Class 05: Data Visualization with GGPLOT

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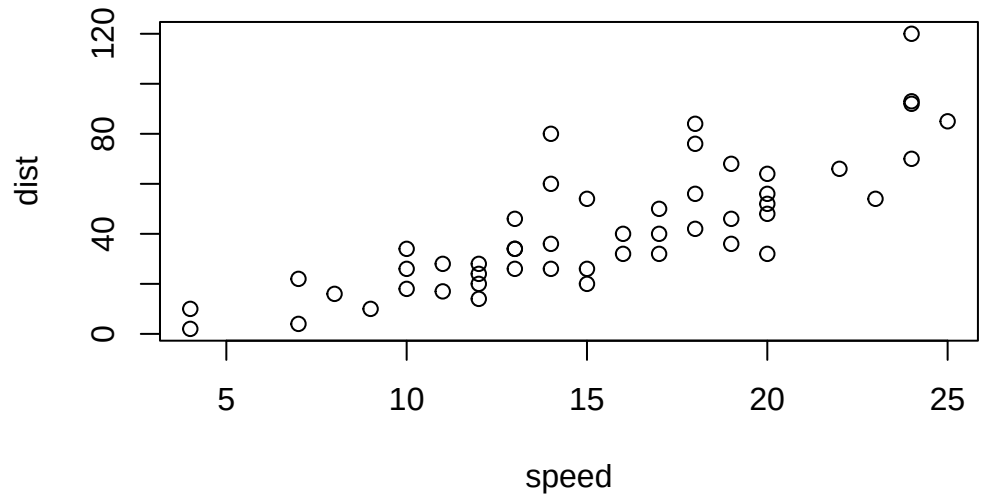
Plotting in R

Q1. For which phases is data visualization important in our scientific workflows? All of the above.

Q2. True or False? The ggplot2 package comes already installed with R? FALSE

R has lots of ways to mke plots and figures. This includes so-called **base** graphics and packages like **ggplot2**

```
plot(cars)
```



This is a **base** R plot of the in-built `cars` dataset that has only two columns:

```
head(cars)
```

```
  speed dist
1     4    2
2     4   10
3     7    4
4     7   22
5     8   16
6     9   10
```

Q. How would we plot this wee dataset with **ggplot2**?

Q3. Which plot types are typically NOT used to compare distributions of numeric variables? Network graphs

Q4. Which statement about data visualization with ggplot2 is incorrect? ggplot2 is the only way to create plots in R

All ggplot figures have at least 3 layers:

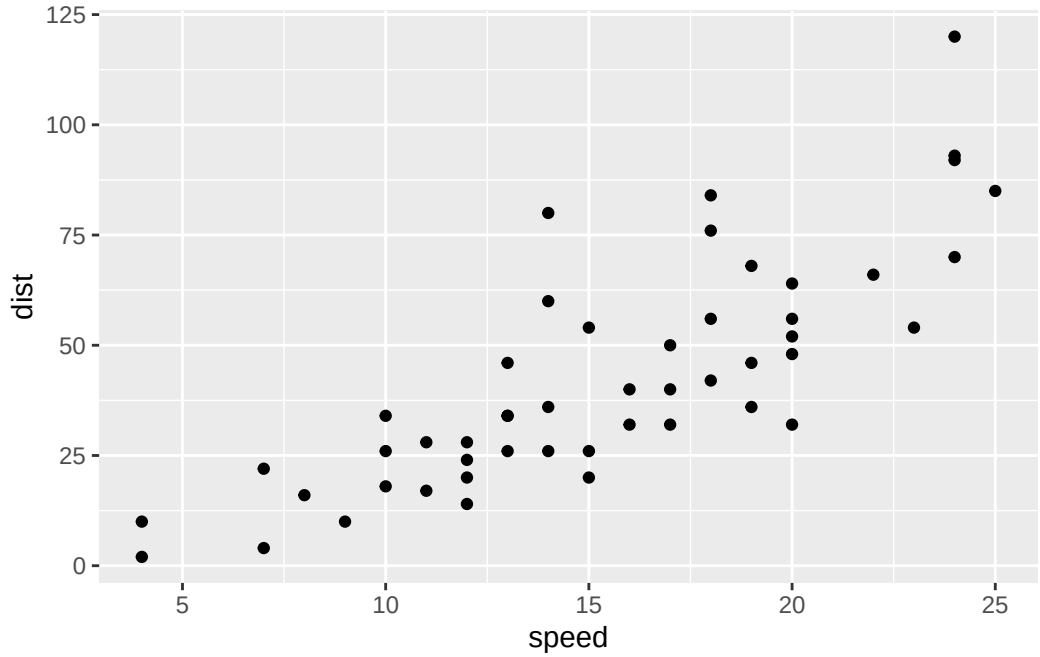
- **data**
- **aes** (how the data map to the plot)
- **geoms** (how we draw the plot, lines, points, etc.)

Before I use any new package I need to download and install it with the `install.packages()` command.

I never use `install.packages()` within my quarto document otherwise I will install the package over and over and over again - which is silly!

Once a package is installed I can load it up with the `library()` function.

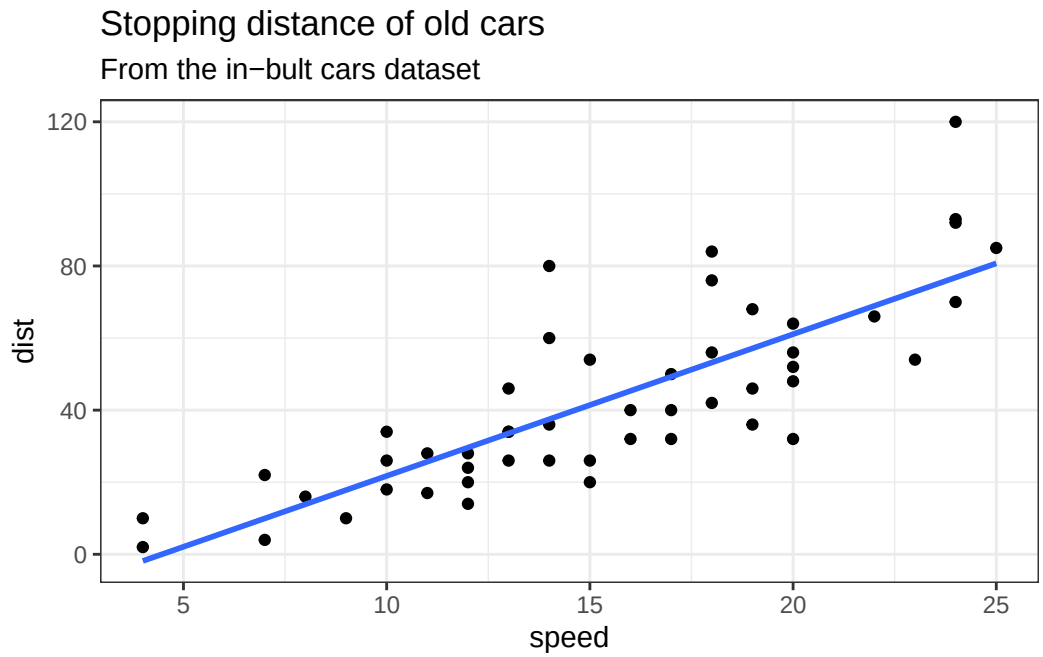
```
# install.packages("ggplot2")
library(ggplot2)

ggplot(cars) +
  aes(x=speed, y=dist) +
  geom_point()
```



Key-point: For simple plots (like the one above) ggplot is more verbose (we need to do more typing) but as plots get more complicated ggplot starts to be more clear and simple than base R plot()

```
ggplot(cars) +
  aes(speed, dist) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(title="Stopping distance of old cars", subtitle= "From the in-bult cars dataset") +
  theme_bw()
```

```
`geom_smooth()` using formula = 'y ~ x'
```



Q5. Which geometric layer should be used to create scatter plots in ggplot2? geom_point()

Put all your code in here

```
url <- "https://bioboot.github.io/bimm143_S20/class-material/up_down_expression.txt"
genes <- read.delim(url)
head(genes)
```

```
        Gene Condition1 Condition2      State
1      A4GNT -3.6808610 -3.4401355 unchanging
2       AAAS  4.5479580  4.3864126 unchanging
3      AASDH  3.7190695  3.4787276 unchanging
4       AATF  5.0784720  5.0151916 unchanging
5       AATK  0.4711421  0.5598642 unchanging
6 AB015752.4 -3.6808610 -3.5921390 unchanging
```

```
nrow(genes)
```

```
[1] 5196
```

```
colnames(genes)
```

```
[1] "Gene"       "Condition1" "Condition2" "State"
```

```
ncol(genes)
```

```
[1] 4
```

```
table(genes$State)
```

```
      down unchanging         up
        72       4997        127
```

```
round(table(genes$State)/nrow(genes) * 100, 2)
```

```
      down unchanging         up
      1.39      96.17       2.44
```

Q6. Use the nrow() function to find out how many genes are in this dataset. What is your answer? 5196

Q7. Use the colnames() function and the ncol() function on the genes data frame to find out what the column names are (we will need these later) and how many columns there are. How many columns did you find? 4

Q8. Use the table() function on the State column of this data.frame to find out how many 'up' regulated genes there are. What is your answer? 127

Q9. Using your values above and 2 significant figures. What fraction of total genes is up-regulated in this dataset? 2.44

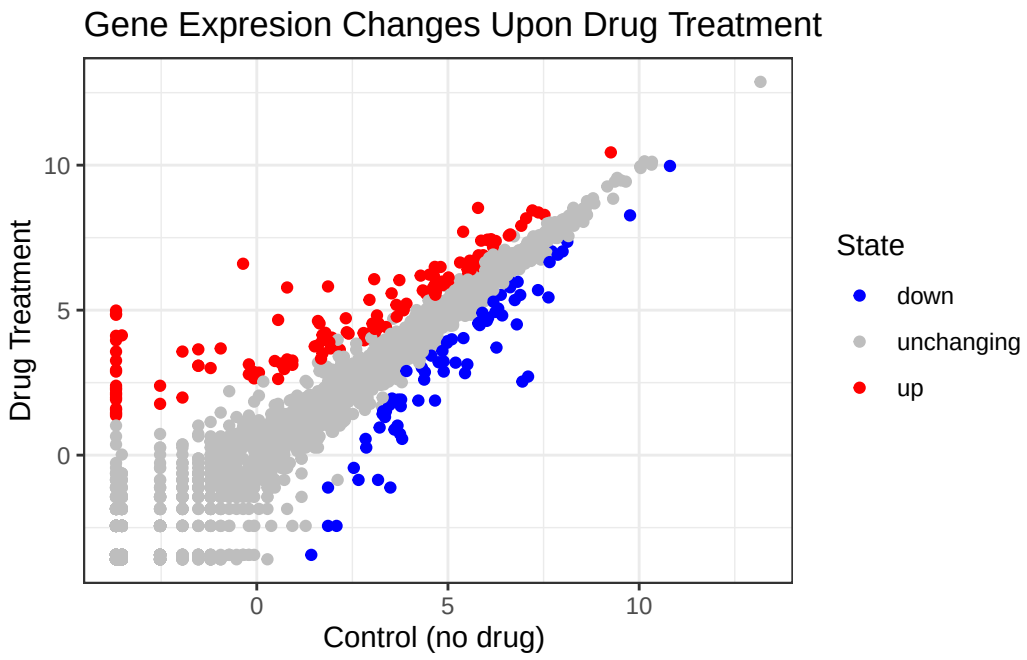
`nrow()` and `ncol()` `table()` is very useful for getting counts finally `round()`

A first plot:

```
p <- ggplot(genes) +
  aes(x=Condition1, y=Condition2, col=State) +
  geom_point()
```

Change the color scale so unchanging genes are not so obvious as I want to highlight the Up and Down genes.

```
p + theme_bw() +
  scale_colour_manual( values=c("blue","gray","red") ) +
labs(title="Gene Expresion Changes Upon Drug Treatment",
         x="Control (no drug) ",
         y="Drug Treatment")
```



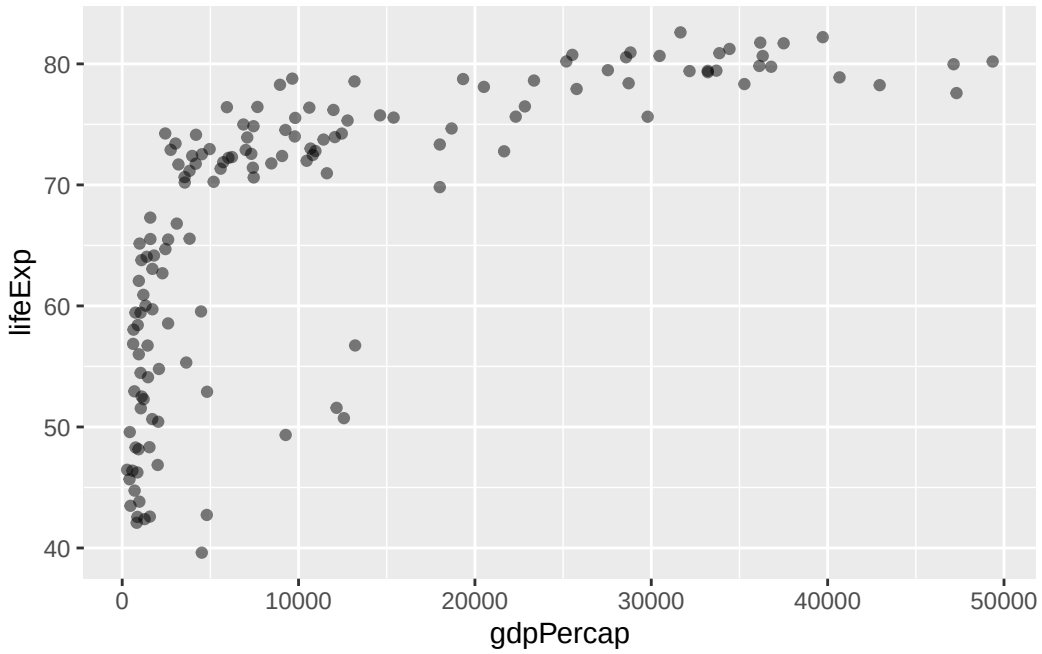
Going Further

```
url <- "https://raw.githubusercontent.com/jennybc/gapminder/master/inst/extdata/gapminder.ts

gapminder <- read.delim(url)

library(dplyr)
```

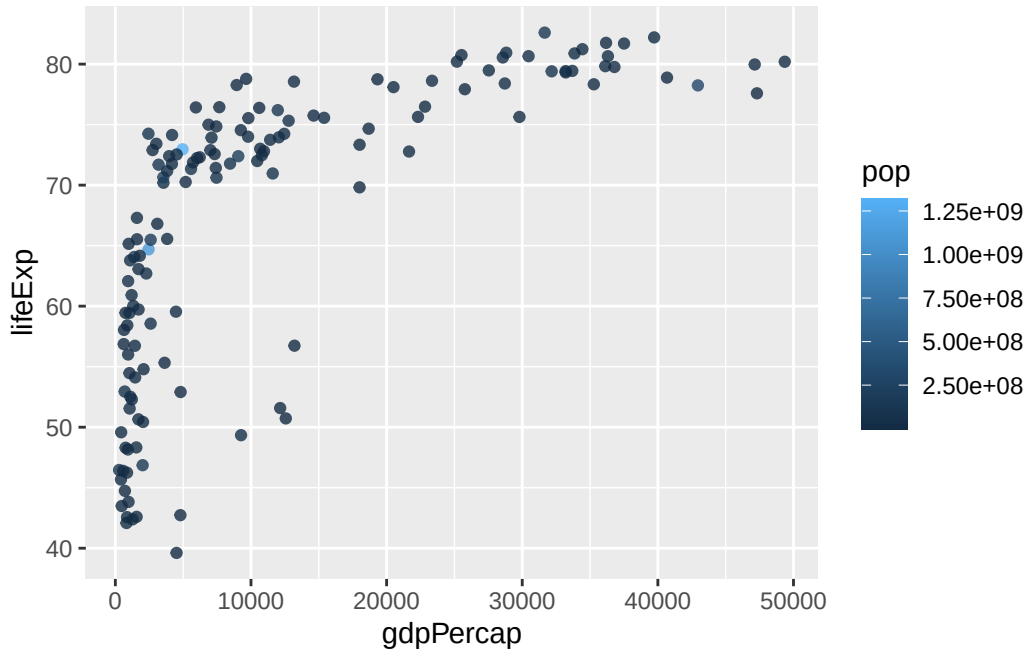
```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag
```

```
The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

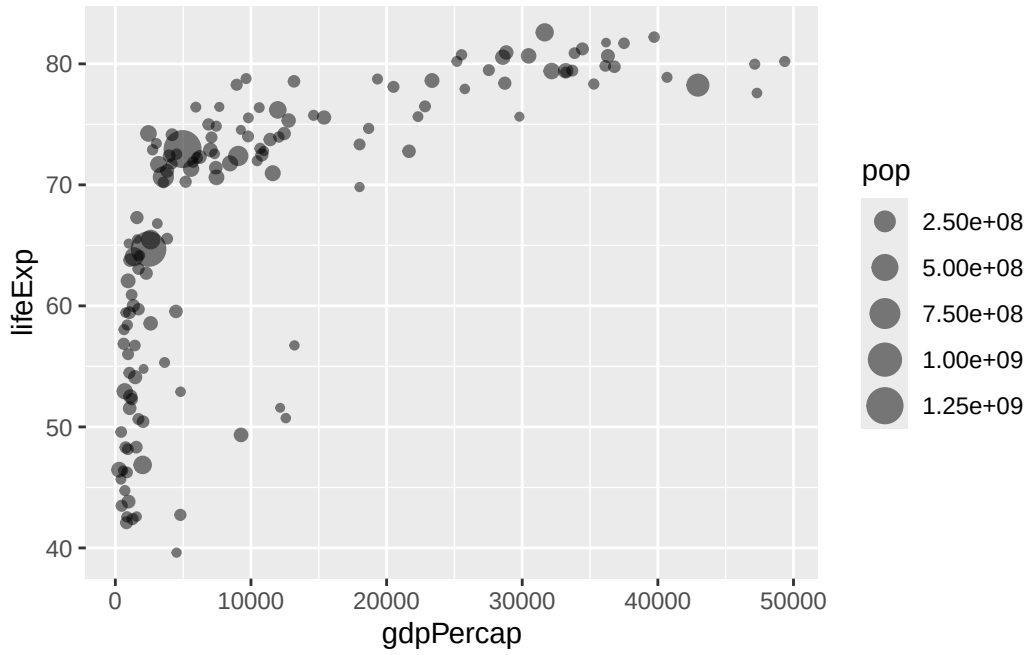
```
gapminder_2007 <- gapminder %>% filter(year==2007)

library(ggplot2)

ggplot(gapminder_2007) +
  aes(x=gdpPercap, y=lifeExp) +
  geom_point(alpha=0.5)
```



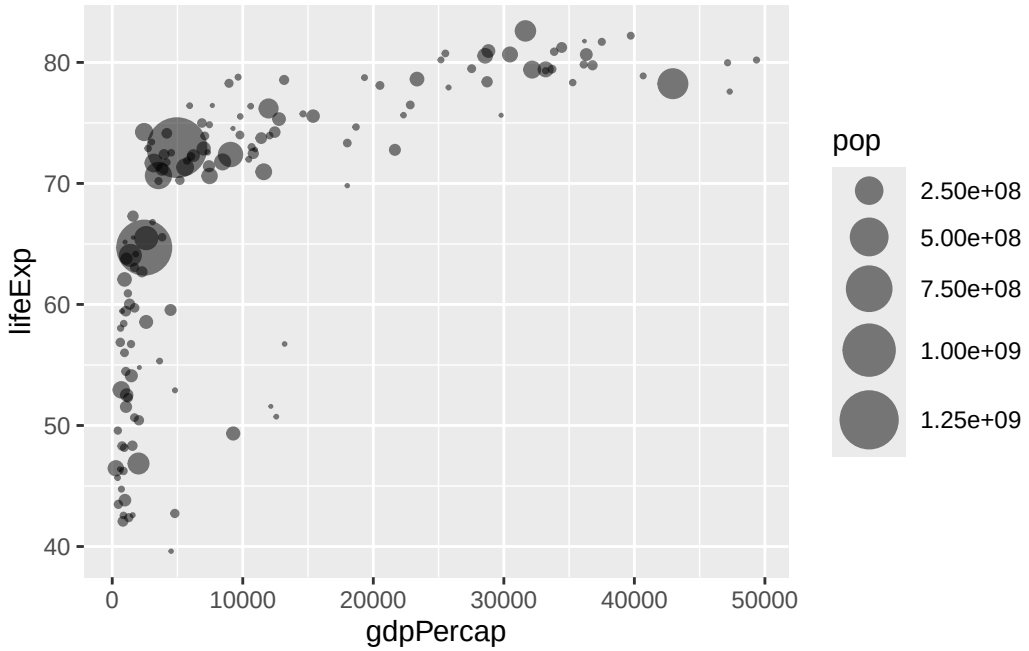

```
ggplot(gapminder_2007) +
  aes(x = gdpPercap, y = lifeExp, color = pop) +
  geom_point(alpha=0.8)
```



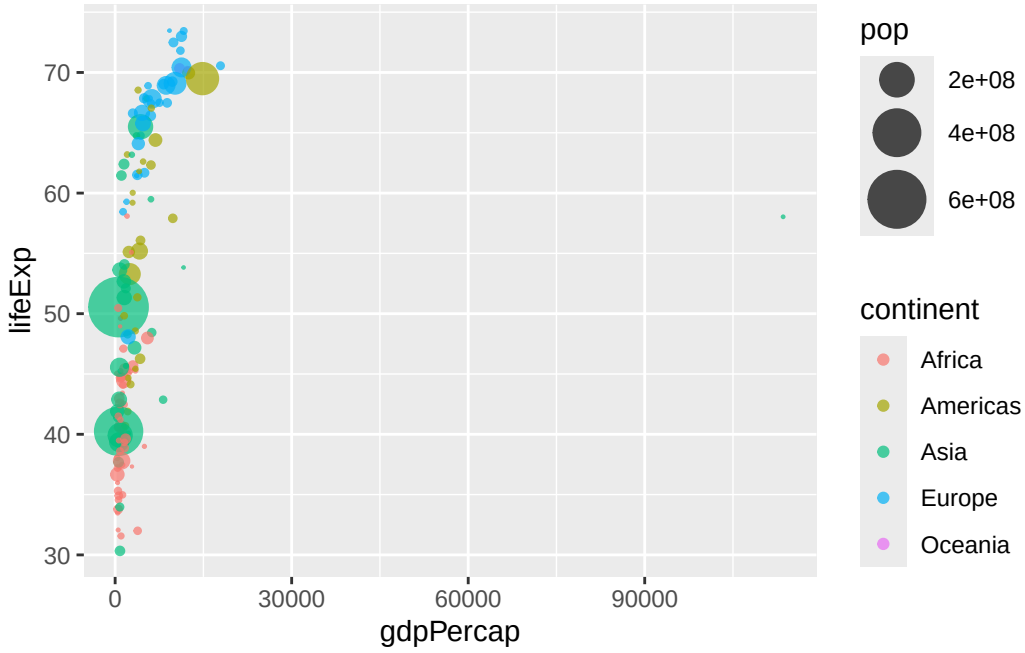

```
ggplot(gapminder_2007) +
  aes(x = gdpPercap, y = lifeExp, size = pop) +
  geom_point(alpha=0.5)
```



```
ggplot(gapminder_2007) +
  geom_point(aes(x = gdpPercap, y = lifeExp,
                 size = pop), alpha=0.5) +
  scale_size_area(max_size = 10)
```




```
gapminder_1957 <- gapminder %>% filter(year==1957)

ggplot(gapminder_1957) +
  aes(x = gdpPercap, y = lifeExp, color=continent,
                 size = pop) +
  geom_point(alpha=0.7) +
  scale_size_area(max_size = 10)
```



Q. How many years are in this dataset?

```
length(gapminder$year)
```

```
[1] 1704
```

```
table(gapminder$year)
```

```
1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 2002 2007
 142  142  142  142  142  142  142  142  142  142  142  142
```

```
unique(gapminder$year)
```

```
 [1] 1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 2002 2007
```

```
length(unique(gapminder$year))
```

```
[1] 12
```

```
library(dplyr)
```

```
filter(gapminder, country=="United States")
```

```
         country continent year lifeExp       pop gdpPercap
1  United States  Americas 1952  68.440 157553000  13990.48
2  United States  Americas 1957  69.490 171984000  14847.13
3  United States  Americas 1962  70.210 186538000  16173.15
4  United States  Americas 1967  70.760 198712000  19530.37
5  United States  Americas 1972  71.340 209896000  21806.04
6  United States  Americas 1977  73.380 220239000  24072.63
7  United States  Americas 1982  74.650 232187835  25009.56
8  United States  Americas 1987  75.020 242803533  29884.35
9  United States  Americas 1992  76.090 256894189  32003.93
10 United States  Americas 1997  76.810 272911760  35767.43
11 United States  Americas 2002  77.310 287675526  39097.10
12 United States  Americas 2007  78.242 301139947  42951.65
```

Q. Extract data for the US in 1992.

```
filter(gapminder, country=="United States", year=="1992")
```

```
        country continent year lifeExp       pop gdpPercap
1 United States  Americas 1992   76.09 256894189  32003.93
```

Q. Wht is the population of Ireland in the last year we have data for?

```
filter(gapminder, country=="Ireland", year=="2007")
```

```
  country continent year lifeExp     pop gdpPercap
1 Ireland    Europe 2007  78.885 4109086     40676
```

Q. What countries in data set had pop smller than Ireland in 2007?

- First limit/subset the dataset to the year 2007

```
gap07 <- filter(gapminder, year==2007)
```

- Then find the pop value for Ireland

```
ire_pop <- filter(gap07, country=="Ireland")["pop"]
ire_pop
```

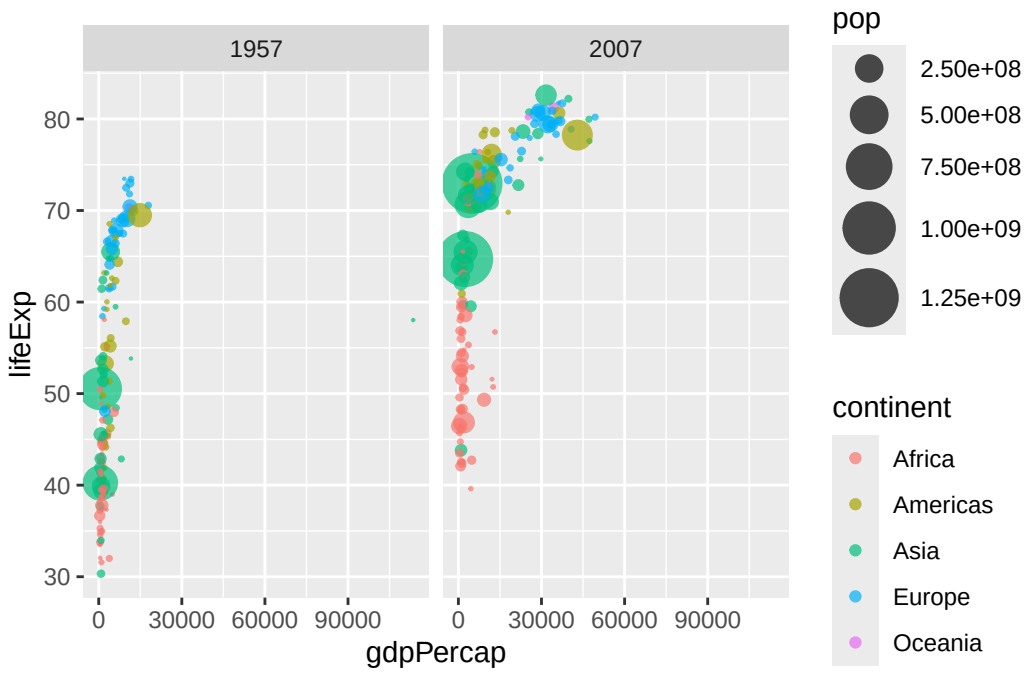
```
      pop
1 4109086
```

- Then extract all rows with pop less than Ireland's

```
filter(gap07, pop < 4109086)
```

```
                country continent year lifeExp     pop  gdpPercap
1               Albania    Europe 2007  76.423 3600523  5937.0295
2               Bahrain      Asia 2007  75.635  708573 29796.0483
3              Botswana    Africa 2007  50.728 1639131 12569.8518
4               Comoros    Africa 2007  65.152  710960   986.1479
5          Congo, Rep.    Africa 2007  55.322 3800610  3632.5578
6              Djibouti    Africa 2007  54.791  496374  2082.4816
7     Equatorial Guinea    Africa 2007  51.579  551201 12154.0897
8                 Gabon    Africa 2007  56.735 1454867 13206.4845
9                Gambia    Africa 2007  59.448 1688359   752.7497
10        Guinea-Bissau    Africa 2007  46.388 1472041   579.2317
11              Iceland    Europe 2007  81.757  301931 36180.7892
12              Jamaica  Americas 2007  72.567 2780132  7320.8803
13               Kuwait      Asia 2007  77.588 2505559 47306.9898
14              Lebanon      Asia 2007  71.993 3921278 10461.0587
15              Lesotho    Africa 2007  42.592 2012649  1569.3314
16              Liberia    Africa 2007  45.678 3193942   414.5073
17           Mauritania    Africa 2007  64.164 3270065  1803.1515
18            Mauritius    Africa 2007  72.801 1250882 10956.9911
19             Mongolia      Asia 2007  66.803 2874127  3095.7723
20           Montenegro    Europe 2007  74.543  684736  9253.8961
21              Namibia    Africa 2007  52.906 2055080  4811.0604
22                 Oman      Asia 2007  75.640 3204897 22316.1929
23               Panama  Americas 2007  75.537 3242173  9809.1856
24          Puerto Rico  Americas 2007  78.746 3942491 19328.7090
25              Reunion    Africa 2007  76.442  798094  7670.1226
26 Sao Tome and Principe    Africa 2007  65.528  199579  1598.4351
27             Slovenia    Europe 2007  77.926 2009245 25768.2576
28            Swaziland    Africa 2007  39.613 1133066  4513.4806
29  Trinidad and Tobago  Americas 2007  69.819 1056608 18008.5092
30              Uruguay  Americas 2007  76.384 3447496 10611.4630
31   West Bank and Gaza      Asia 2007  73.422 4018332  3025.3498
```

```
gapminder_1957 <- gapminder %>% filter(year==1957 | year==2007)

ggplot(gapminder_1957) +
  geom_point(aes(x = gdpPercap, y = lifeExp, color=continent,
                 size = pop), alpha=0.7) +
  scale_size_area(max_size = 10) +
  facet_wrap(~year)
```

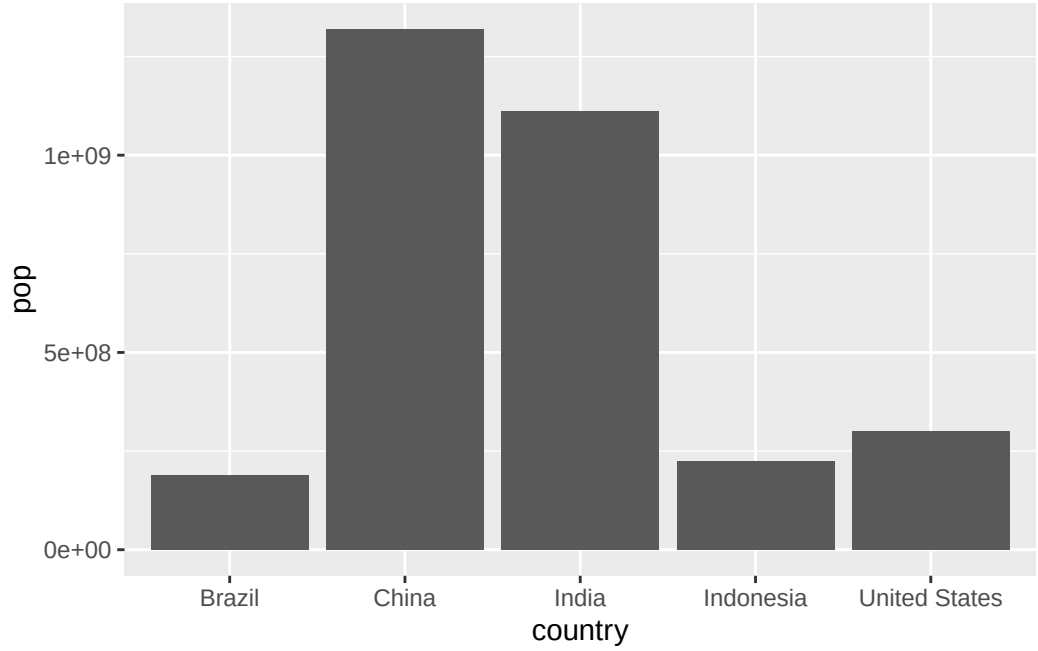


OPTIONAL: Bar Charts

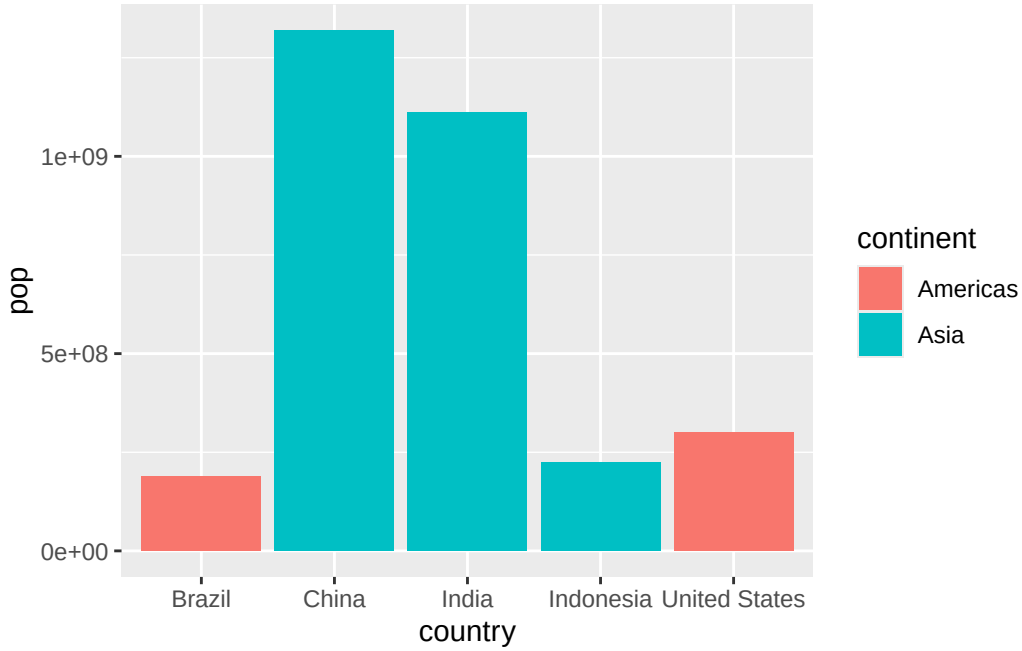
```
gapminder_top5 <- gapminder %>%
  filter(year==2007) %>%
  arrange(desc(pop)) %>%
  top_n(5, pop)

gapminder_top5
```

```
        country continent year lifeExp        pop gdpPercap
1         China      Asia 2007  72.961 1318683096  4959.115
2         India      Asia 2007  64.698 1110396331  2452.210
3 United States  Americas 2007  78.242  301139947 42951.653
4     Indonesia      Asia 2007  70.650  223547000  3540.652
5        Brazil  Americas 2007  72.390  190010647  9065.801
```

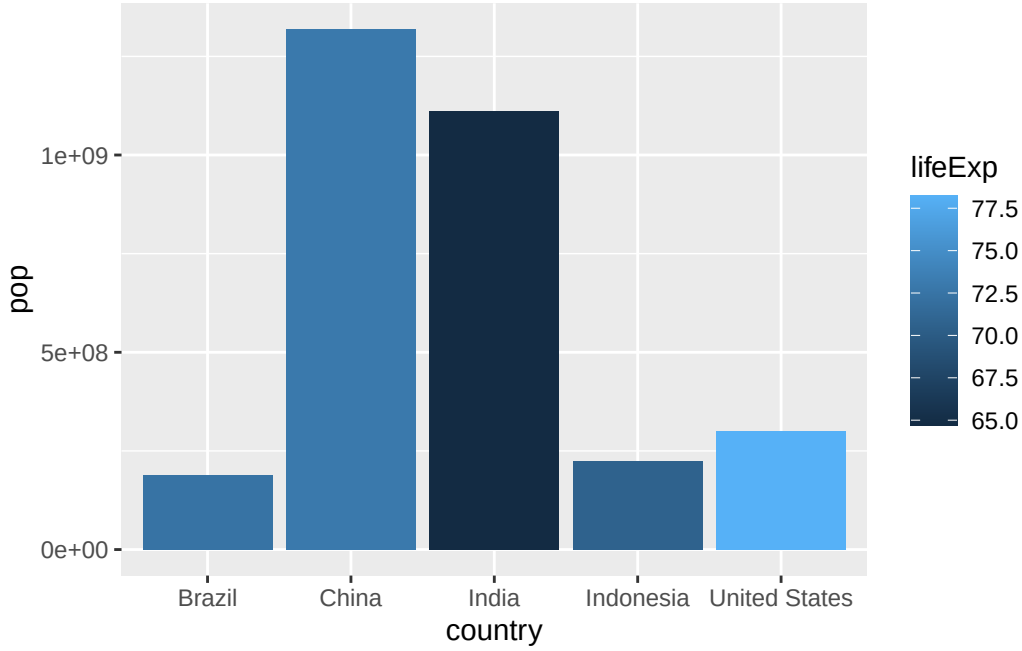
```
ggplot(gapminder_top5) +
  geom_col(aes(x = country, y = pop))
```



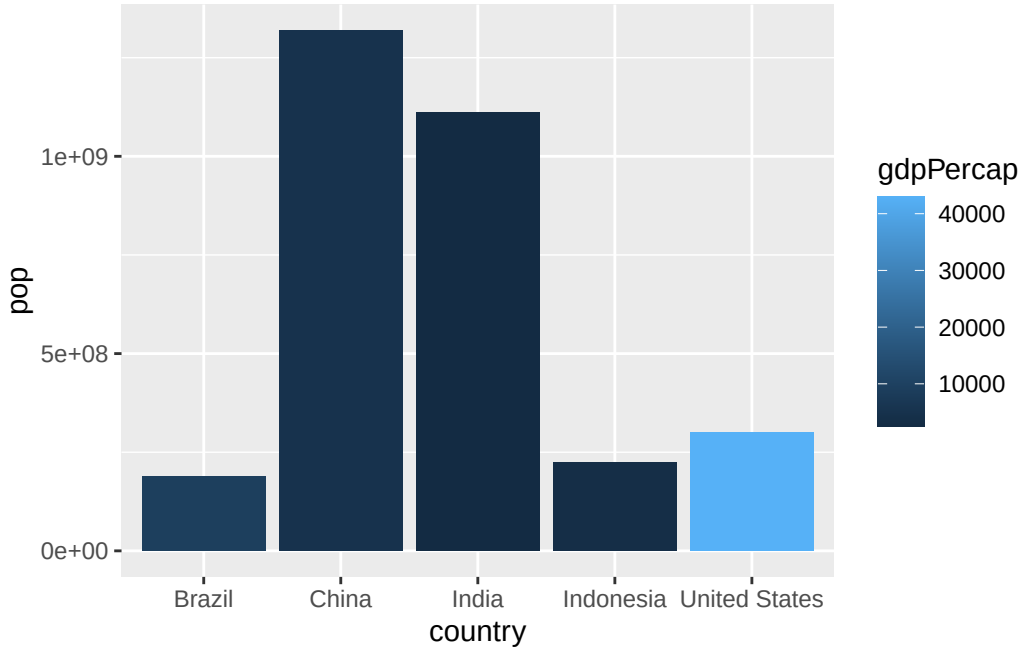

```
ggplot(gapminder_top5) +
  geom_col(aes(x = country, y = pop, fill = continent))
```



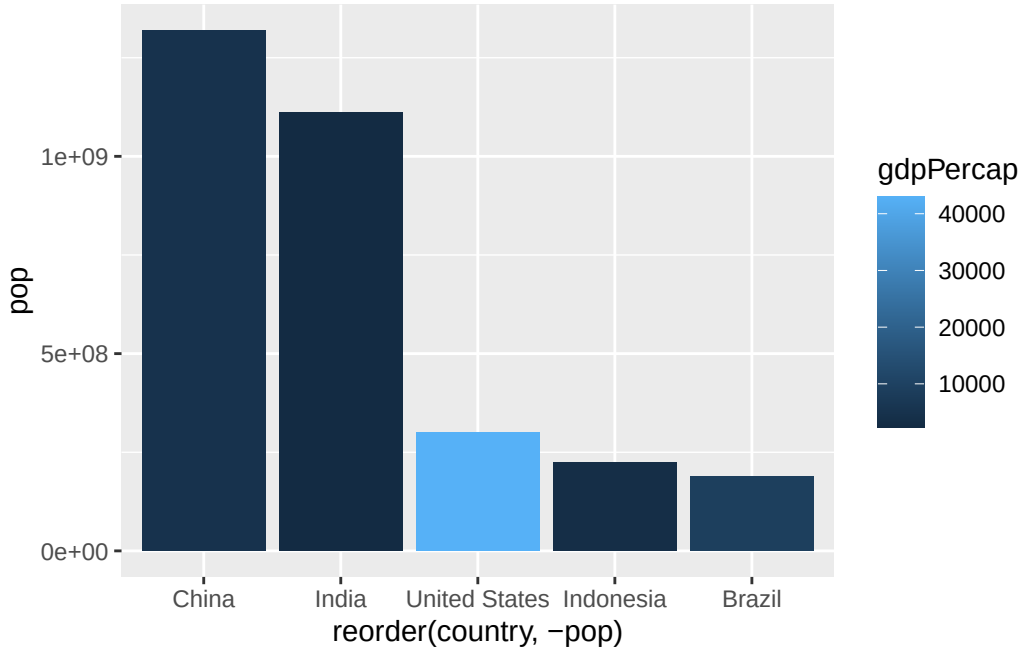

```
ggplot(gapminder_top5) +
  geom_col(aes(x = country, y = pop, fill = lifeExp))
```



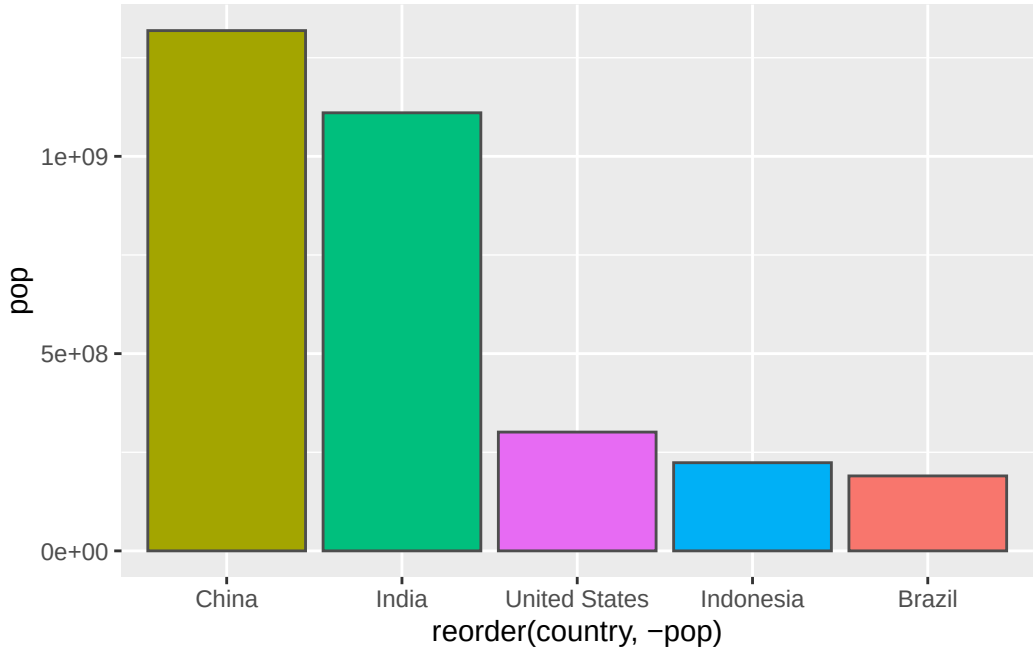
```
ggplot(gapminder_top5) +
  aes(x=country, y=pop, fill=gdpPercap) +
  geom_col()
```




```
ggplot(gapminder_top5) +
  aes(x=reorder(country, -pop), y=pop, fill=gdpPercap) +
  geom_col()
```



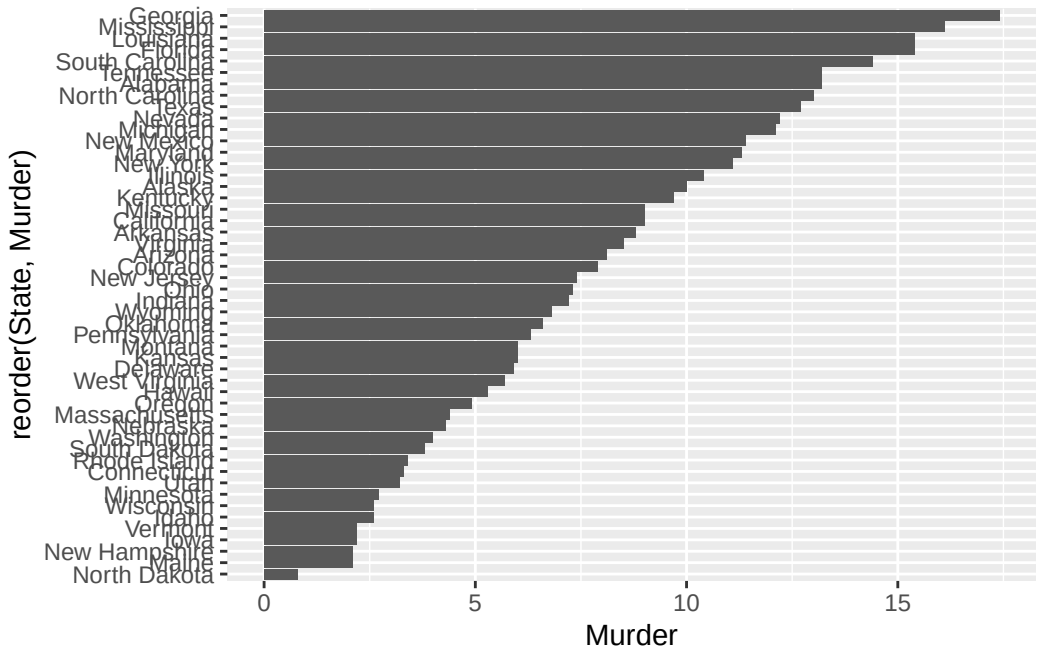

```
ggplot(gapminder_top5) +
  aes(x=reorder(country, -pop), y=pop, fill=country) +
  geom_col(col="gray30") +
  guides(fill="none")
```



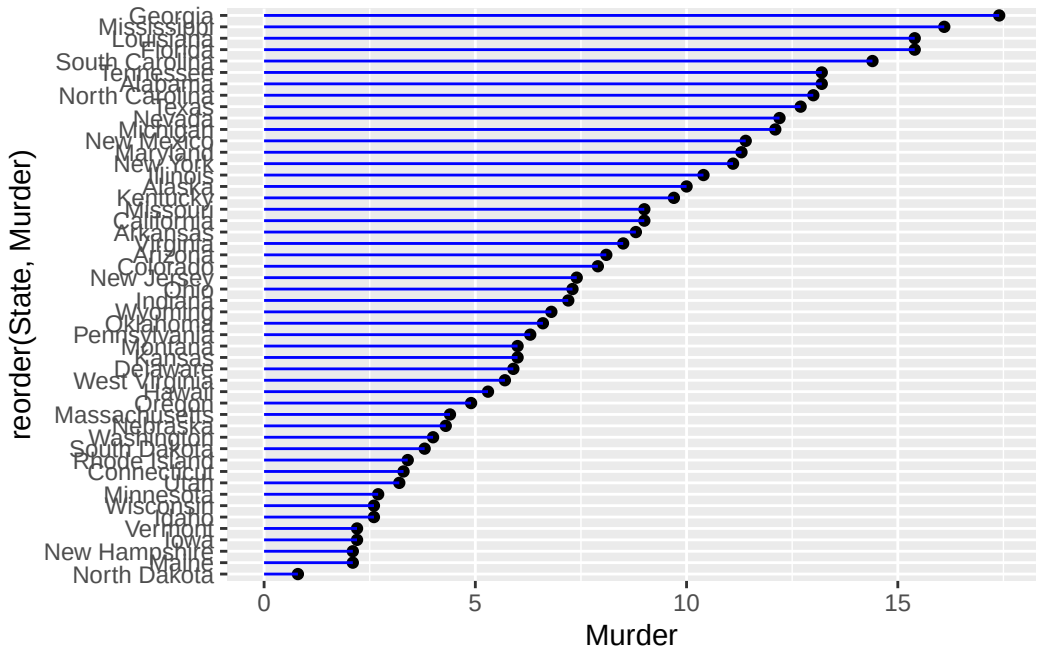

```
head(USArrests)
```

```
           Murder Assault UrbanPop Rape
Alabama      13.2     236       58 21.2
Alaska       10.0     263       48 44.5
Arizona       8.1     294       80 31.0
Arkansas      8.8     190       50 19.5
California    9.0     276       91 40.6
Colorado      7.9     204       78 38.7
```

```
USArrests$State <- rownames(USArrests)
ggplot(USArrests) +
  aes(x=reorder(State,Murder), y=Murder) +
  geom_col() +
  coord_flip()
```




```
ggplot(USArrests) +
  aes(x=reorder(State,Murder), y=Murder) +
  geom_point() +
  geom_segment(aes(x=State,
                   xend=State,
                   y=0,
                   yend=Murder), color="blue") +
  coord_flip()
```



Extensions: Animation

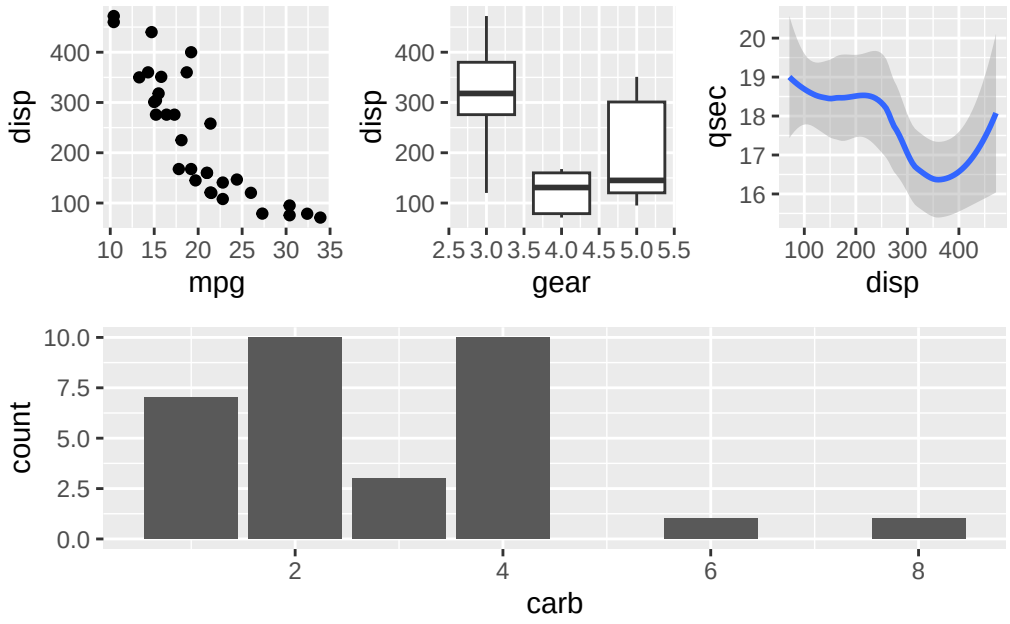
```
library(gapminder)
library(gganimate)

ggplot(gapminder, aes(gdpPercap, lifeExp, size = pop, colour = country)) +
  geom_point(alpha = 0.7, show.legend = FALSE) +
  scale_colour_manual(values = country_colors) +
  scale_size(range = c(2, 12)) +
  scale_x_log10() +
  # Facet by continent
  facet_wrap(~continent) +
  # Here comes the gganimate specific bits
  labs(title = 'Year: {frame_time}', x = 'GDP per capita', y = 'life expectancy') +
  transition_time(year) +
  shadow_wake(wake_length = 0.1, alpha = FALSE)
```

Combining Plots

```
library(patchwork)

p1 <- ggplot(mtcars) + geom_point(aes(mpg, disp))
p2 <- ggplot(mtcars) + geom_boxplot(aes(gear, disp, group = gear))
```

```
p3 <- ggplot(mtcars) + geom_smooth(aes(disp, qsec))
p4 <- ggplot(mtcars) + geom_bar(aes(carb))

(p1 | p2 | p3) /
      p4
```

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



About this document

```
sessionInfo()
```

```
R version 4.4.1 (2024-06-14 ucrt)
Platform: x86_64-w64-mingw32/x64
Running under: Windows 10 x64 (build 19045)

Matrix products: default


locale:
[1] LC_COLLATE=English_United States.utf8
```

```
[2] LC_CTYPE=English_United States.utf8
[3] LC_MONETARY=English_United States.utf8
[4] LC_NUMERIC=C
[5] LC_TIME=English_United States.utf8

time zone: America/Los_Angeles
tzcode source: internal

attached base packages:
[1] stats     graphics  grDevices utils     datasets  methods   base

other attached packages:
[1] patchwork_1.3.0 dplyr_1.1.4     ggplot2_3.5.1

loaded via a namespace (and not attached):
 [1] vctrs_0.6.5       nlme_3.1-164      cli_3.6.3         knitr_1.48
 [5] rlang_1.1.4       xfun_0.48         generics_0.1.3    jsonlite_1.8.9
 [9] labeling_0.4.3    glue_1.8.0        colorspace_2.1-1  htmltools_0.5.8.1
[13] scales_1.3.0      fansi_1.0.6       rmarkdown_2.28    grid_4.4.1
[17] evaluate_1.0.1    munsell_0.5.1     tibble_3.2.1      fastmap_1.2.0
[21] yaml_2.3.10       lifecycle_1.0.4   compiler_4.4.1    pkgconfig_2.0.3
[25] mgcv_1.9-1        lattice_0.22-6    farver_2.1.2      digest_0.6.37
[29] R6_2.5.1          tidyselect_1.2.1  utf8_1.2.4        splines_4.4.1
[33] pillar_1.9.0      magrittr_2.0.3    Matrix_1.7-0      withr_3.0.1
[37] tools_4.4.1       gtable_0.3.5
```