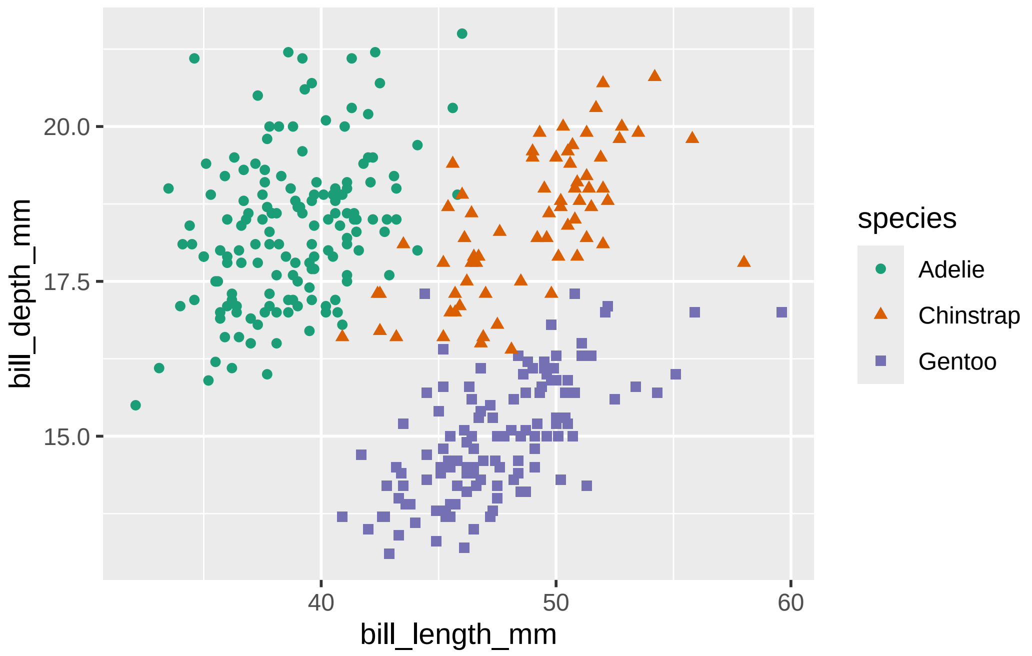
```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(color = species)) +
  scale_color_manual(values = c("green","red","blue"),) #adding manual colors to each specie
```



Let's make the shape of the points vary by species to even more clearly separate the points by species:

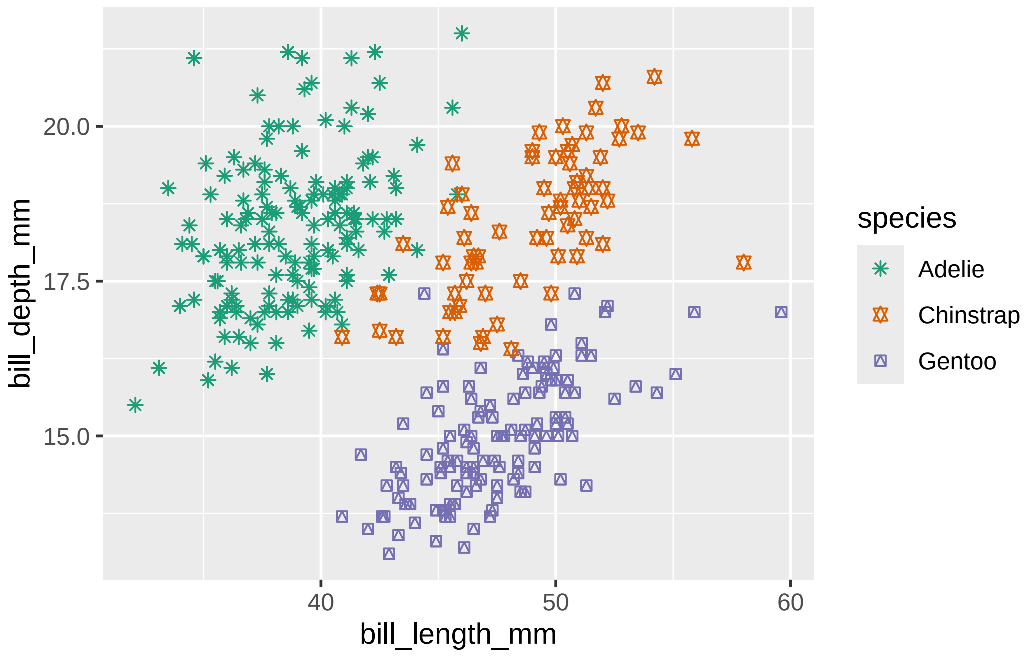
Sidenote: When you're typing within a function, you can hit "Enter" (or "Return" for Mac users) after a comma to continue code on a new line - see how I made a new line within `geom_point(aes())`. *This can make things look much neater if you are typing out many arguments at once! It also does not affect how the code is run at all.*

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(color = species,
                 shape = species)) +
  scale_color_brewer(palette = "Dark2")
```



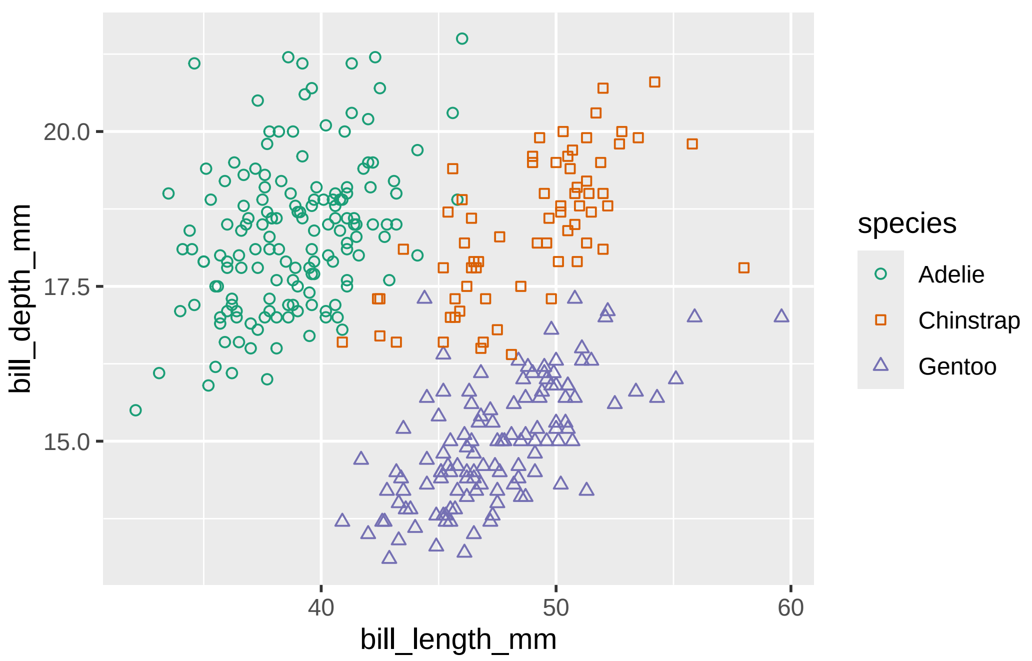
If we want to manually change the shapes that ggplot supplies, we use `scale_shape_manual()`:

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(color = species,
                 shape = species)) +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(8, 11, 14))
```



I personally like using shapes that have a black outline and are filled with the color, rather than being solid throughout. Change the manually selected shapes to 21, 22, and 24

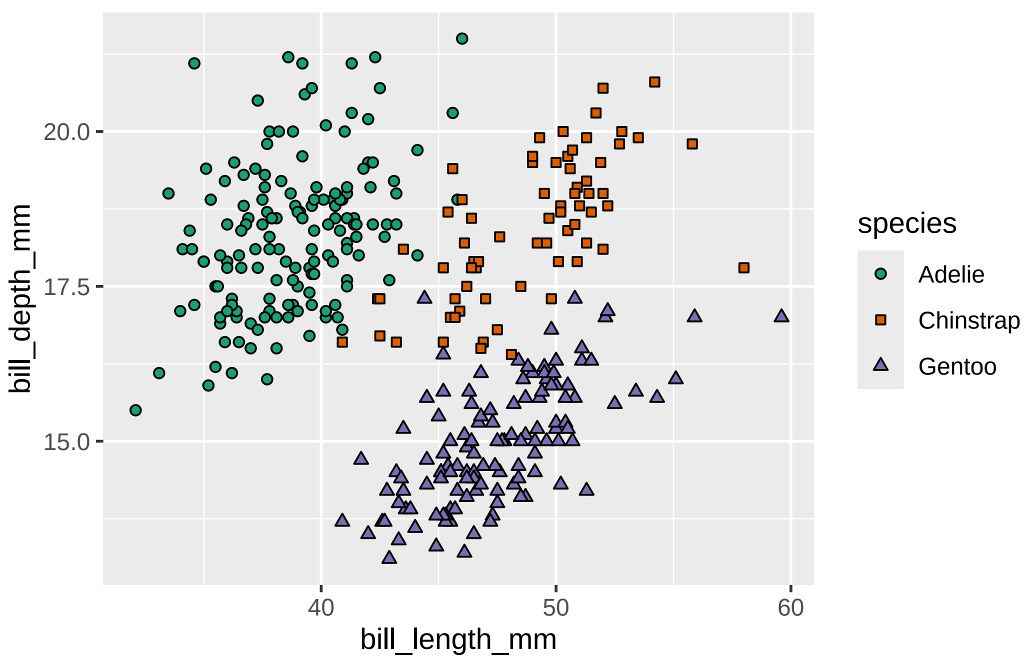
```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(color = species,
                 shape = species)) +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



Why aren't the shapes filled with the color we supplied? Some shapes and geoms in R have both `color` and `fill` capabilities. When they have both, then anything you supply to `color` will color the outline of the shape, while anything supplied to `fill` will fill in the shape (as we want here).

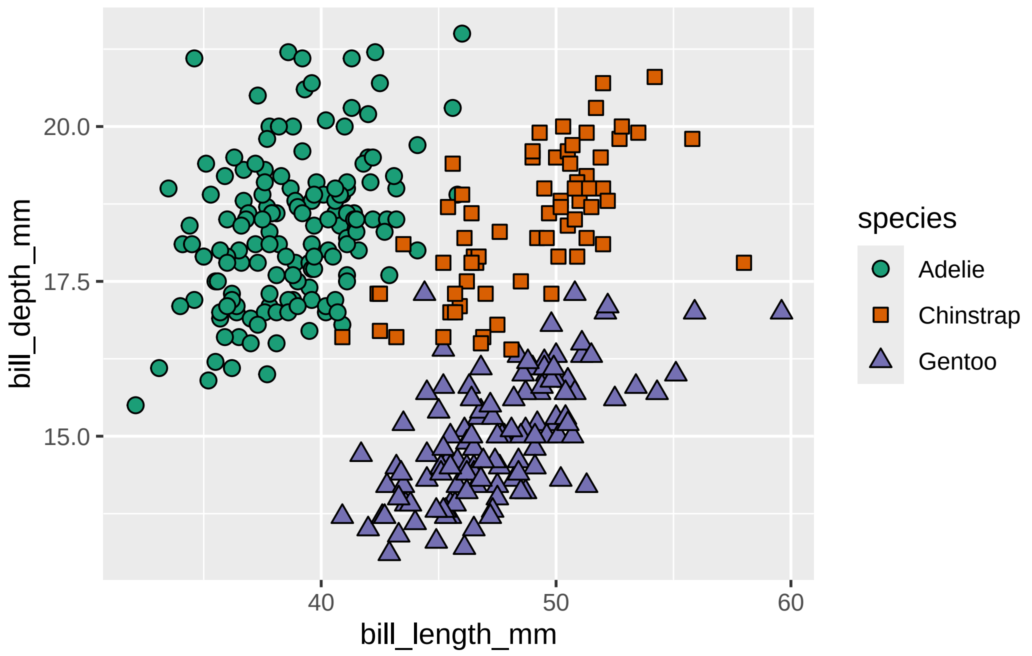
To make this switch, we are going to change the `color = species` aesthetic to `fill = species` and instead of `scale_color_brewer()` we will use `scale_fill_brewer()`

```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



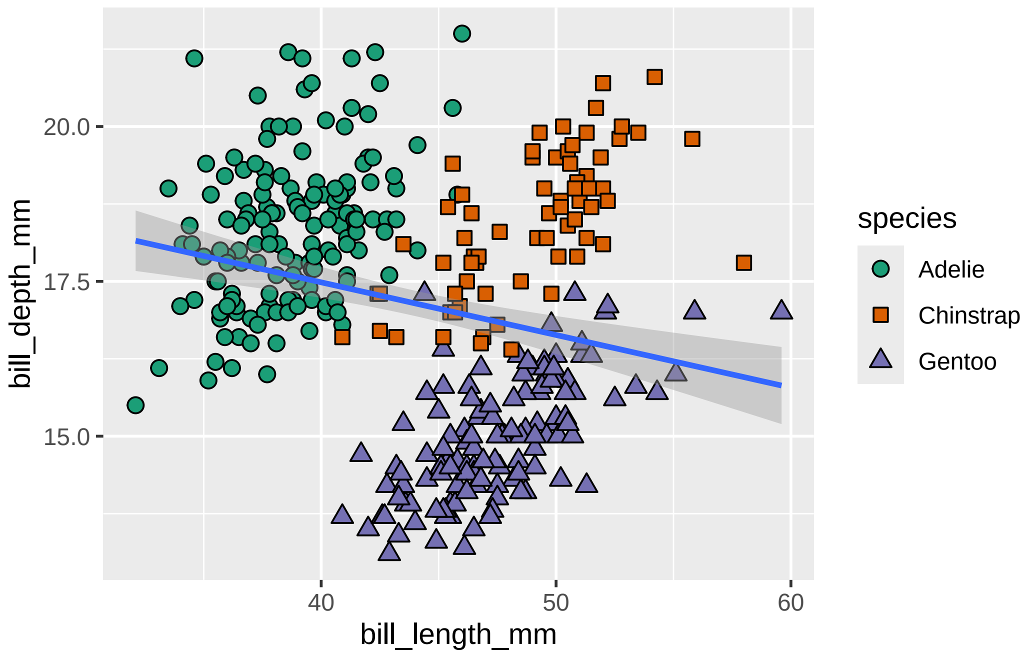
At this point, I'd also like to make the size of the points a little bigger, but I don't want it to vary with something in the data. As in the last activity, to make an element of the geom vary statically across all of the data, put it *outside* of the `aes()` but still within the relevant geom:

```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  scale_fill_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



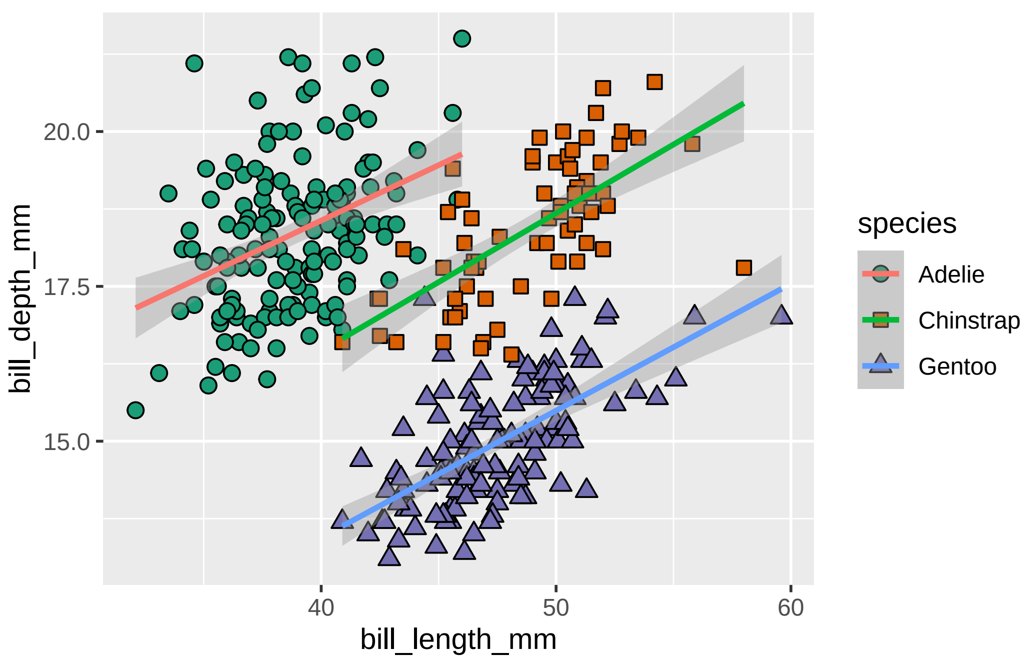
Let’s put a `geom_smooth()` with `method = "lm"` in there to look at the relationships more closely!

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm") +
  scale_fill_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



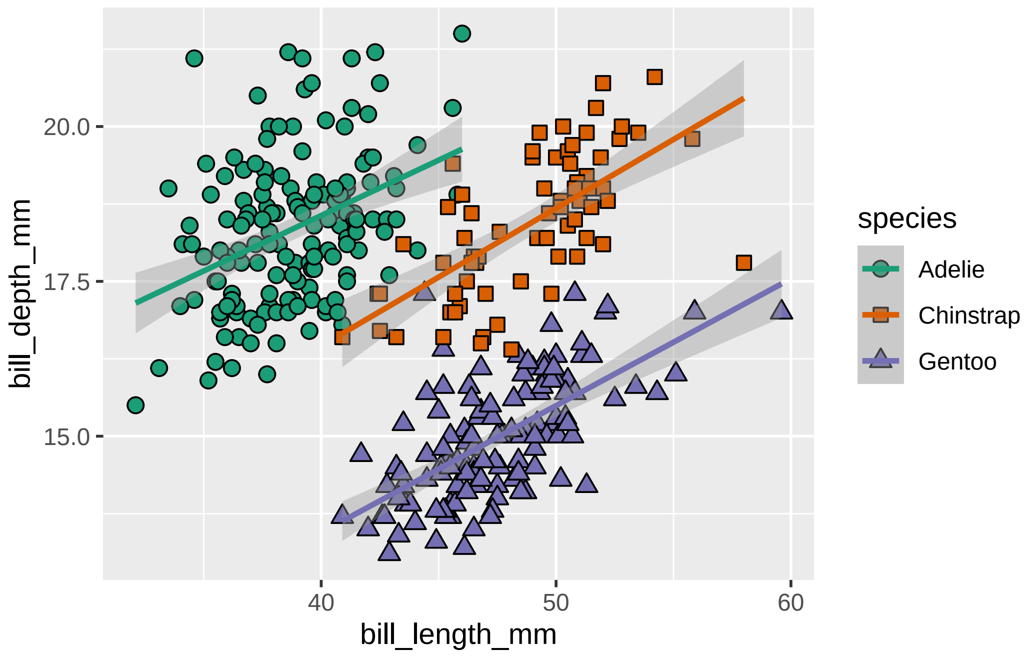
Uh oh, what's going on here? Geoms adopt the aesthetics that are supplied in `ggplot(aes(*))` as default. All we provided `ggplot()` was an `x =` and a `y =`, so as far as `geom_smooth()` is concerned, the `species` column doesn't exist. Let's add in `aes(color = species)` to the `geom_smooth()` function to tell it to color the smoothed line by species.

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



Great! Now there are three separate `geom_smooth()` lines - one for each species. However, our nice custom color scheme isn't applied. That's because `geom_smooth()` uses a `color` aesthetic, and earlier we changed `scale_color_brewer()` into `scale_fill_brewer()` to accommodate Calvin's unreasonable desire to have shapes that fill in with color. Let's re-add `scale_color_brewer()` underneath `scale_fill_brewer()`

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24))
```



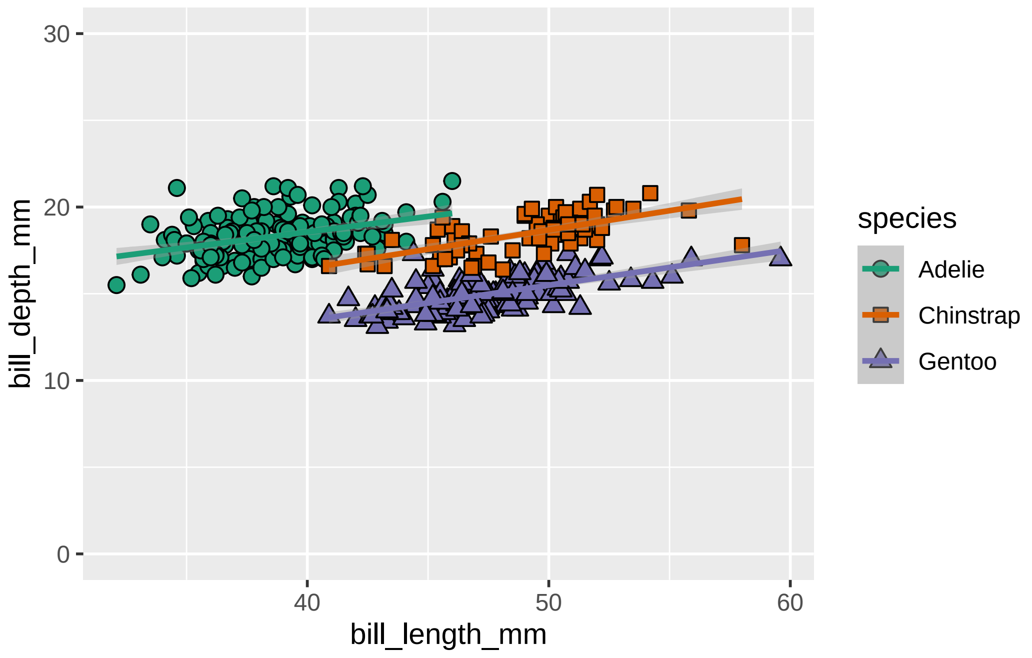
Scales for axis aesthetics specifically

The x- and y- axes are part of the aesthetics too, just like `color`, `fill`, and `shape`. You can modify the scales of the axes too. Two common ways people change up the scales of their graphs are:

1. Changing the limits of their plots and
2. Transforming axis values, for example to log scales.

Let's change the limits of the y-axis to go between 0 and 30mm. It's a continuous variable, so we use `scale_y_continuous()` and provide a vector of a minimum and a maximum to set the limits.

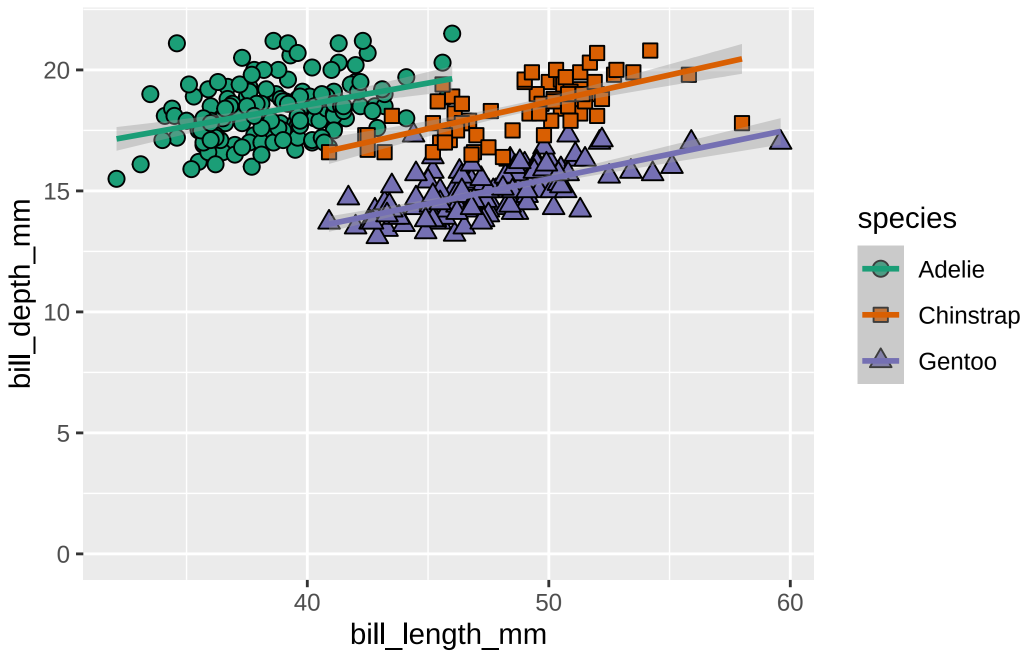
```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  scale_y_continuous(limits = c(0, 30))
```



Q1.4: How to use the existing maximum for limits

Let's say we want our limits to include 0, so we manually specify 0 as the minimum, but we want to use ggplot's default for the maximum y limit. Go to the built-in help page of `scale_y_continuous()` and figure out what to replace the * with in `limits = c(0, *)`. Then modify that code below.

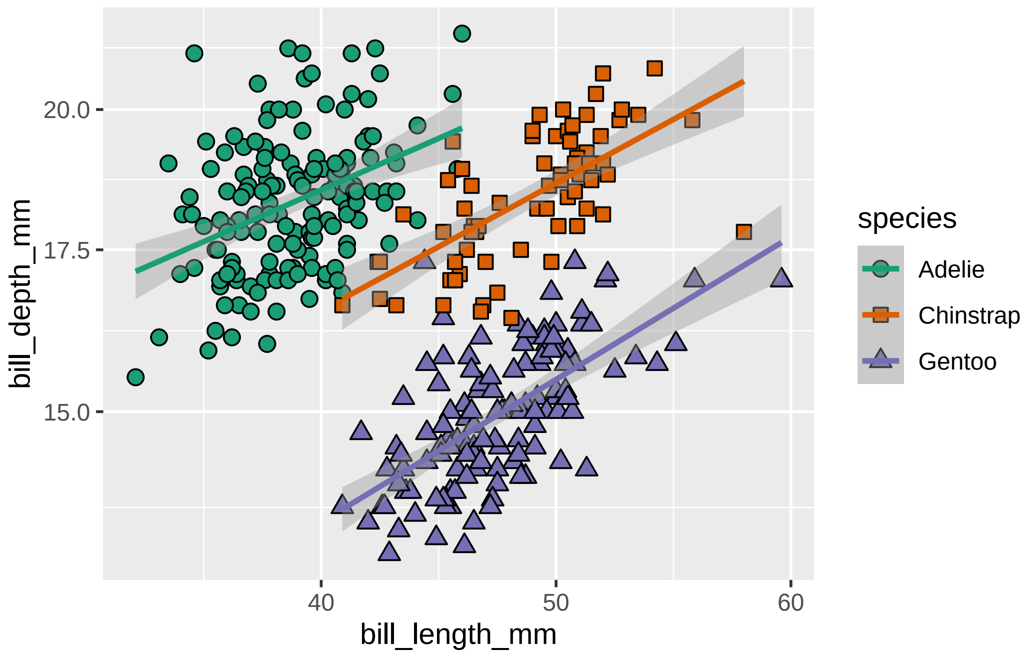
```
?scale_y_continuous()

ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  scale_y_continuous(limits = c(0, NA)) #replacing the "30" value with "NA" to set the max y
```



Another reason to modify the way your axes look is if we want to plot on a log scale. This can be very useful if your data spans many orders of magnitude (multiples of 10), which visually makes the very small values get masked by the large values.

We do this with `scale_y_log10()`, though this isn't a great dataset to use as an example because the data doesn't span a huge range - it won't look very different!

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  scale_y_log10()
```

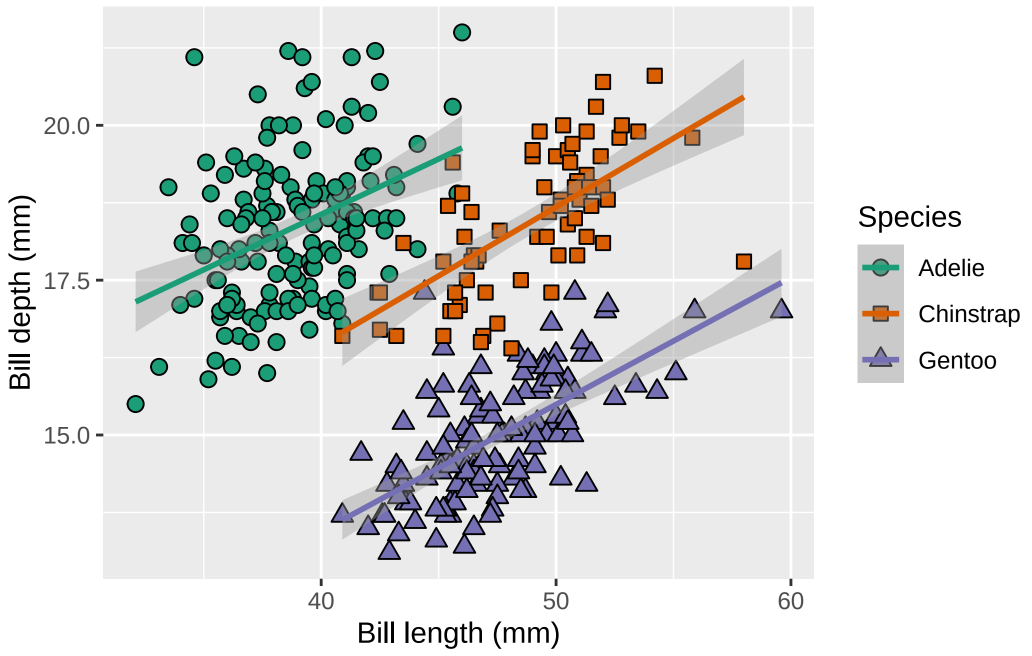


Axis and legend titles

Let's backtrack a little bit to the graph before we started messing with the y-axis and talk about how to make better axis and legend titles. By default, ggplot creates these titles based on the column names that you specify within `aes()`. However, "bill_length_mm" is a pretty lame axis title for a presentation.

To change this, we use the `labs()` function, which allows us to rename whatever `aes()` elements we have specified. We do this with the format `x = "New x axis title"` and/or `fill = "New legend title for the fill"`. Let's change the x and y axis titles:

```r
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species,),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  labs(x = "Bill length (mm)",
       y = "Bill depth (mm)",
       # title = "Bill Length by Bill Depth",
       color = "Species",
       fill = "Species",
       shape = "Species")
```



Q1.5: Change the legend title

The legend title is currently not capitalized - add to the `labs()` function to change the title of the correct aesthetic(s) to make the legend title read "Species". (You may encounter an unexpected result - try and figure out what you can do to make it appear how you want! Hint: how many different aesthetics is `species` currently mapped to?).

Themes

This is looking decent, but there's still more we can do. ggplot provides us with LOTS of flexibility in how the non-data-related components of the graph look (think the font size, background color, axis grid lines, etc.). To modify this, we add **themes** using the `theme()` function.

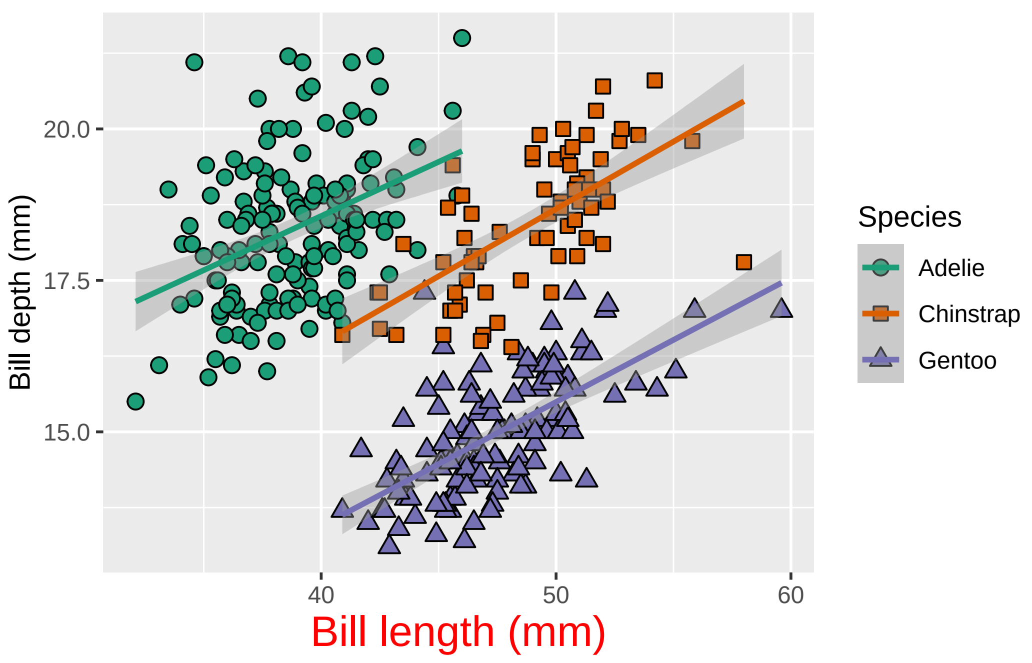
Go to the help page for `theme()`, read the description, and scroll down to see the extent of the components you can modify. Also see this link for a handy visual guide:

https://statsandr.com/blog/best-rstudio-addins-in-rstudio-or-how-to-make-your-coding-life-easier_files/ggplot_theme_system_cheatsheet.pdf

```
?theme()
```

Within the `theme()` function, we specify the element that we want to modify. For instance, the `axis.title.x =` modifies the x axis title. Because the x axis title is a `text` element, we then add `axis.title.x = element_text()` and specify things within the `element_text()` function. Here I will change the text `color` to red and increase the `size`.

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  labs(x = "Bill length (mm)",
       y = "Bill depth (mm)",
       fill = "Species",
       color = "Species",
       shape = "Species") +
  theme(axis.title.x = element_text(color = "red",
                                     size = 16))
```



Depending on what the element is, you use a different `element_*()` function:

- `element_text()`: Controls text appearance (font, size, color, etc.) for titles, labels, and axis text.
- `element_rect()`: Controls the appearance of rectangular elements like the plot background and legend background (fill, border color, etc.).
- `element_line()`: Controls the appearance of line elements like grid lines and axis lines (color, size, linetype, etc.).
- `element_blank()`: Hides or removes an element entirely (e.g., `panel.grid.major = element_blank()`).

Q1.6: What font faces are available?

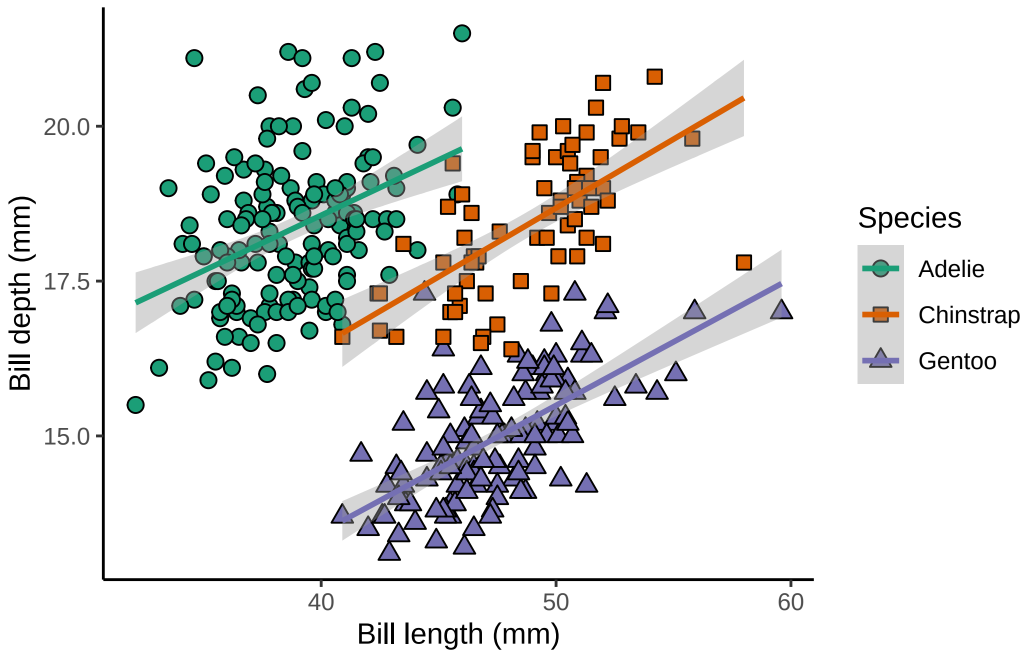
Go to the `element_text()` help page: under "Usage" you will see what arguments each element function can modify, and if you scroll down to "Arguments," you can read more about the specifics of each element you can modify.

What are the four options for the "face" of the text?

```
?element_text
#font face ("plain", "italic", "bold", "bold.italic")
```

Modifying ALL THAT from scratch can be overwhelming! Thankfully, R has a handful of built-in, pre-curated themes that you can choose from. Add on a new line to this graph and start typing `theme_` - note how multiple options pop up! Let's click on and add `theme_classic()`.

```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  labs(x = "Bill length (mm)",
       y = "Bill depth (mm)",
       fill = "Species",
       color = "Species",
       shape = "Species") +
  theme(axis.title.x = element_text(color = "red",
                                    size = 16)) +
  theme_classic()
```

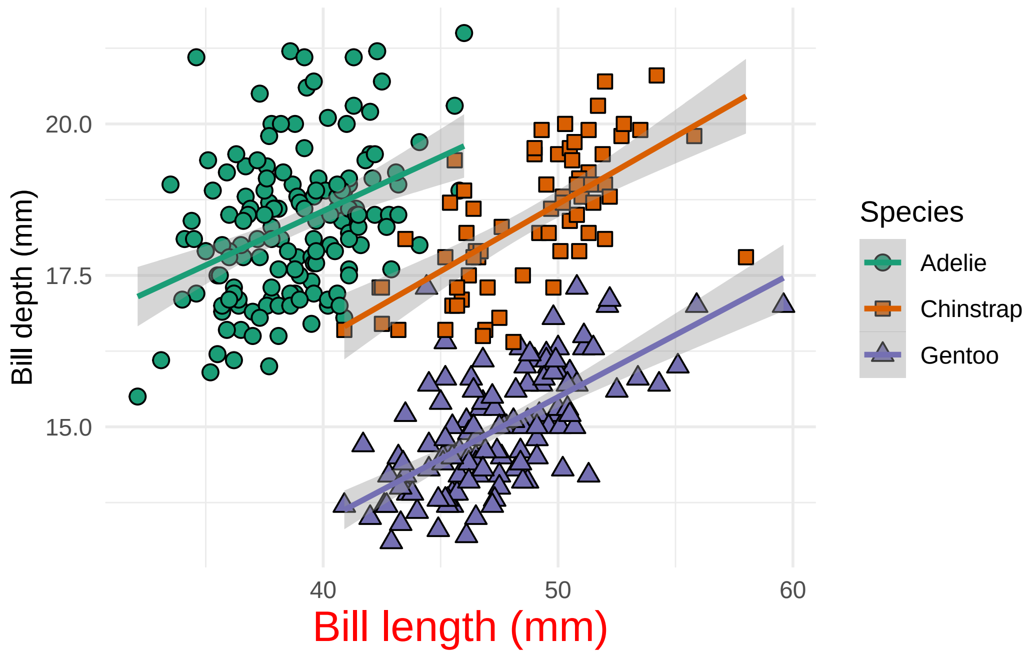


That looks quite nice! The weird gray default background is gone, and there's now a traditional x and y axis with no axis panel grids.

Note that the large, red x-axis title has been overridden by the new theme we put in. What happens when you switch the order and put `theme_classic()` before `theme(...)`? (don't forget to remove/add `+`'s where applicable…).

Try out some of the other built-in themes and see what you like!

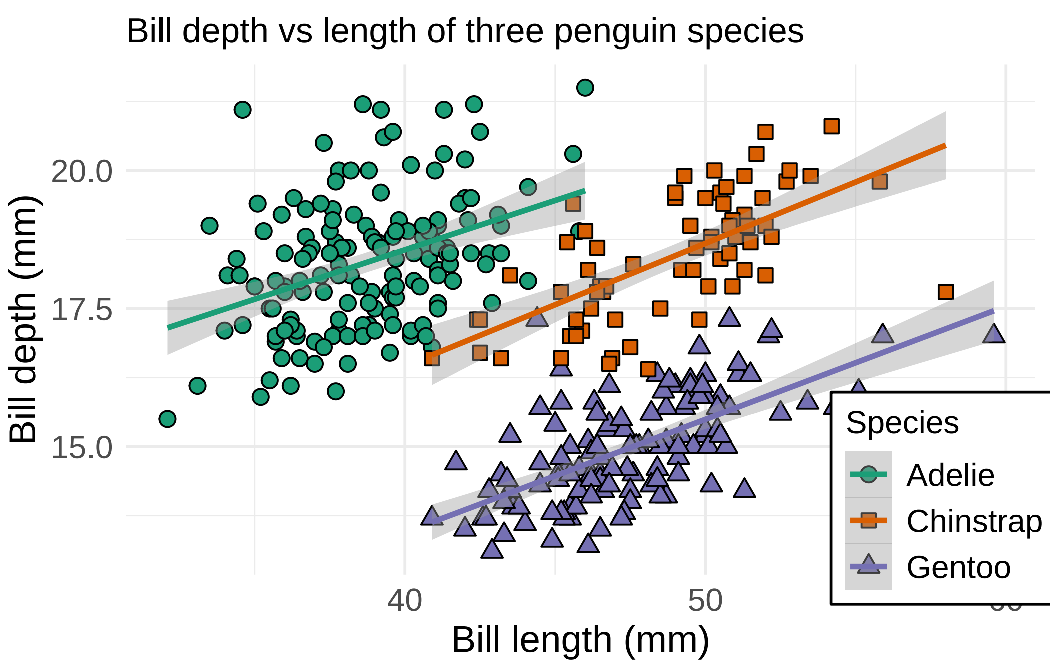
```
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  geom_point(aes(fill = species,
                 shape = species),
             size = 2.5) +
  geom_smooth(method = "lm",
              aes(color = species)) +
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  scale_shape_manual(values = c(21, 22, 24)) +
  labs(x = "Bill length (mm)",
       y = "Bill depth (mm)",
       fill = "Species",
       color = "Species",
       shape = "Species") +
  theme_minimal() +
  theme(axis.title.x = element_text(color = "red",
                                    size = 16))
```



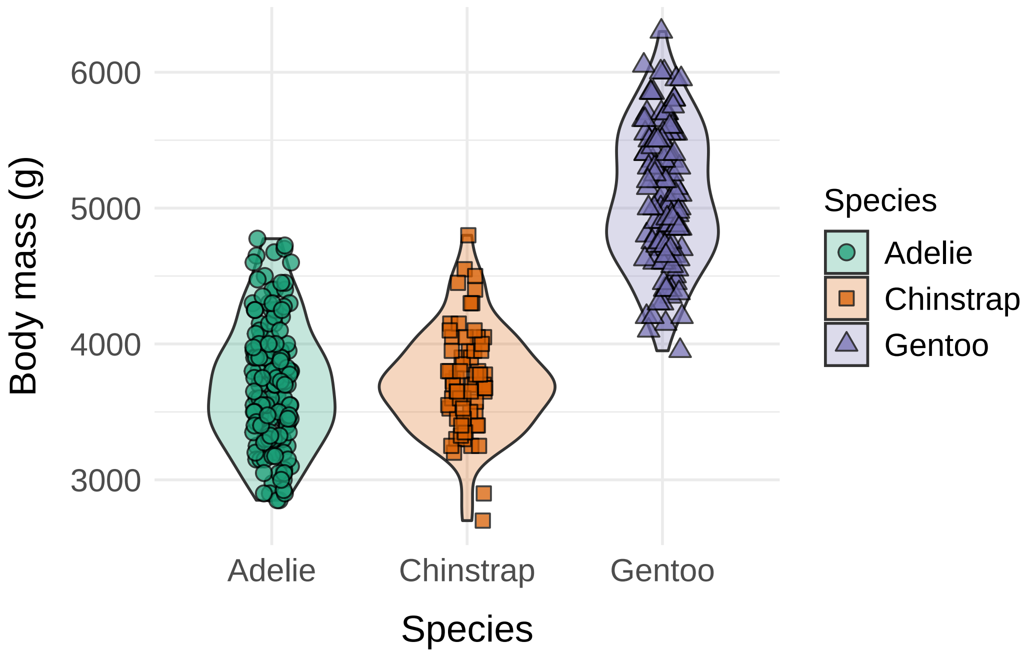
The customization of themes contains far too much content to walk through here - hopefully this provides a springboard into the possibilities! Always remember to revisit help pages and the cheatsheets that have been provided along the way. Here are a couple annotated plots that include a smattering of some other things that we didn't cover:

```
# Graph bill length vs depth
ggplot(data = penguins, aes(x = bill_length_mm, y = bill_depth_mm)) +
  # Add points separated by species
  geom_point(aes(fill = species,
                 shape = species),
             # Change the size of the points
             size = 2.5) +
  # Add a lm line for each species
  geom_smooth(aes(color = species),
              method = "lm") +
  # Customize the fill and color of the geoms
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  # Manually select the shape of the points
  scale_shape_manual(values = c(21, 22, 24)) +
```

```r
# Make nicer axis and legend titles based on the aes() specified above
labs(x = "Bill length (mm)",
     y = "Bill depth (mm)",
     fill = "Species",
     color = "Species",
     shape = "Species") +
# Add in a plot title
ggtitle("Bill depth vs length of three penguin species") +
# Change the theme to theme_minimal
theme_minimal() +
theme(
  # Change the size of axis titles and text (both x and y at once!)
  axis.title = element_text(size = 14),
  axis.text = element_text(size = 12),
  # Change the size of legend title and text
  legend.text = element_text(size = 12),
  legend.title = element_text(size = 12),
  # Place the legend inside the plot, instead of the default outside
  legend.position = "inside",
  # Specify exactly where in x/y space (from 0 to 1) the legend should sit
  legend.position.inside = c(0.9, 0.15),
  # Color (not fill!) the legend - color refers to the outline here
  legend.background = element_rect(color = "black")
)
```



```
# Graph bill length vs depth
ggplot(data = penguins, aes(x = species, y = body_mass_g)) +
  # Put violin plots, which show the distribution of points like a histogram/density plot, u
  geom_violin(aes(fill = species),
              # make the violin plots quite transparent
              alpha = 0.25
              ) +
  # Add points separated by species
  geom_jitter(aes(fill = species,
                 shape = species),
             # Change the size of the points
             size = 2.5,
             # Change the default amount that the points are "jittered" in the x (width) and
             width = .1,
             height = 0,
             # Make the points slightly transparent
             alpha = 0.75
             ) +
  # Customize the fill and color of the geoms
  scale_fill_brewer(palette = "Dark2") +
  scale_color_brewer(palette = "Dark2") +
  # Manually select the shape of the points
  scale_shape_manual(values = c(21, 22, 24)) +
# Make nicer axis and legend titles based on the aes() specified above
labs(x = "Species",
     y = "Body mass (g)",
     fill = "Species",
     color = "Species",
     shape = "Species") +
# Change the theme to theme_minimal
theme_minimal() +
theme(
  # Change the size of axis titles and text (both x and y at once!)
  axis.title = element_text(size = 14),
  # Add a little bit of space on the top (t) and the right (r) of the x and y axis titles i
  # This separates them from the axis text a bit
  axis.title.x = element_text(margin = margin(t = 10)),
  axis.title.y = element_text(margin = margin(r = 10)),
  axis.text = element_text(size = 12),
  # Change the size of legend title and text
  legend.text = element_text(size = 12),
  legend.title = element_text(size = 12)
)
```



2) Make your abalone figure ready for prime time!

Next, it's time to practice what you've learned!

Please take a look at the feedback you got on the abalone figure (go back to the Google slides, which now have the comments pasted in the speaker notes). Decide which aspects of the feedback you find useful, combined with your own thoughts on how to make the figure more effective as an explanatory graph.

Q2.1: Pick an audience for your explanatory graph.

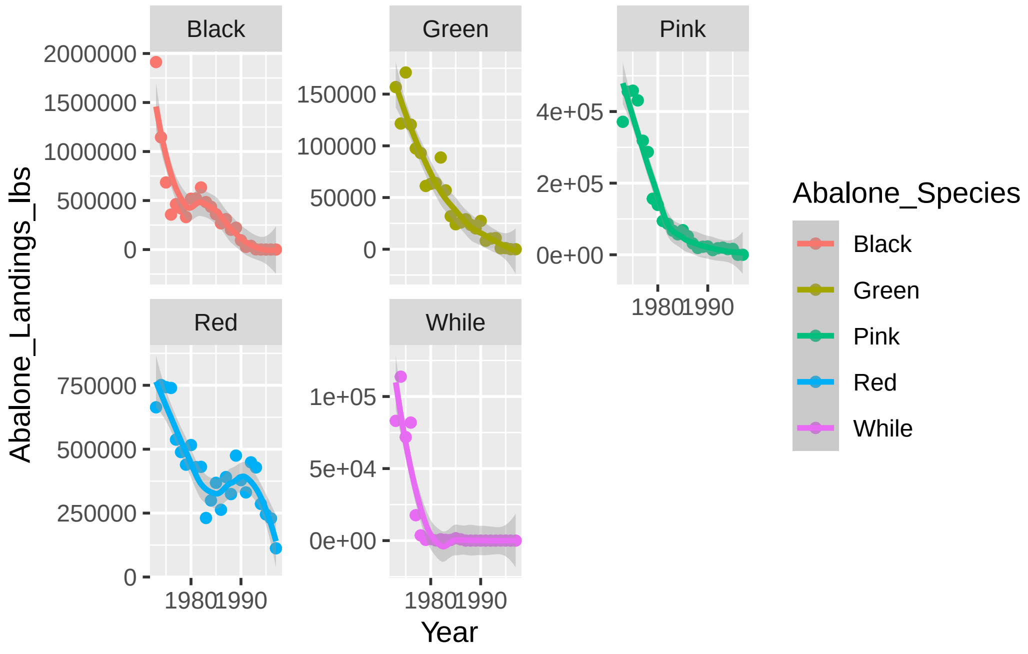
This could be everything from another scientist to a policymaker, a community member, your grandmother, or anyone else. Please write a short explanation of who this person or group of people is.

A: we decided our audience is your grandmother

Q2.2: Remake your original graph from Monday.

This should be as simple as copy and pasting the code you used on Monday (though remember to read in the data!). You'll need to create a new code block below here (remember how to do that?).

```r
ab_data = read.csv("abalone_landings.csv")
ab_plot = ggplot(data = ab_data, mapping = aes(x = Year, y = Abalone_Landings_lbs)) +
  geom_point(aes(color = Abalone_Species)) +
  facet_wrap(Abalone_Species ~., scales = "free_y") +
  geom_smooth(aes(color = Abalone_Species))

ab_plot
```



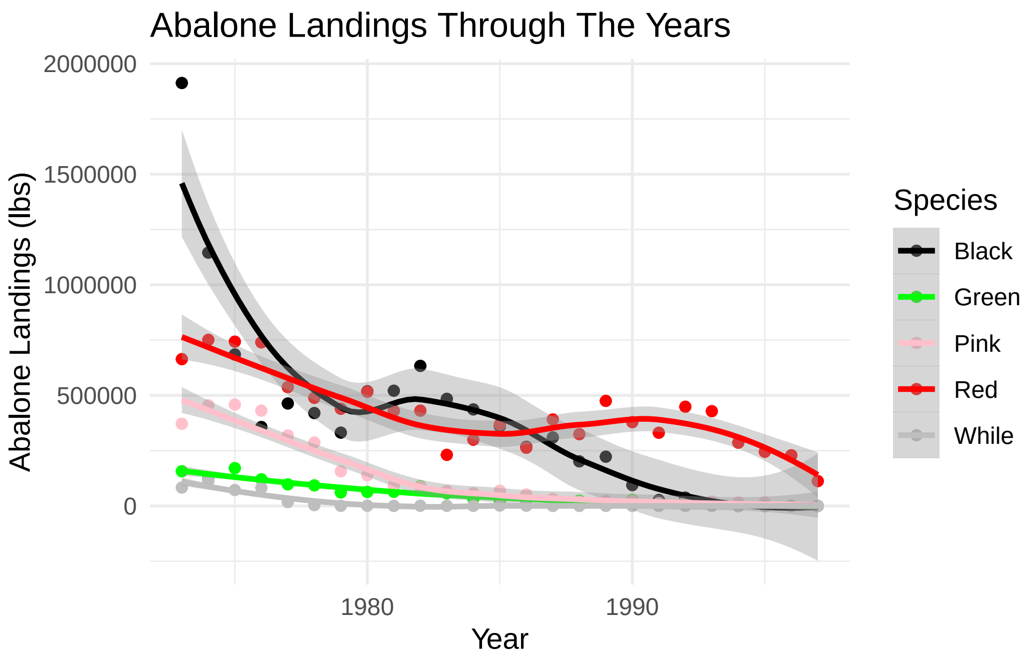
Q2.3: Describe how you would like to modify the figure to make it more effective as an explanatory graph for the audience you chose in Q2.1.

The past two activities have provided a brief sampling of the possibilities of customizing graphs using ggplot. You are welcome to explore other possibilities, too, either on your own or by talking with the teaching team.

Q2.4 Make the explanatory graph!

Use what you have learned and make a Really Nice Graph for your audience! Go wild with making it pretty.

```r
ab_data = read.csv("abalone_landings.csv")
ab_plot = ggplot(data = ab_data, mapping = aes(x = Year, y = Abalone_Landings_lbs)) +
  geom_point(aes(color = Abalone_Species)) +
  geom_smooth(aes(color = Abalone_Species)) +
  scale_color_manual(values = c("black","green","pink", "red","gray")) +
   labs(x = "Year",
       y = "Abalone Landings (lbs)",
       fill = "Species",
       color = "Species",
       shape = "Species",
       title = "Abalone Landings Through The Years") +

  theme_minimal()


ab_plot
```



Q2.5: Explain your graph

Write a couple sentences explaining the message you hope your audience will take away from seeing your graph.

A: this graph is much more appealing for your grandmother to understand, less individual facets to look at and colors that match that of the ablone species. All wrapped up with nice text formatting and the minimal theme.

Wrap up and submit

As in the previous lesson, render this Quarto document to a PDF (if you can; see guidance at the top) and submit this through GradeScope.