Data visualization with ggplot2

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Motivation

- The following material is adapted from Kieran Healy's wonderful book (2018) on data visualization.
- Why should we care?
- Sometimes, pictures are better tools than words in 1) exploring, 2) understanding, and 3) explaining data.

Anscombe's quartet

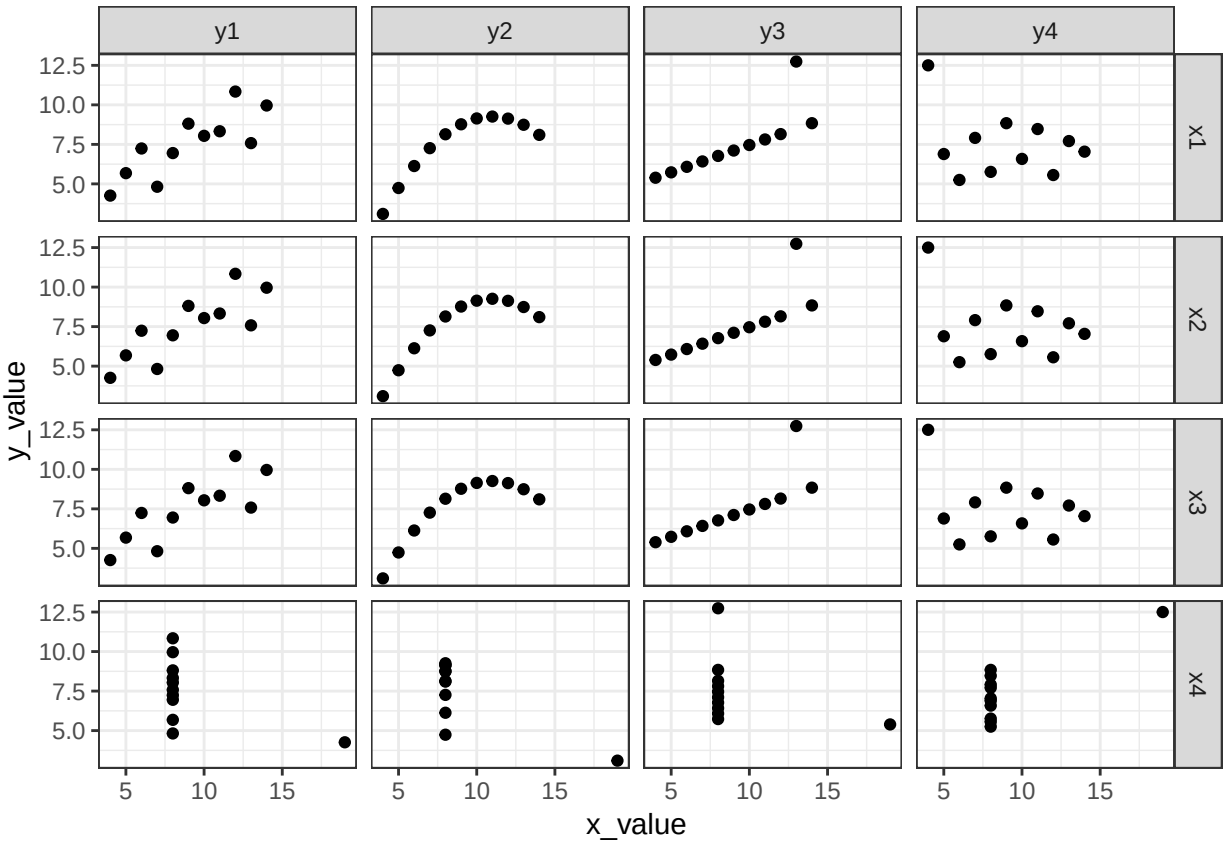
```
# data
anscombe
```

```
##    x1 x2 x3 x4    y1   y2    y3    y4
## 1  10 10 10  8  8.04 9.14  7.46  6.58
## 2   8  8  8  8  6.95 8.14  6.77  5.76
## 3  13 13 13  8  7.58 8.74 12.74  7.71
## 4   9  9  9  8  8.81 8.77  7.11  8.84
## 5  11 11 11  8  8.33 9.26  7.81  8.47
## 6  14 14 14  8  9.96 8.10  8.84  7.04
## 7   6  6  6  8  7.24 6.13  6.08  5.25
## 8   4  4  4 19  4.26 3.10  5.39 12.50
## 9  12 12 12  8 10.84 9.13  8.15  5.56
## 10  7  7  7  8  4.82 7.26  6.42  7.91
## 11  5  5  5  8  5.68 4.74  5.73  6.89
```

```
# correlation
cor(anscombe)[c(1:4),c(5:8)]
```

```
##            y1         y2         y3         y4
## x1  0.8164205  0.8162365  0.8162867 -0.3140467
## x2  0.8164205  0.8162365  0.8162867 -0.3140467
## x3  0.8164205  0.8162365  0.8162867 -0.3140467
## x4 -0.5290927 -0.7184365 -0.3446610  0.8165214
```

```
# plot
anscombe %>%
  gather(x_name, x_value, x1:x4) %>%
  gather(y_name, y_value, y1:y4) %>%
  ggplot(aes(x = x_value, y = y_value)) +
           geom_point() +
           facet_grid(x_name ~ y_name) +
  theme_bw()
```



ggplot2 basics

- Workflow:
  1. Tidy data
  2. Mapping
  3. Geom
  4. Cor_ordinates and scales
  5. Labels and guides
  6. Themes
  7. Save files

Tidy data

- We covered tiday data in the previous sessions.

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       1962    32.0 10267083      853.
##  4 Afghanistan Asia       1967    34.0 11537966      836.
##  5 Afghanistan Asia       1972    36.1 13079460      740.
##  6 Afghanistan Asia       1977    38.4 14880372      786.
##  7 Afghanistan Asia       1982    39.9 12881816      978.
```

```
##  8 Afghanistan Asia       1987    40.8 13867957      852.
##  9 Afghanistan Asia       1992    41.7 16317921      649.
## 10 Afghanistan Asia       1997    41.8 22227415      635.
## # ... with 1,694 more rows
```

What is the difference between typeof and class?

```
typeof(gapminder)
```

```
## [1] "list"
```

```
class(gapminder)
```

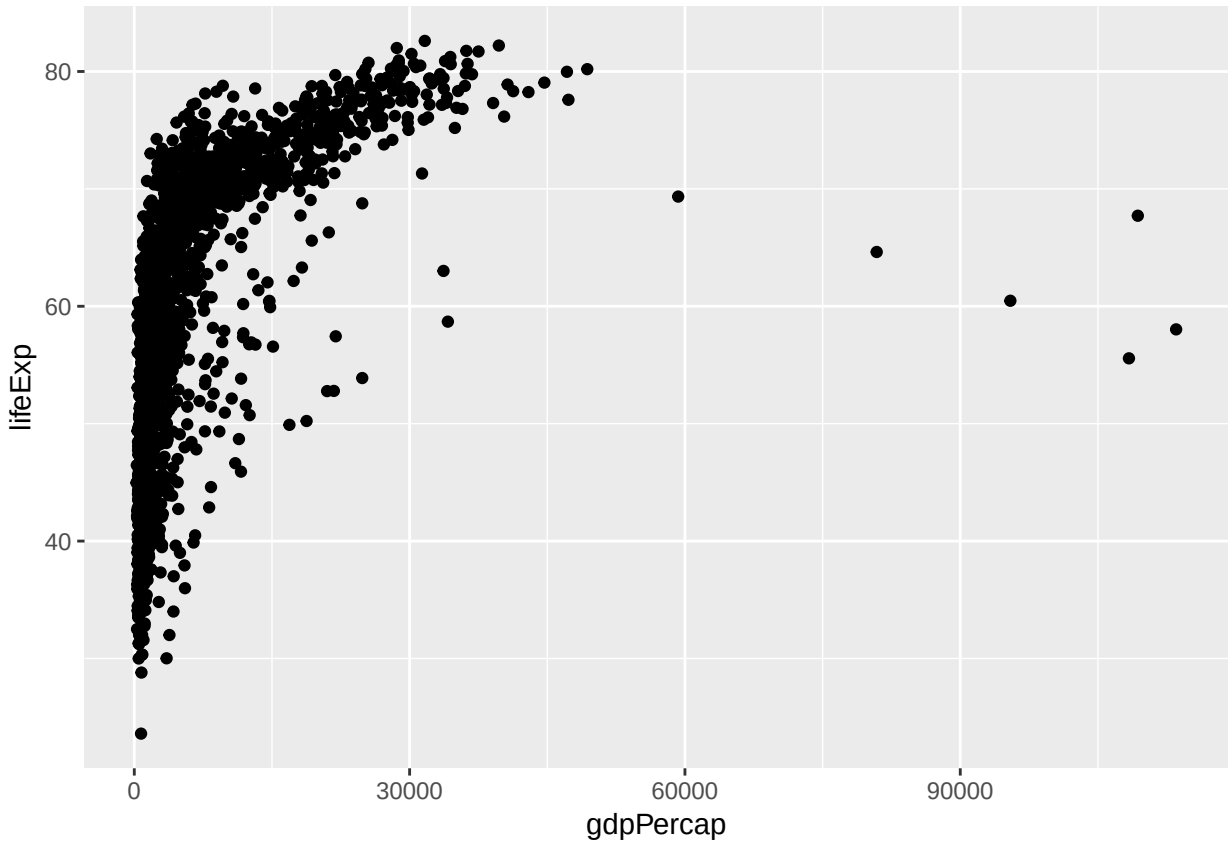
```
## [1] "tbl_df"     "tbl"        "data.frame"
```

Mapping and Geom

- ggplot tells what is your data
- aes (aesthetic mappings or aesthetics) tells what is your variables of interests in the data
- geom_ tlles the type of plot you are going to use

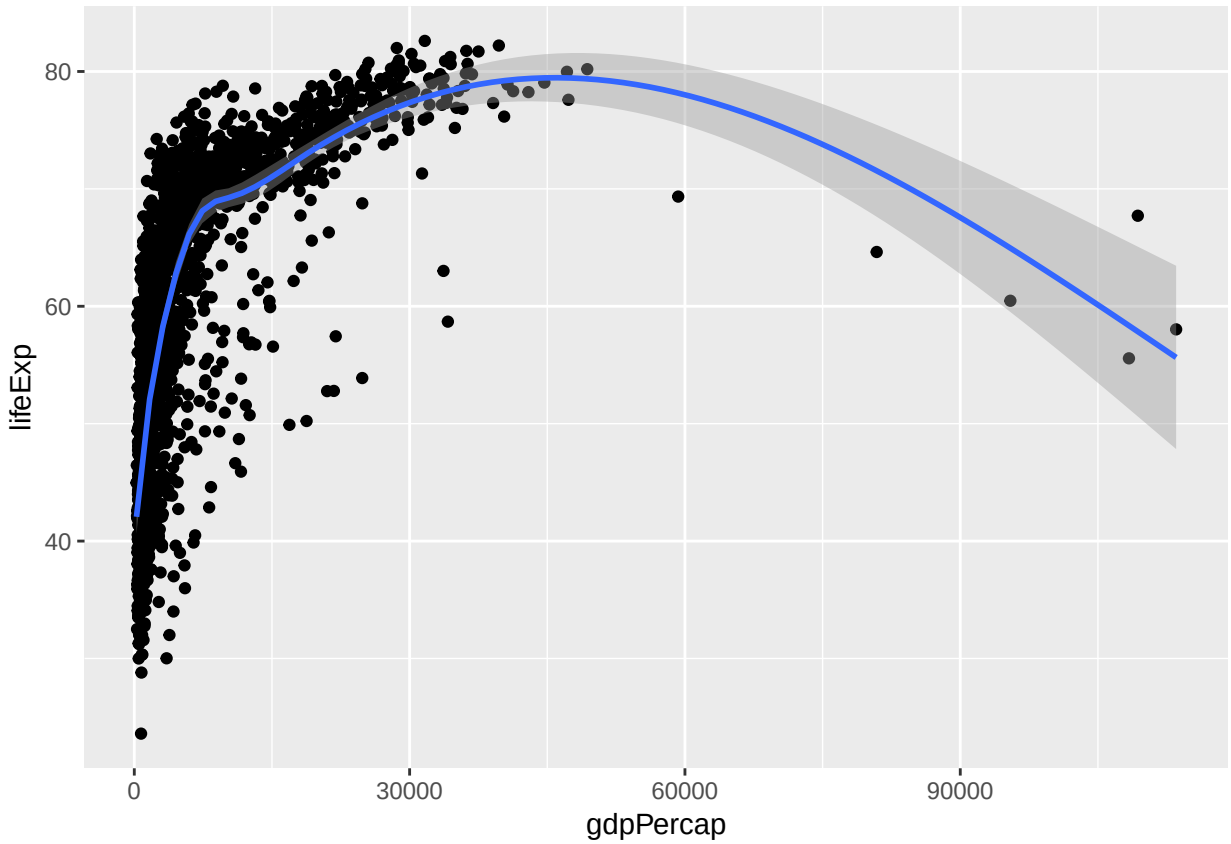
Basic aes (x , y)

```
p <- ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp))

p + geom_point()
```




```
p + geom_point() + geom_smooth()
```

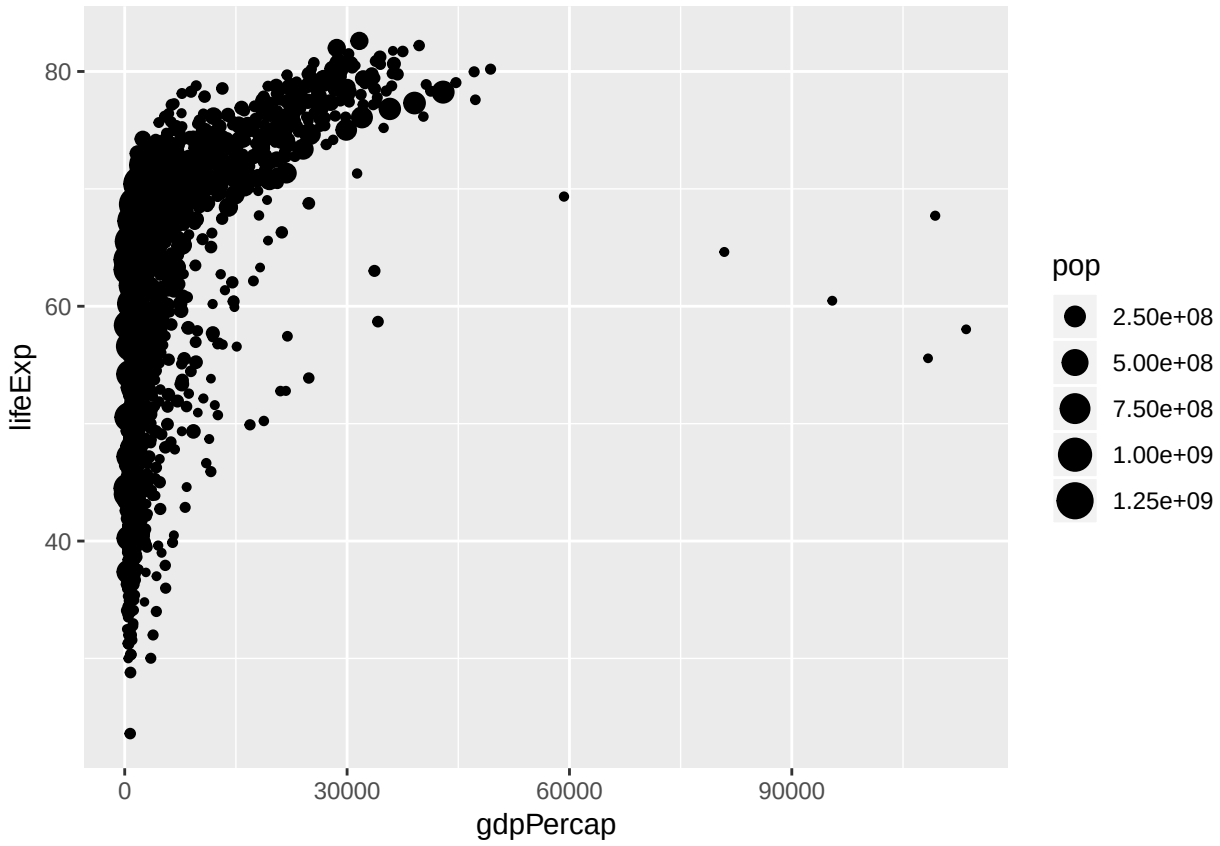
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



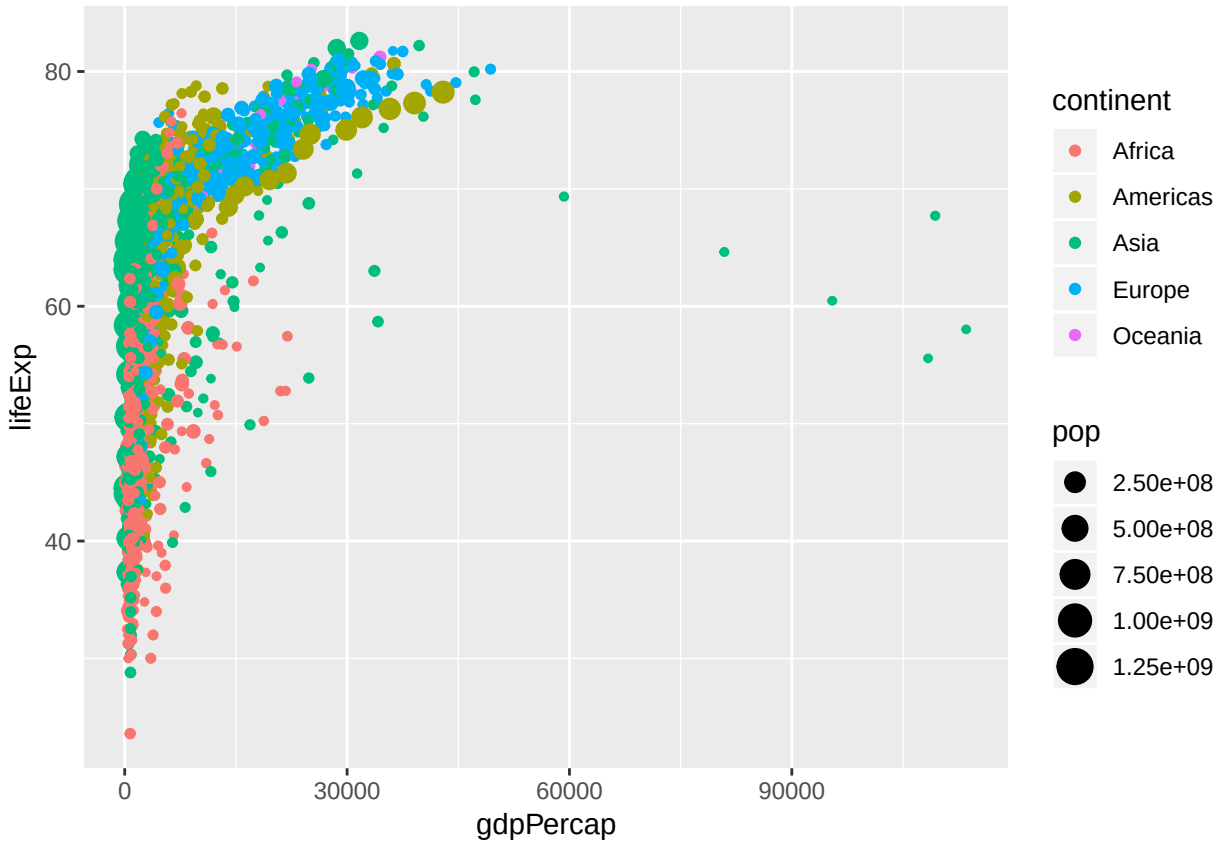
Advanced aes (size, color)

- There's also fill argument (mostly used in geom_bar()).
- The property size/color/fill represents...

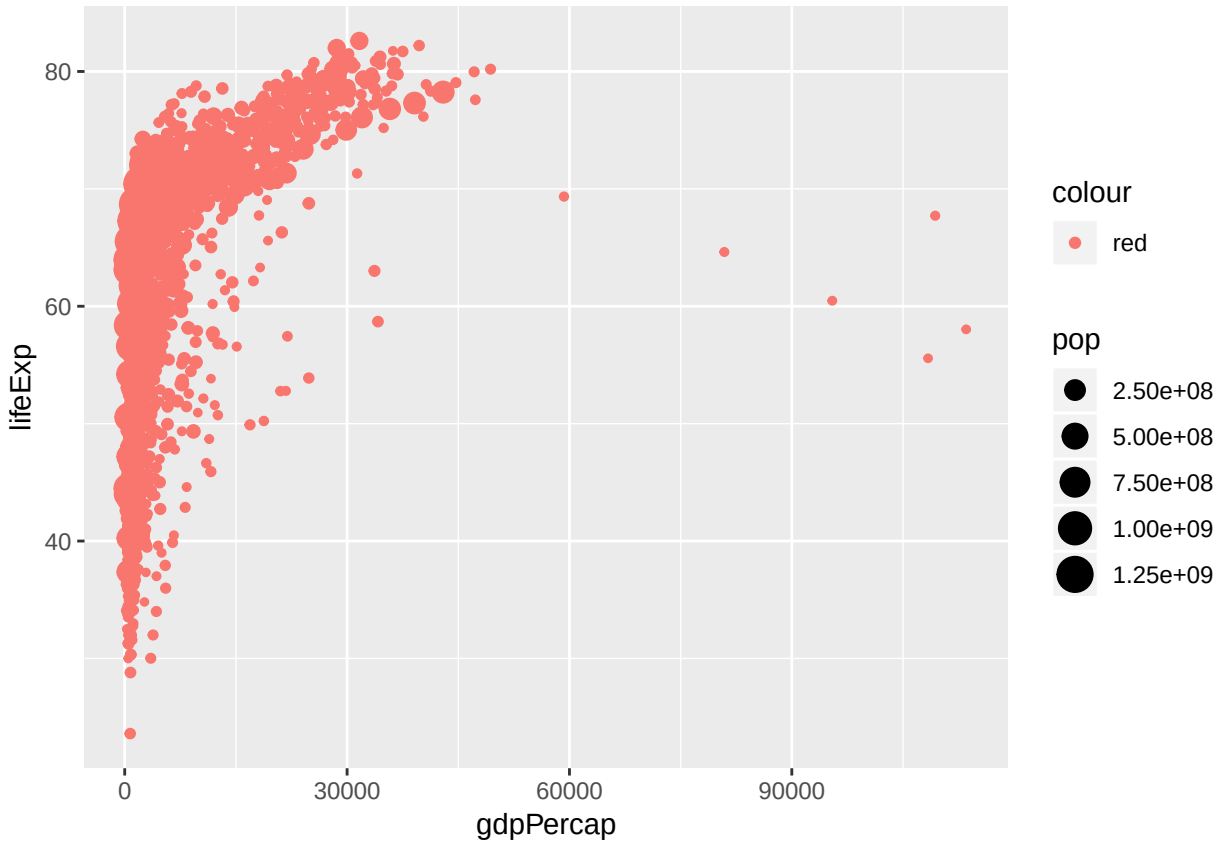
```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          size = pop)) +
  geom_point()
```




```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          size = pop,
                          color = continent)) +
  geom_point()
```

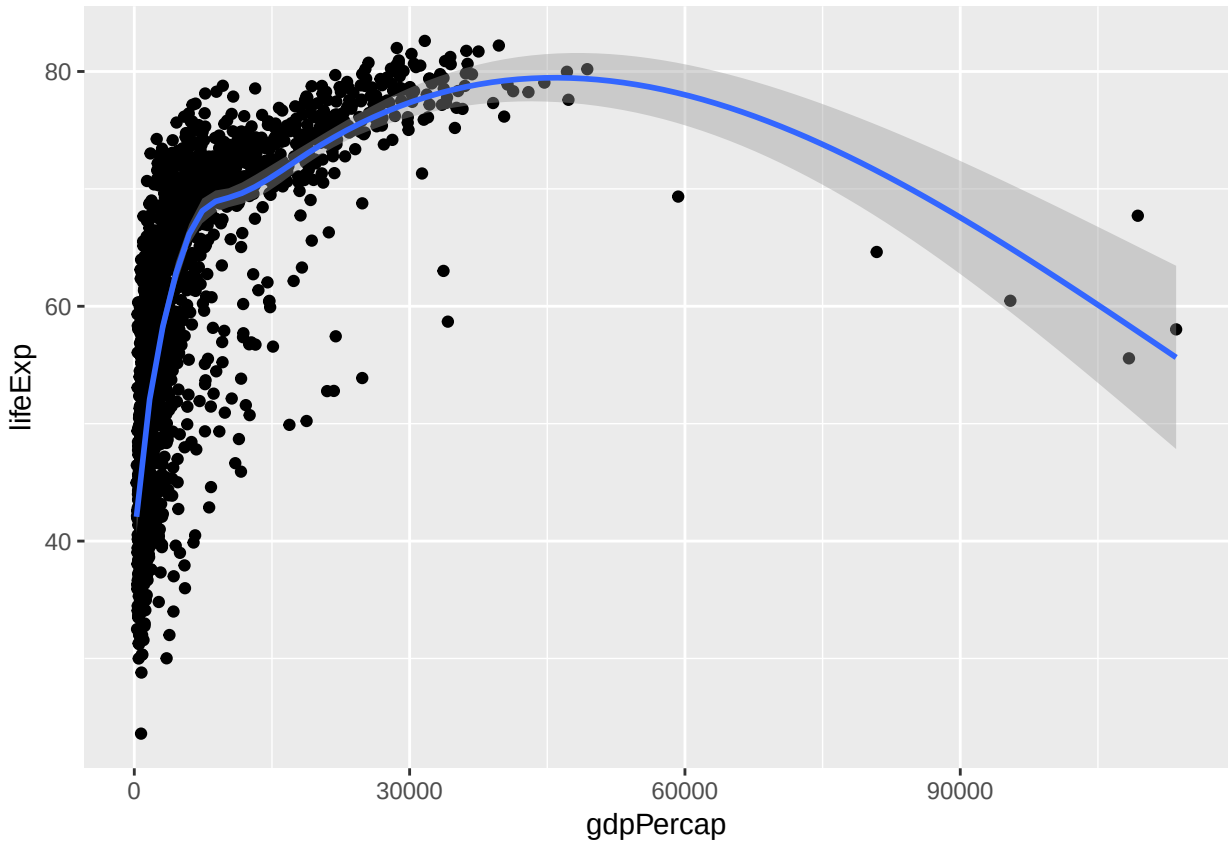



```
# try red instead of "red"
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          size = pop,
                          color = "red")) +
  geom_point()
```



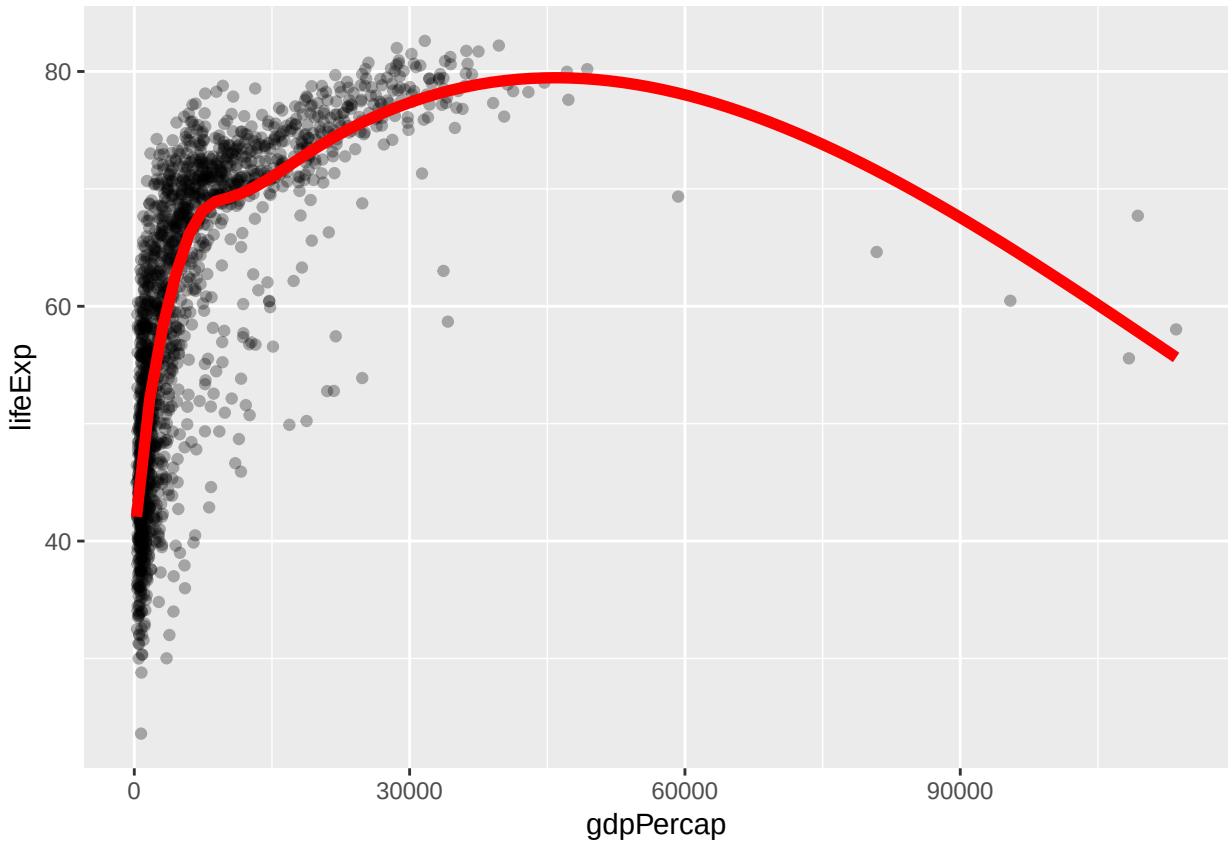

```
p + geom_point() +
  geom_smooth()
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



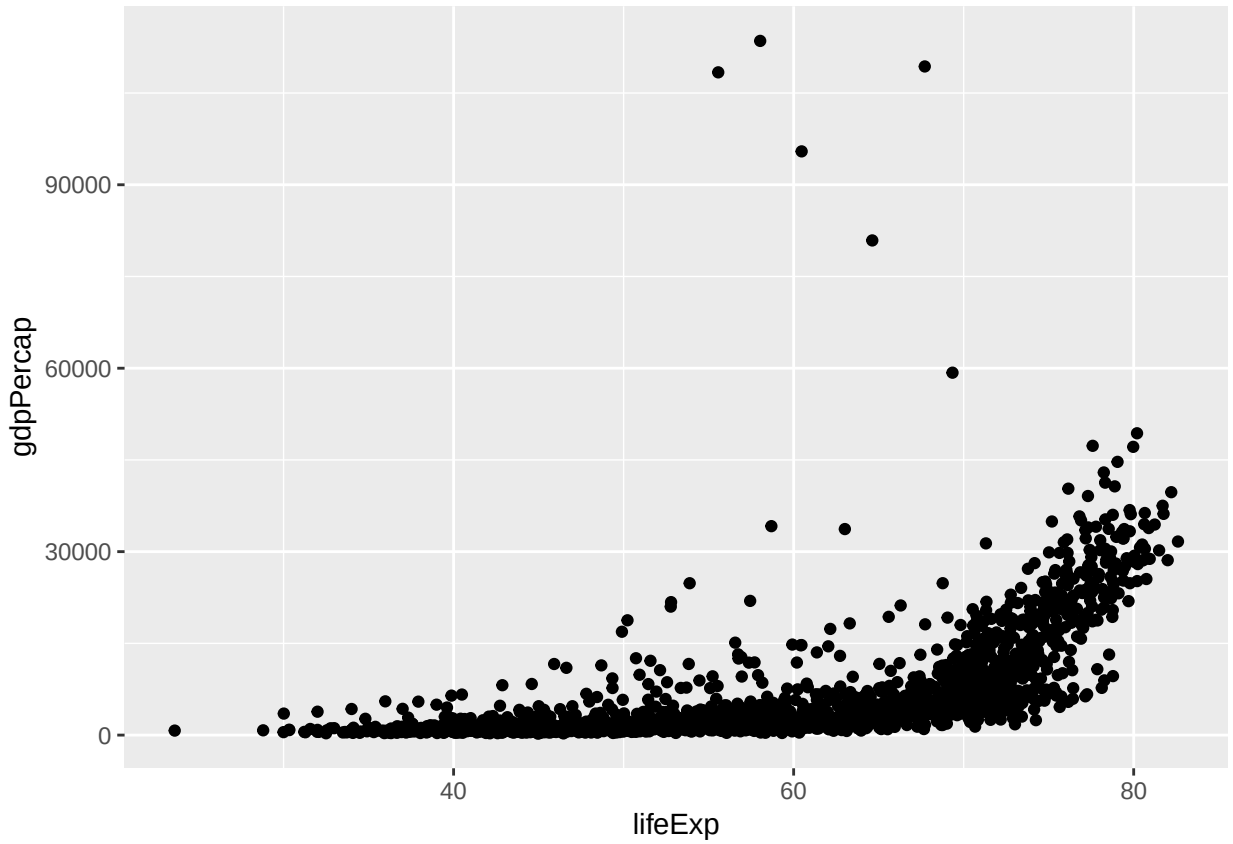

```
p + geom_point(alpha = 0.3) + # alpha controls transparency
  geom_smooth(color = "red", se = FALSE, size = 2)
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

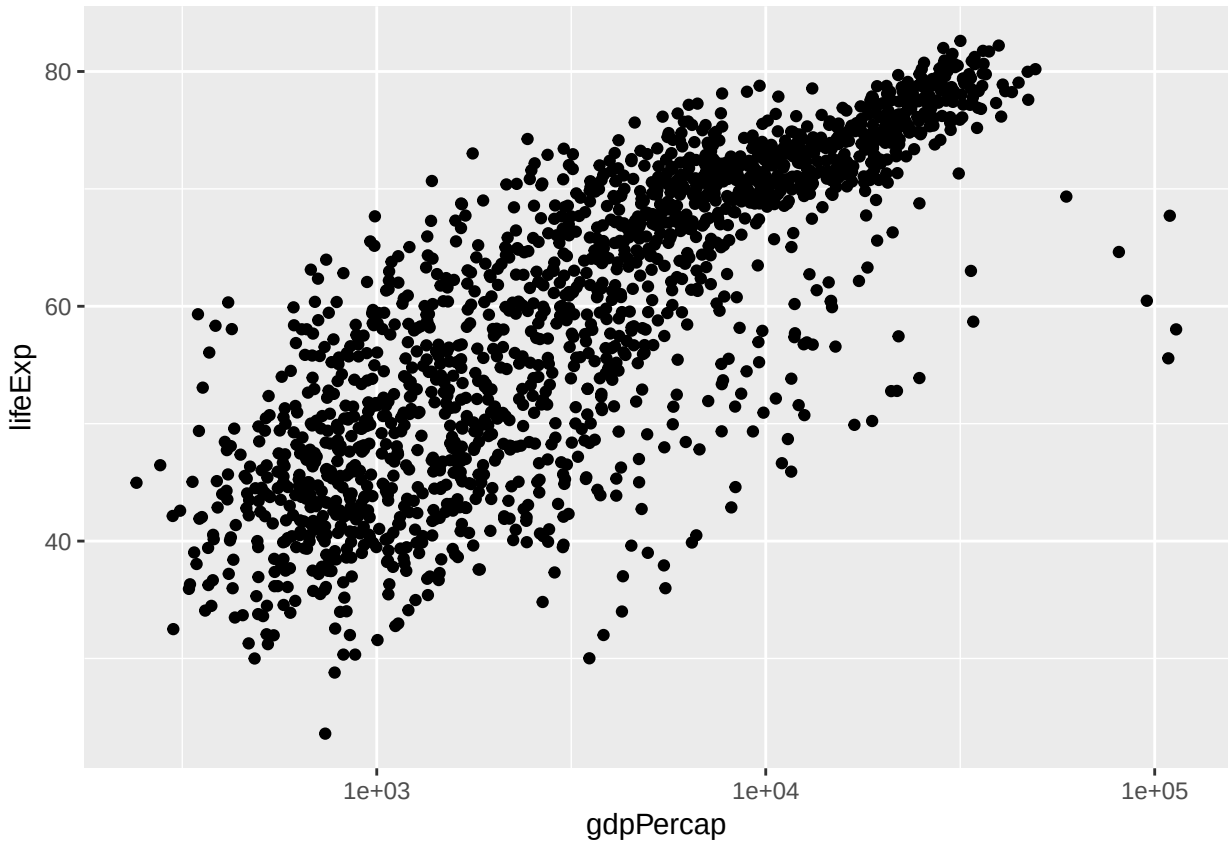


Co-ordinates and scales

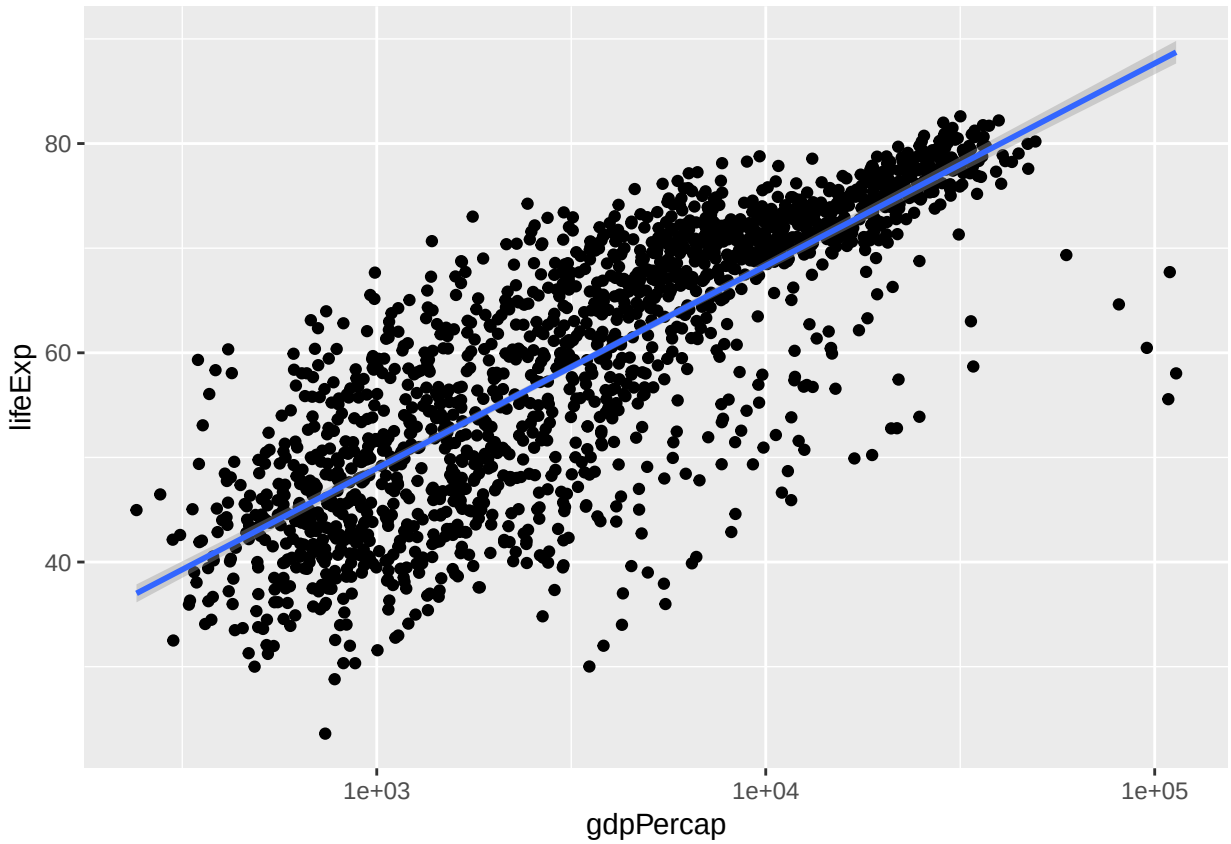
```
p + geom_point() +
  coord_flip() # coord_type
```



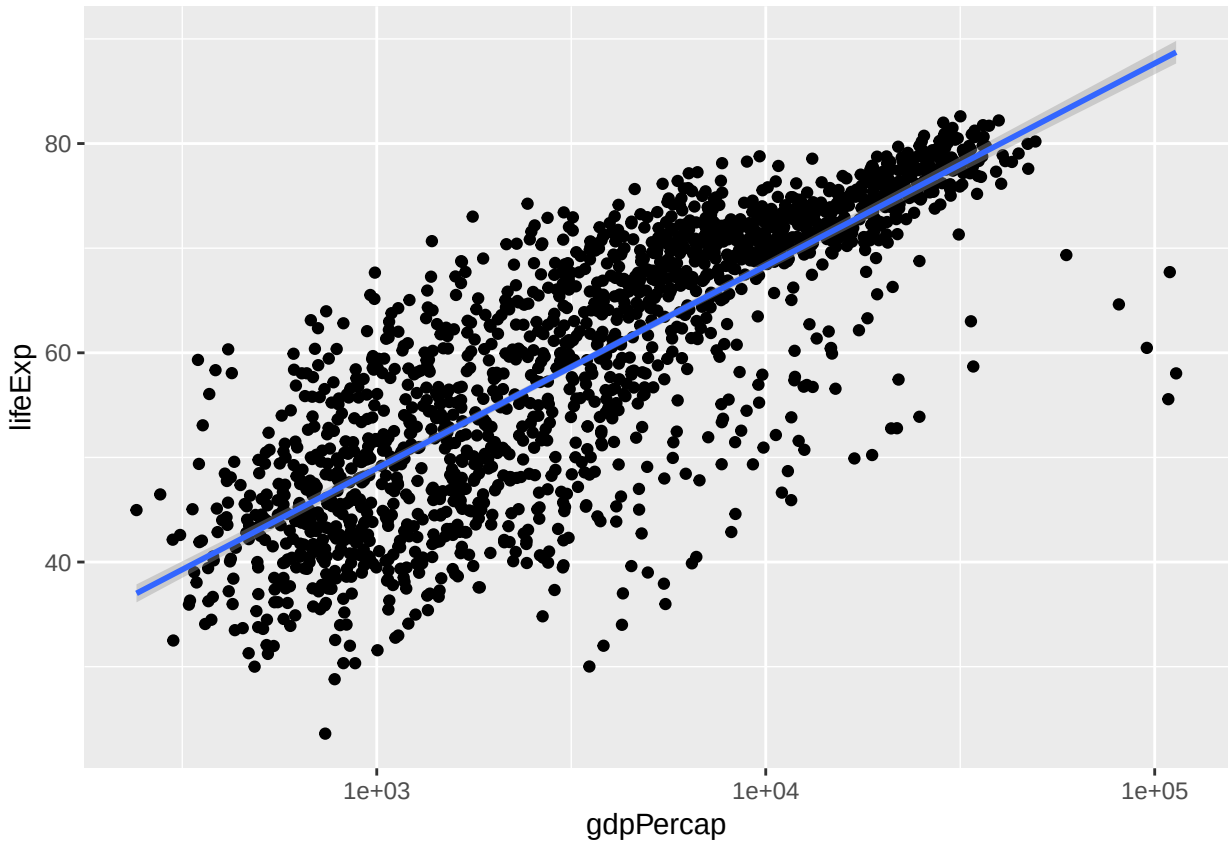

```
p + geom_point() +
  scale_x_log10() # scale_mapping_type
```




```
p + geom_point() +
  geom_smooth(method = "lm") +
  scale_x_log10()
```

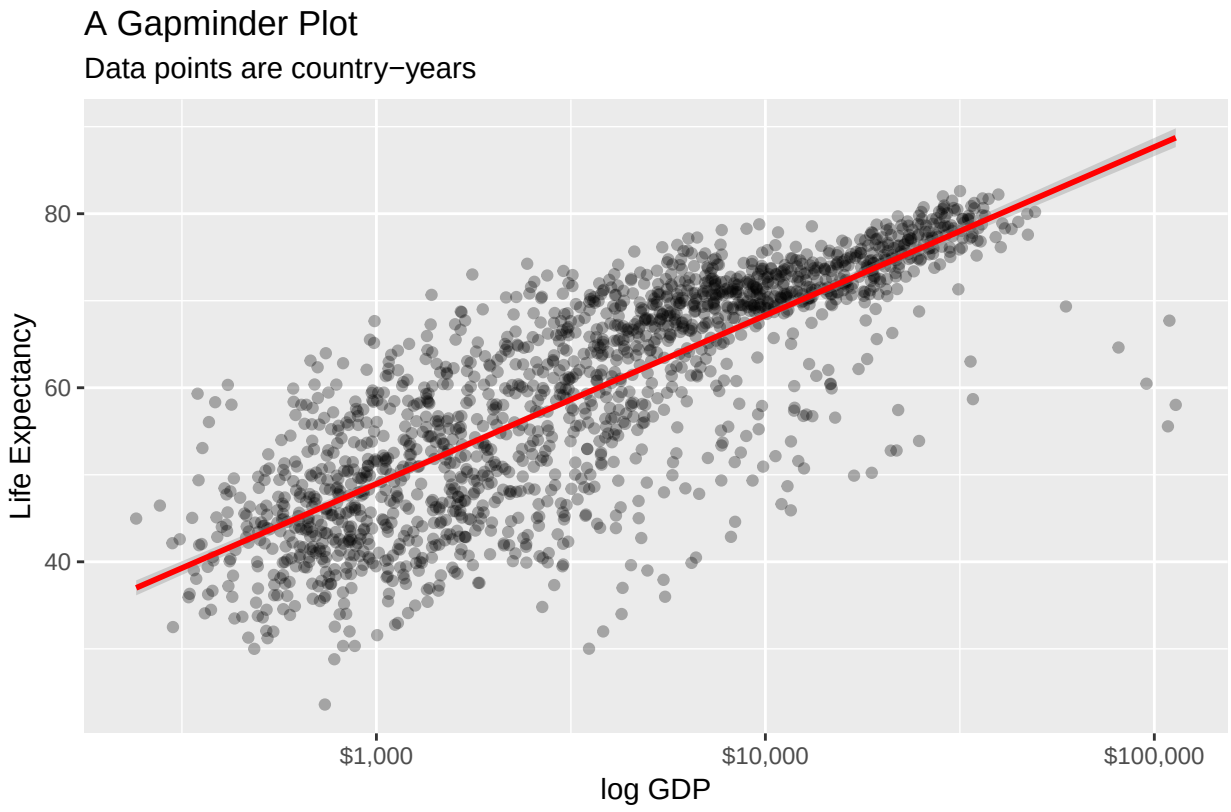



```
p + geom_point() +
  geom_smooth(method = "lm") +
  scale_x_log10()
```

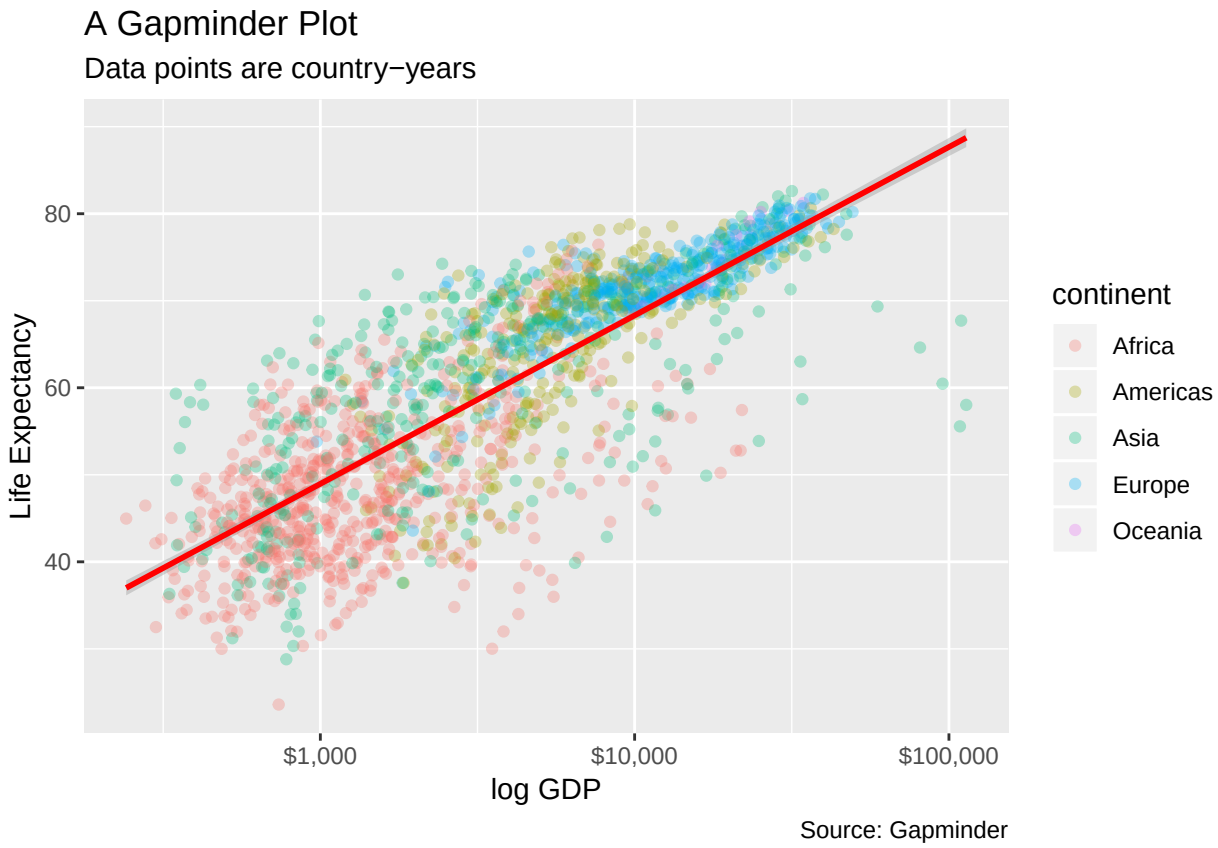


Labels and guides

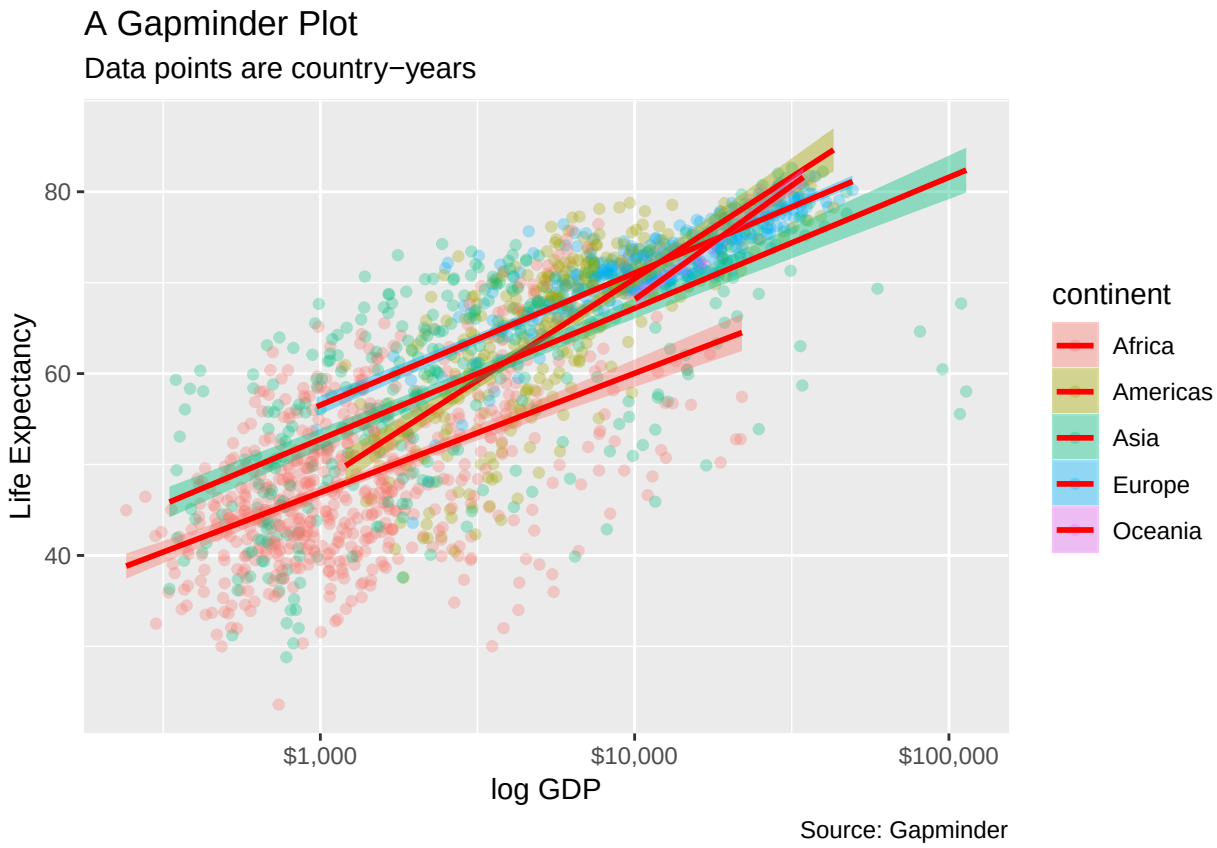
```
p + geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder")
```




```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          color = continent)) +
  geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder")
```

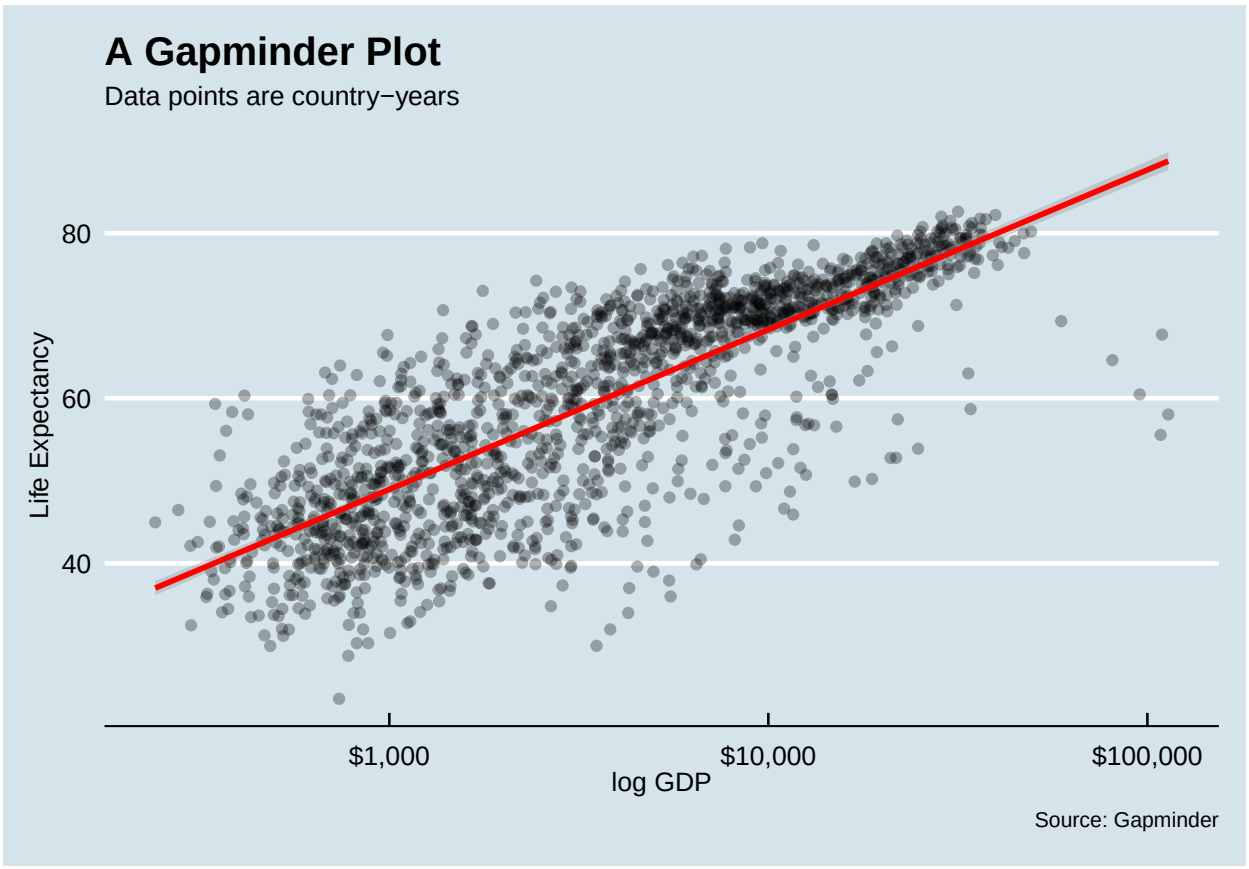



```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          color = continent,
                          fill = continent)) +
  geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder")
```



6. Themes

```
p + geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder") +
  theme_economist()
```



Save files

- I highly recommned to save your file in a subdirectory named output or figures or something like that.

```
figure_example <- p + geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder") +
  theme_economist()

ggsave(filename = "figure_example.png", plot = figure_example)
```

```
## Saving 6.5 x 4.5 in image
```

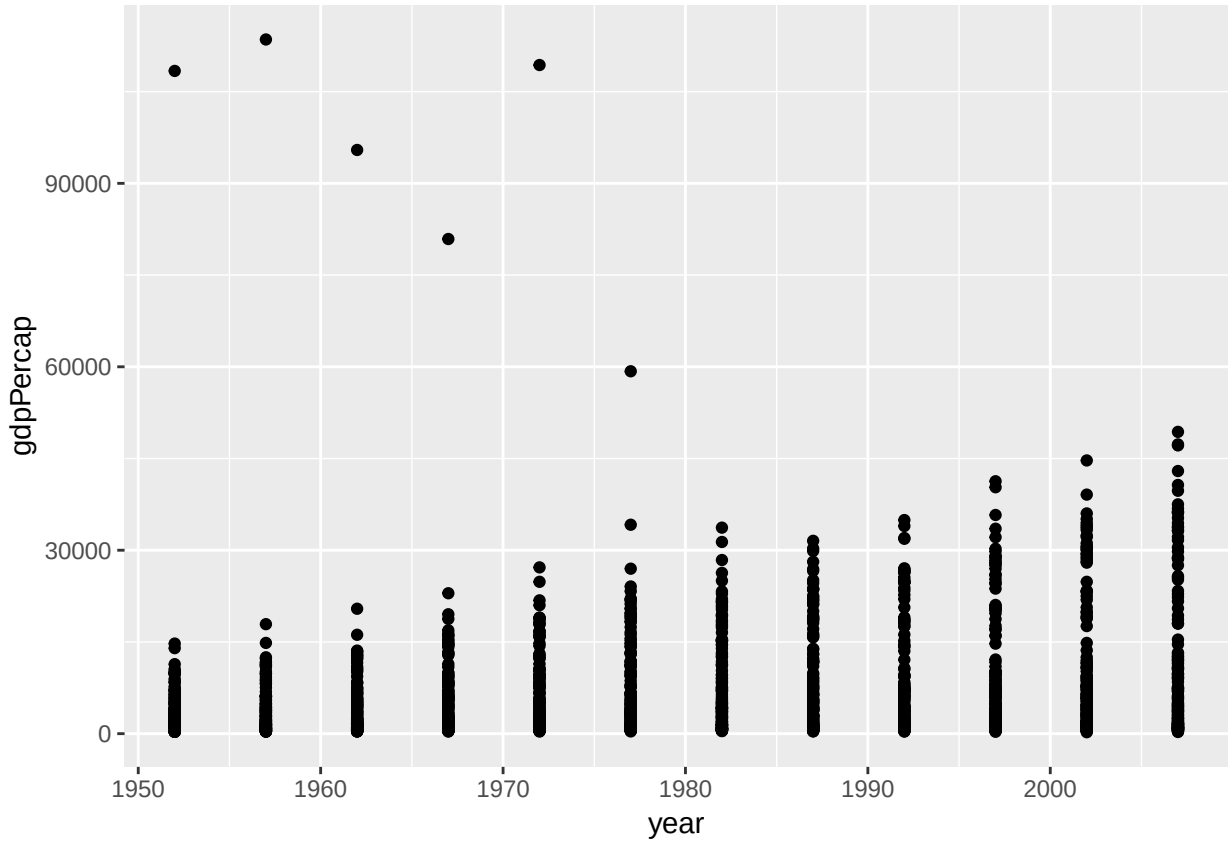
```
ggsave(filename = "figure_example_modified.png", plot = figure_example,
       height = 8,
       width = 10,
       units = "in")
```

ggplot2 intermediates

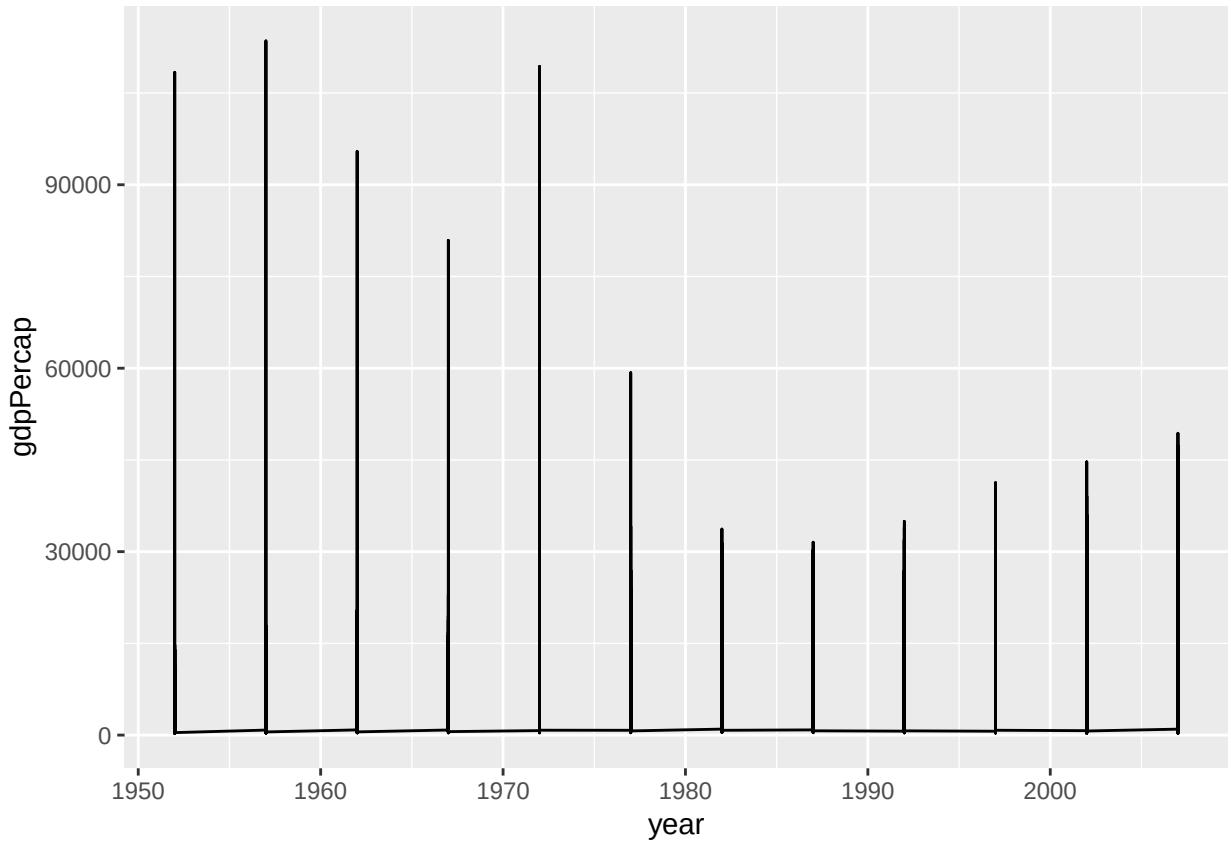
Grouping and facetting

- Can you guess what's wrong?

```
p <- ggplot(gapminder, aes(x = year, y = gdpPercap))

p + geom_point()
```




```
p + geom_line()
```

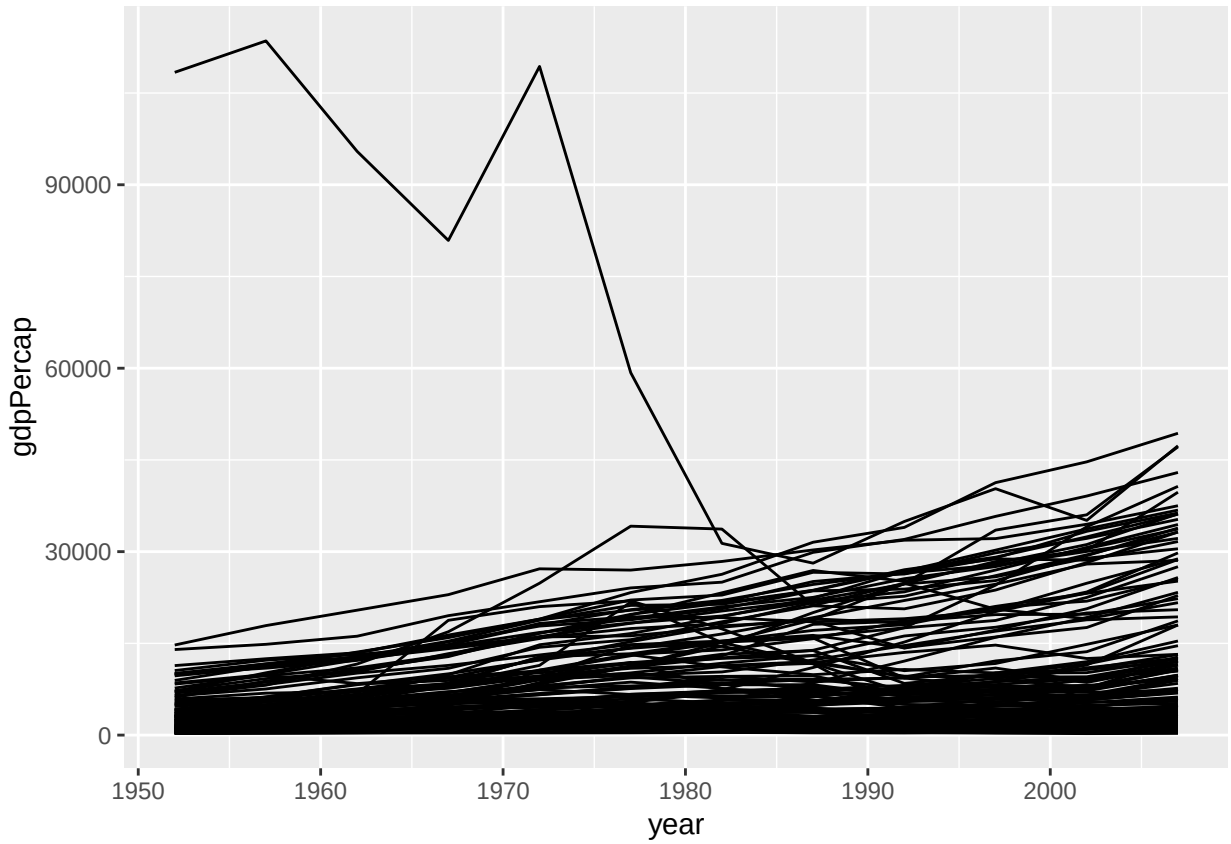



```
gapminder
```

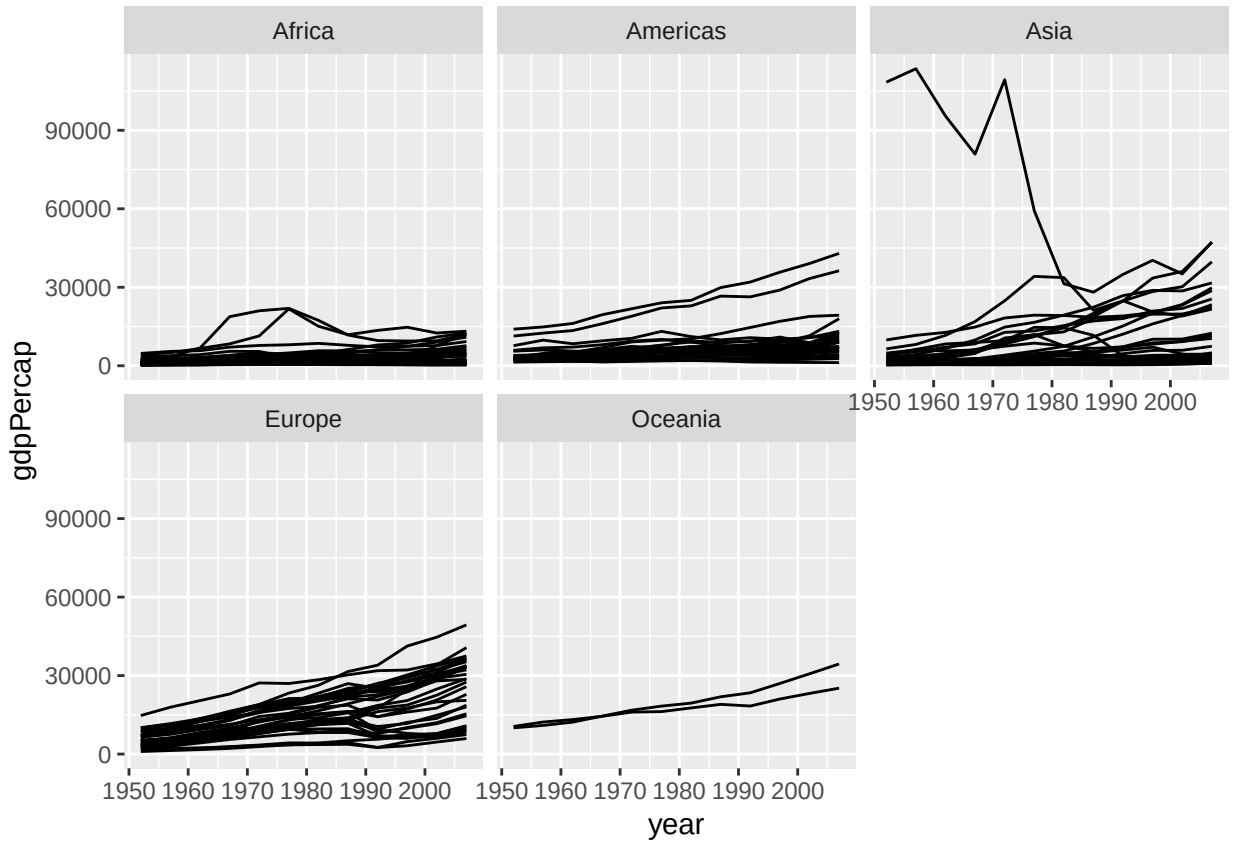
```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       1962    32.0 10267083      853.
##  4 Afghanistan Asia       1967    34.0 11537966      836.
##  5 Afghanistan Asia       1972    36.1 13079460      740.
##  6 Afghanistan Asia       1977    38.4 14880372      786.
##  7 Afghanistan Asia       1982    39.9 12881816      978.
##  8 Afghanistan Asia       1987    40.8 13867957      852.
##  9 Afghanistan Asia       1992    41.7 16317921      649.
## 10 Afghanistan Asia       1997    41.8 22227415      635.
## # ... with 1,694 more rows
```

- Use grouping and facetting to clarify

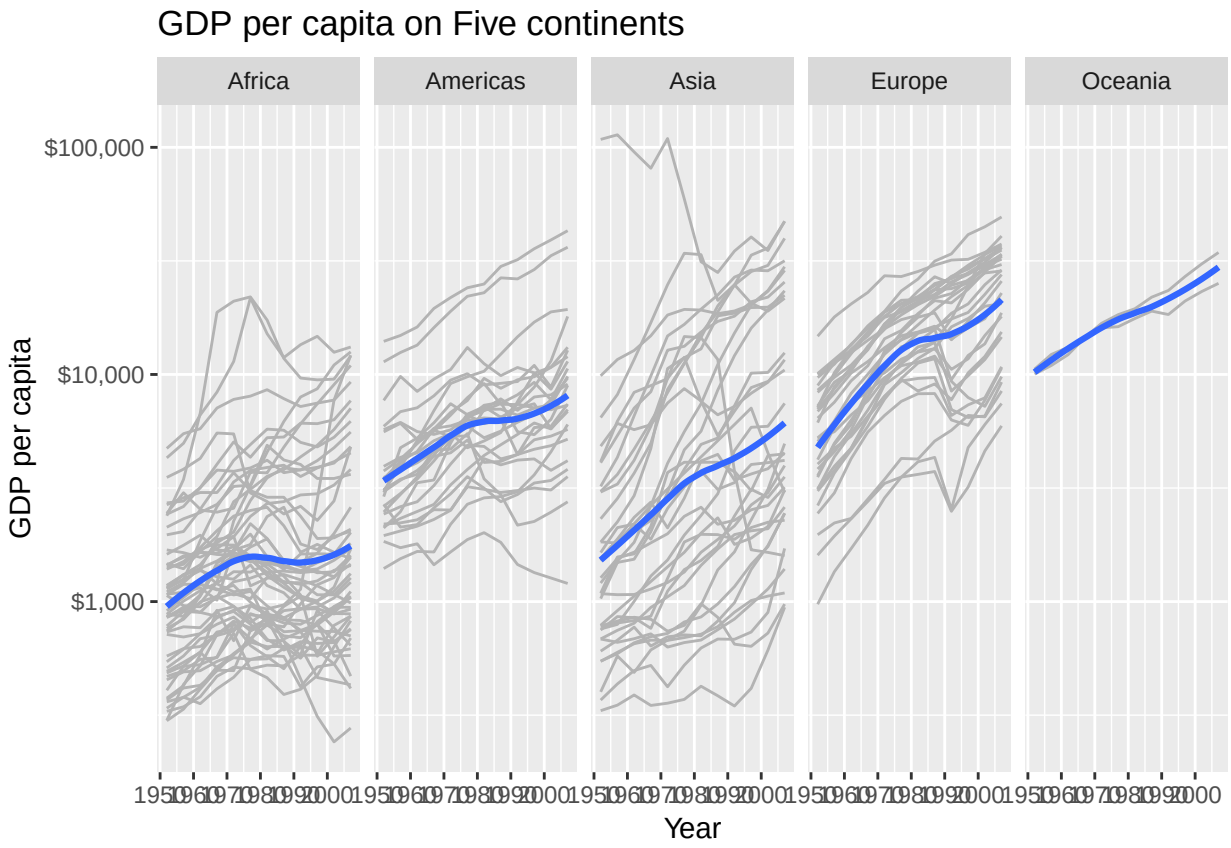
```
p <- ggplot(gapminder, aes(x = year, y = gdpPercap))

p + geom_line(aes(group = country)) # group by
```




```
p + geom_line(aes(group = country)) + facet_wrap(~continent) # facetting
```

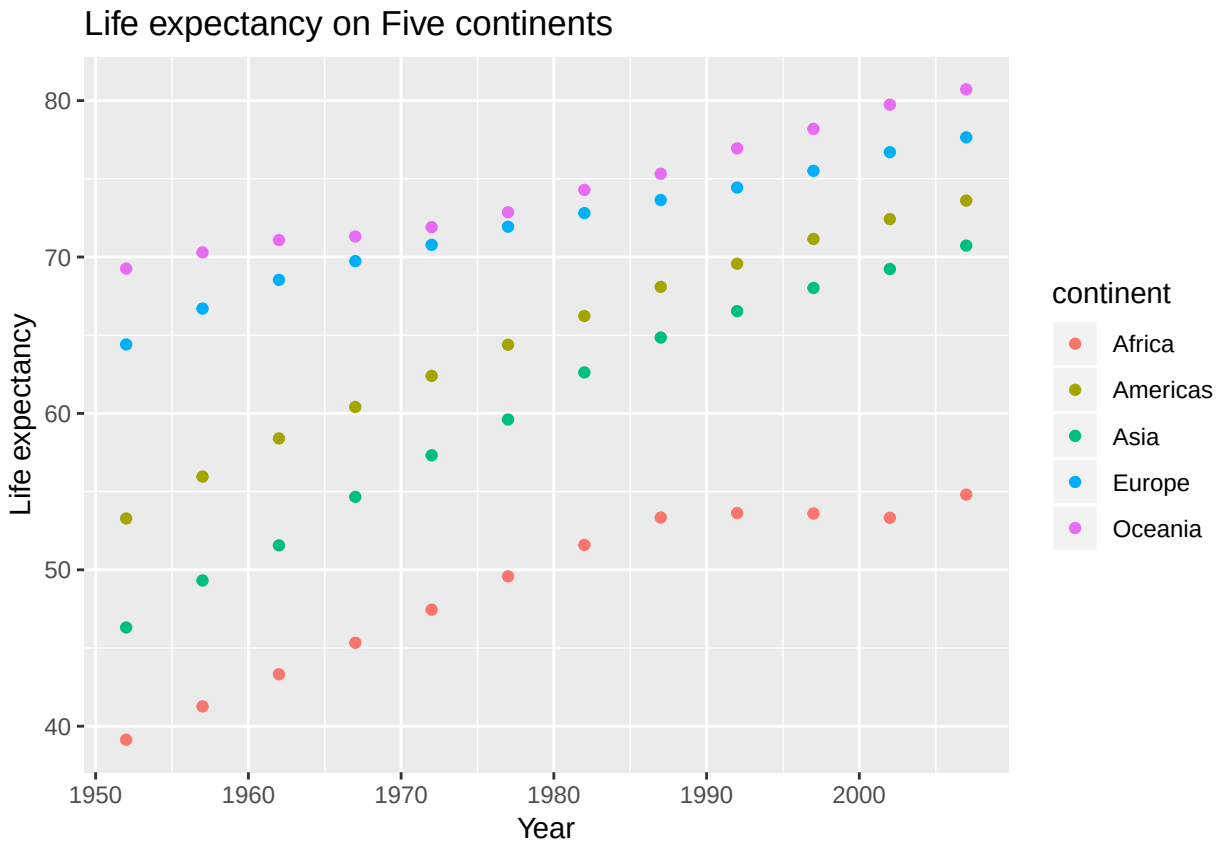



```
p + geom_line(aes(group = country), color = "gray70") +
  geom_smooth(size = 1.1, method = "loess", se = FALSE) +
  scale_y_log10(labels = scales::dollar) +
  facet_wrap(~continent, ncol = 5) + # for single categorical variable; for multiple categorical variab
  labs(x = "Year",
       y = "GDP per capita",
       title = "GDP per capita on Five continents")
```

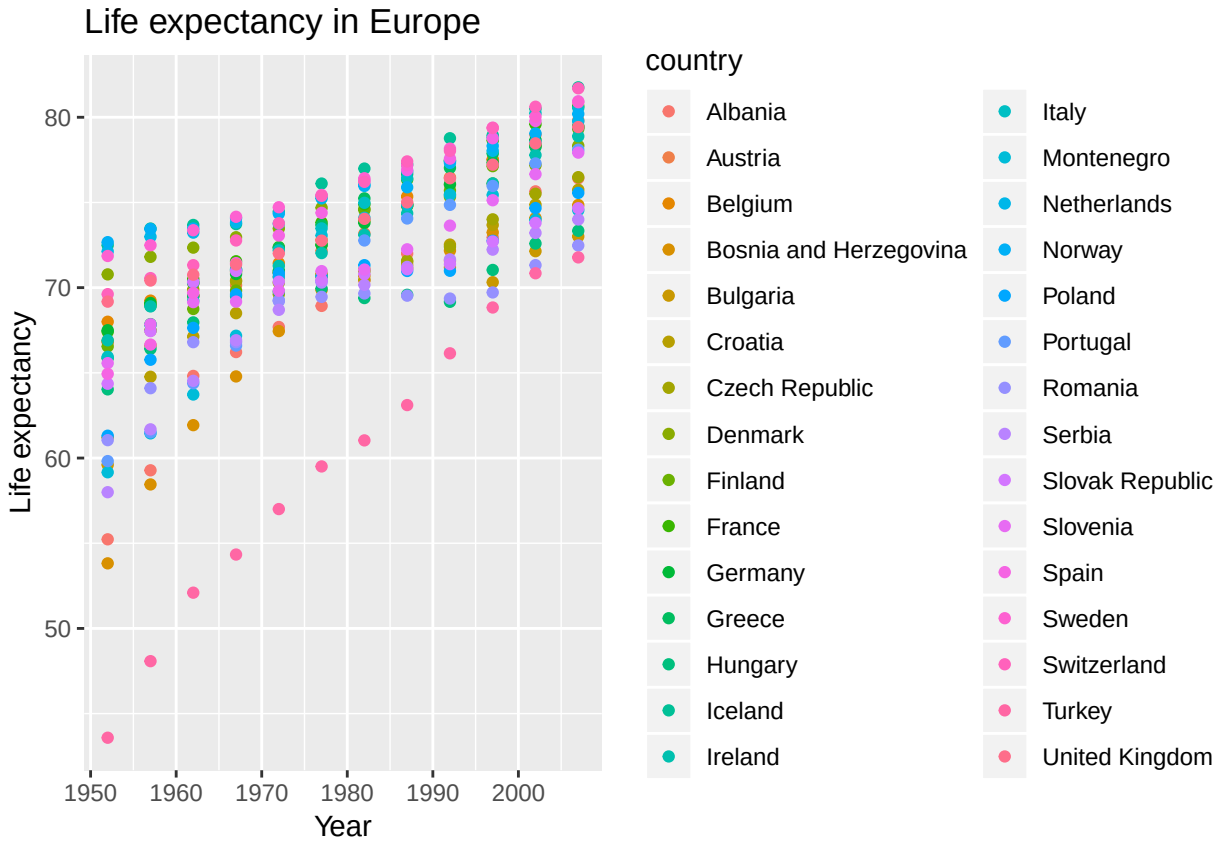


Use pipes to summarize data

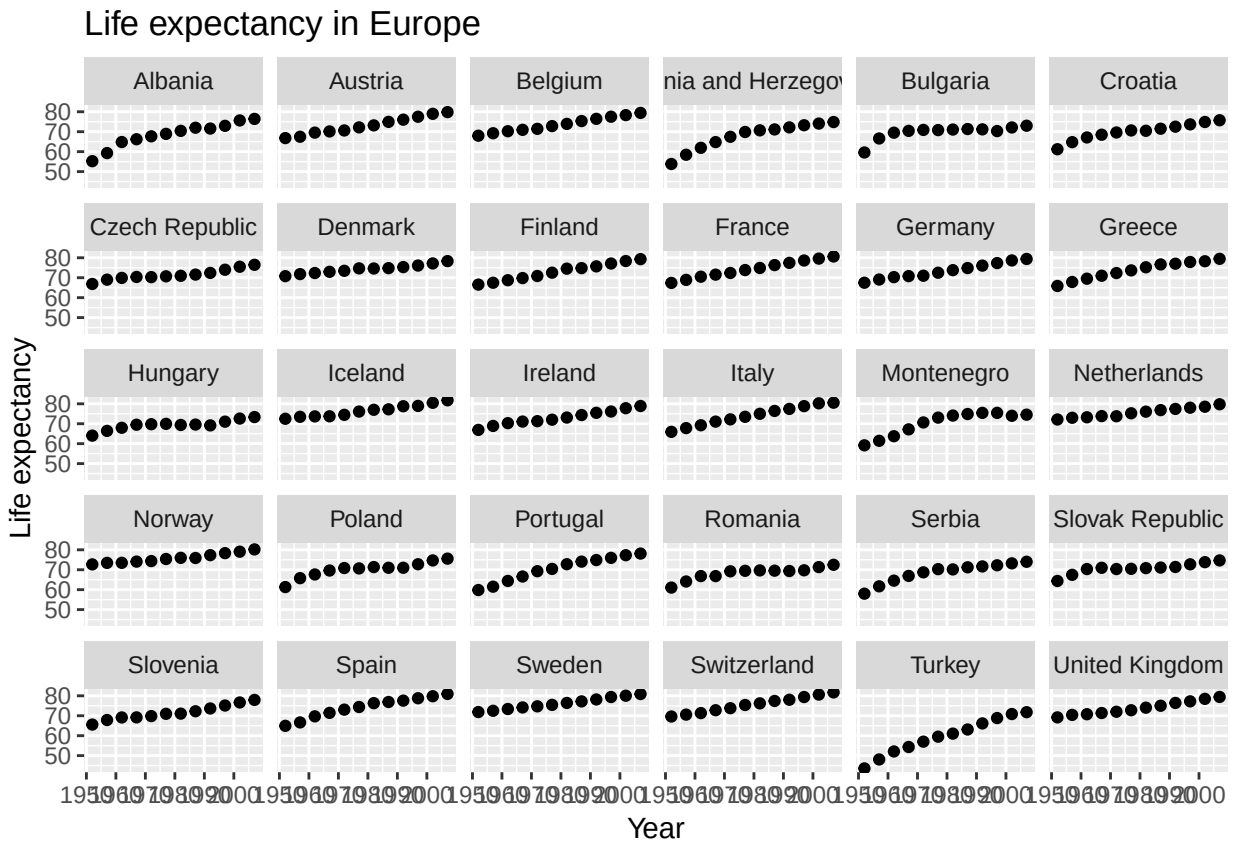
```
gapminder %>%
  group_by(continent, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean, color = continent)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy on Five continents")
```



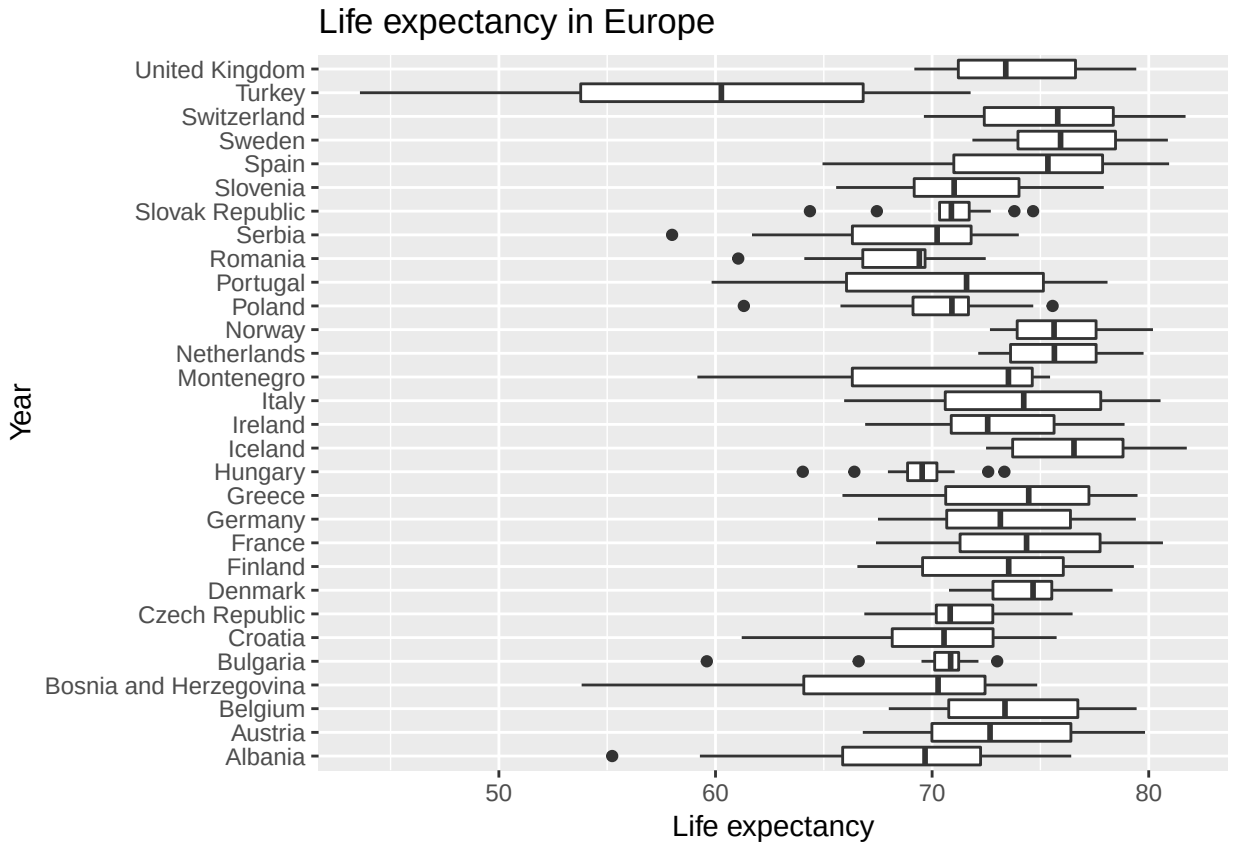

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean, color = country)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy in Europe")
```



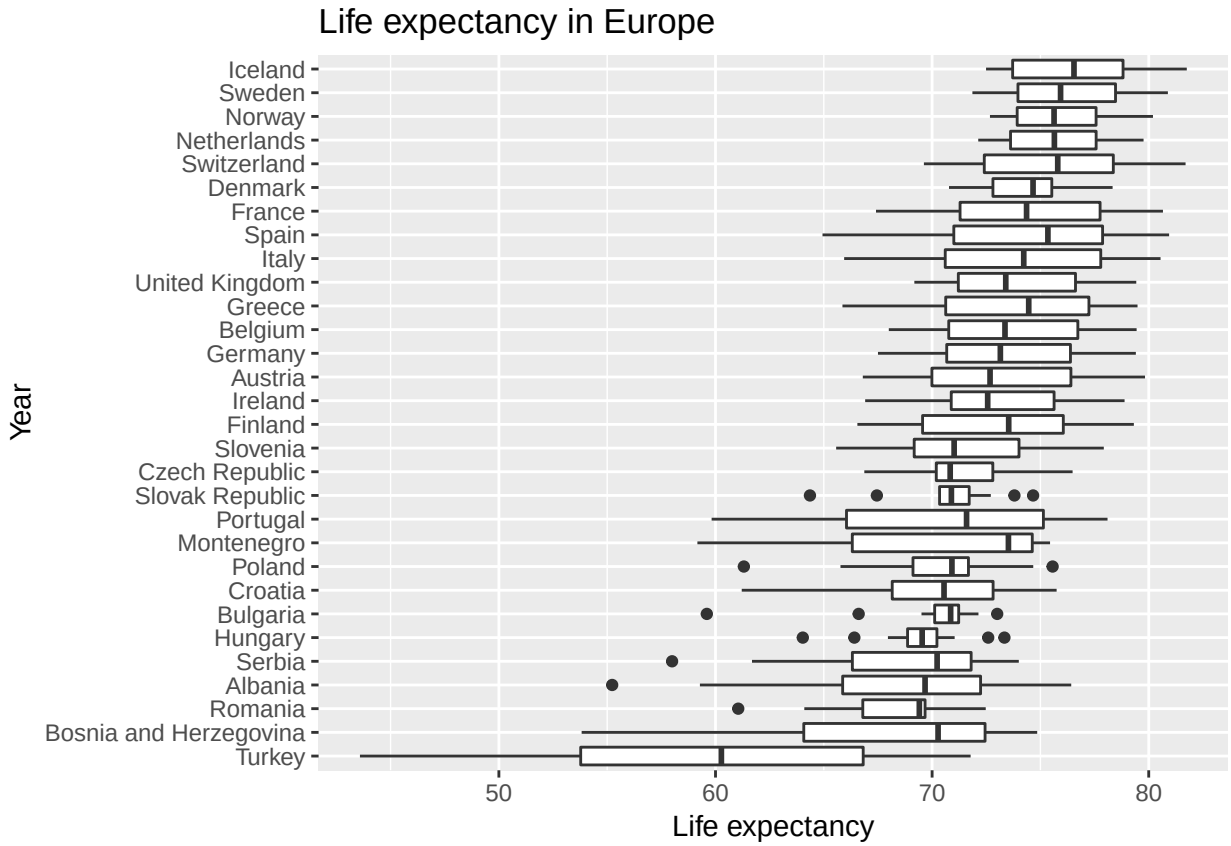

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy in Europe") +
  facet_wrap(~country)
```



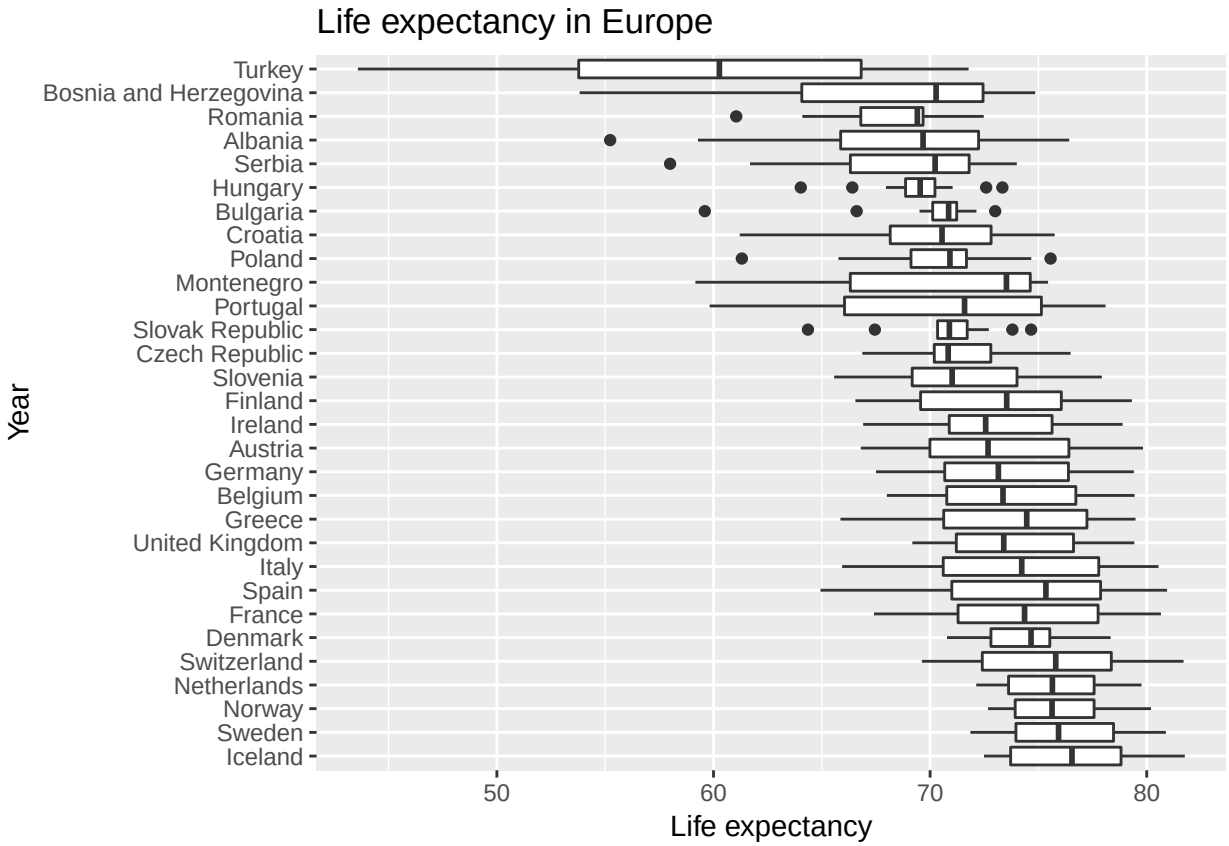

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = country, y = lifeExp_mean)) +
  geom_boxplot() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy in Europe") +
  coord_flip()
```




```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = reorder(country, lifeExp_mean), y = lifeExp_mean)) +
  geom_boxplot() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy in Europe") +
  coord_flip()
```

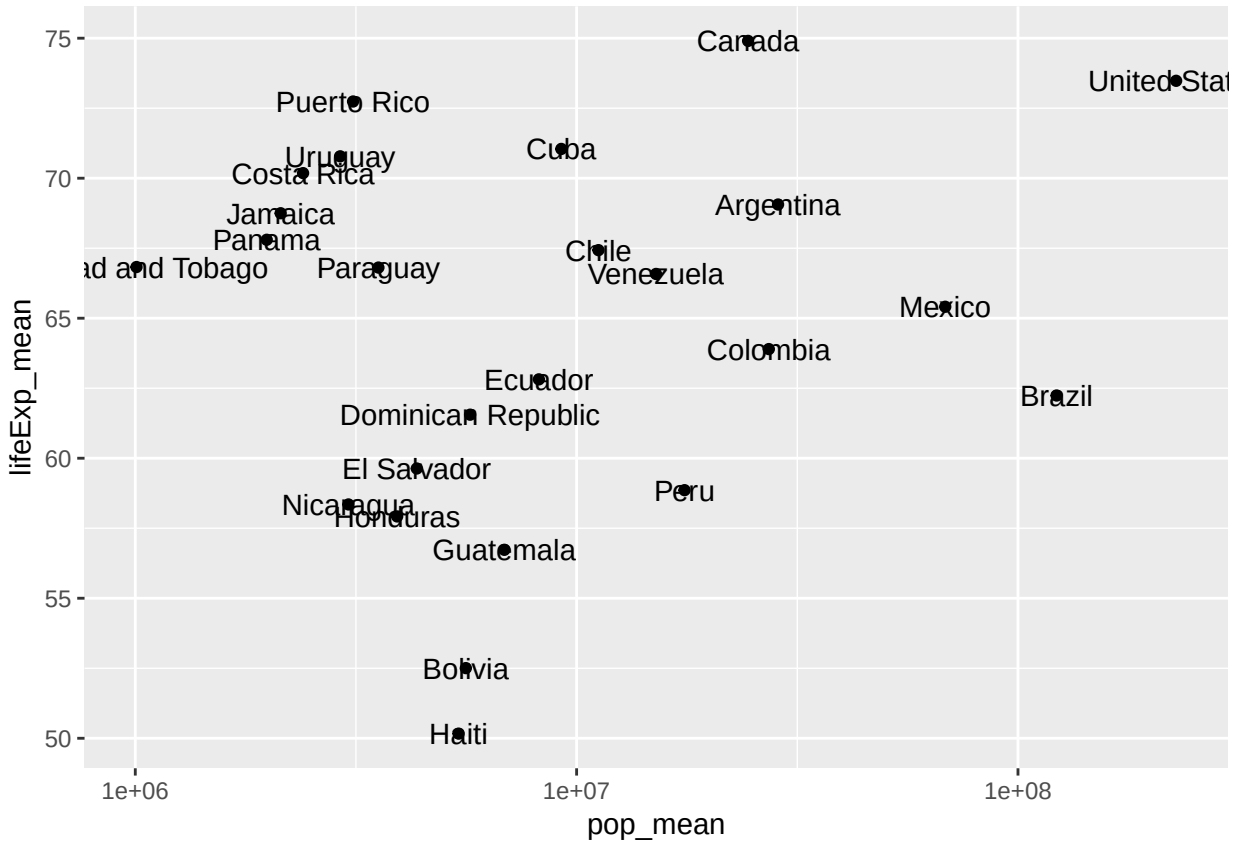



```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = reorder(country, -lifeExp_mean), y = lifeExp_mean)) +
  geom_boxplot() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy in Europe") +
  coord_flip()
```



Plotting text

```
gapminder %>%
  filter(continent == "Americas") %>%
  group_by(continent, country) %>%
  summarize(pop_mean = mean(pop),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = pop_mean, y = lifeExp_mean)) +
  geom_point() +
  geom_text(aes(label = country)) +
  scale_x_log10()
```


75
70
65
60
55
50
lifeExp_mean
Canada
United Stat
Puerto Rico
Cuba
Uruguay
Costa Rica
Jamaica
Panama
Argentina
Chile
Paraguay
Venezuela
Mexico
Colombia
Ecuador
Brazil
Dominican Republic
El Salvador
Peru
Nicaragua
Honduras
Guatemala
Bolivia
Haiti
1e+06
1e+07
1e+08
pop_mean