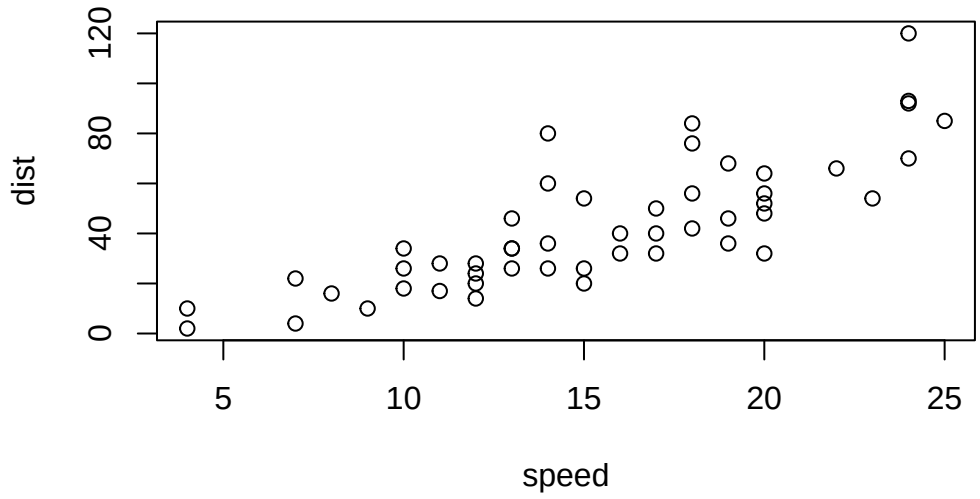
Class 5: Data Viz with ggplot

Nathaniel Nono (PID: A16782656)

Plotting in R

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

```
plot(cars)
```



This is a **base** R plot of the in-build `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**?

All ggplot figures have at least 3 layers:

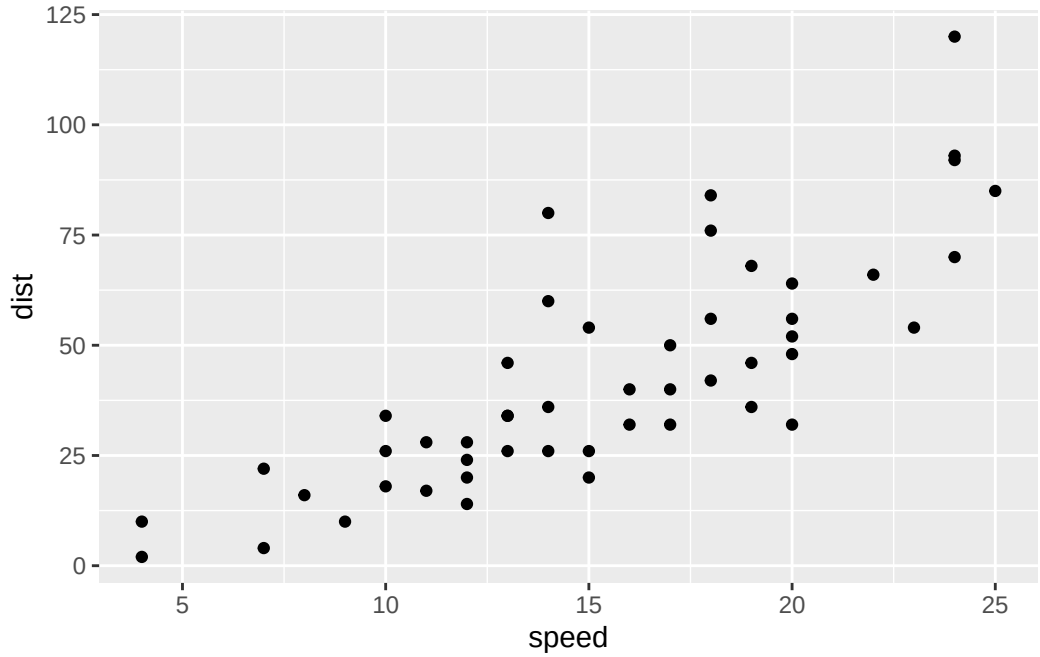
- **data**
- **aesthetics**(how the data map to the plot)
- **geoms**(how we draw the plot, lines, points, etc.)

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

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

There are hundreds of packages installed on the computer via R or through the internet. Need to just call the package with a `library()` command.

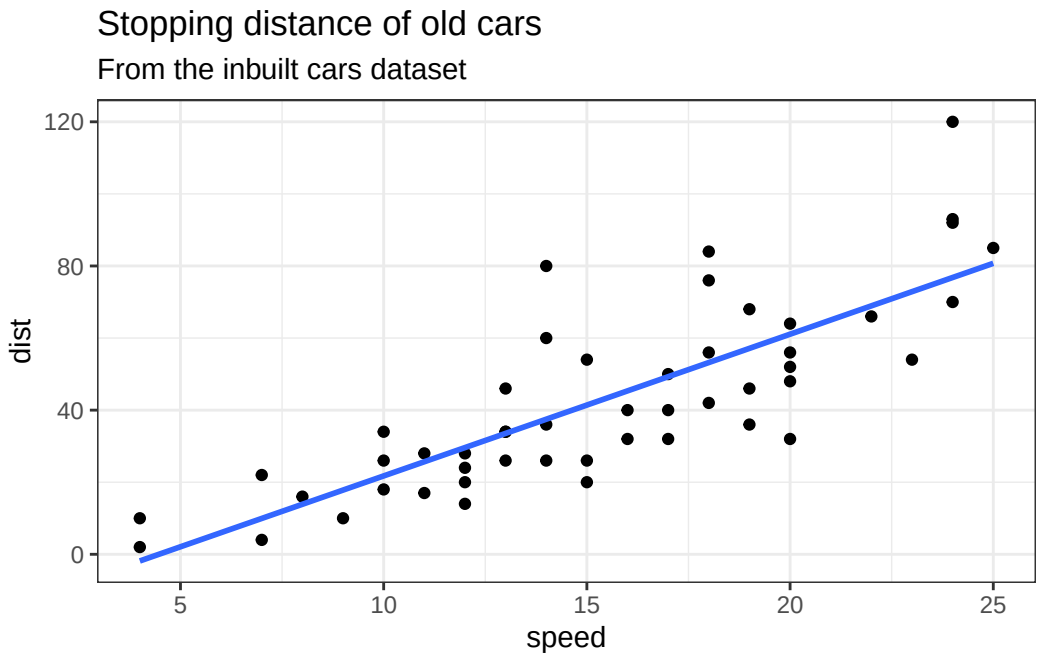
```
# install.packages('ggplot2')
library(ggplot2)
ggplot(cars) +
  aes(x=speed, y=dist) +
  geom_point()
```



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(se=F, method='lm') +
  labs(title='Stopping distance of old cars',
       subtitle = 'From the inbuilt cars dataset') +
  theme_bw()
```

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



Running Code

When you click the **Render** button a document will be generated that includes both content and the output of embedded code. You can embed code like this:

```
1 + 1
```

```
[1] 2
```

You can add options to executable code like this

```
[1] 4
```

The `echo: false` option disables the printing of code (only output is displayed).

Class 5 Lab Section

5: Common Plot Types

Others

> Q. Which plot types are typically NOT used to compare distributions of numeric variables?

Network Graphs

> Q. Which statement about data visualization with ggplot2 is incorrect?

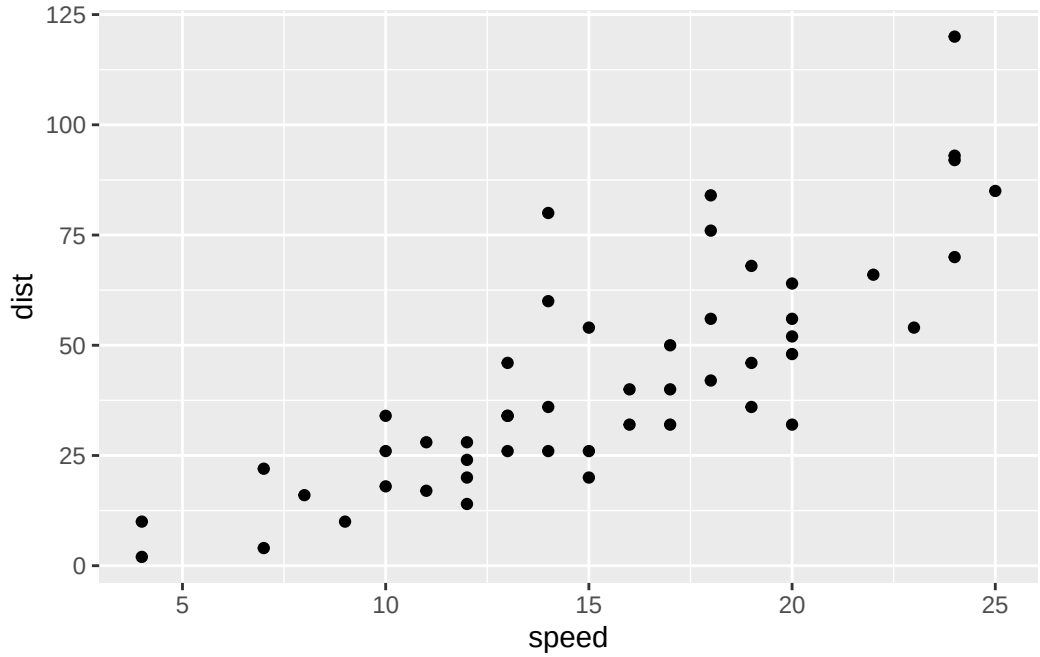
ggplot is the only way to create plots in R

6: Creating Scatter Plots

Introduction to Scatter plots

- Defining a dataset for your plot using the main `ggplot()` function.
- Specifying how your data maps to plot aesthetics with the `aes()` function.
- Adding geometric layers using the geom_point() function.
- Combining the above function calls with + operator to make your plot.

```
ggplot(cars) +
  aes(speed, dist) +
  geom_point()
```



Specificing a dataset mappings with `ggplot()`

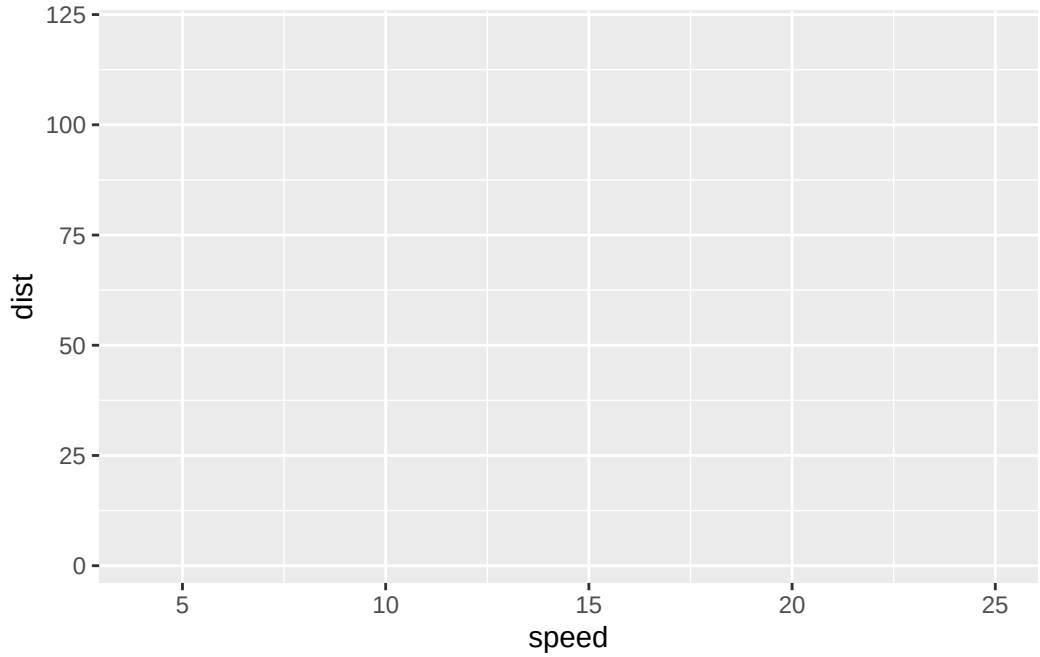
- Plot using the in-built `cars` dataset -> Does not display anything

```
ggplot(cars)
```

Specificing aesthetic mappings with `aes()`

- Displays a x and y coordinate plane but datapoints

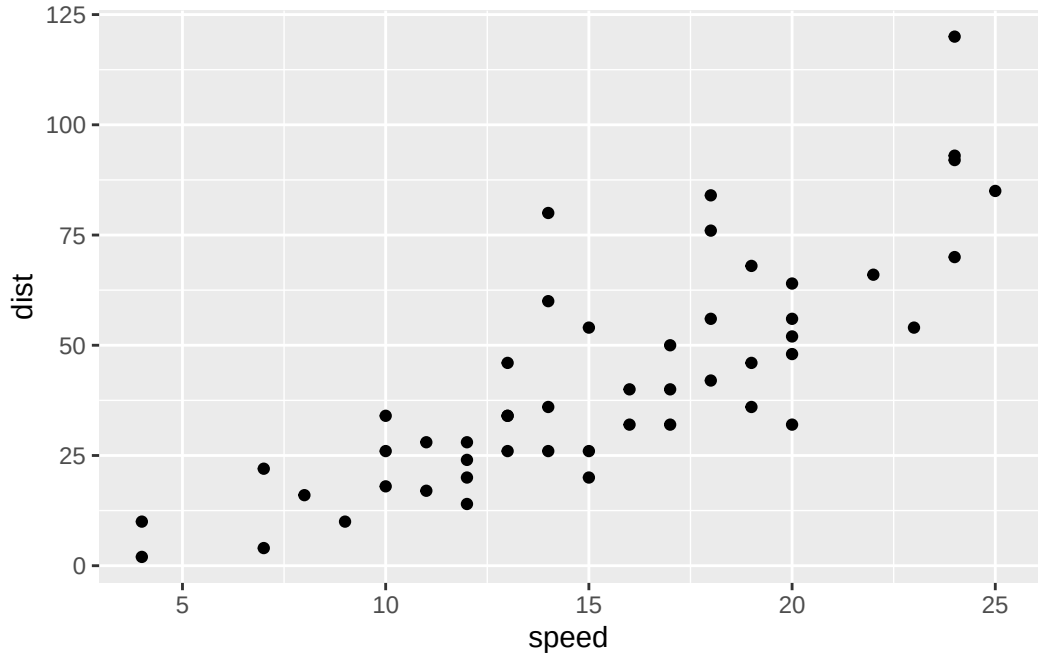
```
ggplot(cars) +
  aes(x=speed, y=dist)
```



Specificing a geom layer with `geom_point()`

- `geom_line()` -> Produces a line plot
- `geom_bar()` -> Produces a bar plot
- `geom_boxplot()` -> Produces a box plot

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



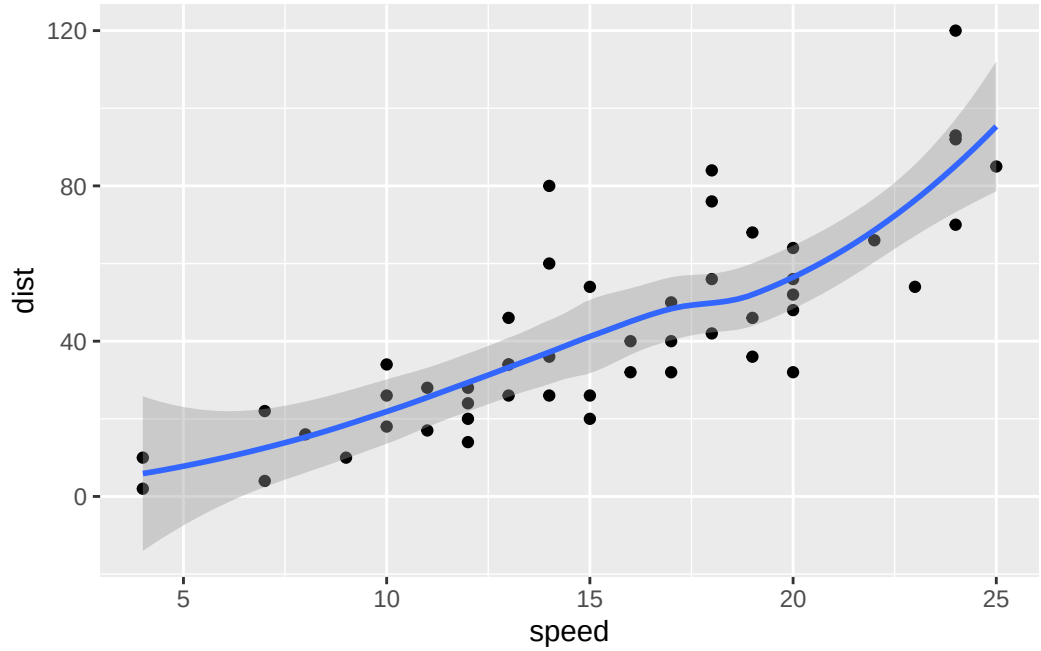
Q. Which geometric layer should be used to create scatter plots in ggplot2?

geom_point()

Q. In your own RStudio can you add a trend line layer to help show the relationship between the plot variables with the geom_smooth() function?

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

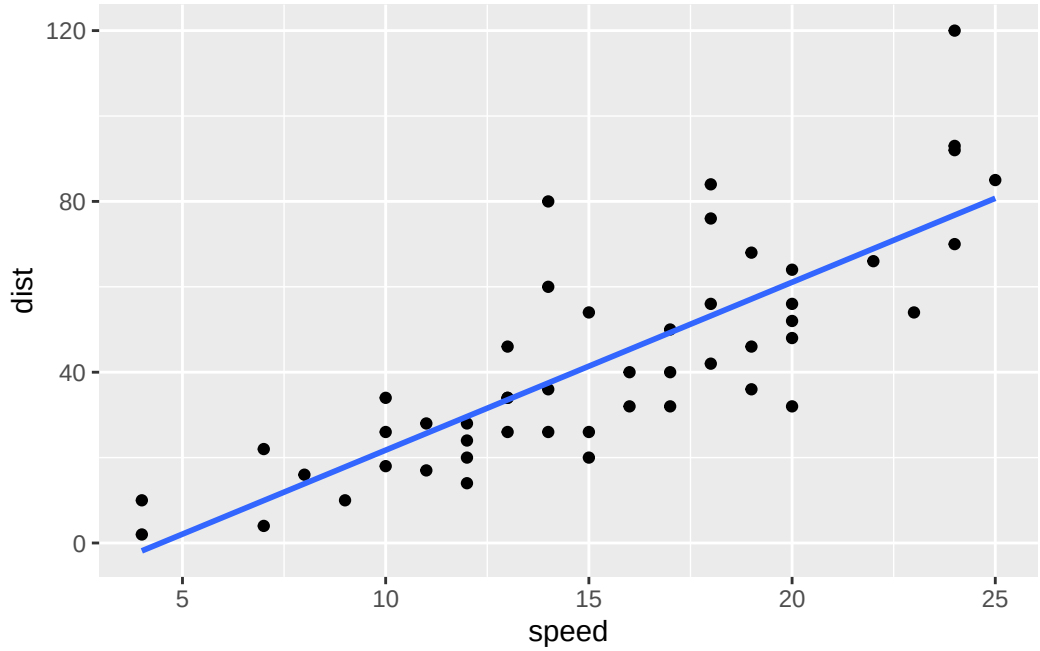
```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



Q. Argue with geom_smooth() to add a straight line from a linear model without the shaded standard error region?

```
ggplot(cars) +
  aes(x=speed, y=dist) +
  geom_point() +
  geom_smooth(se=F,method='lm')
```

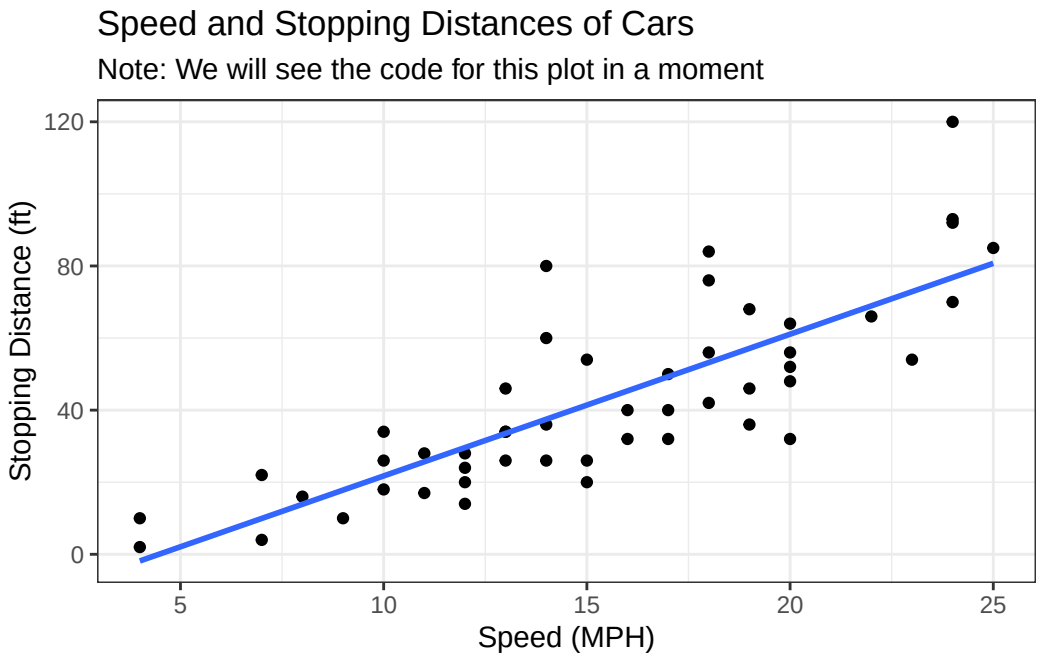
```
`geom_smooth()` using formula = 'y ~ x'
```



Q. Can you finish this plot by adding various label annotations with the labs() function and changing the plot look to a more conservative "black & white" theme by adding the theme_bw() function:

```
ggplot(cars) +
  aes(x=speed, y=dist) +
  geom_point() +
  geom_smooth(se=F,method='lm') +
  labs(title = 'Speed and Stopping Distances of Cars',
       subtitle = 'Note: We will see the code for this plot in a moment',
       x = 'Speed (MPH)',
       y = 'Stopping Distance (ft)') +
  theme_bw()
```

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



Adding more plot aesthetics through `aes()`

Here we will cover how to: - Adjust the point size of a scatter plot using the `size` parameter. - Change the point color of a scatter plot using the `color` parameter. - Set a parameter `alpha` to change the transparency of all points.

- Aesthetic Mappings - plot features you want mapped to variables in your data
- Constant Parameters - Specifications of plot features you want to remain the same or therwise come from elsewhere

The code below reads the results of a differential expression analysis where a new anti-viral drug is being tested:

```
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
```

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

```
nrow(genes)
```

```
[1] 5196
```

5196 genes in the dataset

Q. 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?

```
colnames(genes)
```

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

```
ncol(genes)
```

```
[1] 4
```

4 genes: 'Gene', 'Condition1', 'Condition2', 'State'

Q. 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?

```
table(genes[,'State'])
```

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

127 upregulated genes in the dataset

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

```
# Fraction of up regulated genes
up_regulated <- table(genes$State)/nrow(genes)
up_regulated
```

```
      down unchanging         up
0.01385681 0.96170131 0.02444188
```

```
# Percent of up regulated genes rounded to significant figures
fraction_regulated <- round((up_regulated * 100), 2)
fraction_regulated
```

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

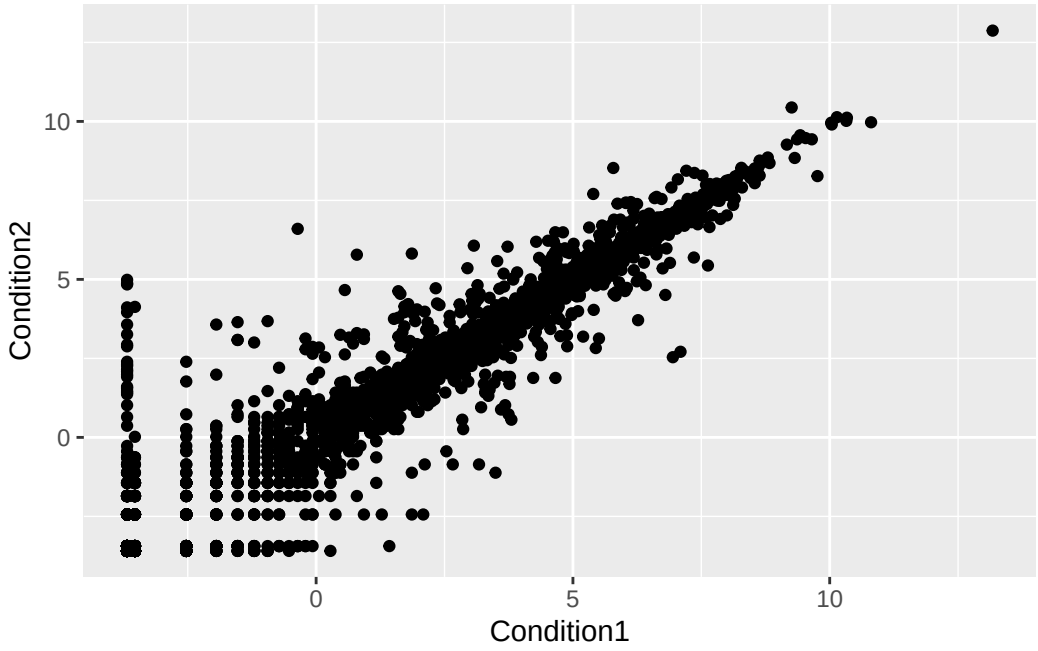
2.44% are regulated from the entire data set

We can make a first basic scatter plot of this data set, by following the same recipe we have already seen, namely:

- Pass the genes data.frame as input to the ggplot() function.
- Then use the aes() function to set the x and y aesthetic mappings to the Condition1 and Condition2 columns.
- Finally add a geom_point() layer to add points to the plot.
- Don't forget to add layers step-wise with the + operator at the end of each line.

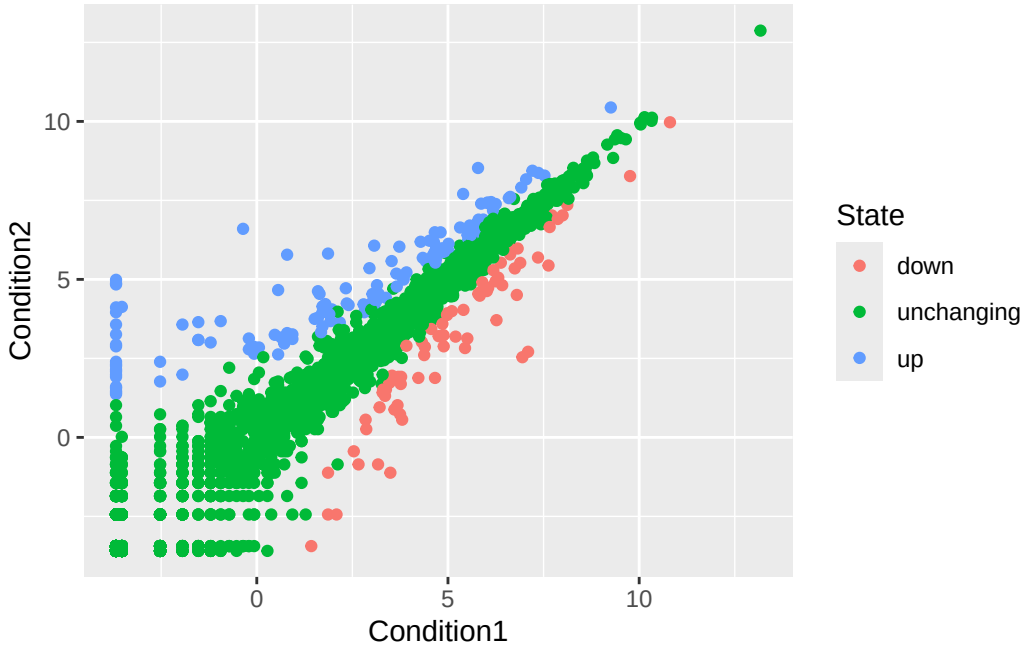
Q. Complete the code below to produce the following plot

```
ggplot(genes) +
  aes(x=Condition1, y=Condition2) +
  geom_point()
```



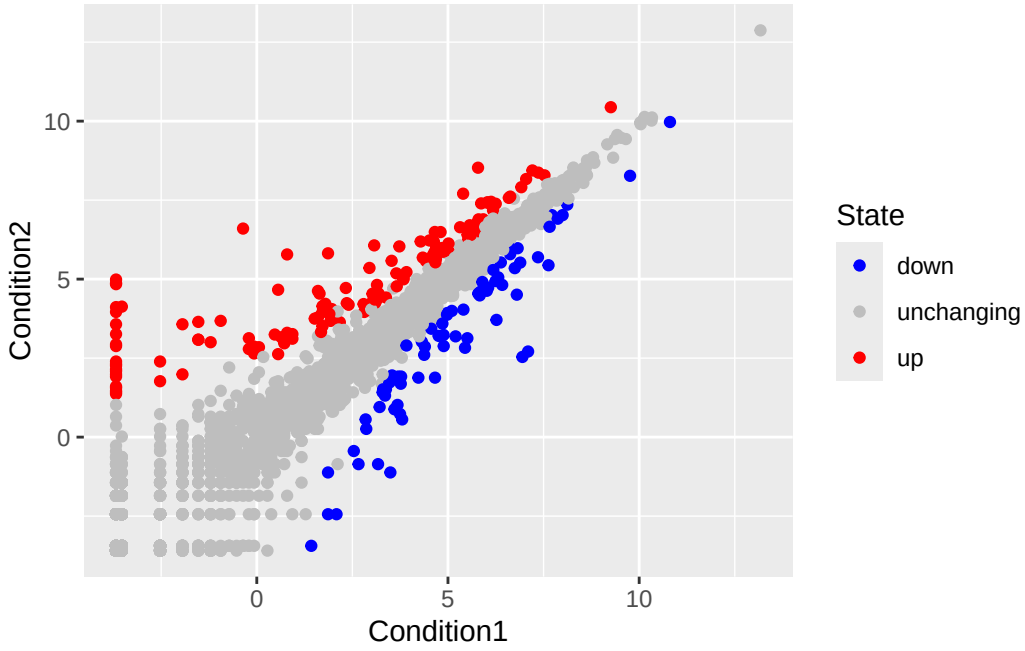
Inclduing the State column tells us whether the difference in expression values vetween codnitions is statistically signficant. Let's map this column to point colour

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

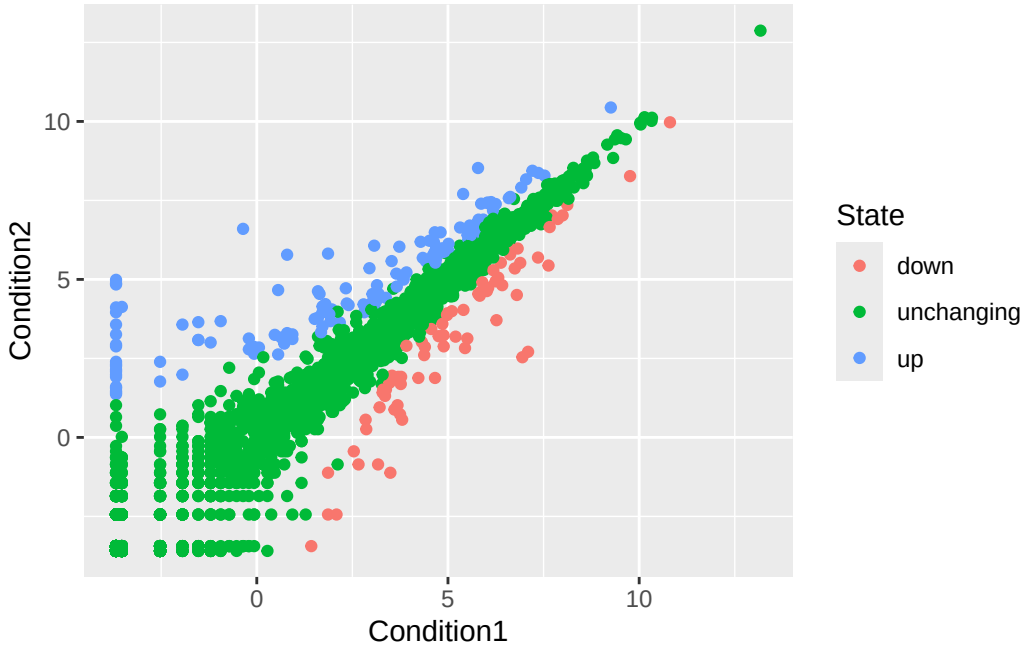


Add more layers to the previous plot

```
p + scale_colour_manual( values=c("blue","gray","red") )
```

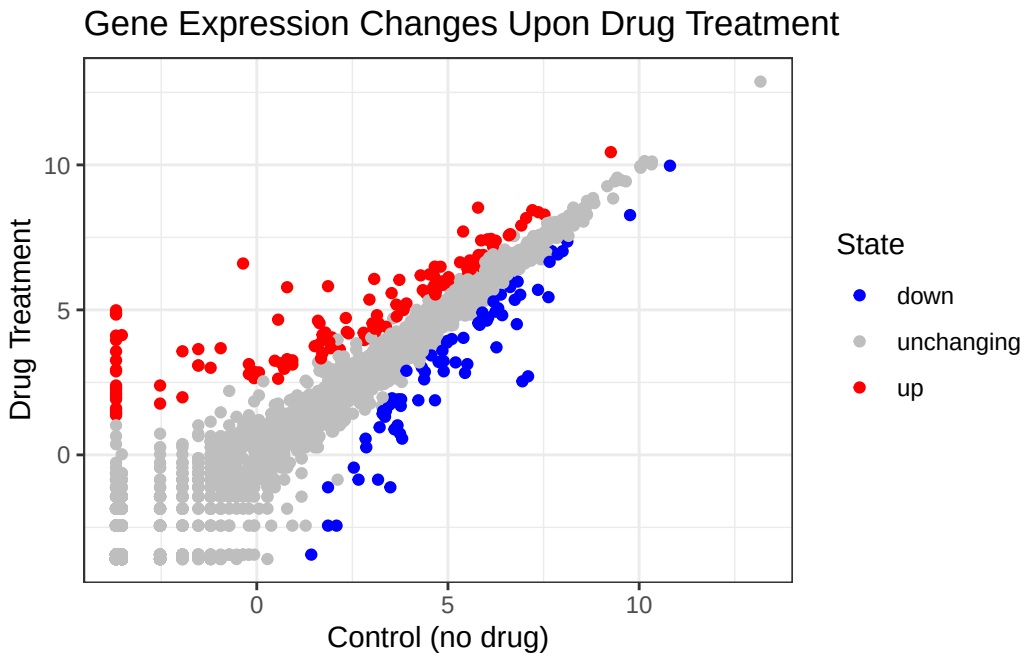


```
p
```

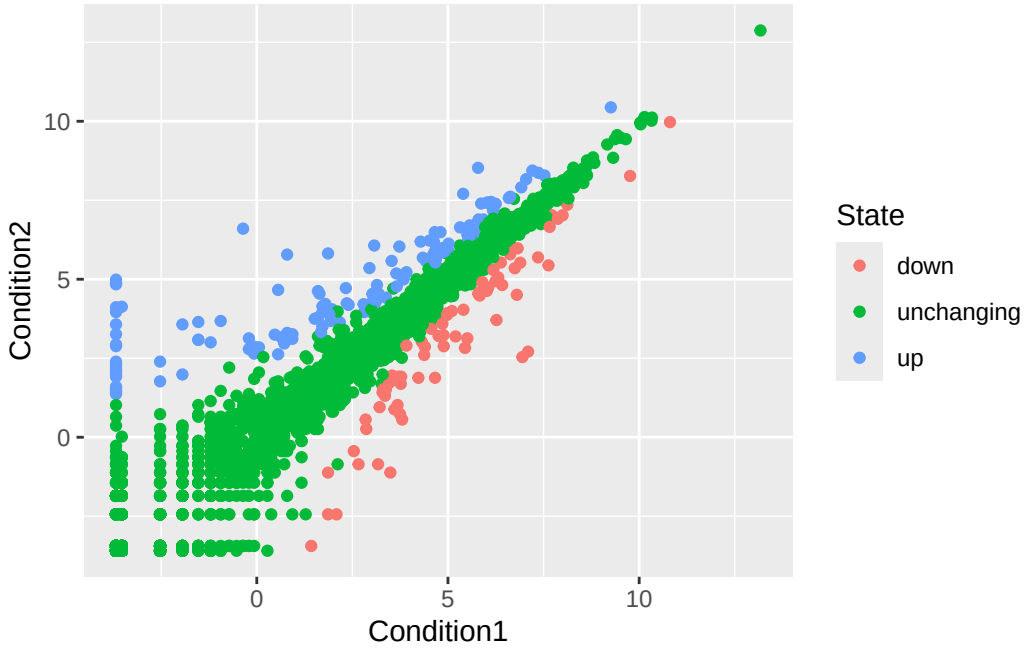


Q. Nice, now add some plot annotations to the p object with the labs() function so your plot looks like the following:

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


Gene Expression Changes Upon Drug Treatment
Drug Treatment
Control (no drug)
0
5
10
State
down
unchanging
up

```
p
```


Condition2
Condition1
0
5
10
State
down
unchanging
up

7: Going Further

After installing the `install.packages('gapminder')` call the function in the console

```
library(gapminder)
```

Other option:

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

gapminder <- read.delim(url)
```

`dplyr` code used to focus in a single year. Need to isntall first then call the function

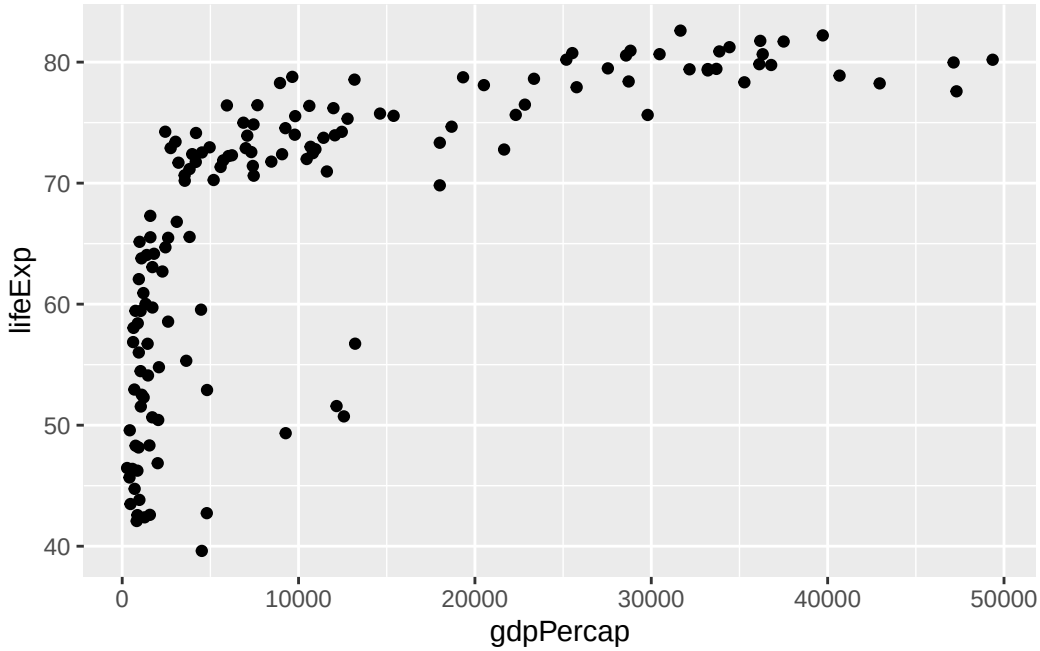
```
# install.packages("dplyr")  ## un-comment to install if needed
library(dplyr)
```

```
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)
```

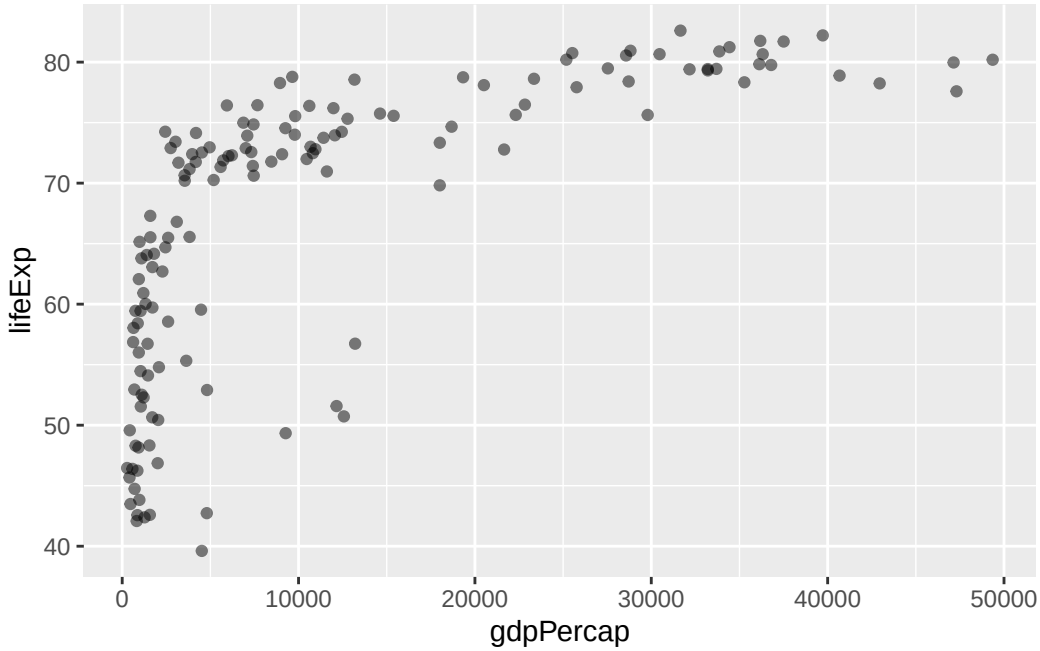
> Q. Complete the code below to produce a first basic scater plot of this gapminder_2007 dataset:

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



Make the points more transparent with the `alpha` argument in the `geom_point` layer

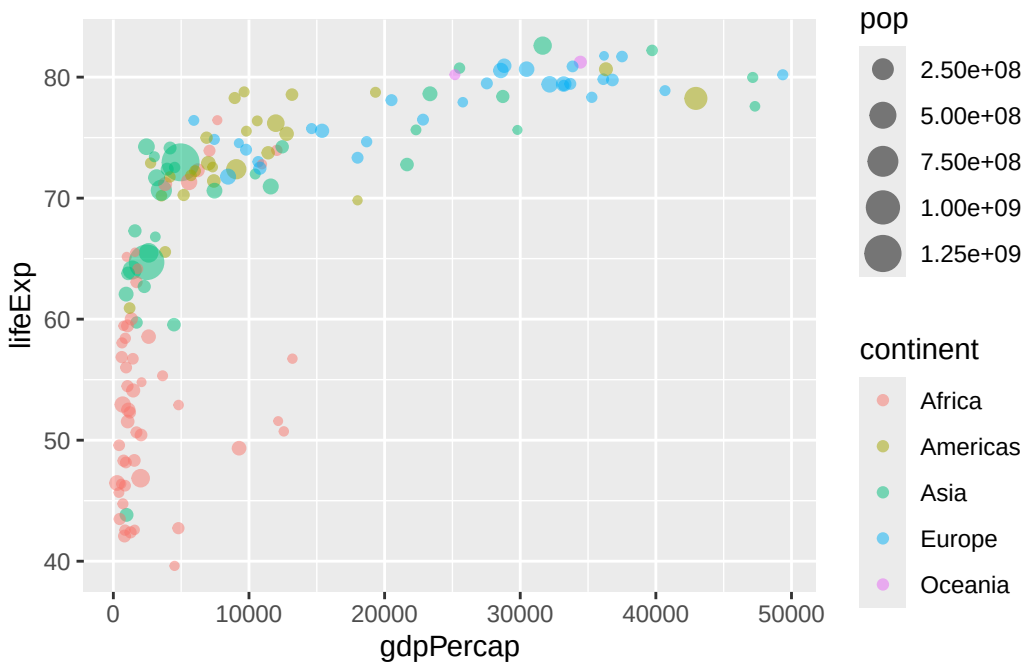
```
ggplot(gapminder_2007) +
  aes(x=gdpPercap, y=lifeExp) +
  geom_point(alpha=0.5)
```



Adding more variable to `aes()`

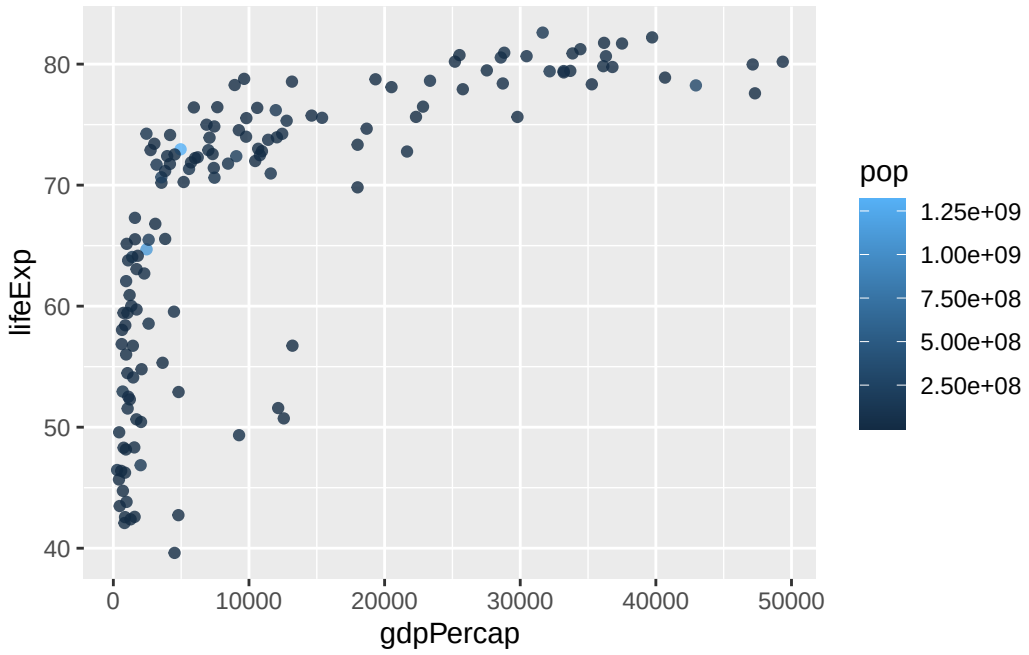
- Map continent variable to the point color aesthetic
- Map population (in millions) through the point size argument to aes()

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



- Coloring the points by the numeric variable population pop

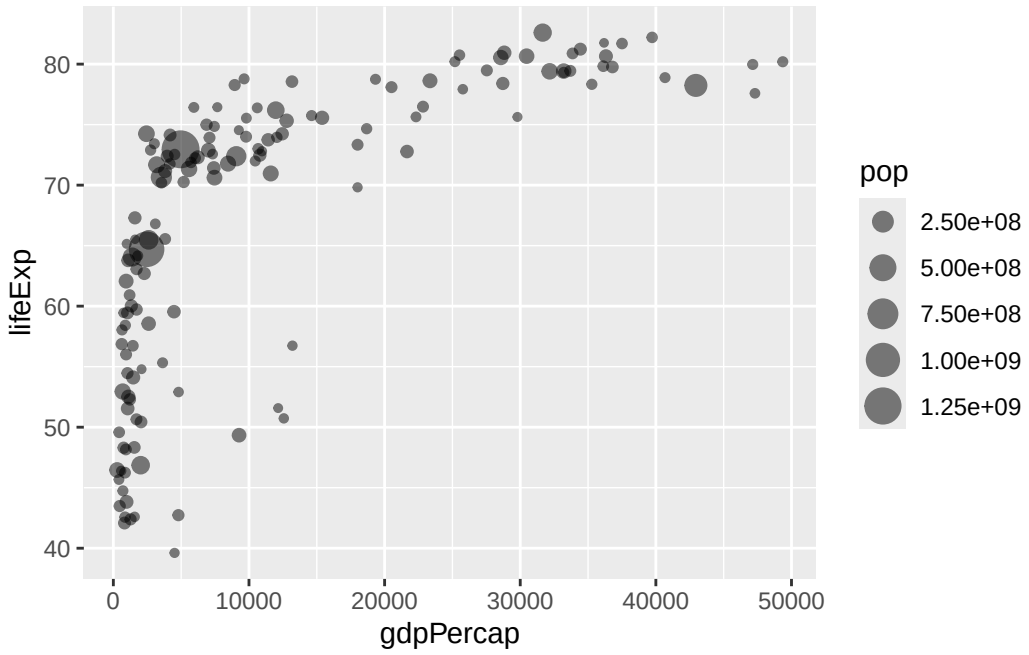
```
ggplot(gapminder_2007) +
  aes(x = gdpPercap, y = lifeExp, color = pop) +
  geom_point(alpha=0.8)
```



Adjusting point size

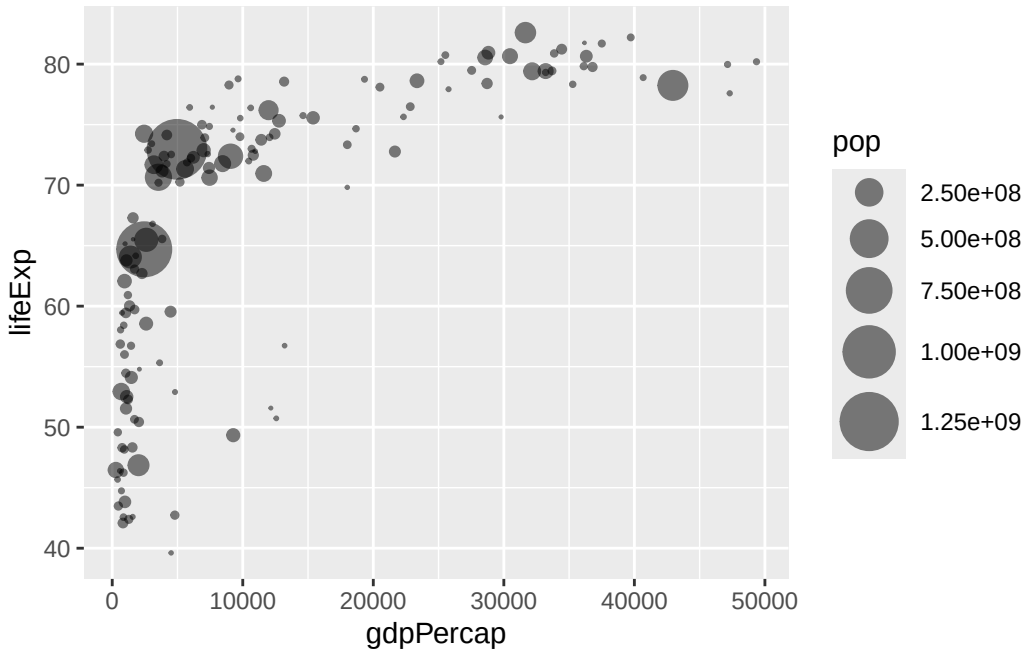
- plot the GDP per capita vs the life expectanncy
- Set the point size base don the population of each country we can use

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



- Reflect the actual population differnces by the point size we can use the scale_size_area() function

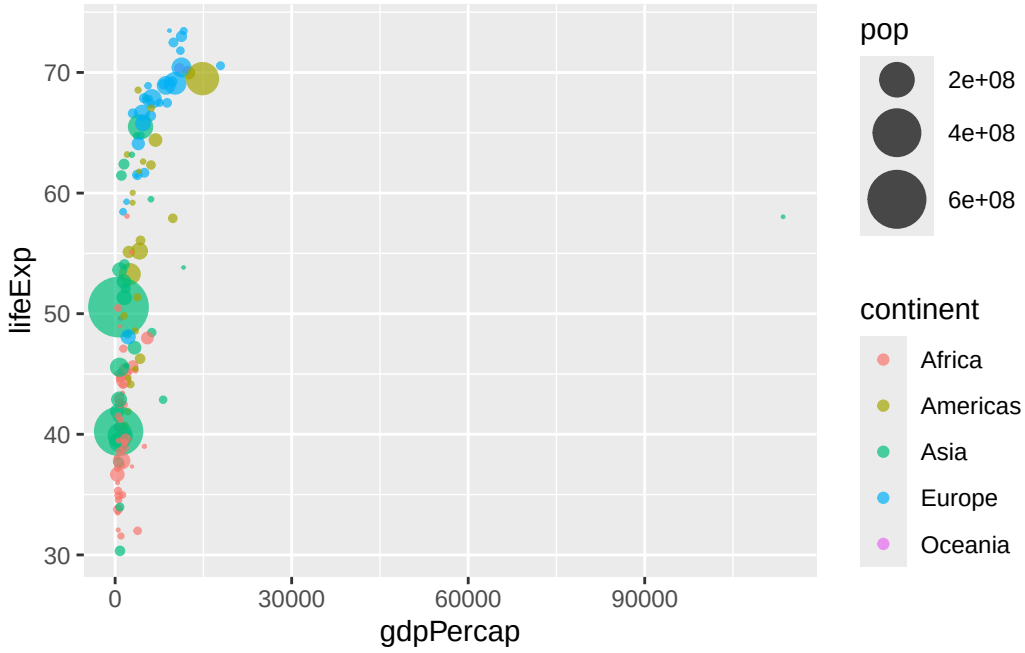
```
ggplot(gapminder_2007) +
  geom_point(aes(x = gdpPercap, y = lifeExp,
                 size = pop), alpha=0.5) +
  scale_size_area(max_size = 10)
```



Can you adapt the code you have learned thus far to reproduce our gapminder scatter plot for the year 1957? What do you notice about this plot is it easy to compare with the one for 2007?

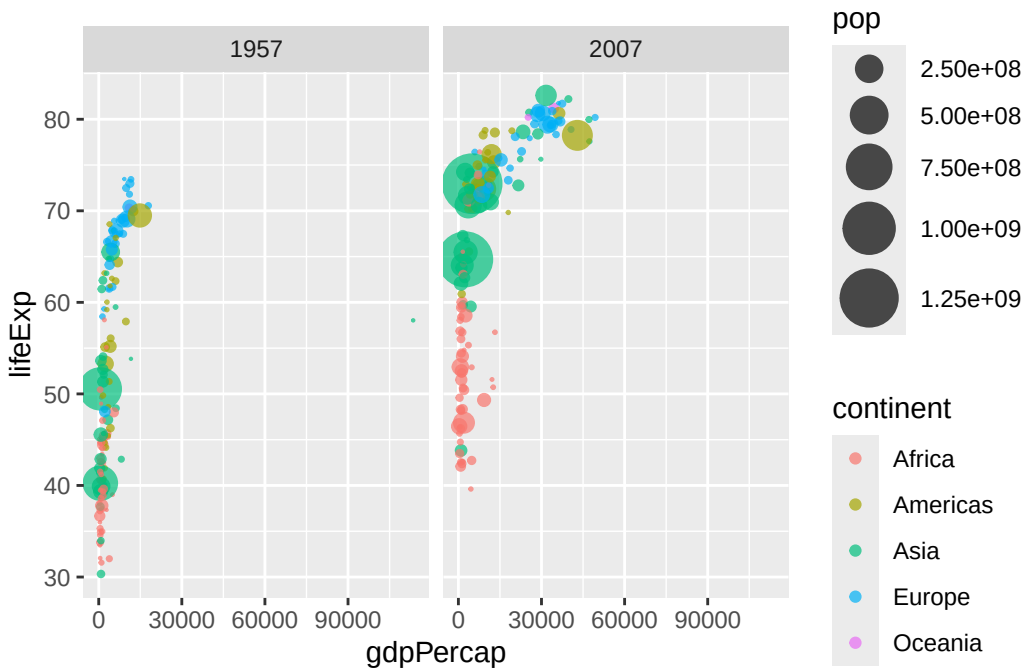
- Use dplyr to filter the gapmider dataset to include only the year 1957 (check above for how we did this for 2007).
- Save your result as gapminder_1957.
- Use the ggplot() function and specify the gapminder_1957 dataset as input
- Add a geom_point() layer to the plot and create a scatter plot showing the GDP per capita gdpPercap on the x-axis and the life expectancy lifeExp on the y-axis
- Use the color aesthetic to indicate each continent by a different color
- Use the size aesthetic to adjust the point size by the population pop
- Use scale_size_area() so that the point sizes reflect the actual population differences and set the max_size of each point to 15 -Set the opacity/transparency of each point to 70% using the alpha=0.7 parameter

```
gapminder_1957 <- gapminder %>% filter(year==1957)
ggplot(gapminder_1957) +
  aes(x=gdpPercap, y=lifeExp, size=pop, color=continent) +
  geom_point(alpha=0.7) +
  scale_size_area(max_size = 10)
```



Q. Do the same steps above but include 1957 and 2007 in your input dataset for ggplot(). You should now include the layer facet_wrap(~year) to produce the following plot:

```
gapminder_1957 <- gapminder %>% filter(year==1957 | year ==2007)
ggplot(gapminder_1957) +
  aes(x=gdpPercap, y=lifeExp, size=pop, color=continent) +
  geom_point(alpha=0.7) +
  scale_size_area(max_size = 10) +
  facet_wrap(~year)
```



Lab Section: Ireland

Q. How many years are in this dataset?

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

```
[1] 1704
```

Still does not say how many years there are because there includes duplicates

```
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
```

142 entries per year but still doesn't answer how many years there are

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

```
[1] 12
```

`length(unique(gapminder$year))` Shows the length of unique years there are

```
library(dplyr)
```

Q. Extract data fro 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. What was 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
```

The population of Ireland in the last year we have data for which was 2007 is 40676

Q. What countries in the dataset have a population smaller than Ireland in 2007?

- First limit/subset the dataset to the year 2007

```
filter(gapminder, year == 2007)
```

```
                    country continent year lifeExp        pop  gdpPercap
1               Afghanistan      Asia 2007  43.828   31889923   974.5803
2                   Albania    Europe 2007  76.423    3600523  5937.0295
3                   Algeria    Africa 2007  72.301   33333216  6223.3675
4                    Angola    Africa 2007  42.731   12420476  4797.2313
5                 Argentina  Americas 2007  75.320   40301927 12779.3796
6                 Australia   Oceania 2007  81.235   20434176 34435.3674
7                   Austria    Europe 2007  79.829    8199783 36126.4927
```

8	Bahrain	Asia	2007	75.635	708573	29796.0483
9	Bangladesh	Asia	2007	64.062	150448339	1391.2538
10	Belgium	Europe	2007	79.441	10392226	33692.6051
11	Benin	Africa	2007	56.728	8078314	1441.2849
12	Bolivia	Americas	2007	65.554	9119152	3822.1371
13	Bosnia and Herzegovina	Europe	2007	74.852	4552198	7446.2988
14	Botswana	Africa	2007	50.728	1639131	12569.8518
15	Brazil	Americas	2007	72.390	190010647	9065.8008
16	Bulgaria	Europe	2007	73.005	7322858	10680.7928
17	Burkina Faso	Africa	2007	52.295	14326203	1217.0330
18	Burundi	Africa	2007	49.580	8390505	430.0707
19	Cambodia	Asia	2007	59.723	14131858	1713.7787
20	Cameroon	Africa	2007	50.430	17696293	2042.0952
21	Canada	Americas	2007	80.653	33390141	36319.2350
22	Central African Republic	Africa	2007	44.741	4369038	706.0165
23	Chad	Africa	2007	50.651	10238807	1704.0637
24	Chile	Americas	2007	78.553	16284741	13171.6388
25	China	Asia	2007	72.961	1318683096	4959.1149
26	Colombia	Americas	2007	72.889	44227550	7006.5804
27	Comoros	Africa	2007	65.152	710960	986.1479
28	Congo, Dem. Rep.	Africa	2007	46.462	64606759	277.5519
29	Congo, Rep.	Africa	2007	55.322	3800610	3632.5578
30	Costa Rica	Americas	2007	78.782	4133884	9645.0614
31	Cote d'Ivoire	Africa	2007	48.328	18013409	1544.7501
32	Croatia	Europe	2007	75.748	4493312	14619.2227
33	Cuba	Americas	2007	78.273	11416987	8948.1029
34	Czech Republic	Europe	2007	76.486	10228744	22833.3085
35	Denmark	Europe	2007	78.332	5468120	35278.4187
36	Djibouti	Africa	2007	54.791	496374	2082.4816
37	Dominican Republic	Americas	2007	72.235	9319622	6025.3748
38	Ecuador	Americas	2007	74.994	13755680	6873.2623
39	Egypt	Africa	2007	71.338	80264543	5581.1810
40	El Salvador	Americas	2007	71.878	6939688	5728.3535
41	Equatorial Guinea	Africa	2007	51.579	551201	12154.0897
42	Eritrea	Africa	2007	58.040	4906585	641.3695
43	Ethiopia	Africa	2007	52.947	76511887	690.8056
44	Finland	Europe	2007	79.313	5238460	33207.0844
45	France	Europe	2007	80.657	61083916	30470.0167
46	Gabon	Africa	2007	56.735	1454867	13206.4845
47	Gambia	Africa	2007	59.448	1688359	752.7497
48	Germany	Europe	2007	79.406	82400996	32170.3744
49	Ghana	Africa	2007	60.022	22873338	1327.6089
50	Greece	Europe	2007	79.483	10706290	27538.4119

51	Guatemala	Americas	2007	70.259	12572928	5186.0500
52	Guinea	Africa	2007	56.007	9947814	942.6542
53	Guinea-Bissau	Africa	2007	46.388	1472041	579.2317
54	Haiti	Americas	2007	60.916	8502814	1201.6372
55	Honduras	Americas	2007	70.198	7483763	3548.3308
56	Hong Kong, China	Asia	2007	82.208	6980412	39724.9787
57	Hungary	Europe	2007	73.338	9956108	18008.9444
58	Iceland	Europe	2007	81.757	301931	36180.7892
59	India	Asia	2007	64.698	1110396331	2452.2104
60	Indonesia	Asia	2007	70.650	223547000	3540.6516
61	Iran	Asia	2007	70.964	69453570	11605.7145
62	Iraq	Asia	2007	59.545	27499638	4471.0619
63	Ireland	Europe	2007	78.885	4109086	40675.9964
64	Israel	Asia	2007	80.745	6426679	25523.2771
65	Italy	Europe	2007	80.546	58147733	28569.7197
66	Jamaica	Americas	2007	72.567	2780132	7320.8803
67	Japan	Asia	2007	82.603	127467972	31656.0681
68	Jordan	Asia	2007	72.535	6053193	4519.4612
69	Kenya	Africa	2007	54.110	35610177	1463.2493
70	Korea, Dem. Rep.	Asia	2007	67.297	23301725	1593.0655
71	Korea, Rep.	Asia	2007	78.623	49044790	23348.1397
72	Kuwait	Asia	2007	77.588	2505559	47306.9898
73	Lebanon	Asia	2007	71.993	3921278	10461.0587
74	Lesotho	Africa	2007	42.592	2012649	1569.3314
75	Liberia	Africa	2007	45.678	3193942	414.5073
76	Libya	Africa	2007	73.952	6036914	12057.4993
77	Madagascar	Africa	2007	59.443	19167654	1044.7701
78	Malawi	Africa	2007	48.303	13327079	759.3499
79	Malaysia	Asia	2007	74.241	24821286	12451.6558
80	Mali	Africa	2007	54.467	12031795	1042.5816
81	Mauritania	Africa	2007	64.164	3270065	1803.1515
82	Mauritius	Africa	2007	72.801	1250882	10956.9911
83	Mexico	Americas	2007	76.195	108700891	11977.5750
84	Mongolia	Asia	2007	66.803	2874127	3095.7723
85	Montenegro	Europe	2007	74.543	684736	9253.8961
86	Morocco	Africa	2007	71.164	33757175	3820.1752
87	Mozambique	Africa	2007	42.082	19951656	823.6856
88	Myanmar	Asia	2007	62.069	47761980	944.0000
89	Namibia	Africa	2007	52.906	2055080	4811.0604
90	Nepal	Asia	2007	63.785	28901790	1091.3598
91	Netherlands	Europe	2007	79.762	16570613	36797.9333
92	New Zealand	Oceania	2007	80.204	4115771	25185.0091
93	Nicaragua	Americas	2007	72.899	5675356	2749.3210

94	Niger	Africa	2007	56.867	12894865	619.6769
95	Nigeria	Africa	2007	46.859	135031164	2013.9773
96	Norway	Europe	2007	80.196	4627926	49357.1902
97	Oman	Asia	2007	75.640	3204897	22316.1929
98	Pakistan	Asia	2007	65.483	169270617	2605.9476
99	Panama	Americas	2007	75.537	3242173	9809.1856
100	Paraguay	Americas	2007	71.752	6667147	4172.8385
101	Peru	Americas	2007	71.421	28674757	7408.9056
102	Philippines	Asia	2007	71.688	91077287	3190.4810
103	Poland	Europe	2007	75.563	38518241	15389.9247
104	Portugal	Europe	2007	78.098	10642836	20509.6478
105	Puerto Rico	Americas	2007	78.746	3942491	19328.7090
106	Reunion	Africa	2007	76.442	798094	7670.1226
107	Romania	Europe	2007	72.476	22276056	10808.4756
108	Rwanda	Africa	2007	46.242	8860588	863.0885
109	Sao Tome and Principe	Africa	2007	65.528	199579	1598.4351
110	Saudi Arabia	Asia	2007	72.777	27601038	21654.8319
111	Senegal	Africa	2007	63.062	12267493	1712.4721
112	Serbia	Europe	2007	74.002	10150265	9786.5347
113	Sierra Leone	Africa	2007	42.568	6144562	862.5408
114	Singapore	Asia	2007	79.972	4553009	47143.1796
115	Slovak Republic	Europe	2007	74.663	5447502	18678.3144
116	Slovenia	Europe	2007	77.926	2009245	25768.2576
117	Somalia	Africa	2007	48.159	9118773	926.1411
118	South Africa	Africa	2007	49.339	43997828	9269.6578
119	Spain	Europe	2007	80.941	40448191	28821.0637
120	Sri Lanka	Asia	2007	72.396	20378239	3970.0954
121	Sudan	Africa	2007	58.556	42292929	2602.3950
122	Swaziland	Africa	2007	39.613	1133066	4513.4806
123	Sweden	Europe	2007	80.884	9031088	33859.7484
124	Switzerland	Europe	2007	81.701	7554661	37506.4191
125	Syria	Asia	2007	74.143	19314747	4184.5481
126	Taiwan	Asia	2007	78.400	23174294	28718.2768
127	Tanzania	Africa	2007	52.517	38139640	1107.4822
128	Thailand	Asia	2007	70.616	65068149	7458.3963
129	Togo	Africa	2007	58.420	5701579	882.9699
130	Trinidad and Tobago	Americas	2007	69.819	1056608	18008.5092
131	Tunisia	Africa	2007	73.923	10276158	7092.9230
132	Turkey	Europe	2007	71.777	71158647	8458.2764
133	Uganda	Africa	2007	51.542	29170398	1056.3801
134	United Kingdom	Europe	2007	79.425	60776238	33203.2613
135	United States	Americas	2007	78.242	301139947	42951.6531
136	Uruguay	Americas	2007	76.384	3447496	10611.4630

```
137               Venezuela  Americas 2007  73.747   26084662 11415.8057
138                 Vietnam      Asia 2007  74.249   85262356  2441.5764
139      West Bank and Gaza      Asia 2007  73.422    4018332  3025.3498
140            Yemen, Rep.      Asia 2007  62.698   22211743  2280.7699
141                 Zambia    Africa 2007  42.384   11746035  1271.2116
142               Zimbabwe    Africa 2007  43.487   12311143   469.7093
```

- Then find the pop for value for Ireland

```
ireland_2007 <- filter(gapminder, country=='Ireland',
                       year == 2007)
ireland_2007
```

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

```
ireland_2007_pop <- ireland_2007['pop']
ireland_2007_pop
```

```
      pop
1 4109086
```

- Then extract all rows with pop less than Ireland

```
filter(filter(gapminder, year == 2007), 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
```

```r
nrow(filter(filter(gapminder, year == 2007), pop<4109086))
```

```
[1] 31
```

OPTIONAL: Bar Charts

Introduction to Bar Charts

- Bar charts are well suited to compare values among different groups
- Below shows the number of people (in millions) in the five biggest countries by population in 2007

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

gapminder_top5
```

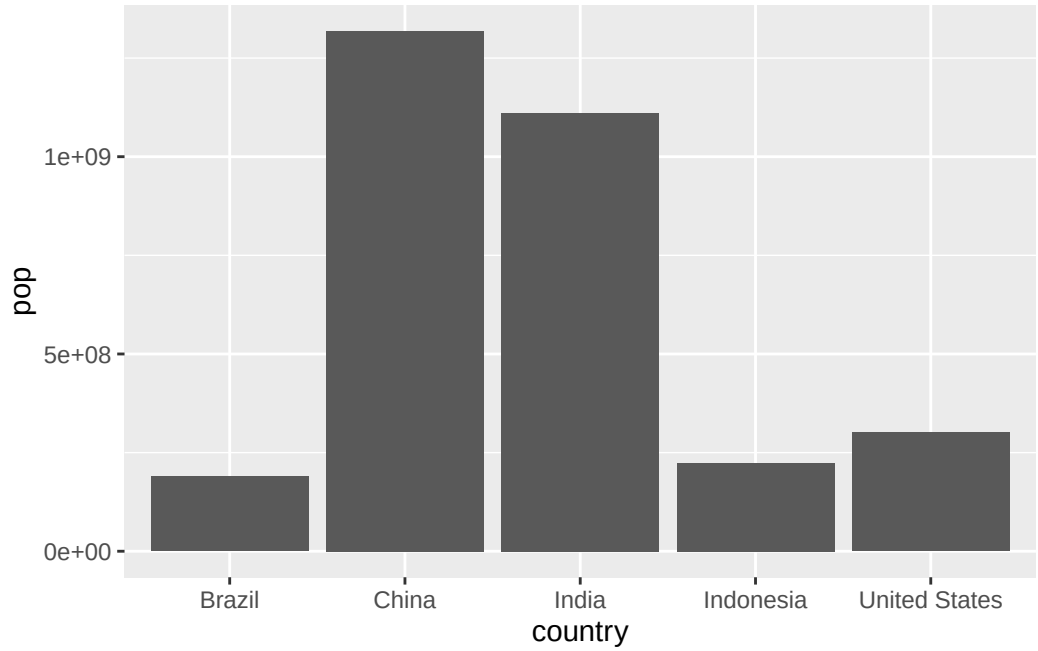
```
       country continent year lifeExp        pop gdpPercap
1        China      Asia 2007  72.961 1318683096  4959.115
2        India      Asia 2007  64.698 1110396331  2452.210
```

```
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
```

Creating a simple bar chart

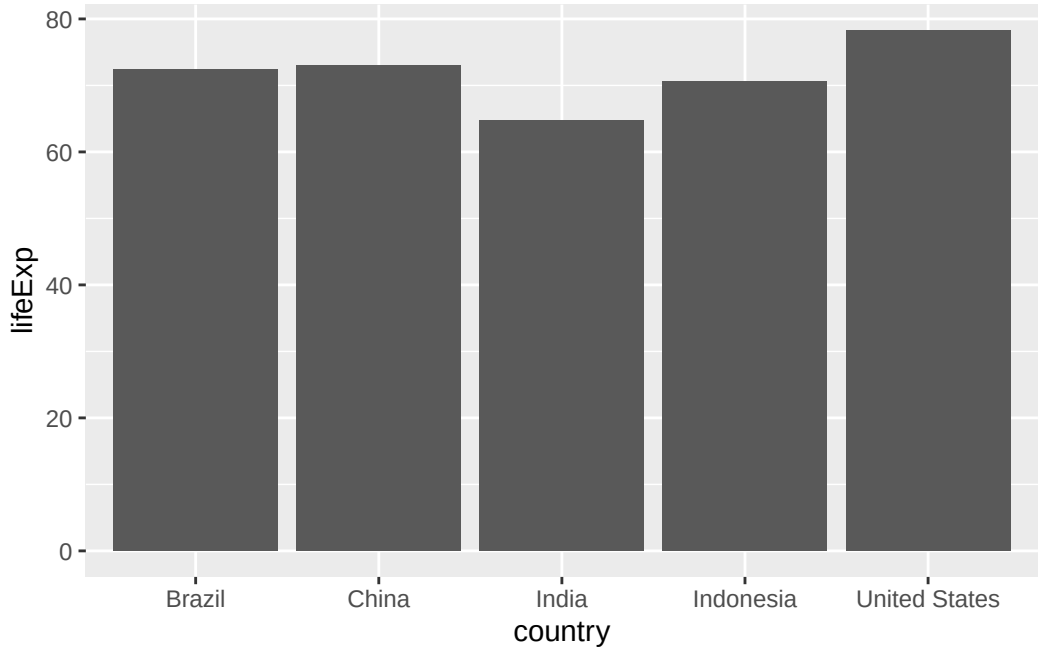
- Bar charts are created using the `geom_col()` geometric layer
- Create a bar chart with the gapminder_top5 dataset. It contains population (in millions) and life expectancy data for the biggest countries by population in 2007.

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



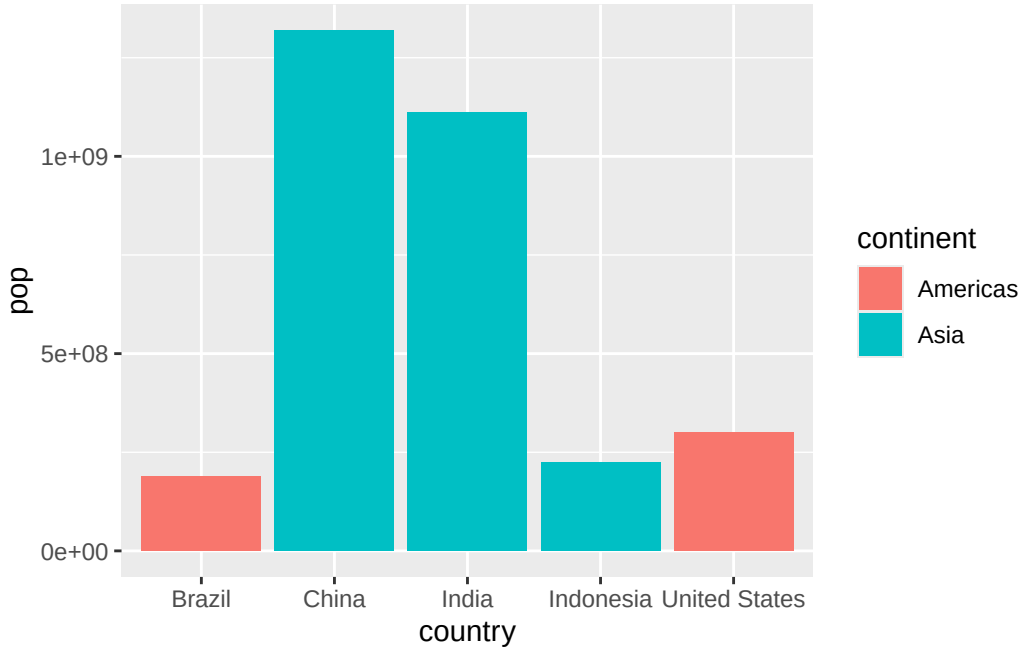
Create a bar chart showing the life expectancy of the five biggest countries by population in 2007.

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

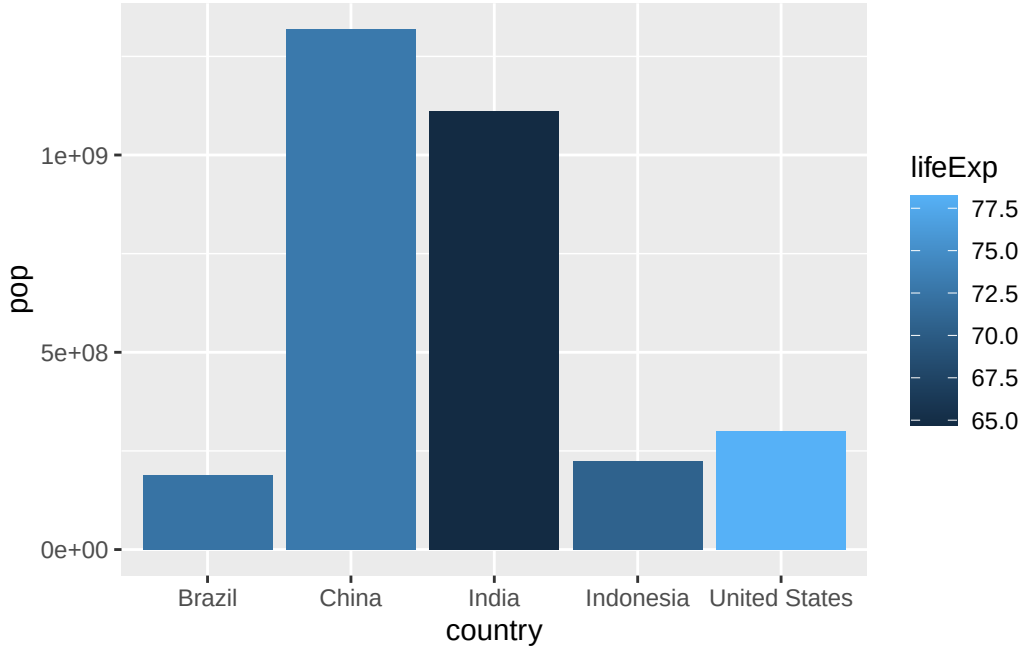


Filling bars with color

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



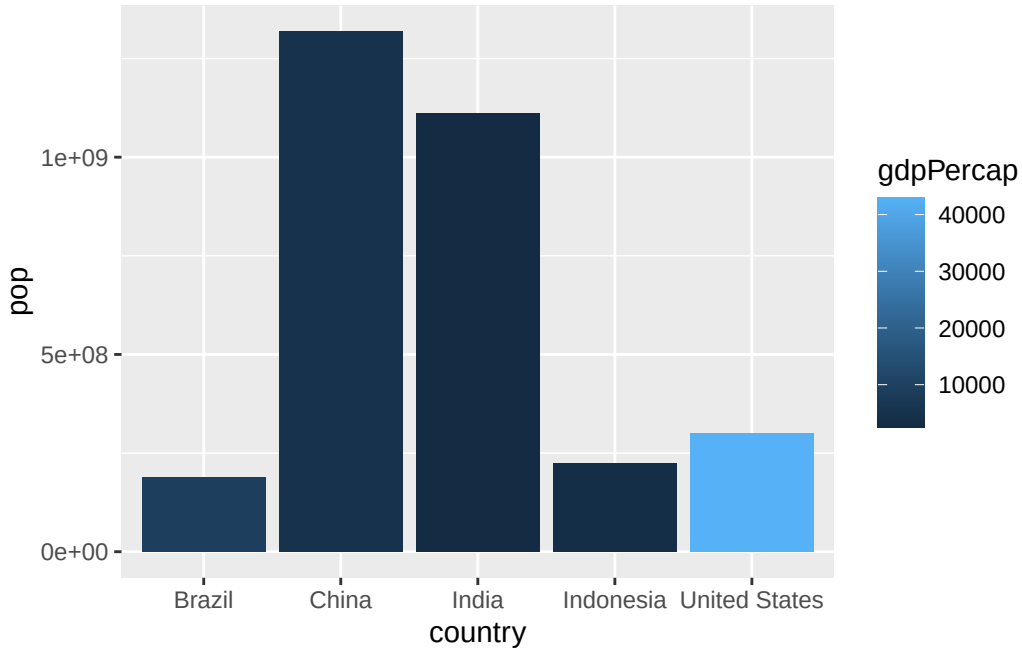

```
ggplot(gapminder_top5) +
  geom_col(aes(x = country, y = pop, fill = lifeExp))
```



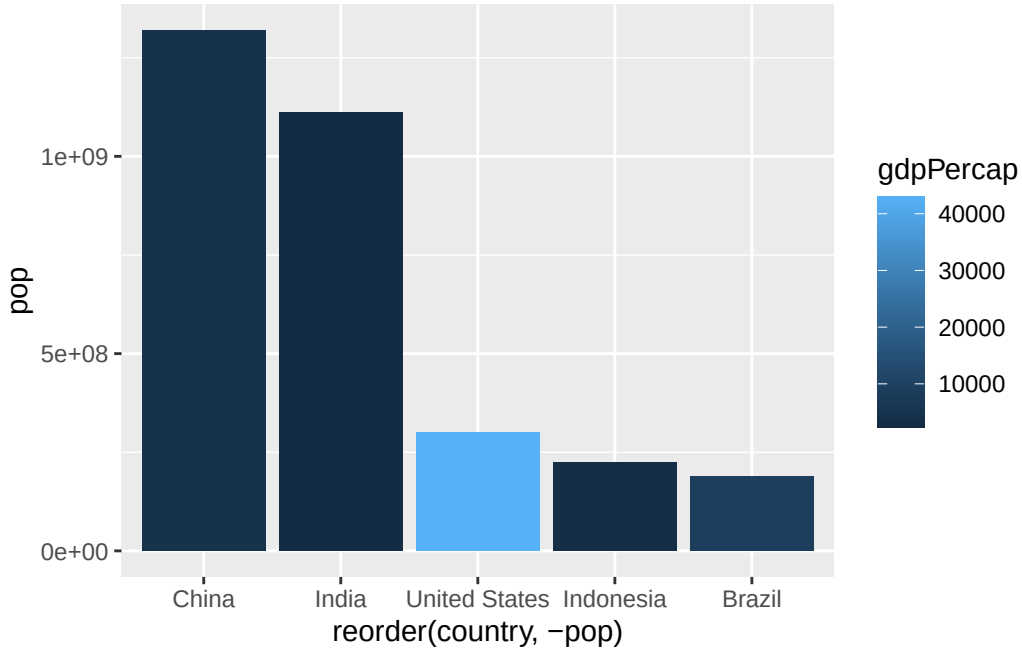
Q. Plot population size by country. Create a bar chart showing the population (in millions) of the five biggest countries by population in 2007.

- Use the ggplot() function and specify the gapminder_top5 dataset as input
- Add a geom_col() layer to the plot
- Plot one bar for each country (x aesthetic)
- Use population pop as bar height (y aesthetic)
- Use the GDP per capita gdpPercap as fill aesthetic

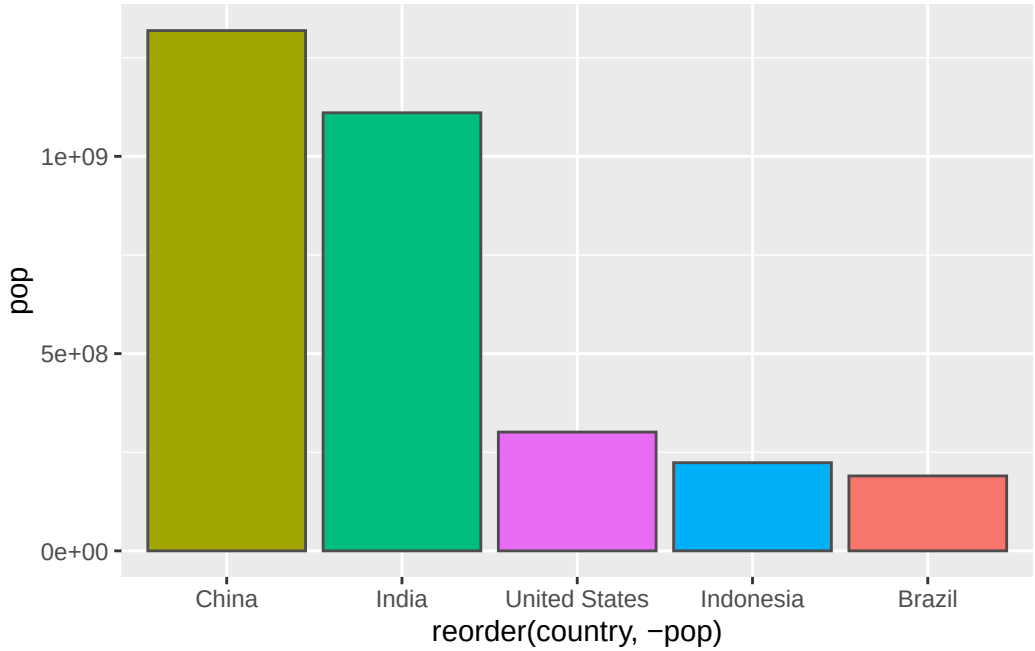
```
ggplot(gapminder_top5) +
  aes(x=country, y=pop, fill=gdpPercap) +
  geom_col()
```




```
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")
```

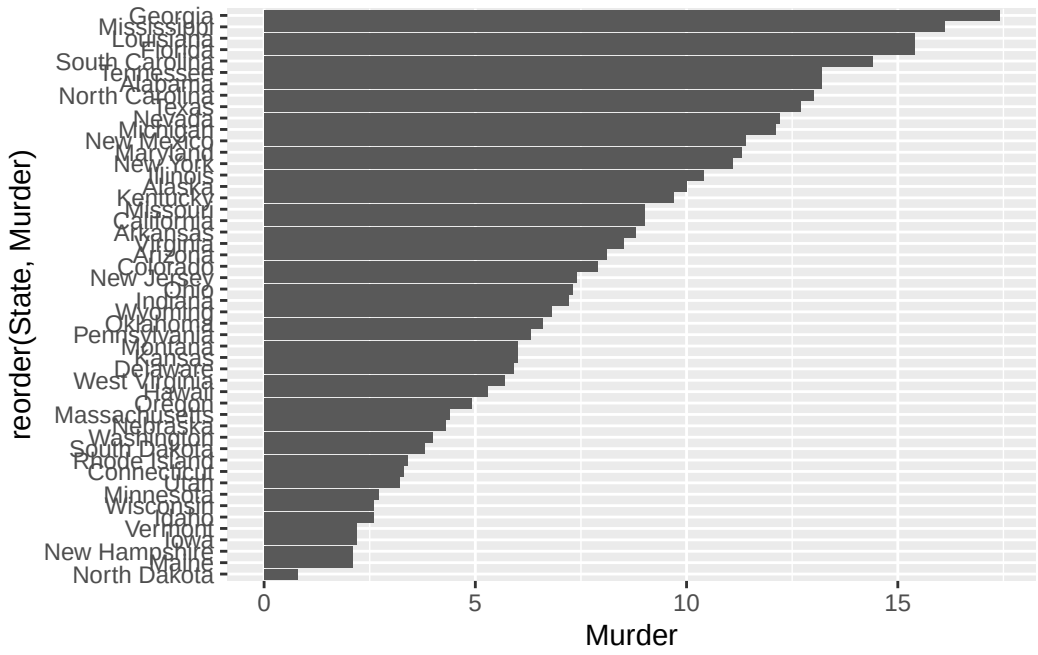


Flipping bar charts

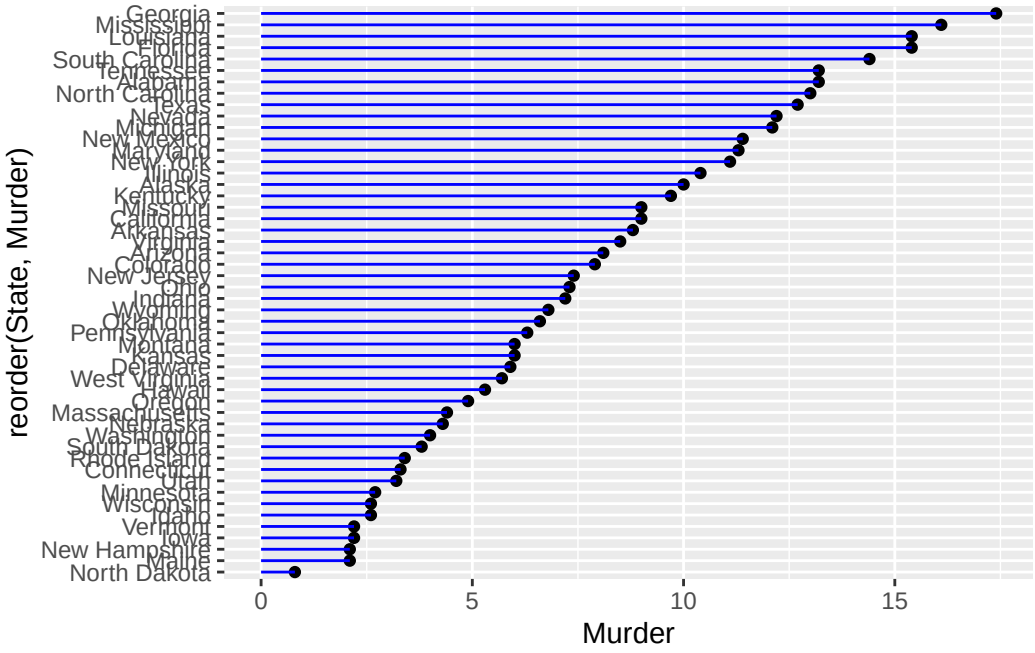
```
head(USArrests)
```

```
           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()
```


reorder(State, Murder)
Georgia
Mississippi
Louisiana
Florida
South Carolina
Tennessee
Alabama
North Carolina
Texas
Nevada
Michigan
New Mexico
Maryland
New York
Illinois
Alaska
Kentucky
Missouri
California
Arkansas
Virginia
Arizona
Colorado
New Jersey
Ohio
Indiana
Wyoming
Oklahoma
Pennsylvania
Montana
Kansas
Delaware
West Virginia
Hawaii
Oregon
Massachusetts
Nebraska
Washington
South Dakota
Rhode Island
Connecticut
Utah
Minnesota
Wisconsin
Idaho
Vermont
Iowa
New Hampshire
Maine
North Dakota
0
5
10
15
Murder