

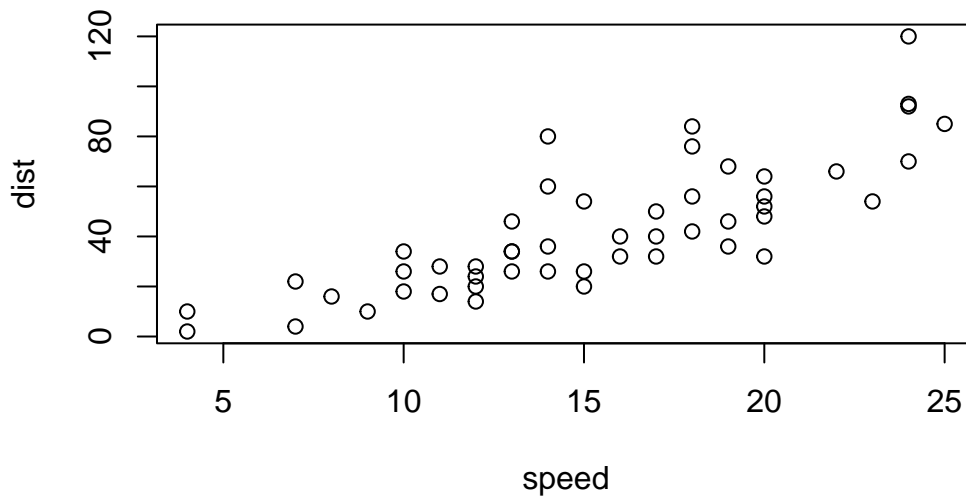
# Class 5 Data Viz with ggplot

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## 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-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 **ggplot**?

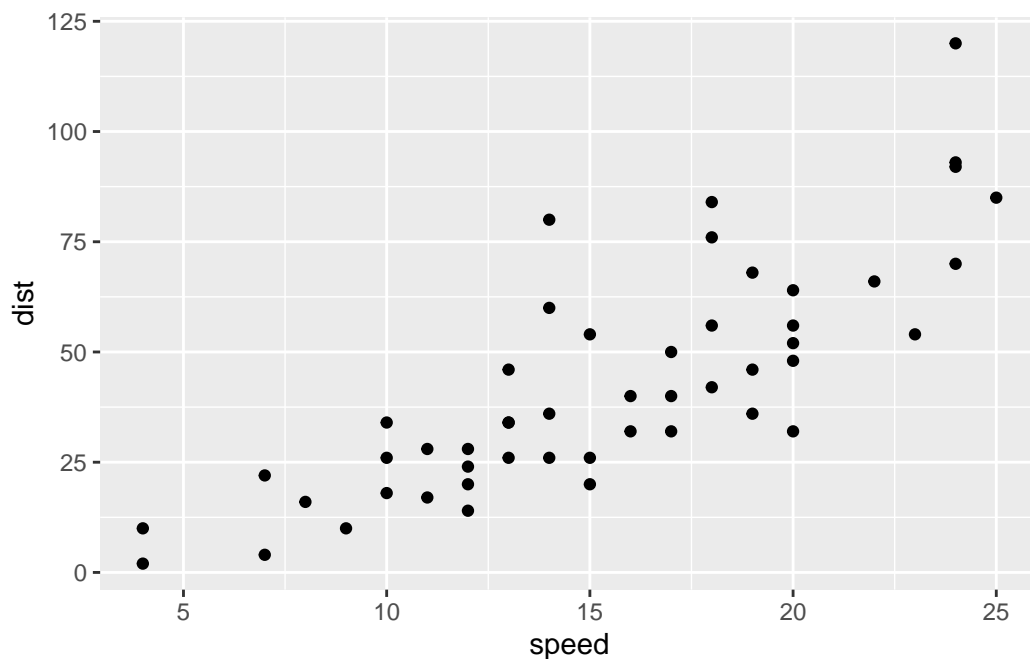
All ggplot figures have at least 3 layers: - **data** - **aes** (how the data map to the plot) - **geoms** (how we draw the plot, lines, points, etc.)

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 its installed, I can load it up with the `library()` function.

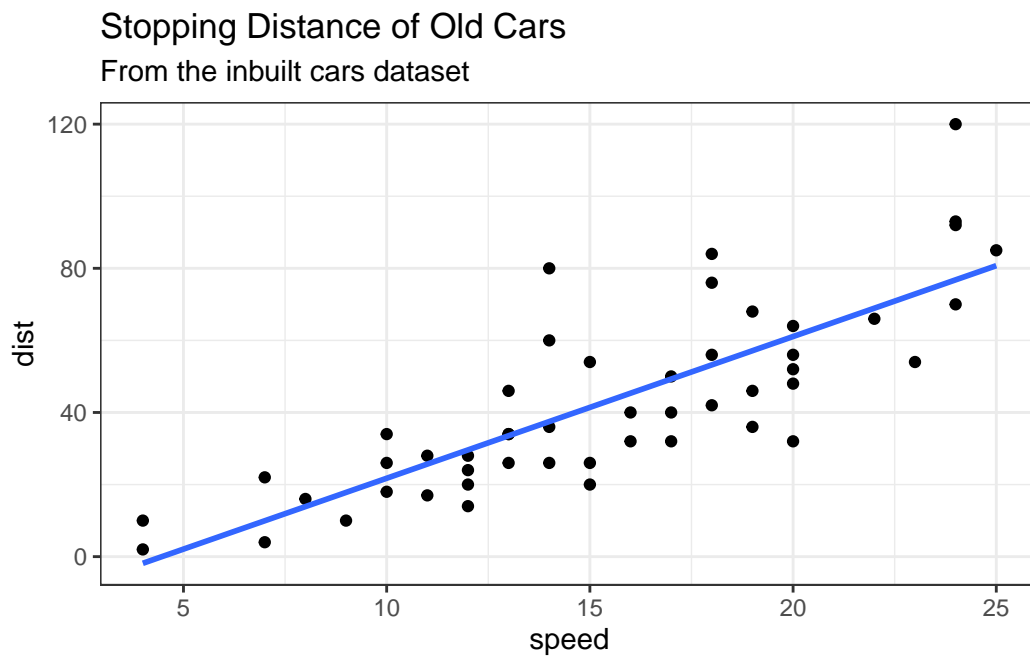
```
#install.packages("ggplot2")
library(ggplot2)
ggplot(cars) +
  aes(x=speed,y=dist) + geom_point()
```



**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 ggplots 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 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).

```
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 )
```

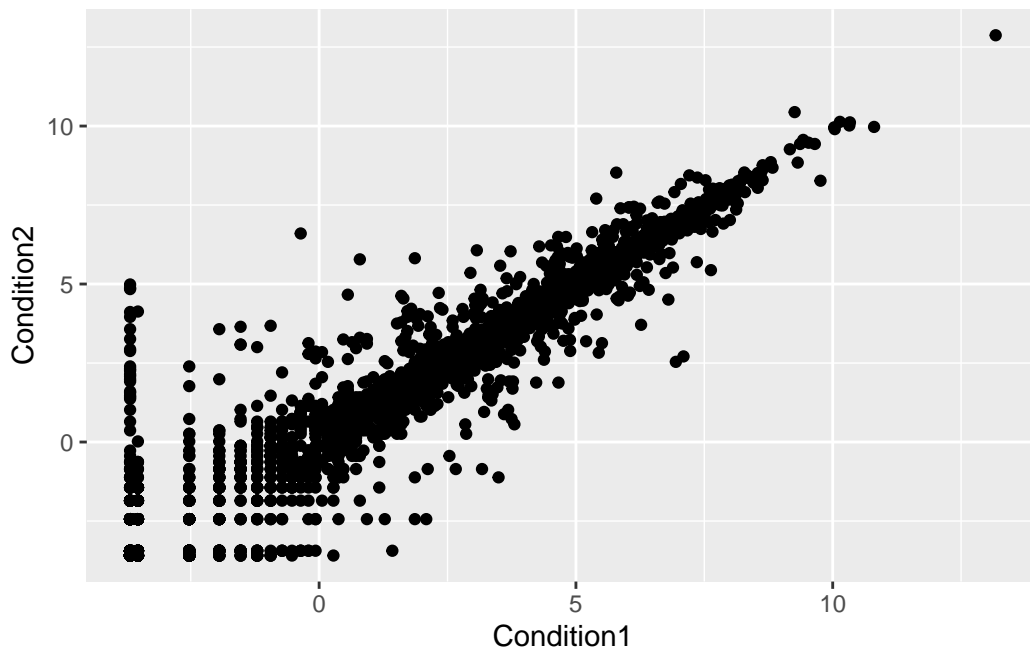
down	unchanging	up
1.39	96.17	2.44

The key functions here where:

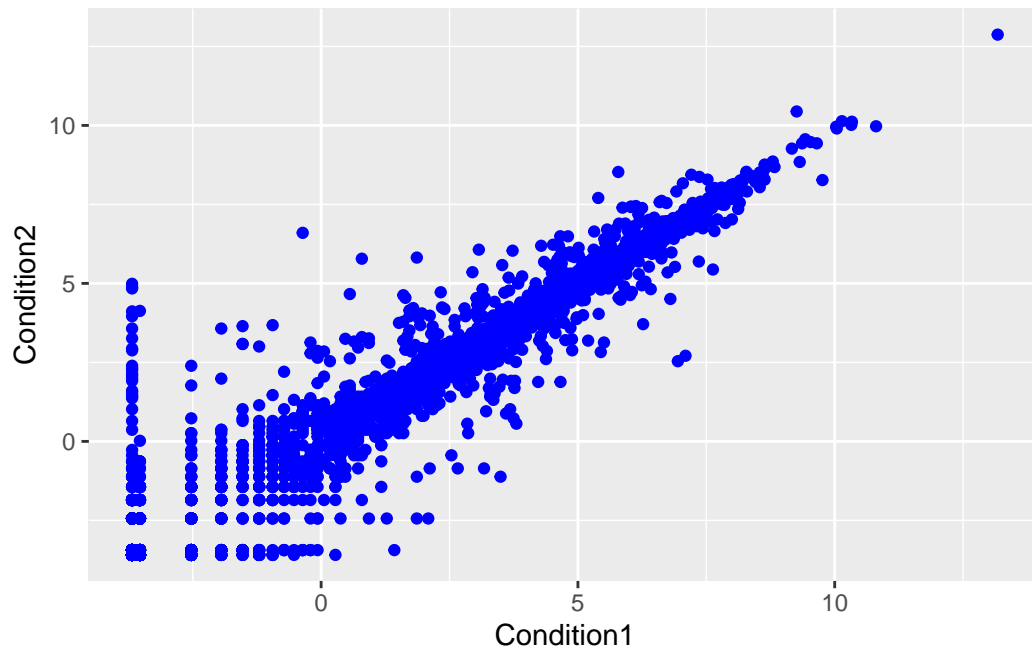
`nrow()` and `ncol` `table()` is very useful for getting counts finally `round`

Q. Complete the code below to produce the following plot

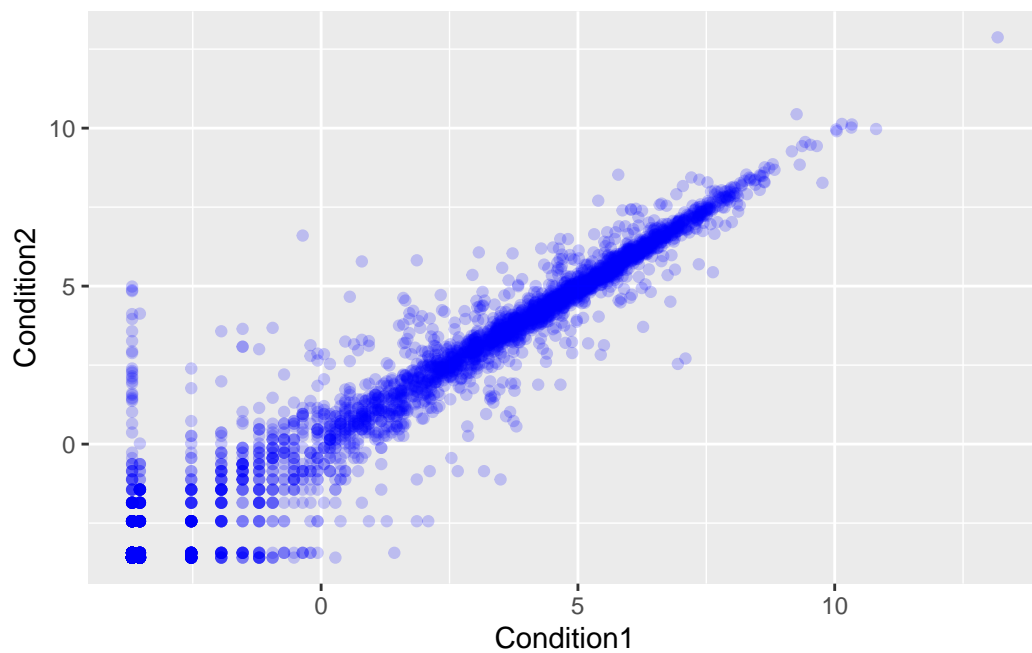
```
ggplot(genes) +
  aes(x=Condition1, y=Condition2)+
  geom_point()
```



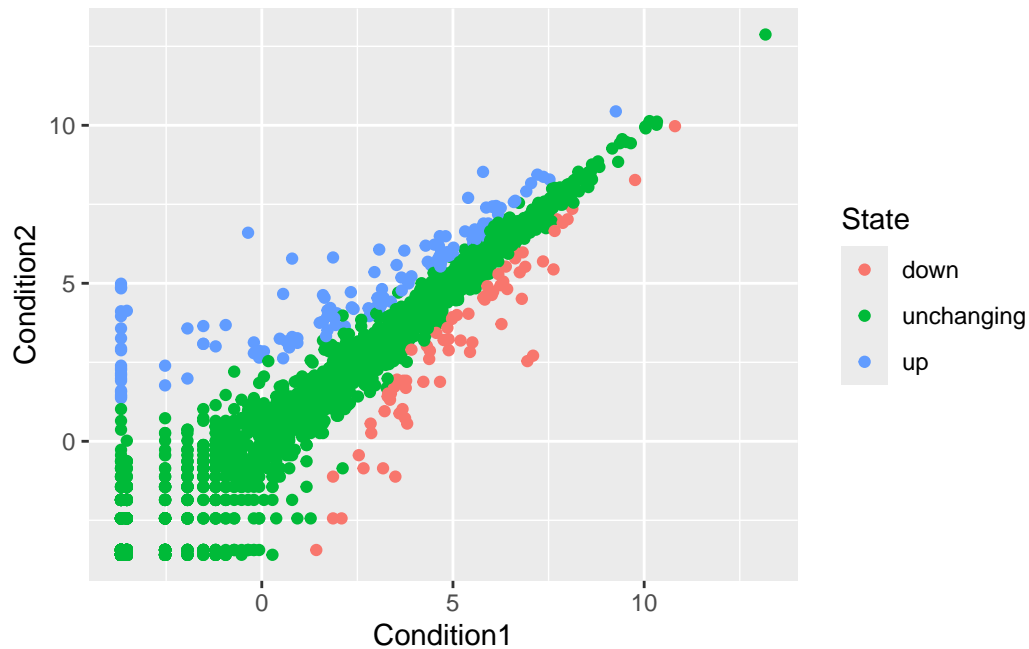
```
ggplot(genes) +
  aes(x=Condition1, y=Condition2)+
  geom_point(col="blue")
```



```
ggplot(genes) +  
  aes(x=Condition1, y=Condition2)+  
  geom_point(col="blue", alpha = 0.2)
```



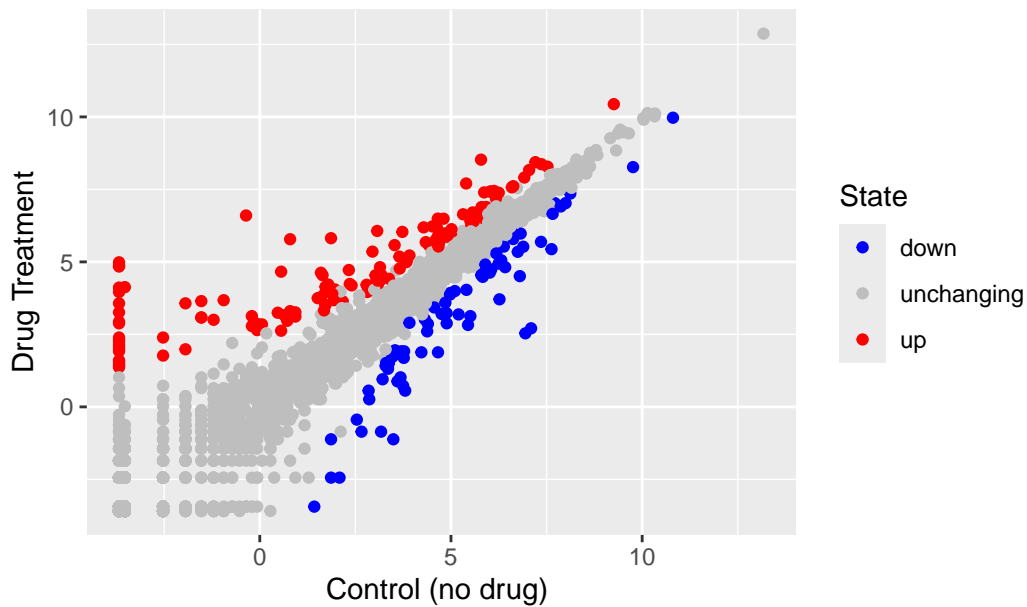
```
p <- ggplot(genes) +
  aes(x=Condition1, y=Condition2, col=State) +
  geom_point()
p
```



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

```
p + 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



```
#install.packages("ggplot2")
library(ggplot2)
# install.packages("dplyr") ## un-comment to install if needed
library(dplyr)
```

Attaching package: 'dplyr'

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

filter, lag

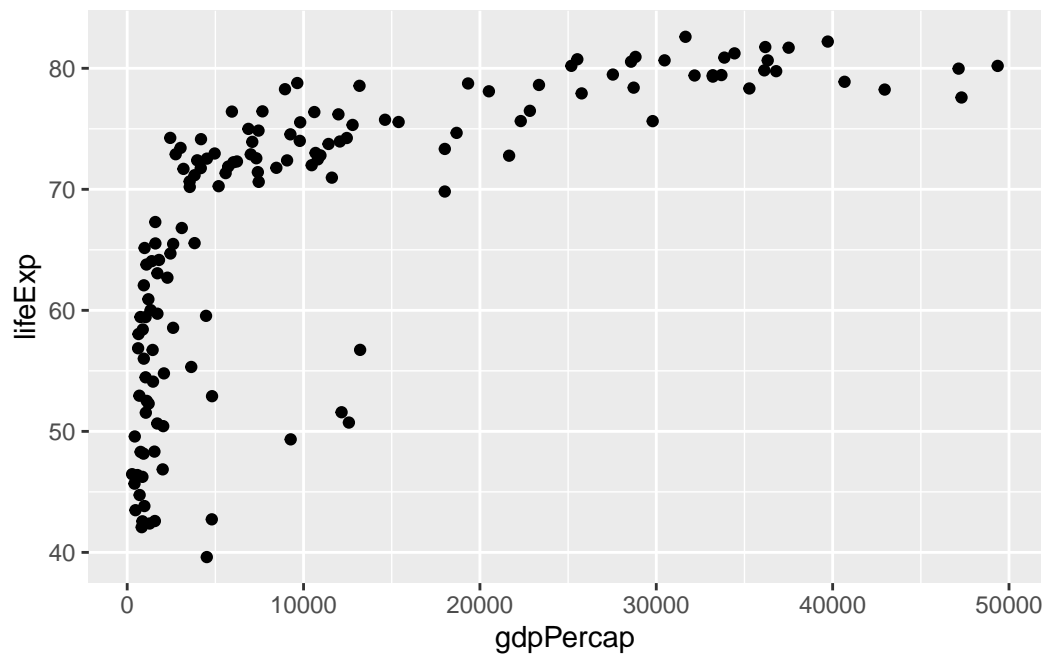
The following objects are masked from 'package:base':

intersect, setdiff, setequal, union

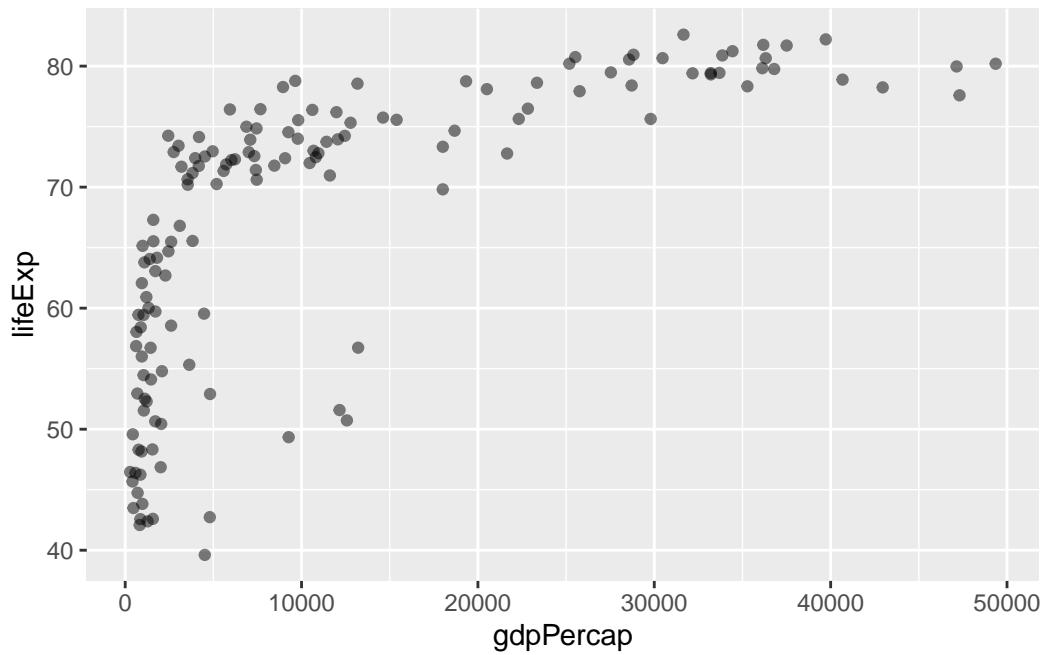
```
url <- "https://raw.githubusercontent.com/jennybc/gapminder/master/inst/extdata/gapminder.tsv"
gapminder <- read.delim(url)
```



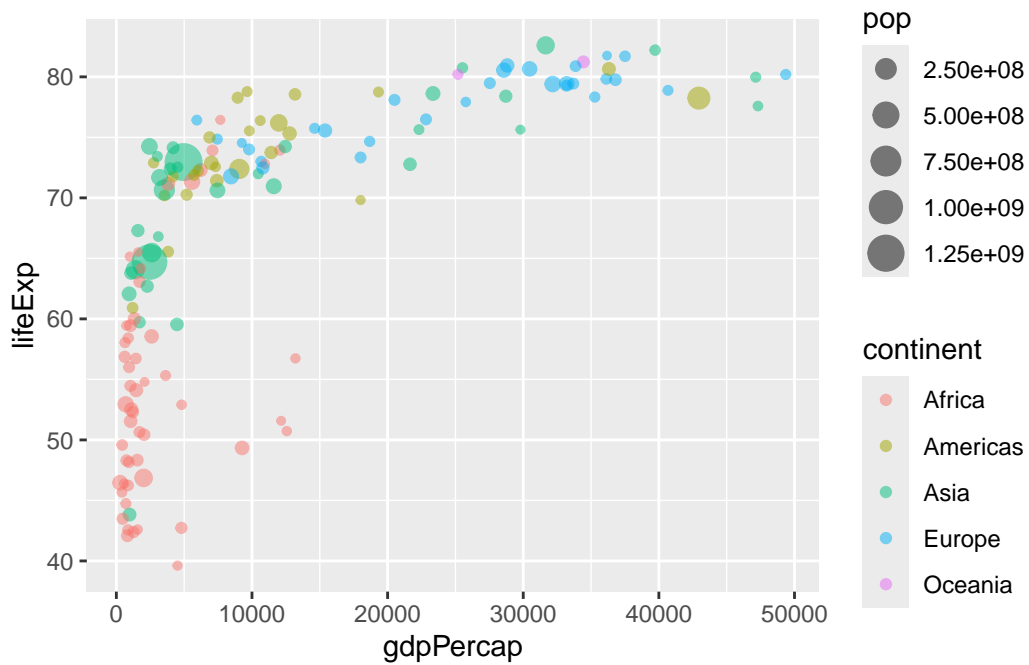
```
gapminder_2007 <- gapminder %>% filter(year==2007)
ggplot(gapminder_2007) +
  aes(x=gdpPercap, y=lifeExp) +
  geom_point()
```



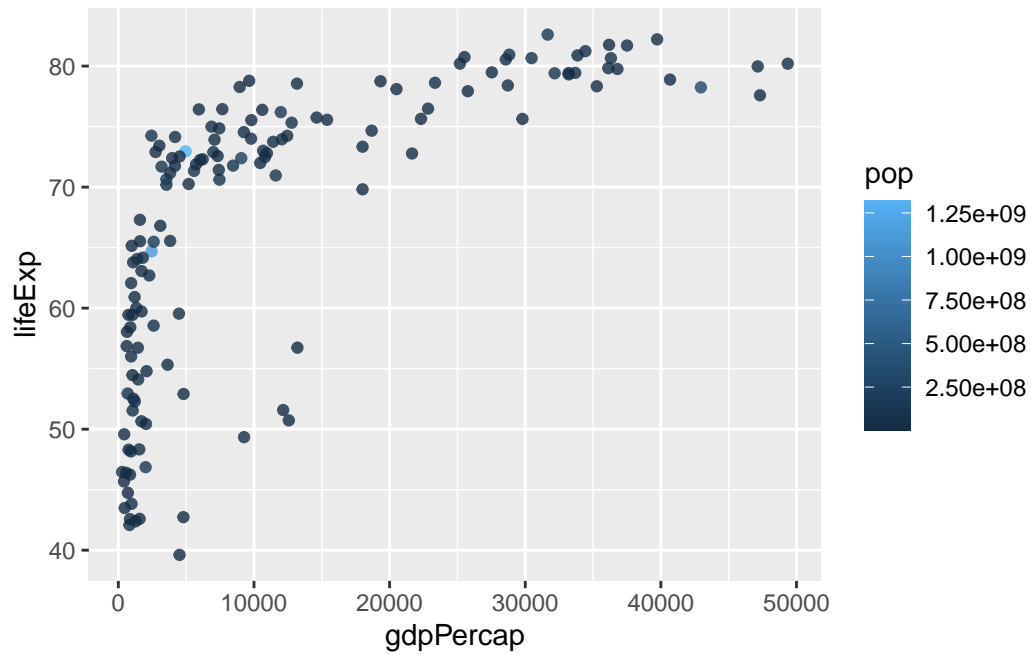
```
ggplot(gapminder_2007) +
  aes(x=gdpPercap, y=lifeExp) +
  geom_point(alpha=0.5)
```



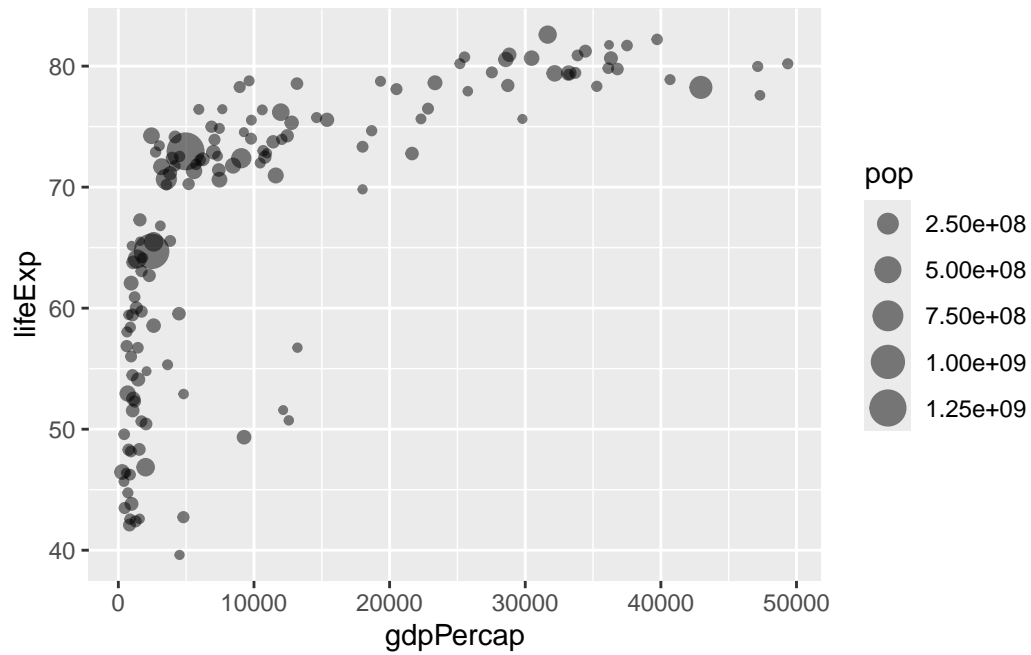
```
ggplot(gapminder_2007) +
  aes(x=gdpPercap, y=lifeExp, color=continent, size=pop) +
  geom_point(alpha=0.5)
```



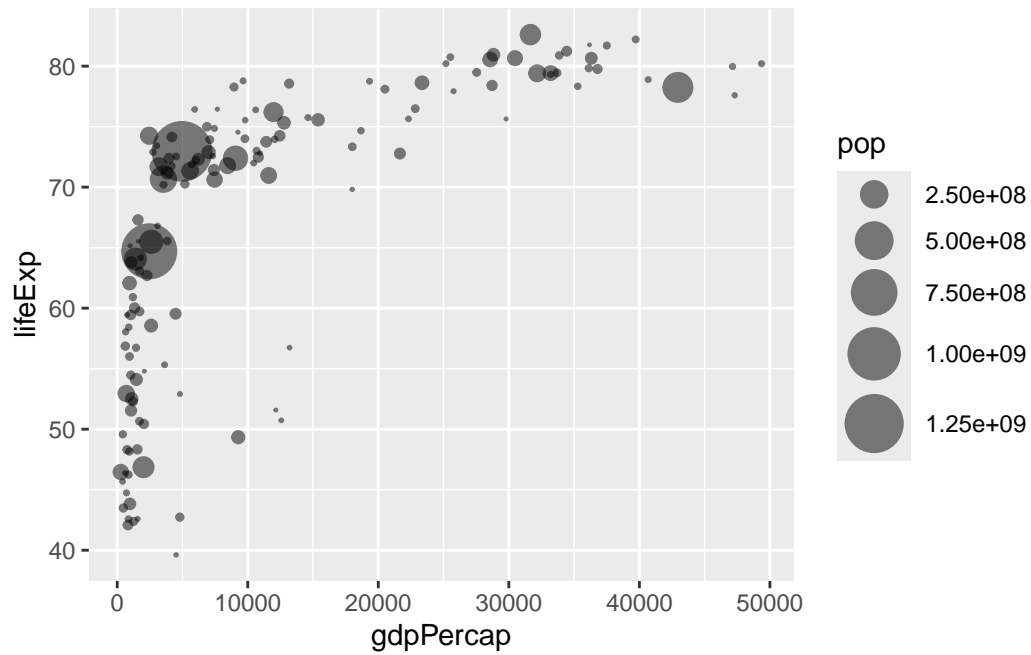
```
ggplot(gapminder_2007) +
  aes(x = gdpPerCap, y = lifeExp, color = pop) +
  geom_point(alpha=0.8)
```



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

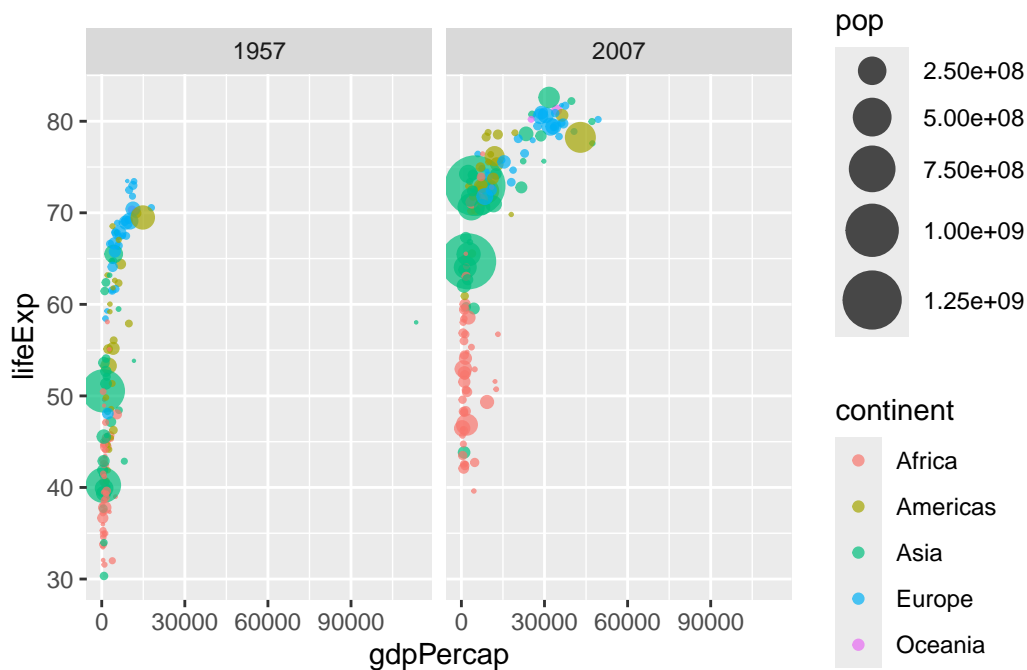


```
ggplot(gapminder_2007) +  
  geom_point(aes(x = gdpPerCap, y = lifeExp,  
                 size = pop), alpha=0.5) +  
  scale_size_area(max_size = 10)
```



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

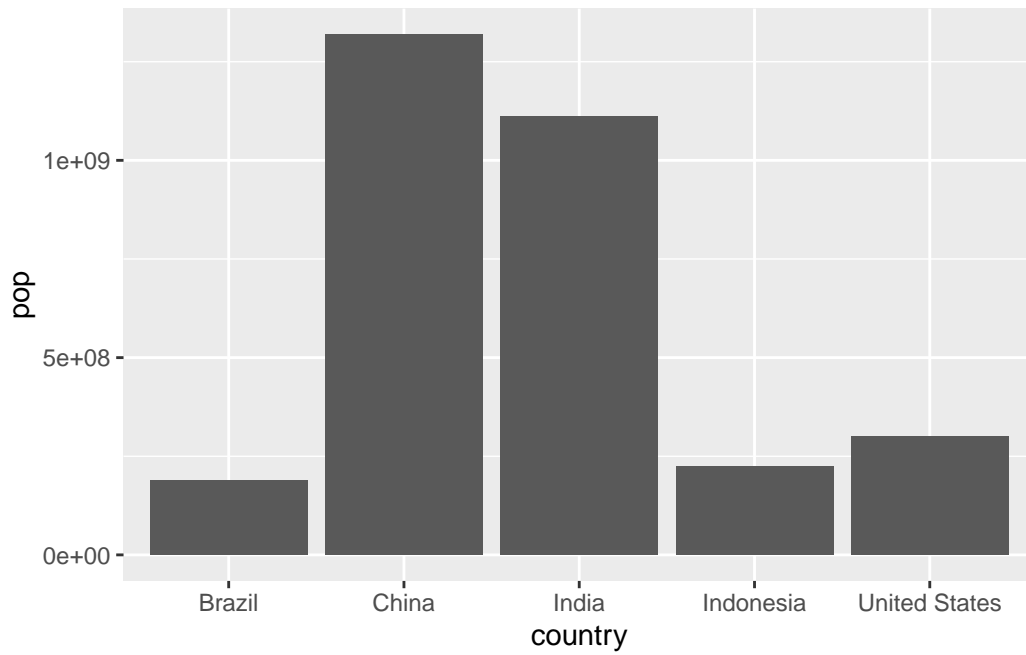


```
gapminder_top5 <- gapminder %>%
  filter(year==2007) %>%
  arrange(desc(pop)) %>%
  top_n(5, pop)

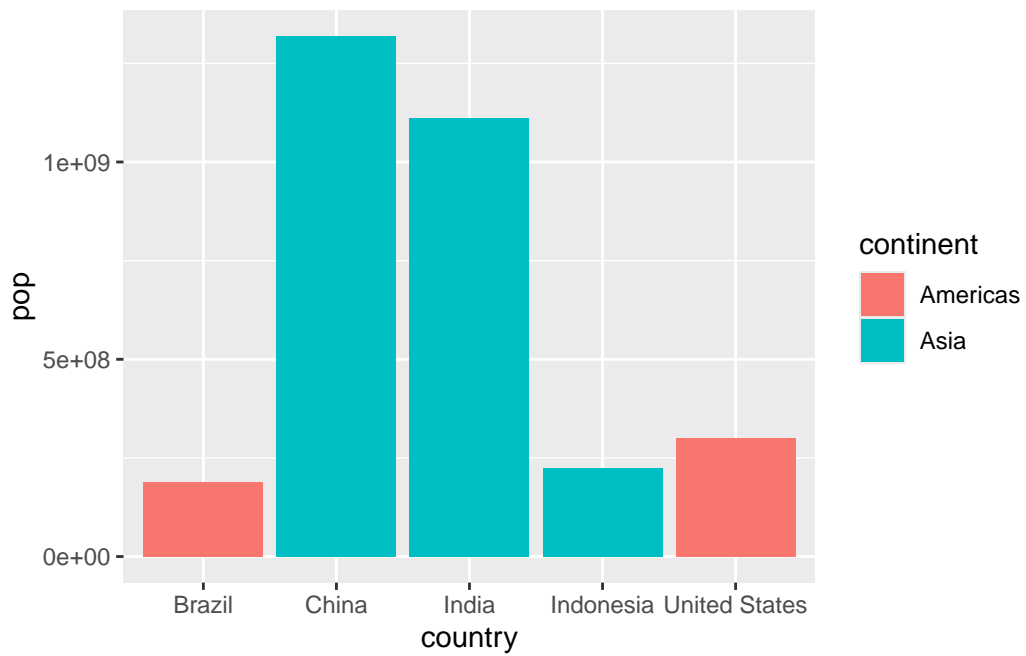
gapminder_top5
```

	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

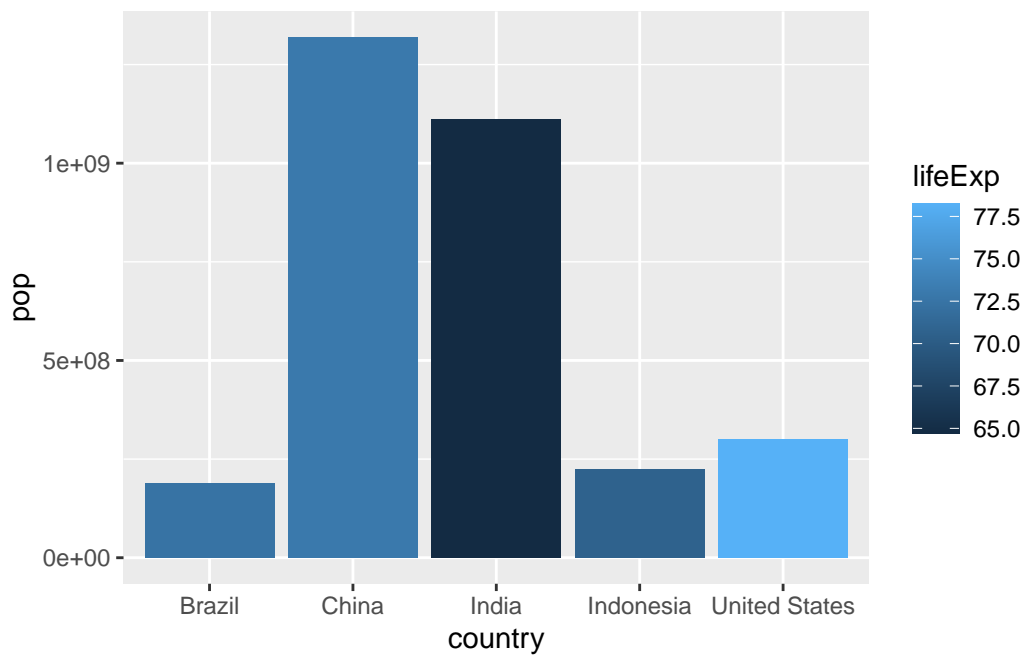
```
ggplot(gapminder_top5) +
  geom_col(aes(x = country, y = pop))
```



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

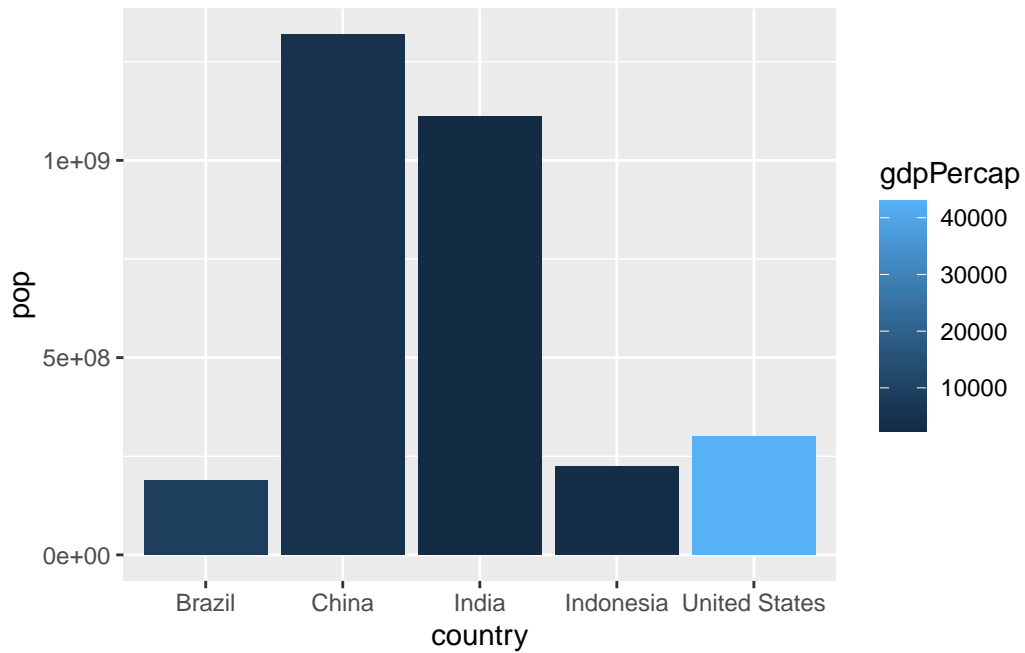


```
ggplot(gapminder_top5) +  
  geom_col(aes(x = country, y = pop, fill = lifeExp))
```

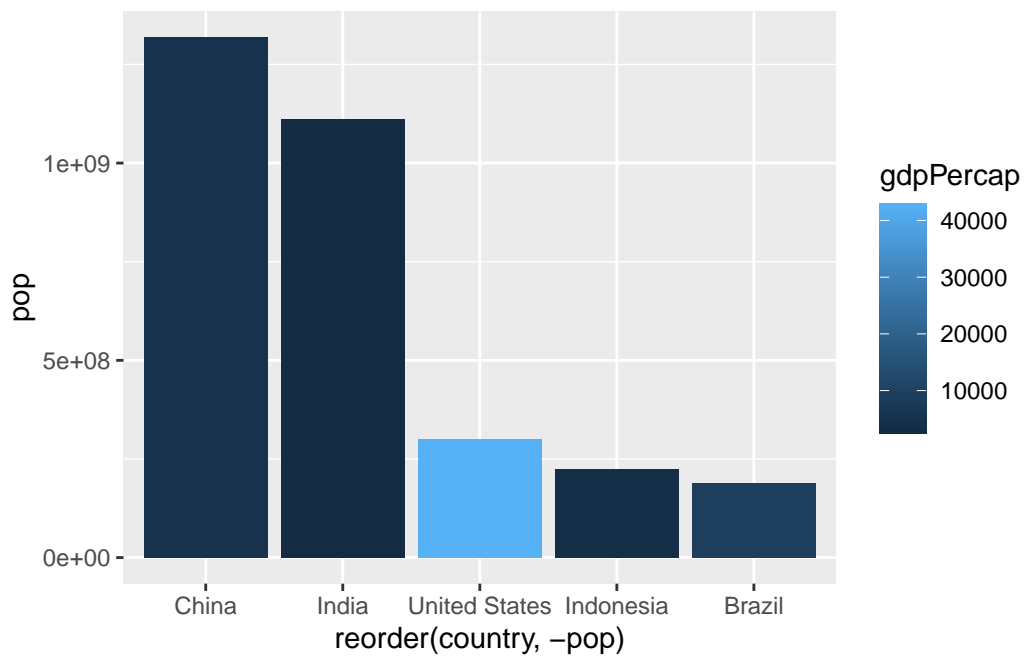


```
ggplot(gapminder_top5) +  
  aes(x=country, y=pop, fill=gdpPercap) +  
  geom_col()
```

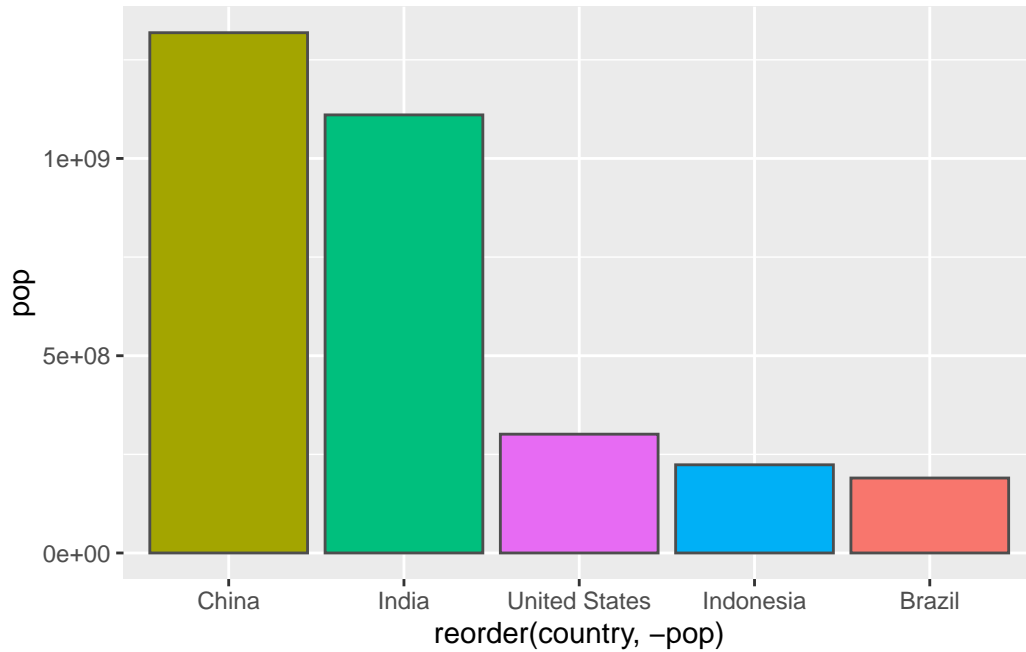




```
ggplot(gapminder_top5) +
  aes(x=reorder(country, -pop), y=pop, fill=gdpPercap) +
  geom_col()
```



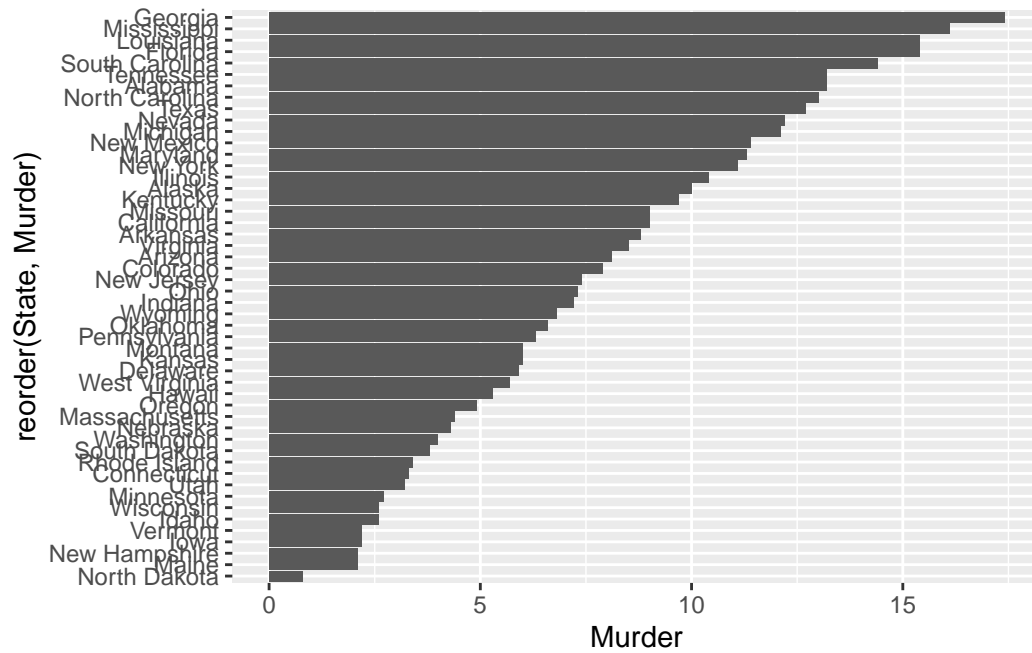
```
ggplot(gapminder_top5) +
  aes(x=reorder(country, -pop), y=pop, fill=country) +
  geom_col(col="gray30") +
  guides(fill="none")
```



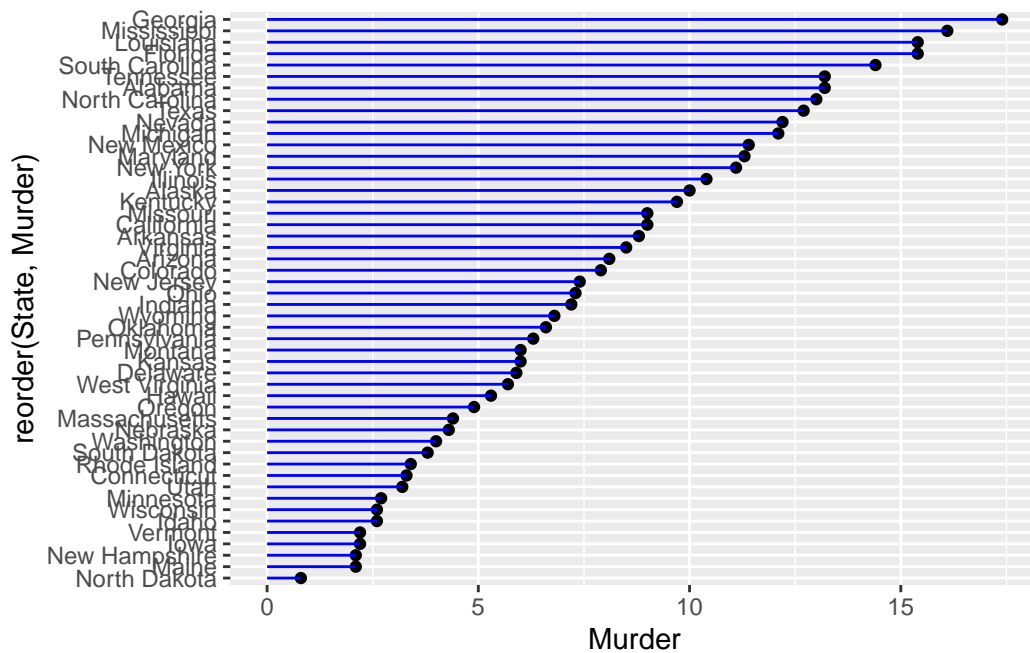
```
head(USArrests)
```

	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()
```



```
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)
```

Q. Extract data for the US in 1992

```
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

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

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

What is the population of Ireland?

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

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

What countries in data set had pop 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

- Next find the pop value for Ireland

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

	country	continent	year	lifeExp	pop	gdpPercap
1	Ireland	Europe	1952	66.910	2952156	5210.280
2	Ireland	Europe	1957	68.900	2878220	5599.078
3	Ireland	Europe	1962	70.290	2830000	6631.597
4	Ireland	Europe	1967	71.080	2900100	7655.569
5	Ireland	Europe	1972	71.280	3024400	9530.773
6	Ireland	Europe	1977	72.030	3271900	11150.981
7	Ireland	Europe	1982	73.100	3480000	12618.321
8	Ireland	Europe	1987	74.360	3539900	13872.867
9	Ireland	Europe	1992	75.467	3557761	17558.816
10	Ireland	Europe	1997	76.122	3667233	24521.947
11	Ireland	Europe	2002	77.783	3879155	34077.049
12	Ireland	Europe	2007	78.885	4109086	40675.996

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

```
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