Data visualization with ggplot2

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26 December, 2018

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

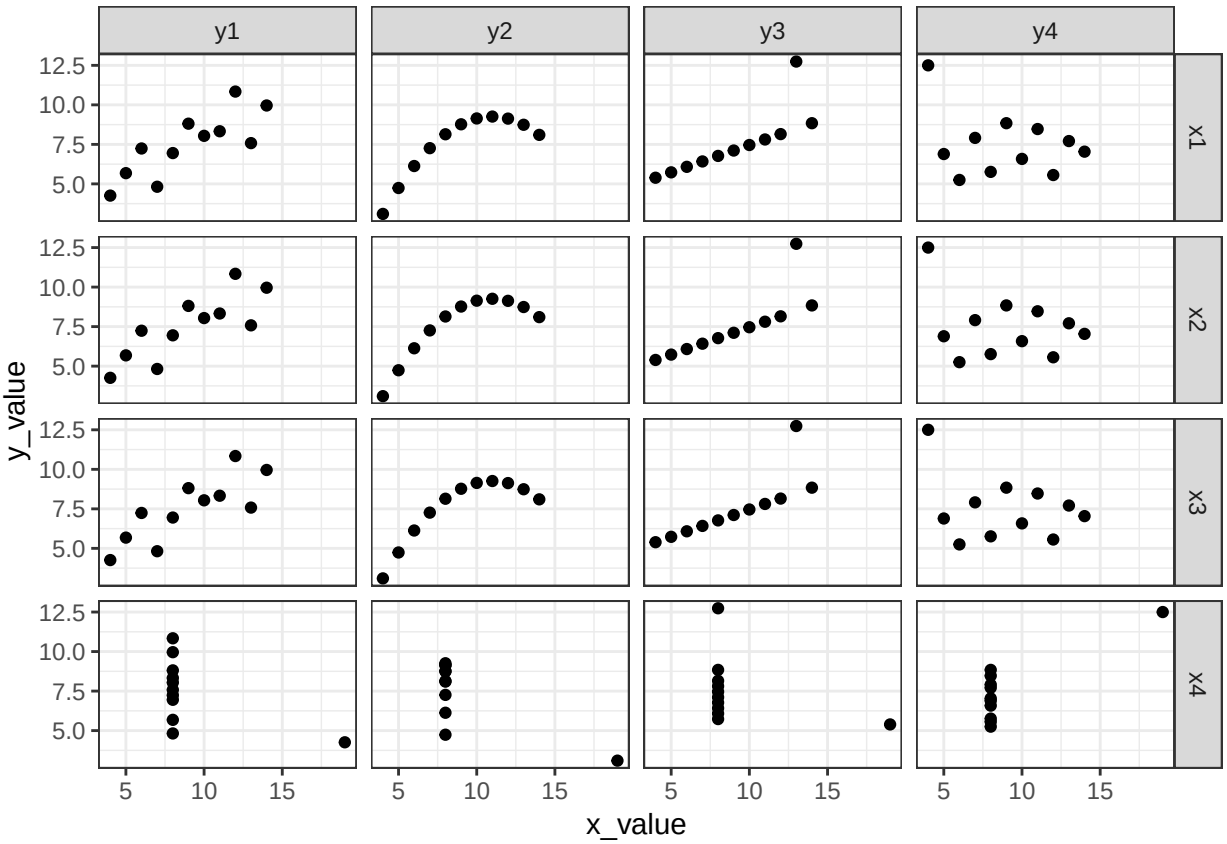
```
# data
anscombe
```

```
##    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)
```

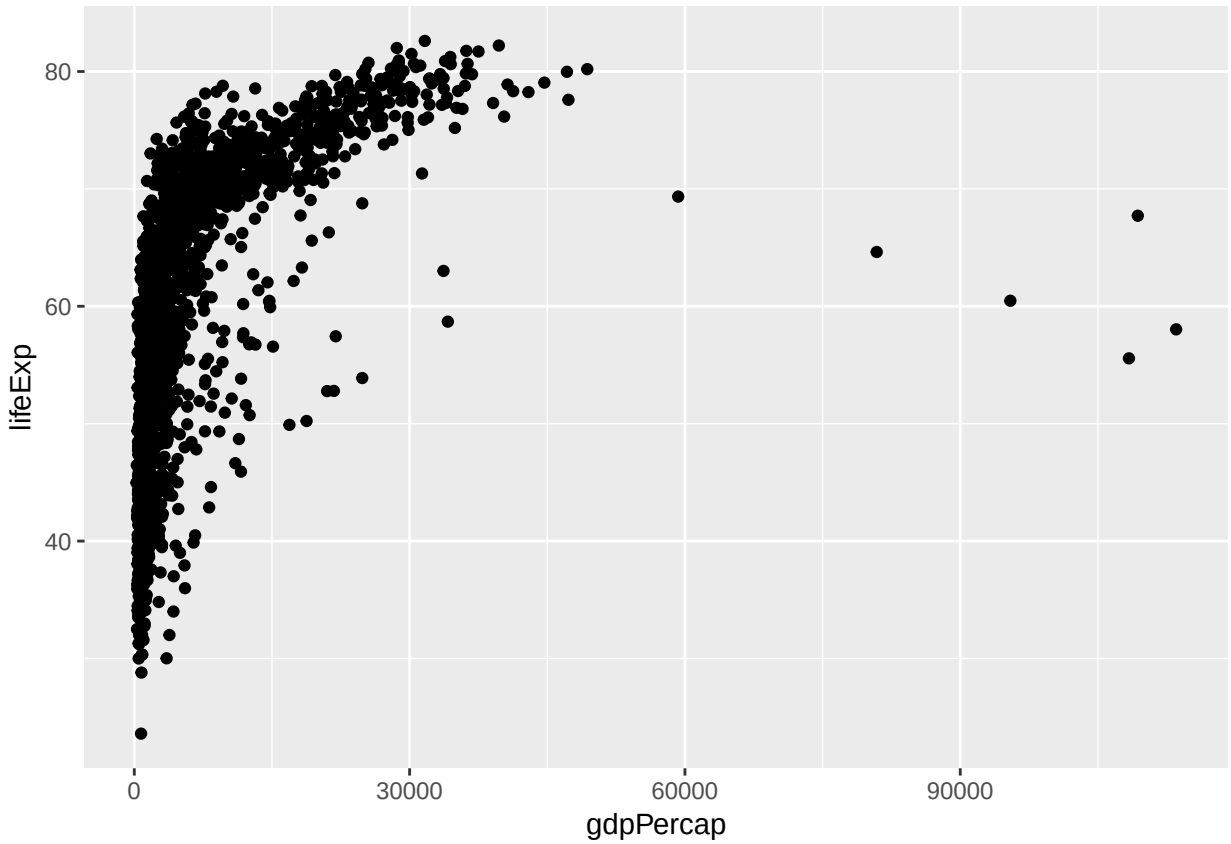
```
## [1] "tbl_df"     "tbl"        "data.frame"
```

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

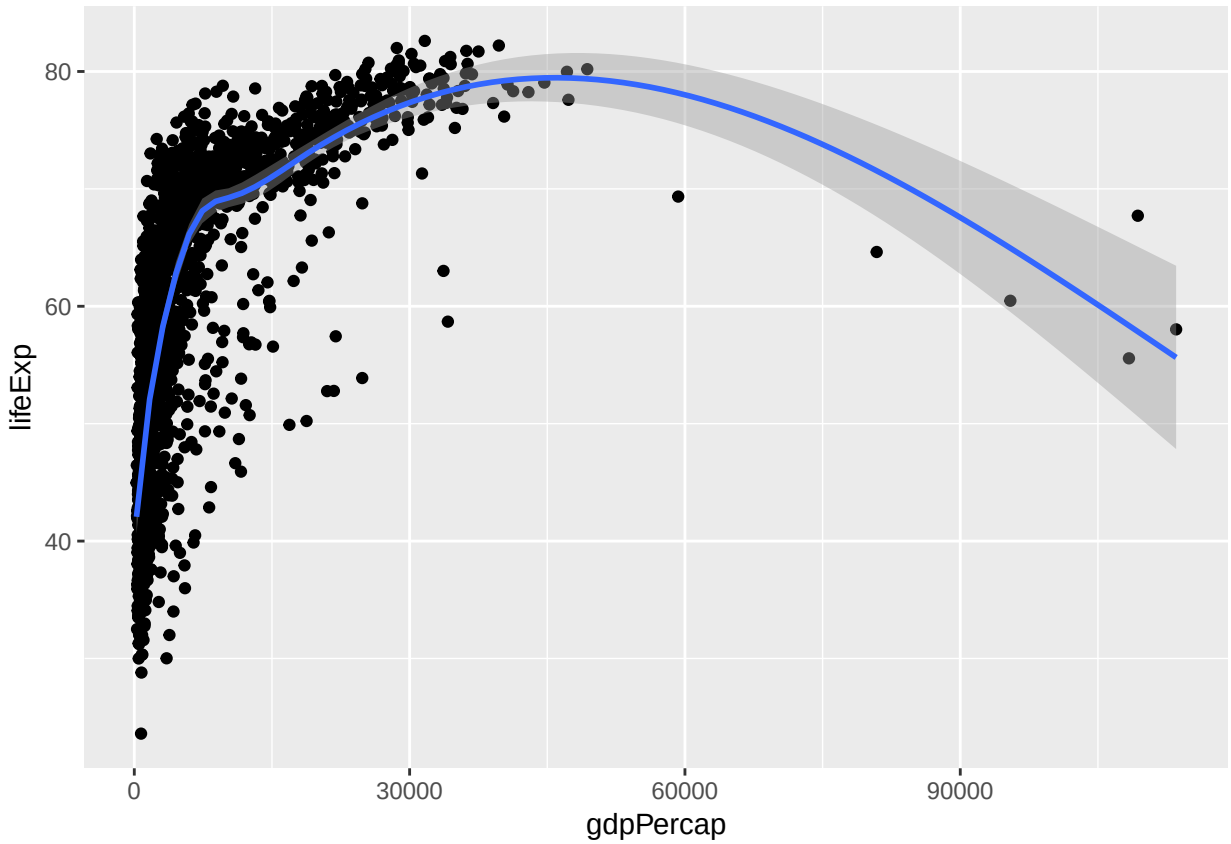
Basic aes (x , y)

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

p + geom_point()
```




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

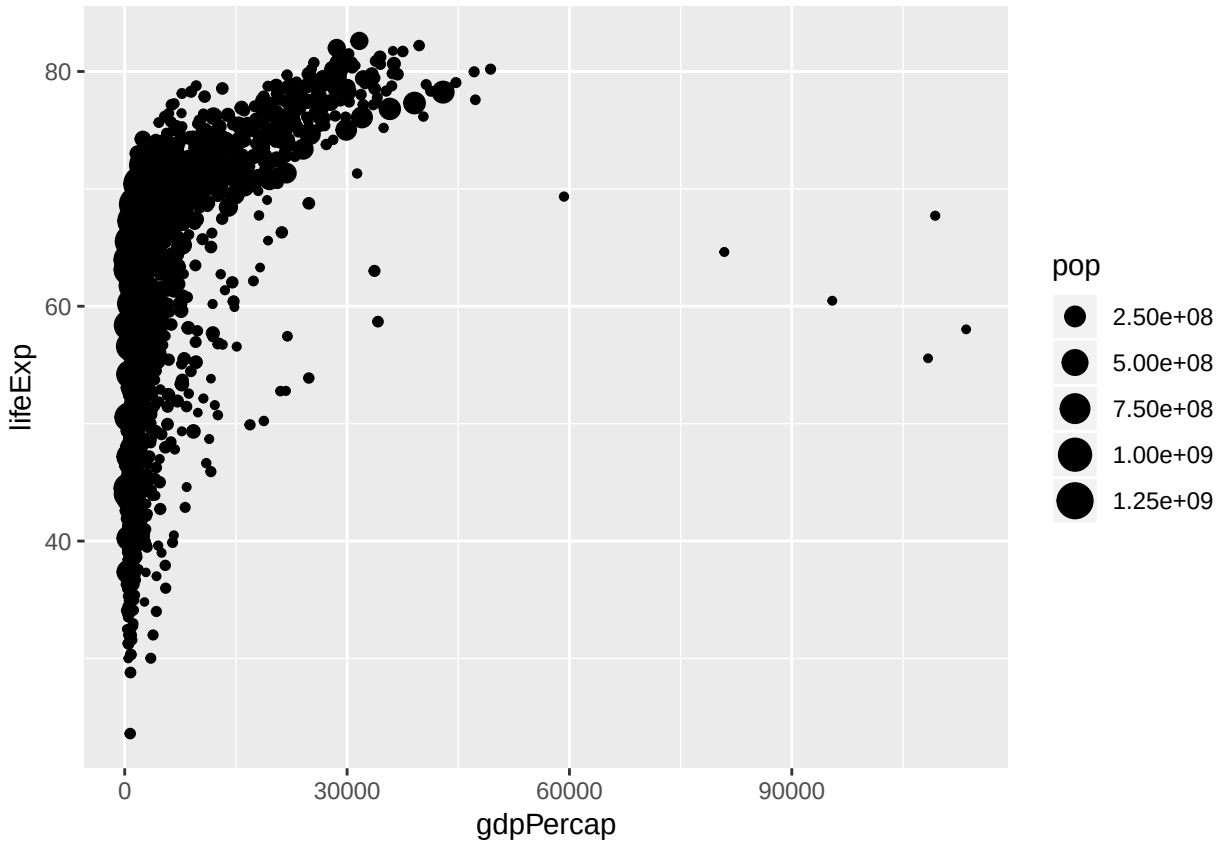
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



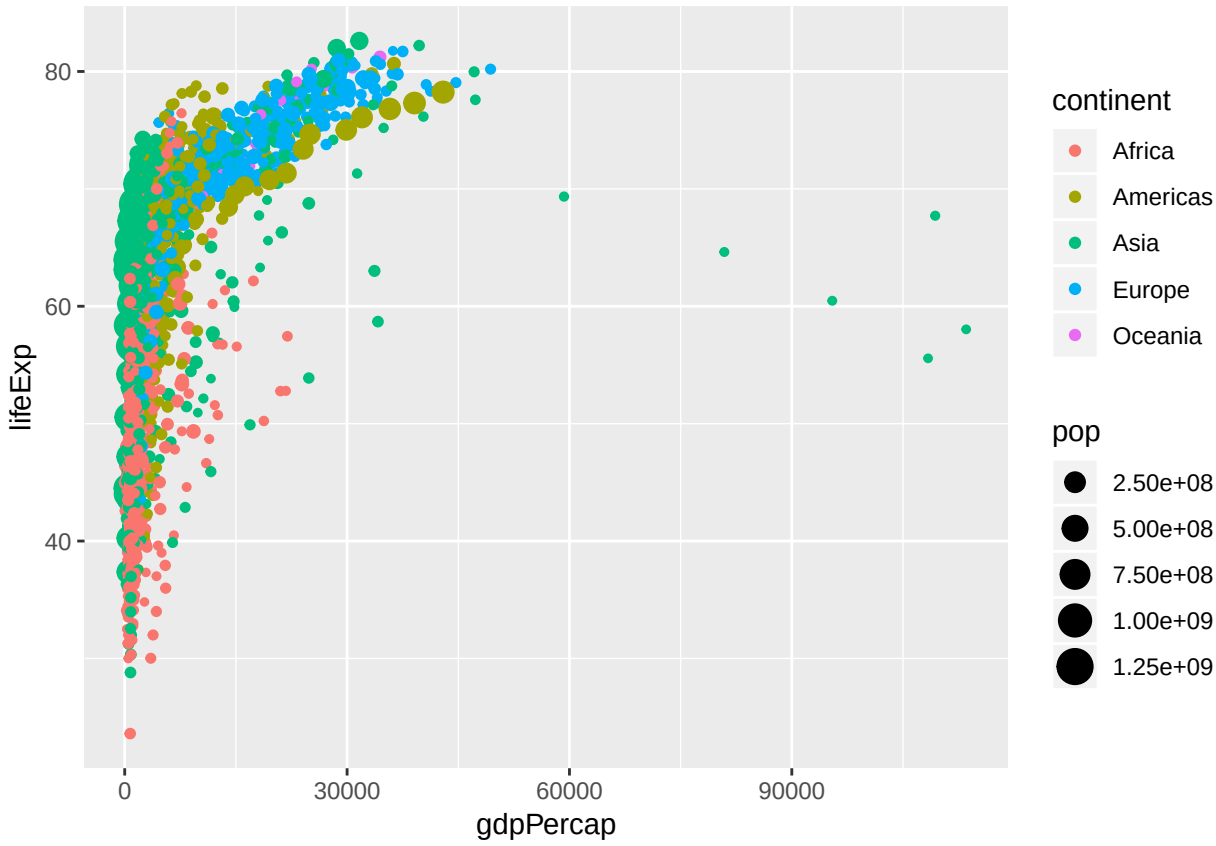
Advanced aes (size, color)

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

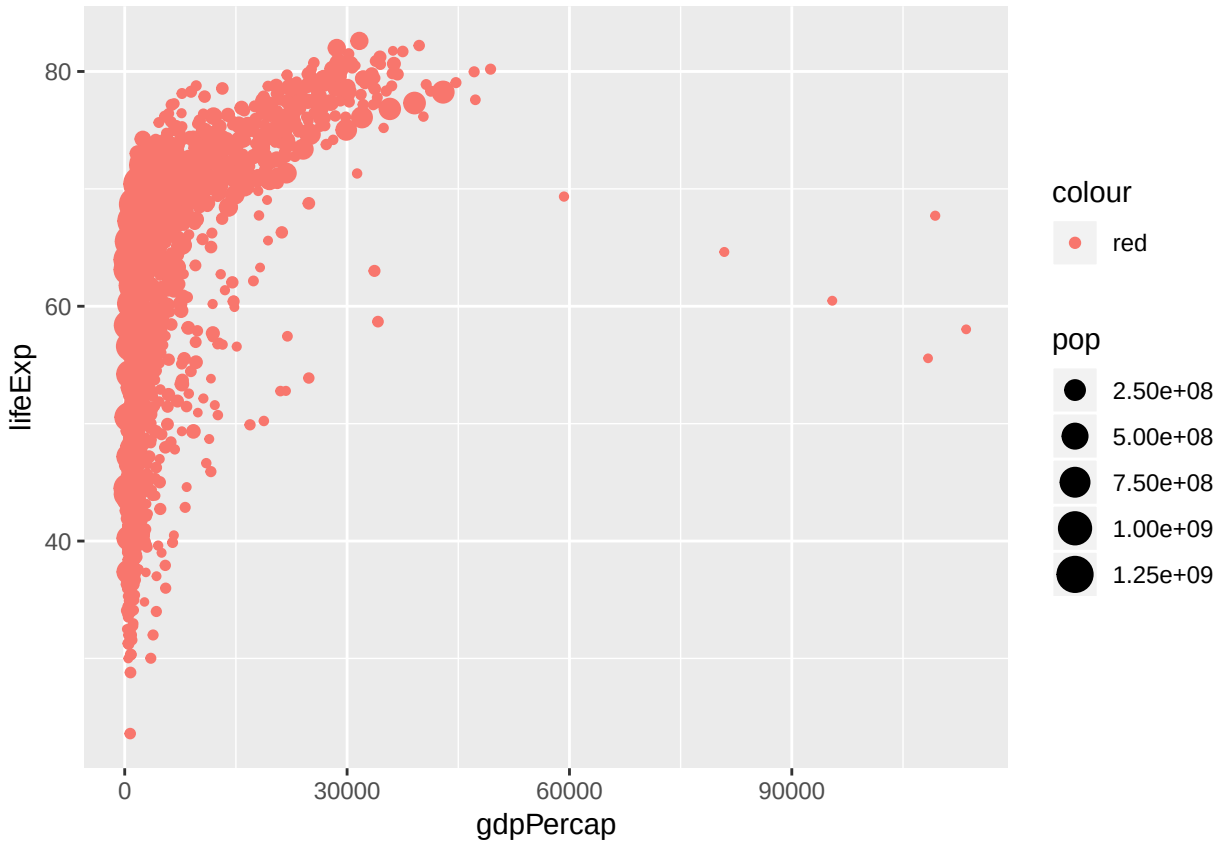
```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          size = pop)) +
  geom_point()
```




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

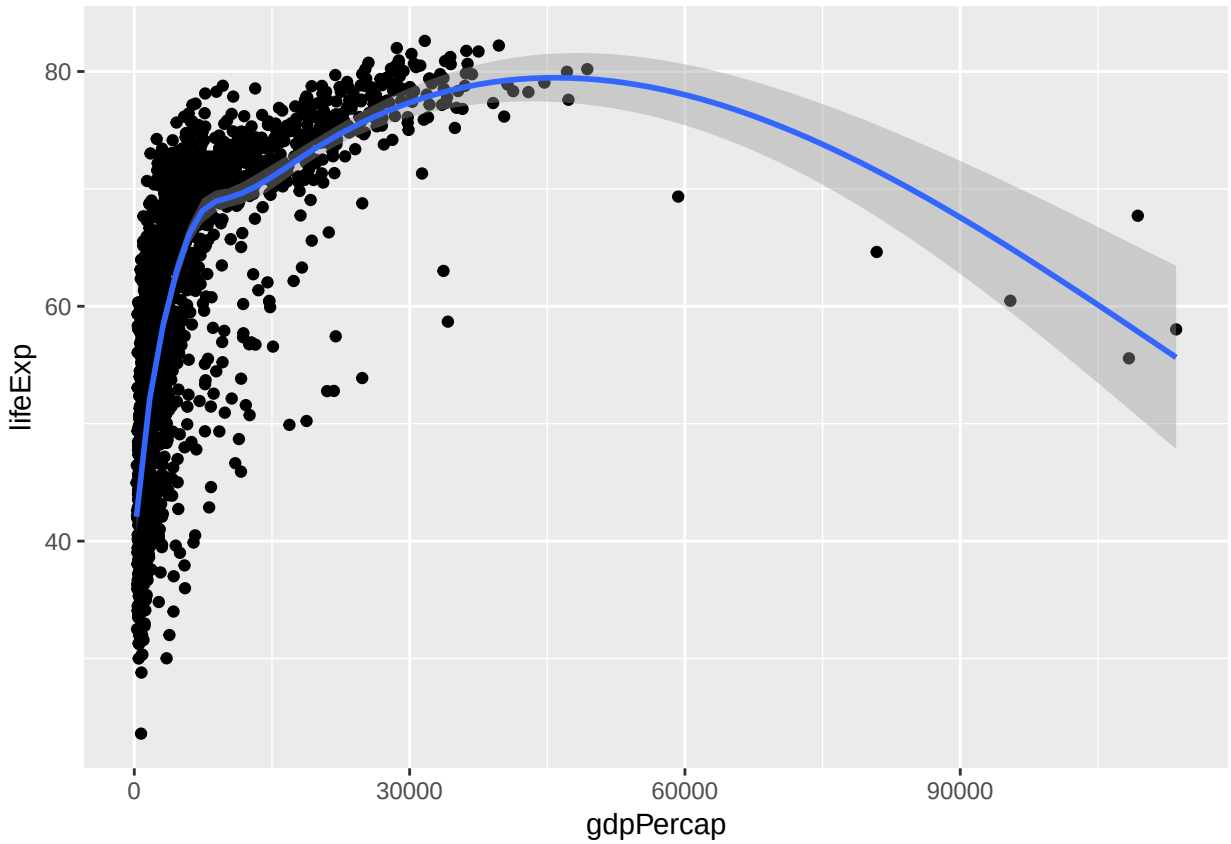



```
# try red instead of "red"
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          size = pop,
                          color = "red")) +
  geom_point()
```



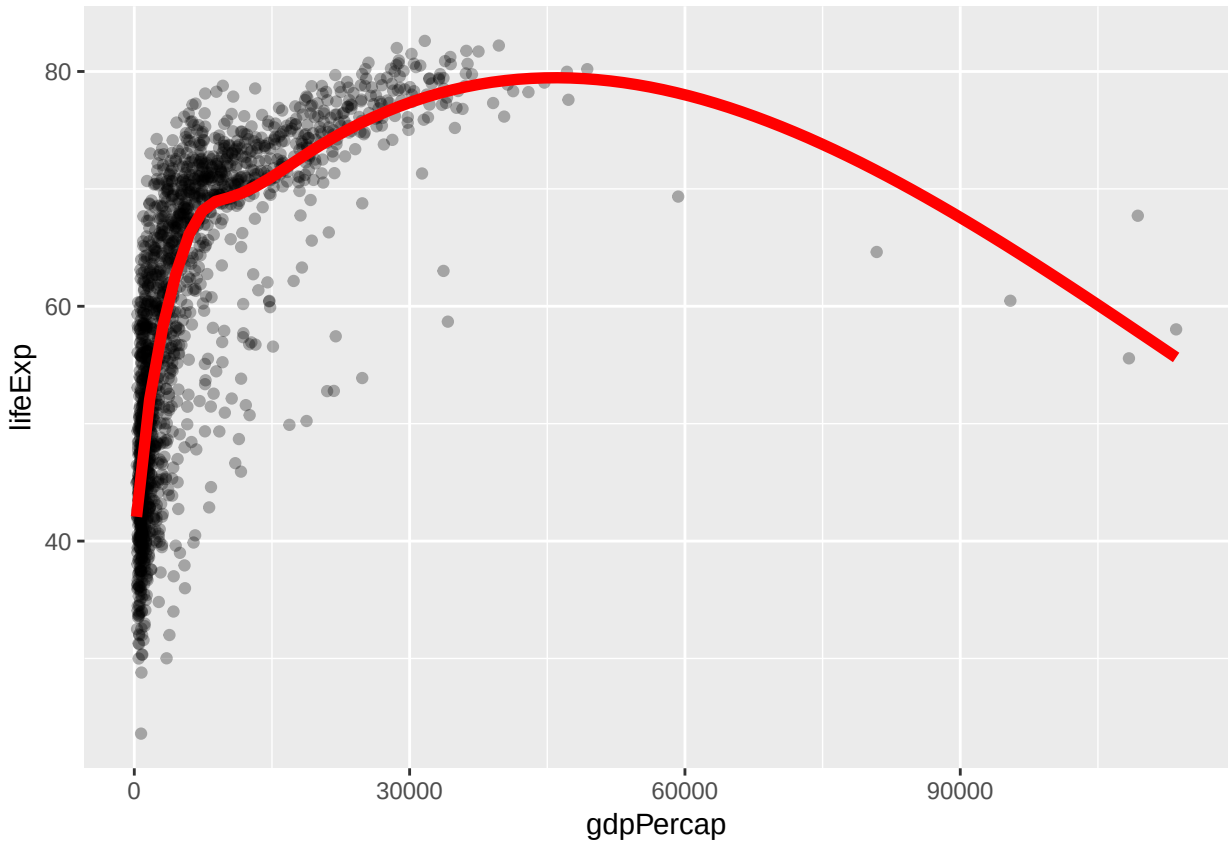

```
p + geom_point() +
  geom_smooth()
```

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



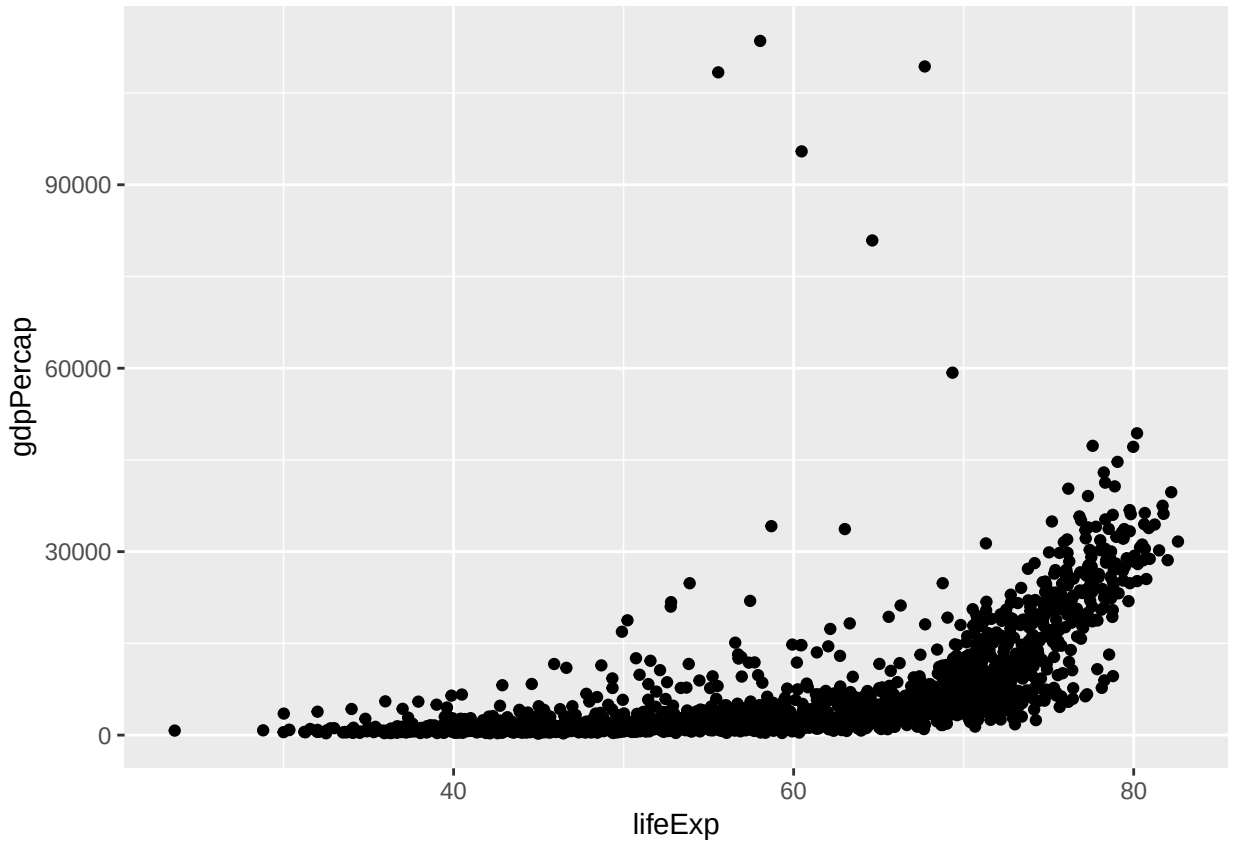

```
p + geom_point(alpha = 0.3) + # alpha controls transparency
  geom_smooth(color = "red", se = FALSE, size = 2)
```

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

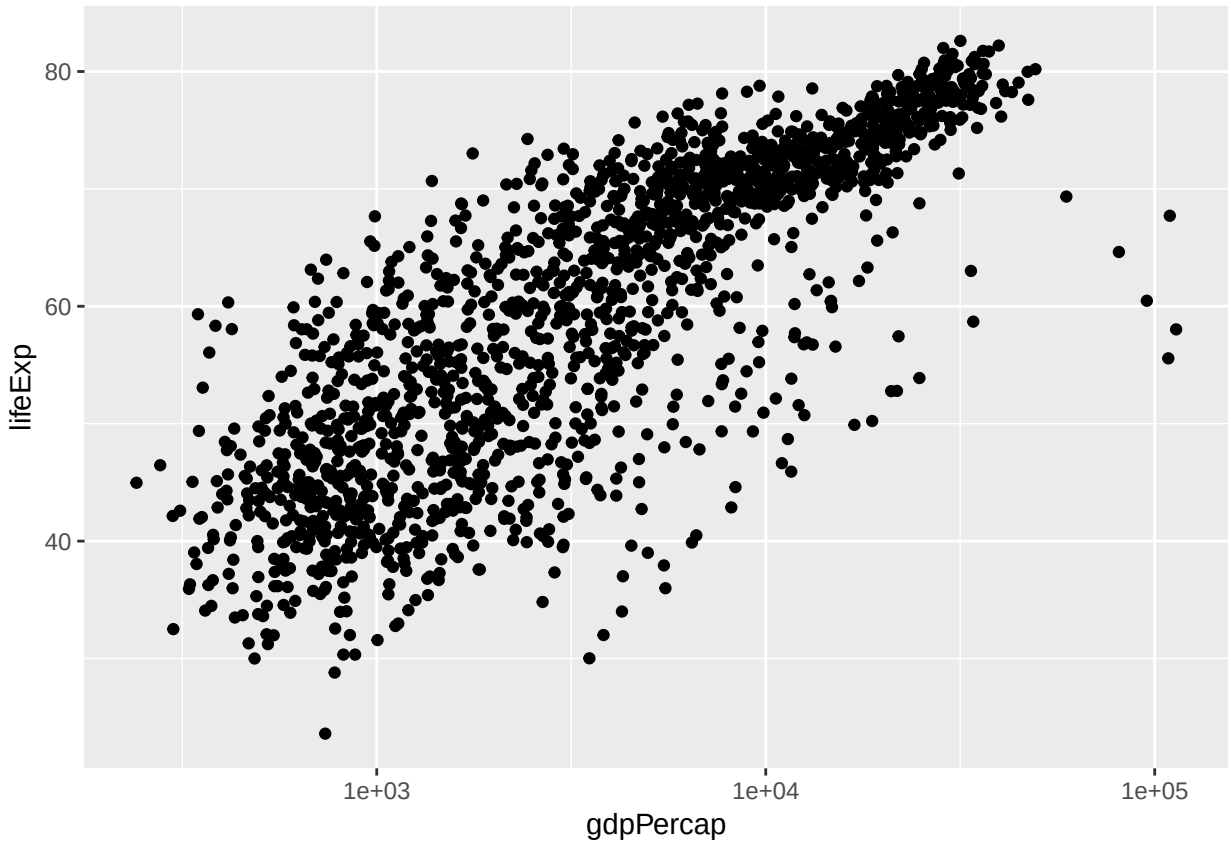


Co-ordinates and scales

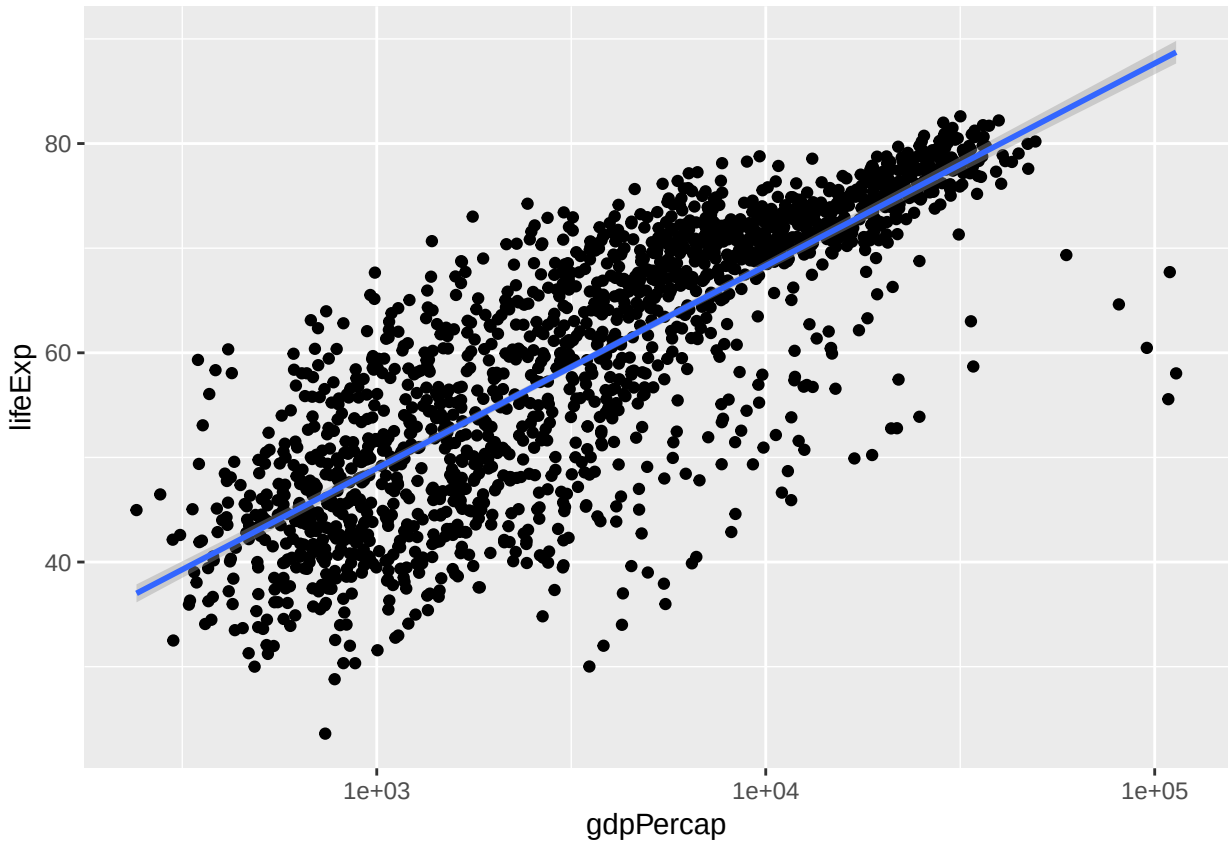
```
p + geom_point() +
  coord_flip() # coord_type
```



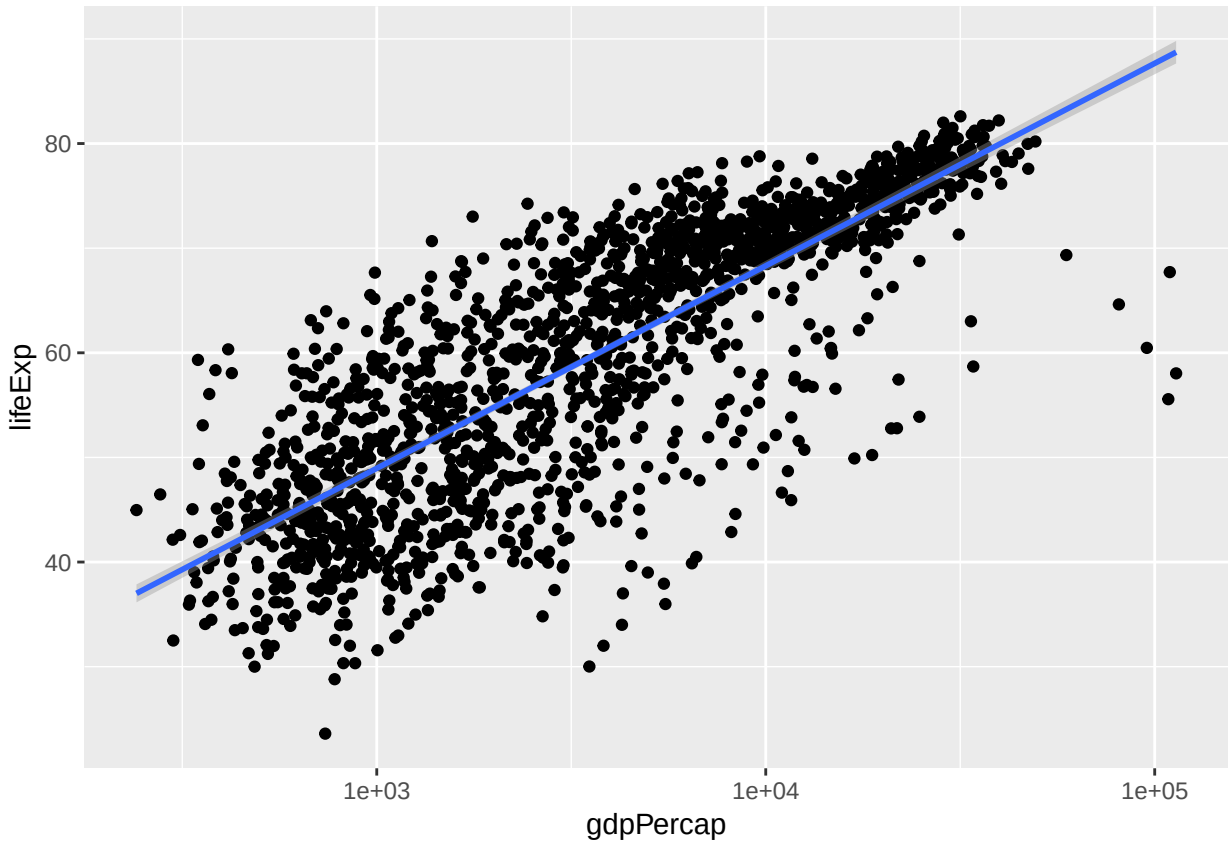

```
p + geom_point() +
  scale_x_log10() # scale_mapping_type
```




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

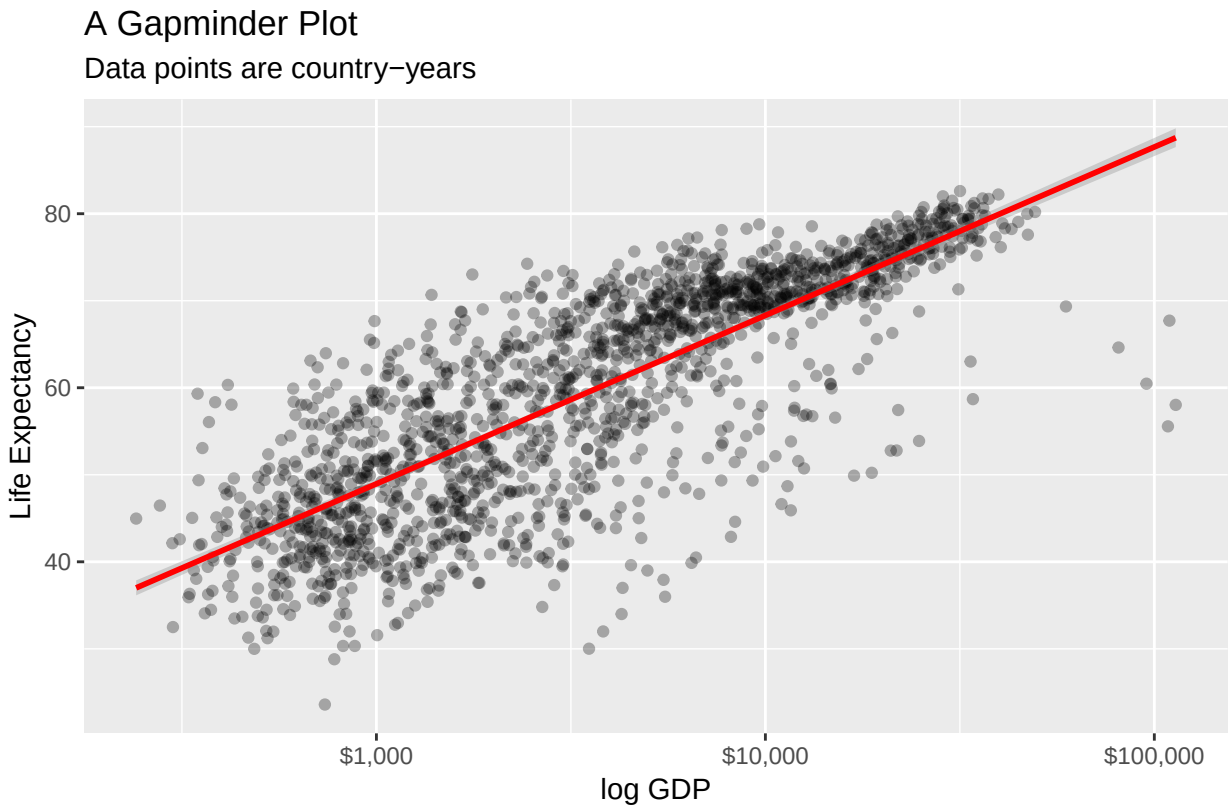



```
p + geom_point() +
  geom_smooth(method = "lm") +
  scale_x_log10()
```

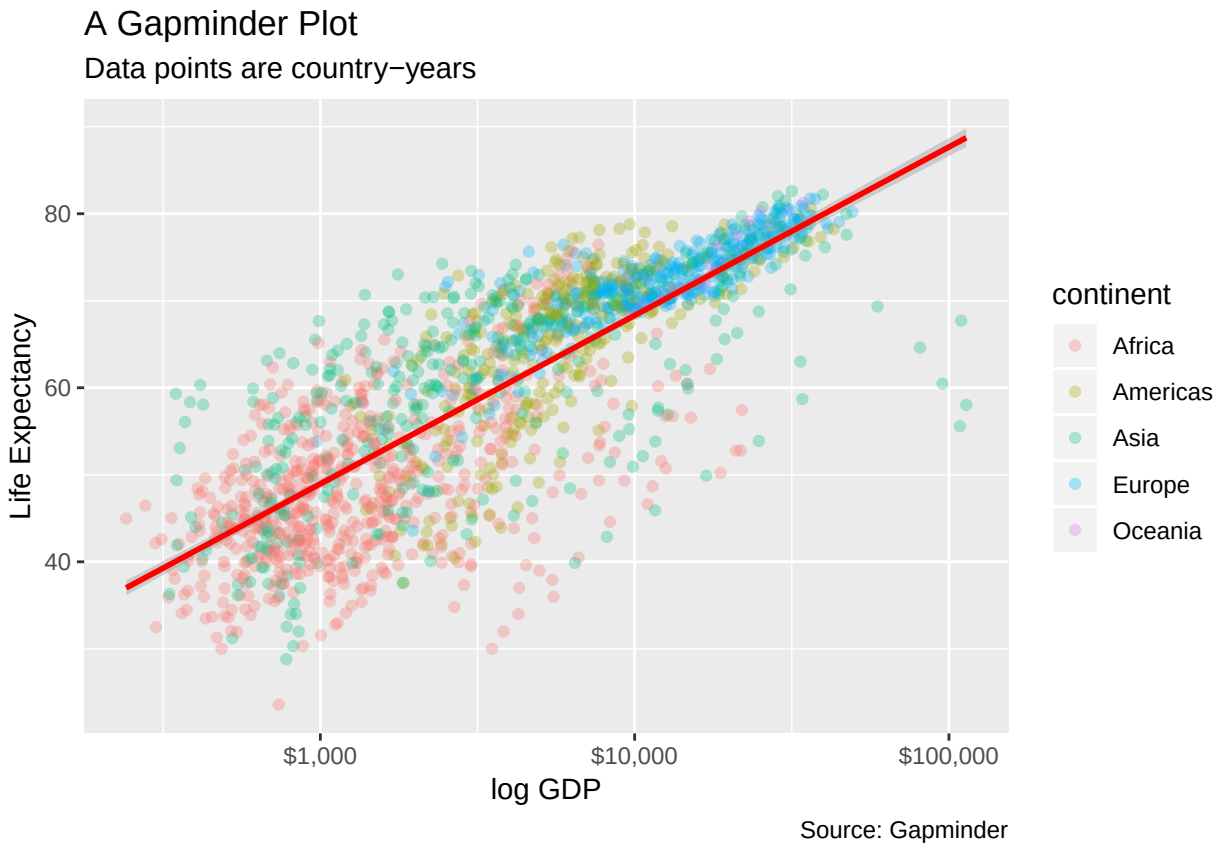


Labels and guides

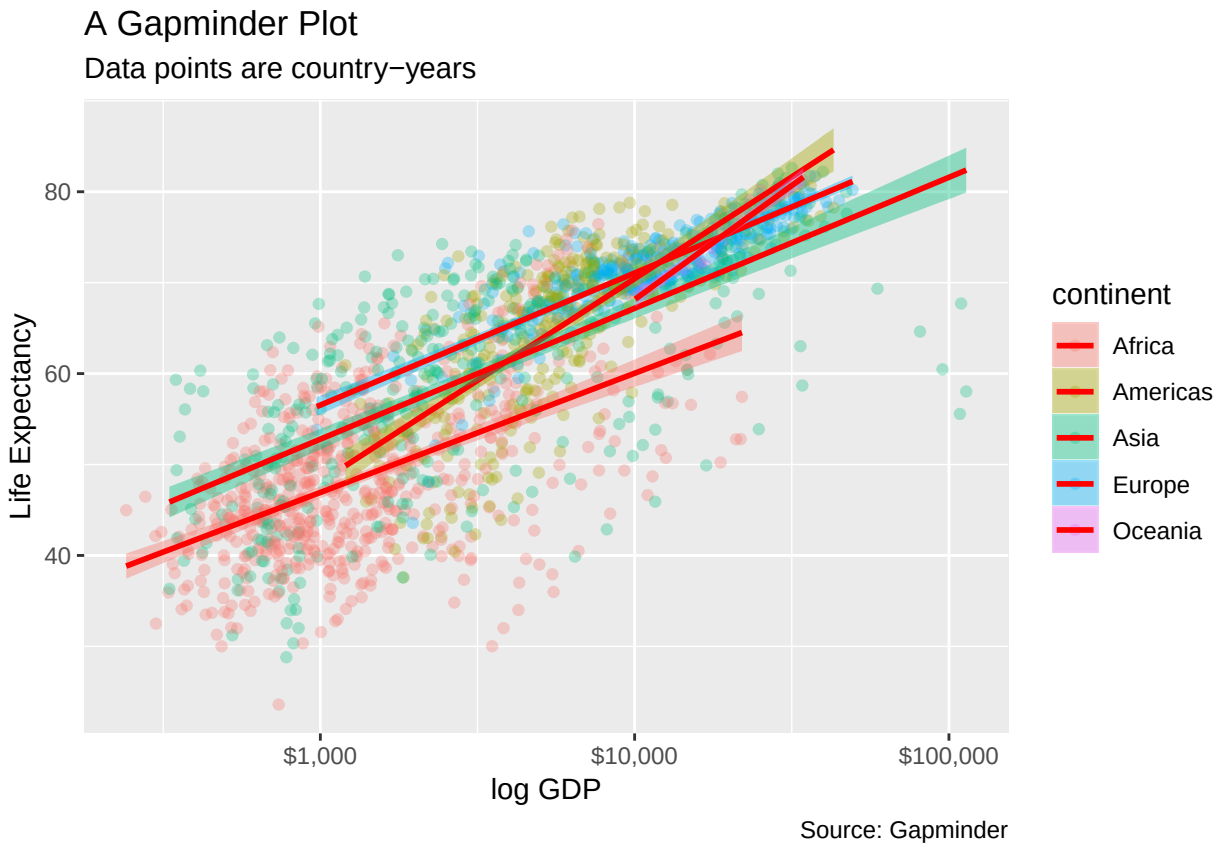
```
p + geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( x = "log GDP",
        y = "Life Expectancy",
        title = "A Gapminder Plot",
        subtitle = "Data points are country-years",
        caption = "Source: Gapminder")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




```
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")
```

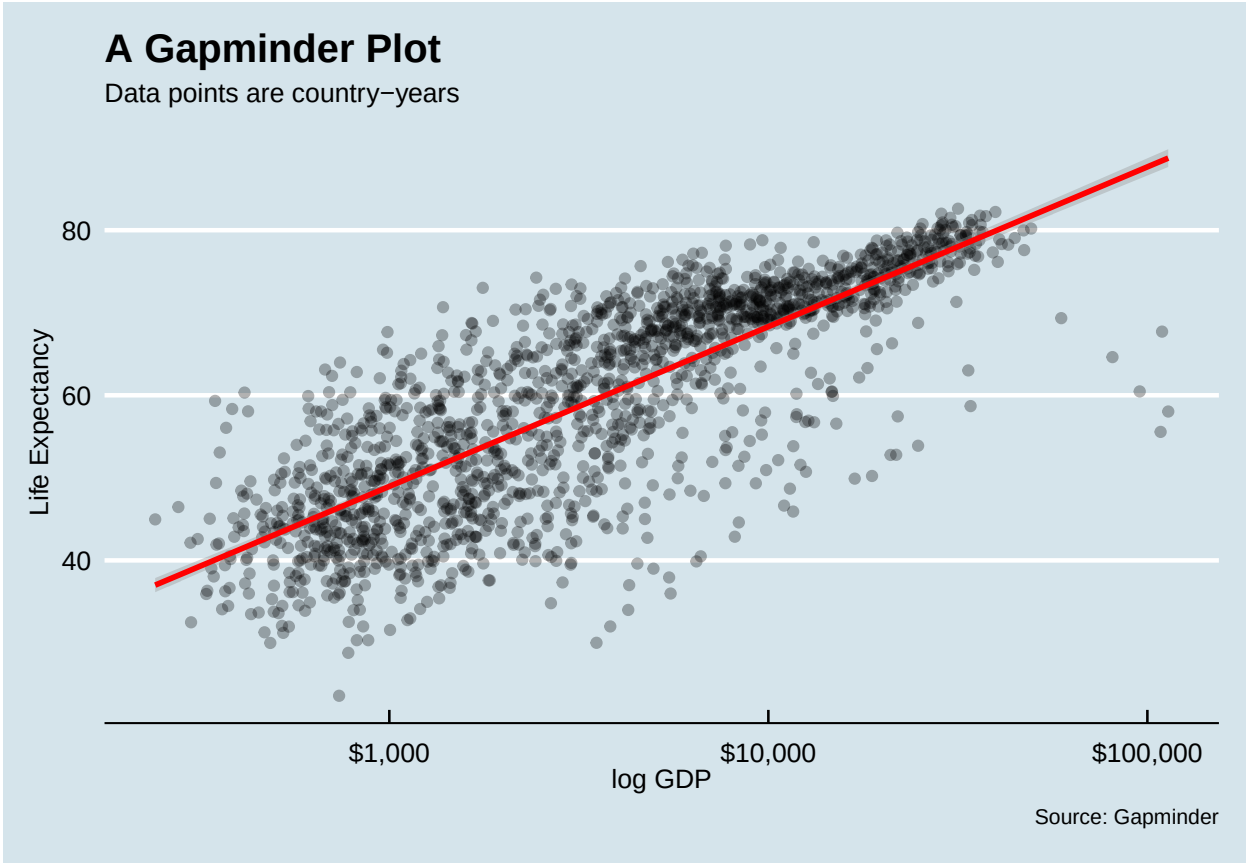



```
ggplot(data = gapminder,
            mapping = aes(x = gdpPercap, y = lifeExp,
                          color = continent,
                          fill = continent)) +
  geom_point(alpha = 0.3) +
  geom_smooth(method = "gam", color = "red") +
  scale_x_log10(labels = scales::dollar) +
  labs( 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 recommend 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
```

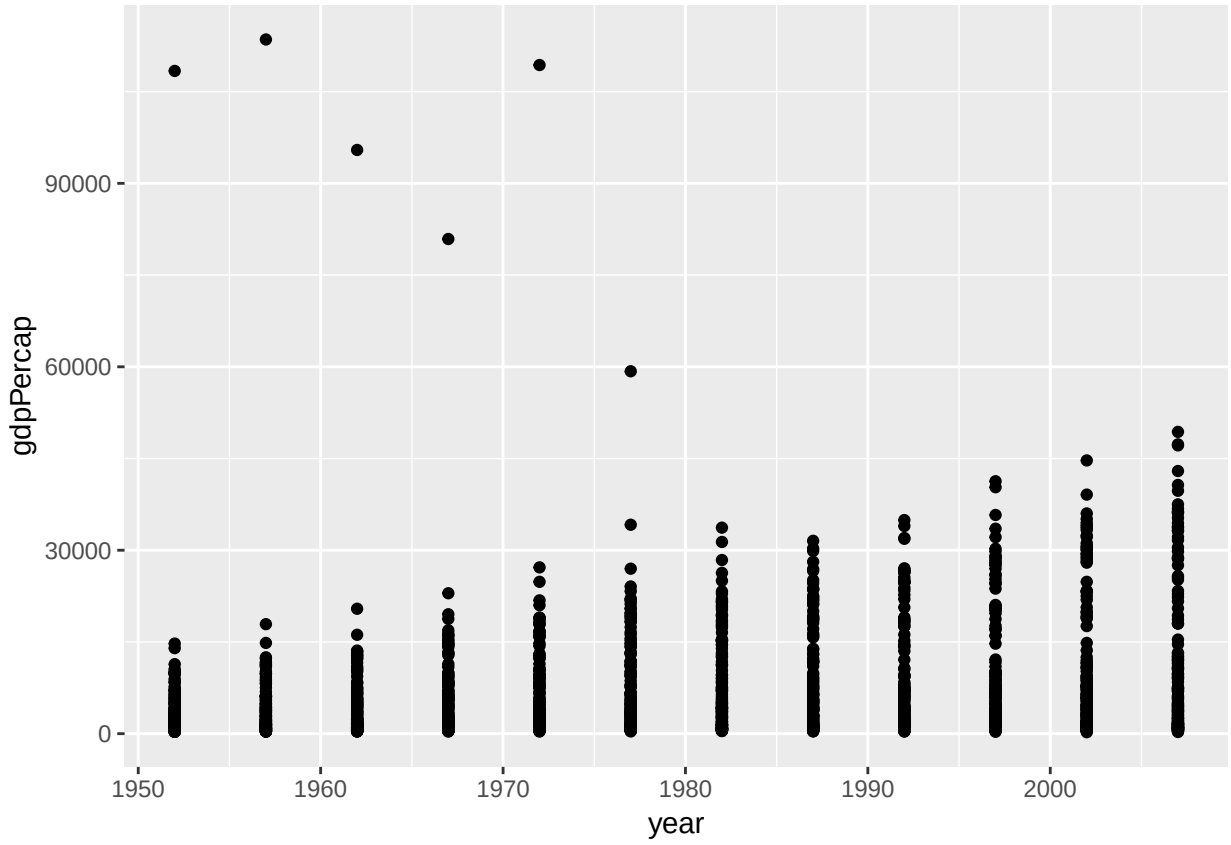
```
ggsave(filename = "figure_example_modified.png", plot = figure_example,
       height = 8,
       width = 10,
       units = "in")
```

ggplot2 intermediates

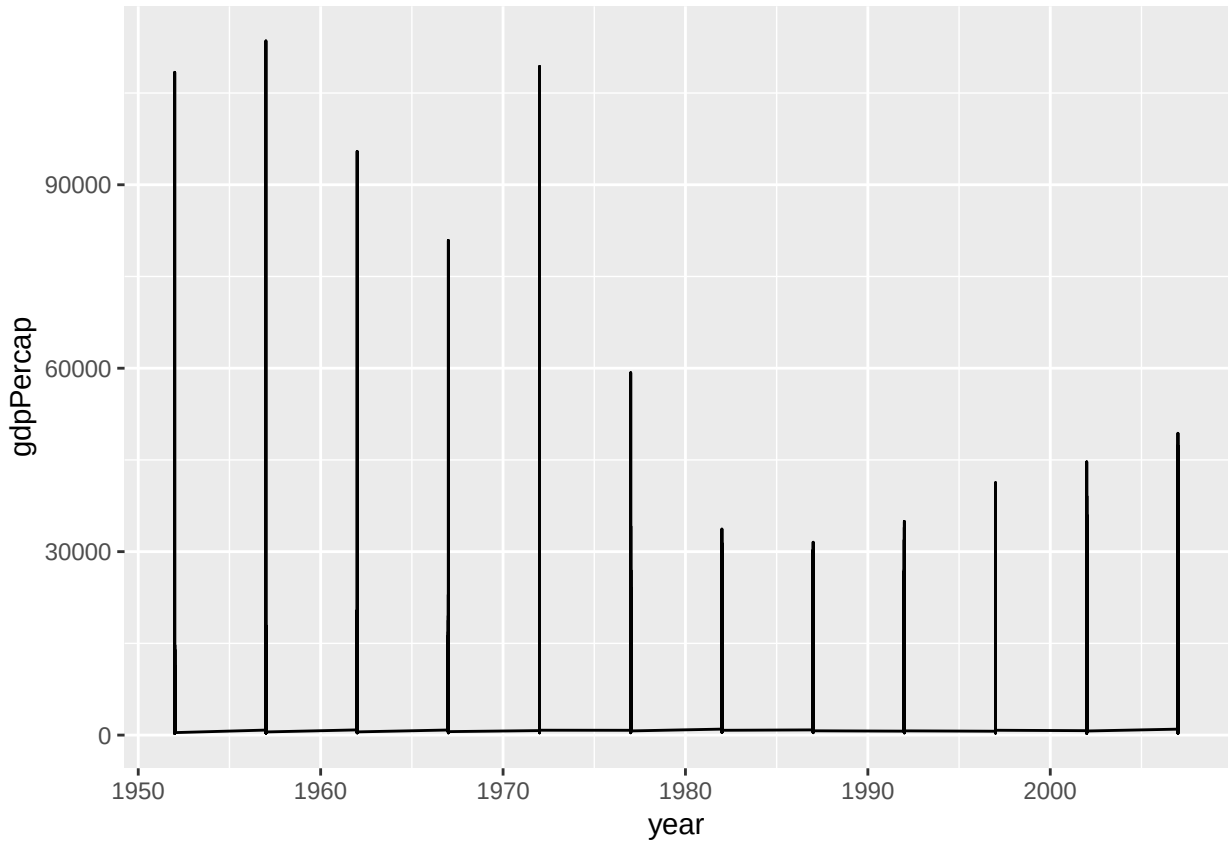
Grouping and facetting

- Can you guess what's wrong?

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

p + geom_point()
```




```
p + geom_line()
```

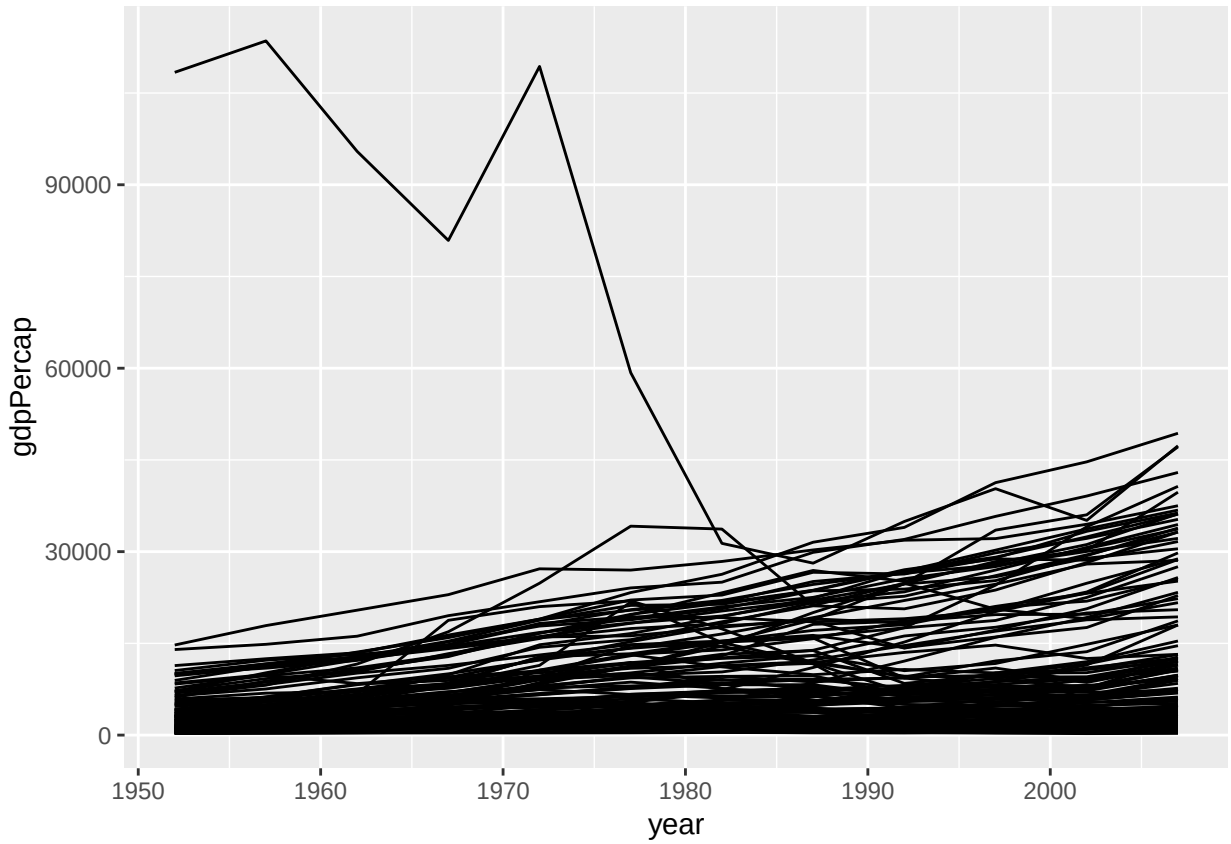



```
gapminder
```

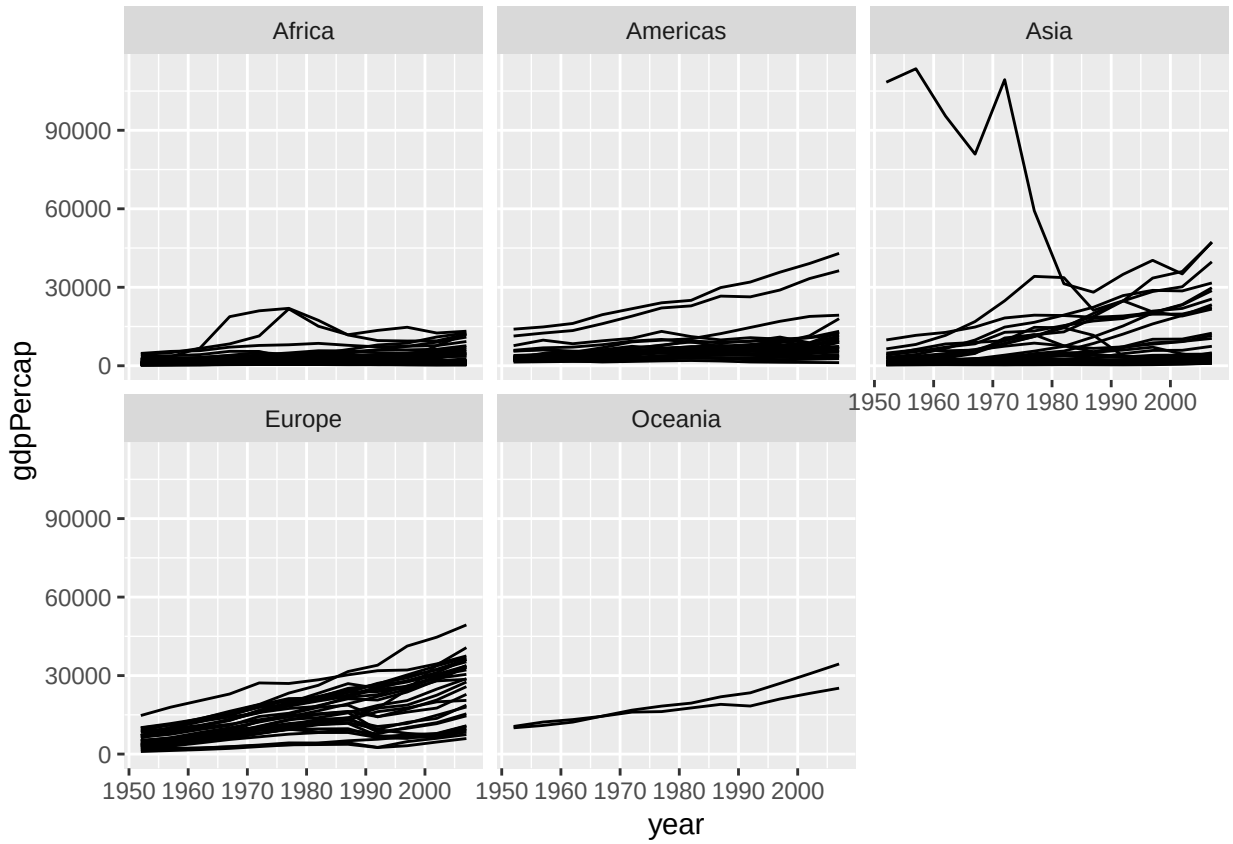
```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       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

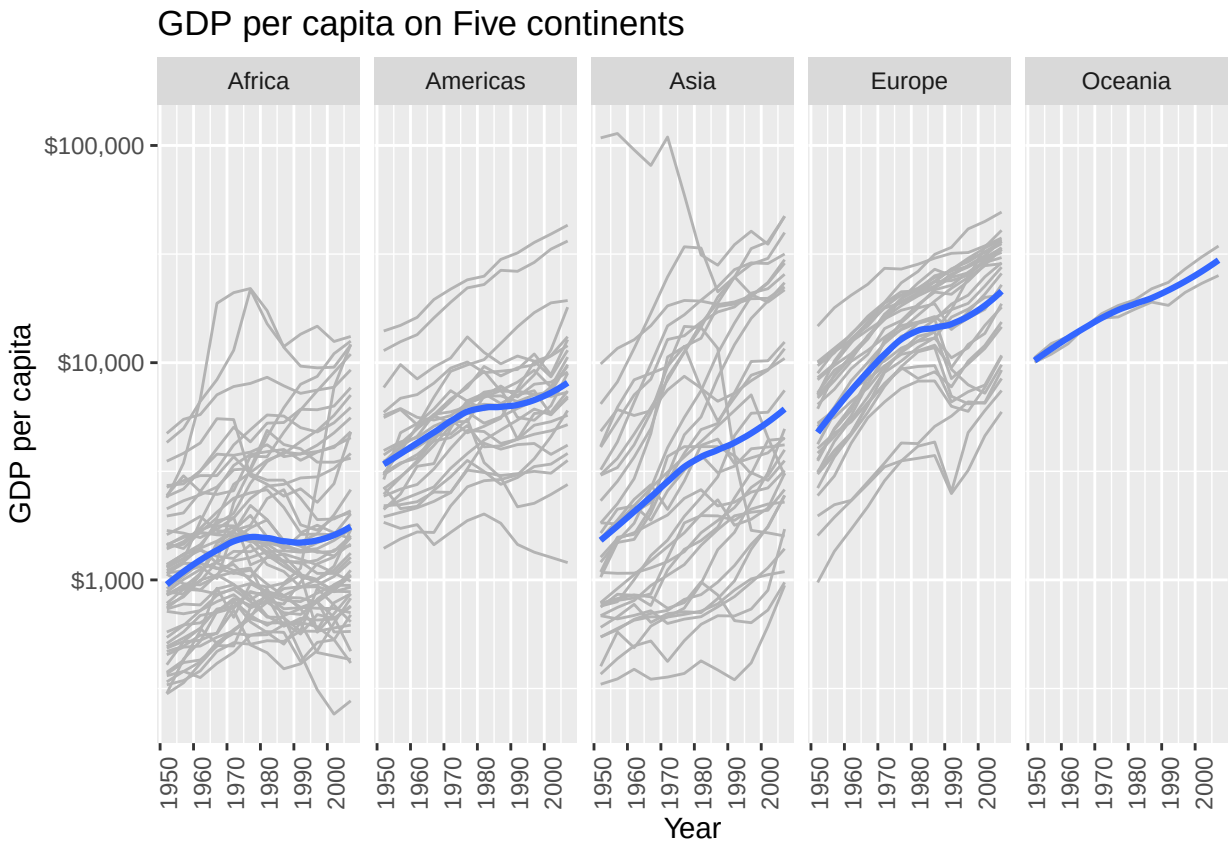
```
p <- ggplot(gapminder, aes(x = year, y = gdpPercap))

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




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

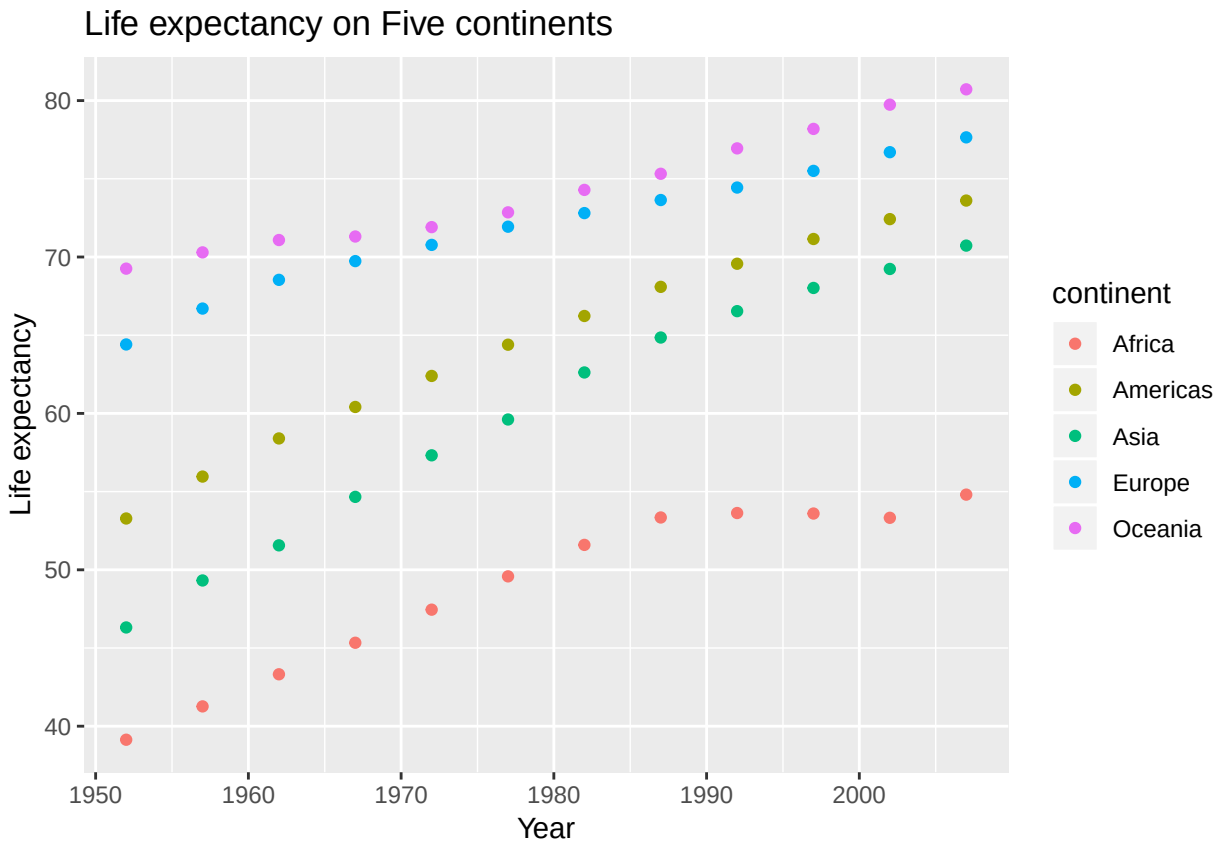



```
p + geom_line(aes(group = country), color = "gray70") +
  geom_smooth(size = 1.1, method = "loess", se = FALSE) +
  scale_y_log10(labels = scales::dollar) +
  facet_wrap(~continent, ncol = 5) + # for single categorical variable; for multiple categorical variab
  labs(x = "Year",
       y = "GDP per capita",
       title = "GDP per capita on Five continents") +
  theme(axis.text.x = element_text(angle = 90, hjust = 1))
```

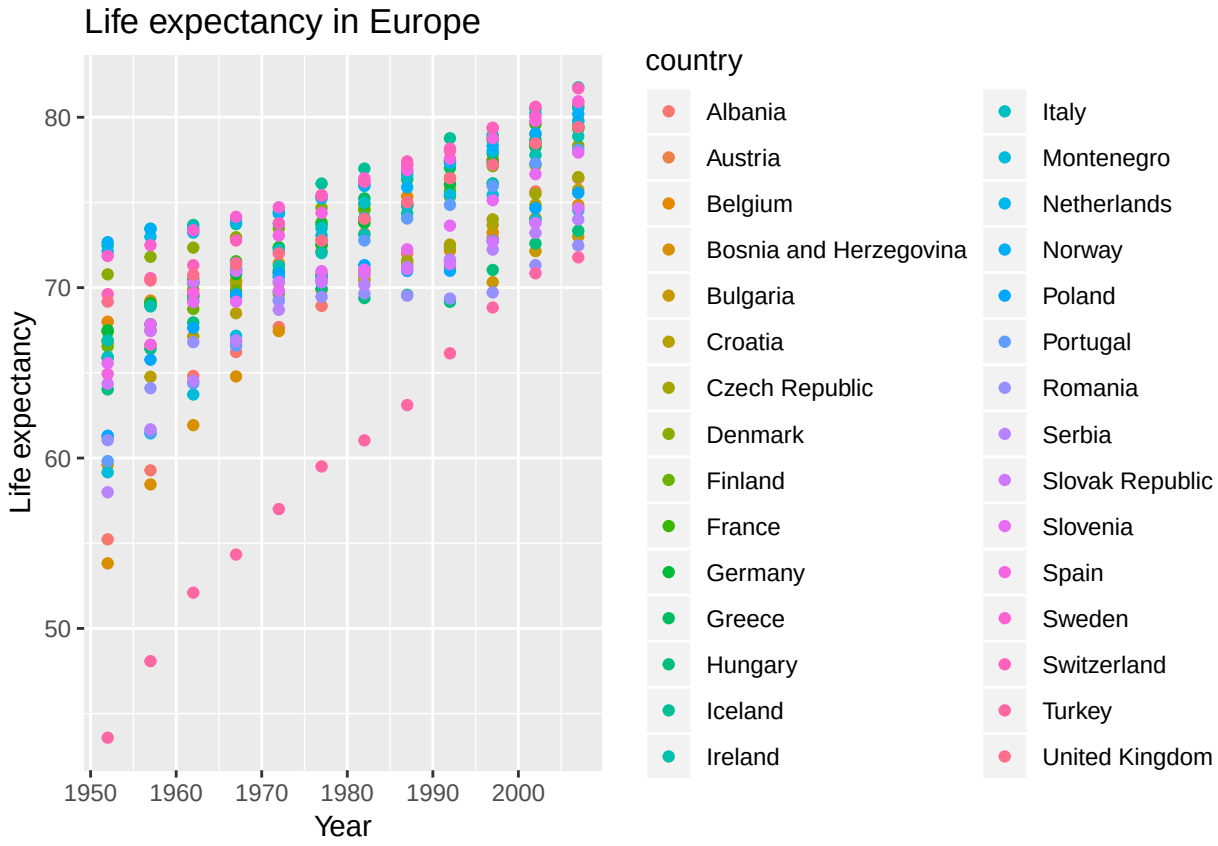


Use pipes to summarize data

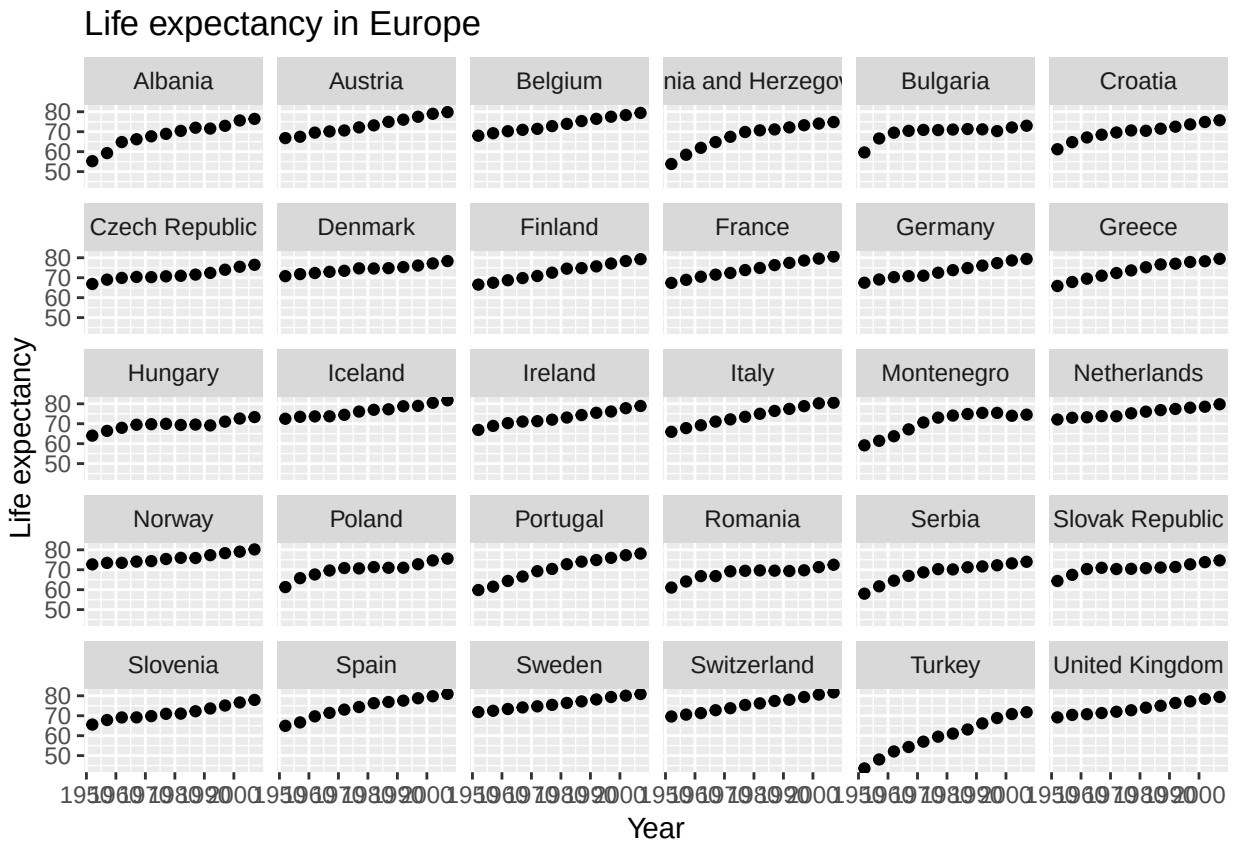
```
gapminder %>%
  group_by(continent, year) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean, color = continent)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life expectancy on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



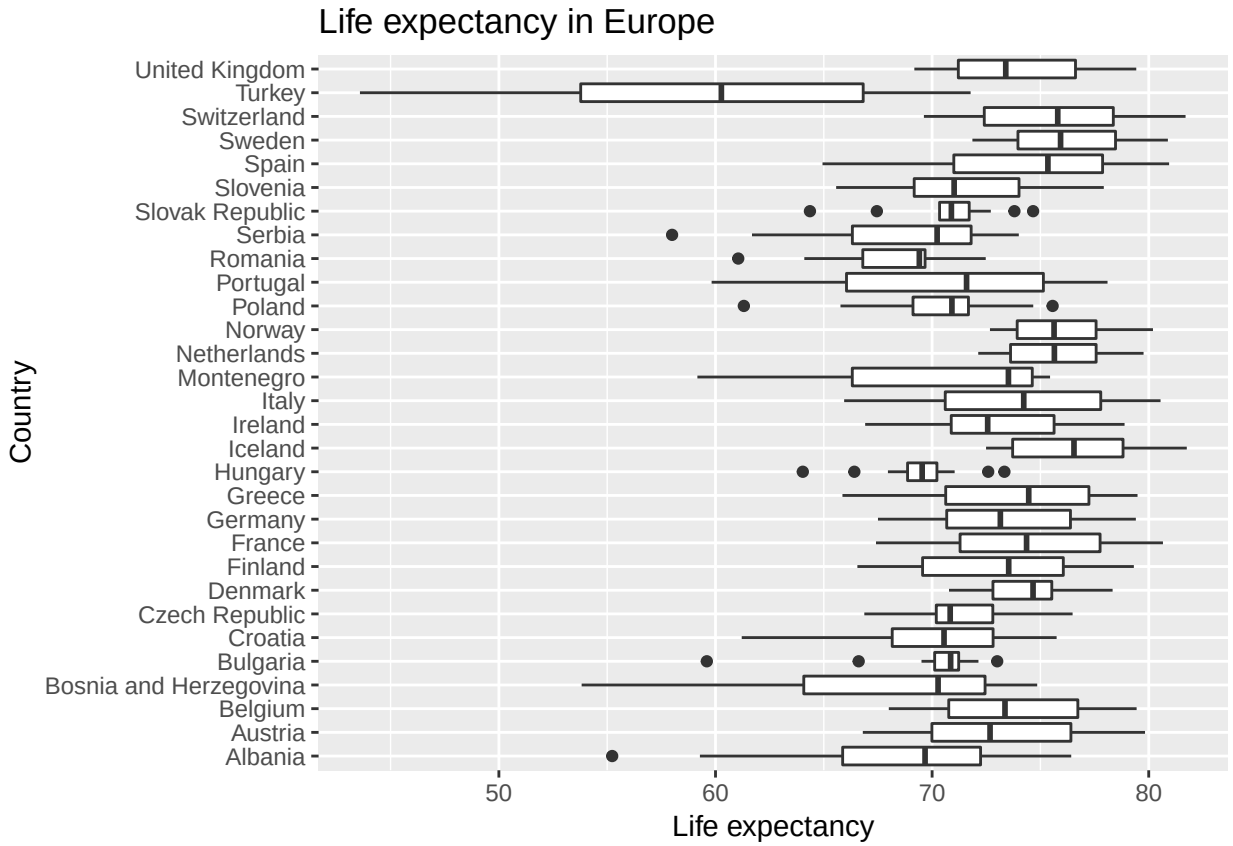

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean, color = country)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
 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



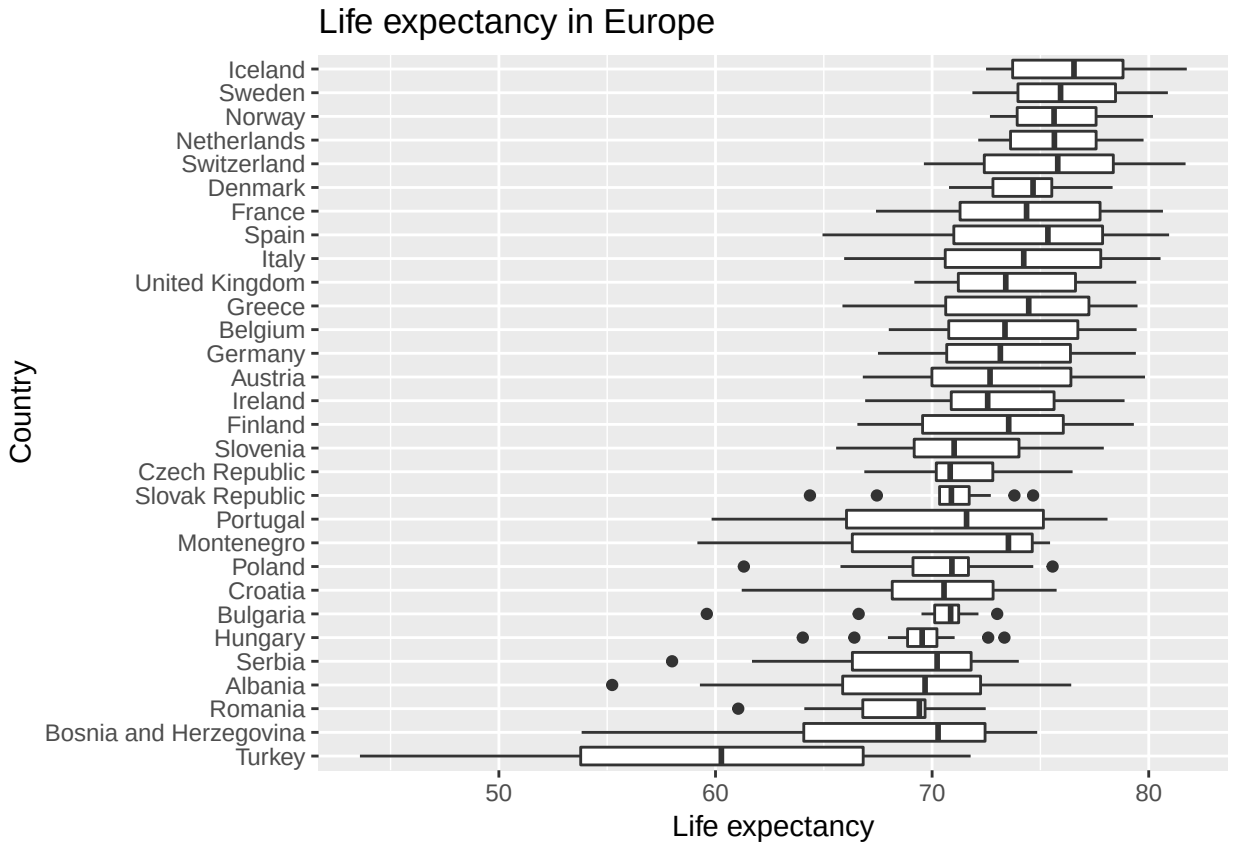

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = year, y = lifeExp_mean)) +
  geom_point() +
    labs(x = "Year",
       y = "Life expectancy",
       title = "Life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



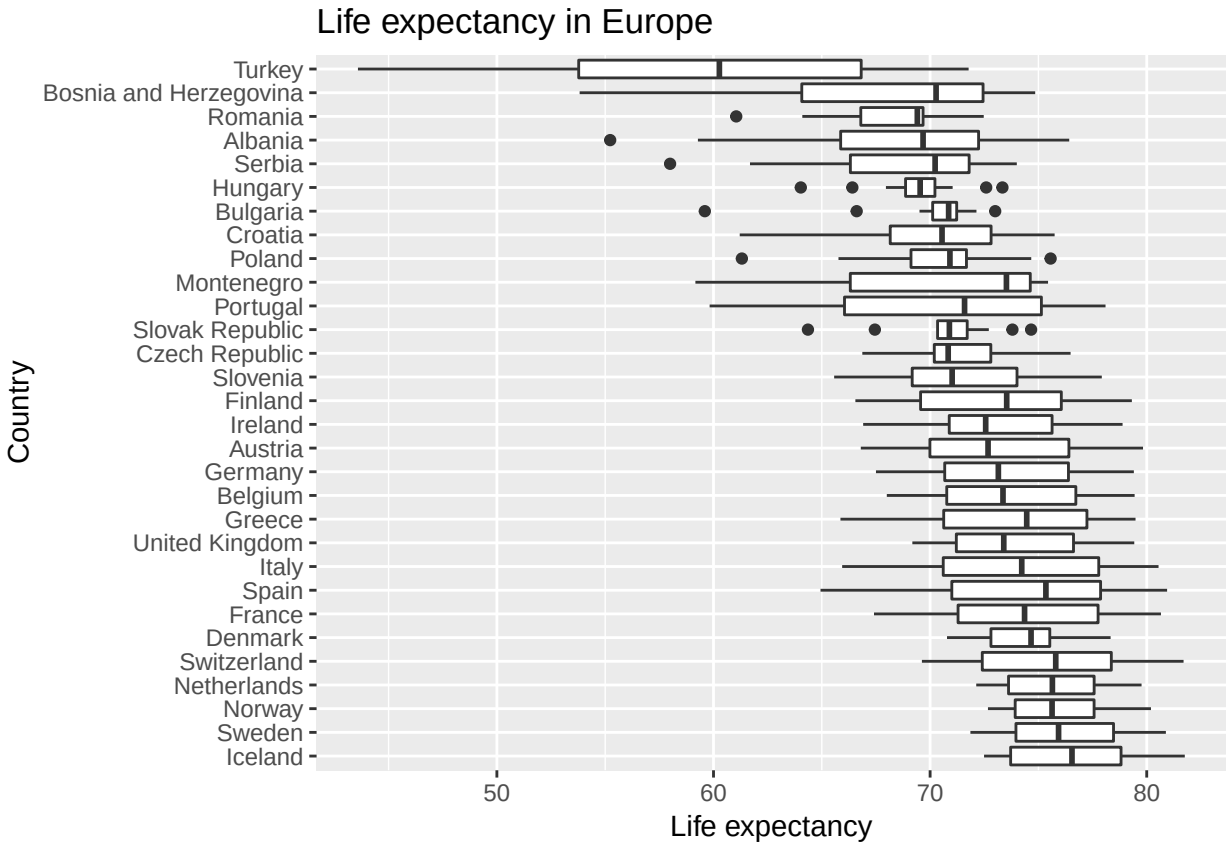

```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = country, y = lifeExp_mean)) +
  geom_boxplot() +
    labs(x = "Country",
       y = "Life expectancy",
       title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




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

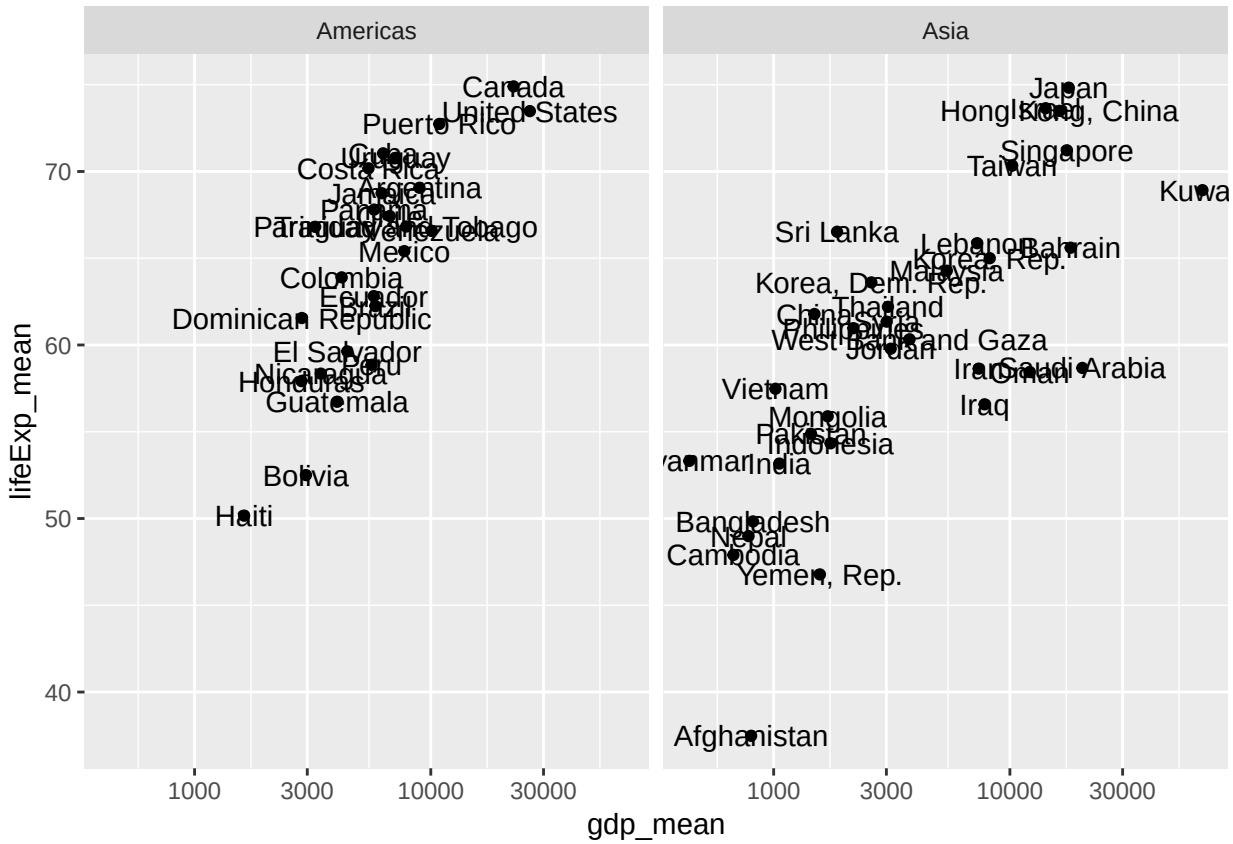



```
gapminder %>%
  filter(continent == "Europe") %>%
  group_by(country, year) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = reorder(country, -lifeExp_mean), y = lifeExp_mean)) +
  geom_boxplot() +
    labs(x = "Country",
       y = "Life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



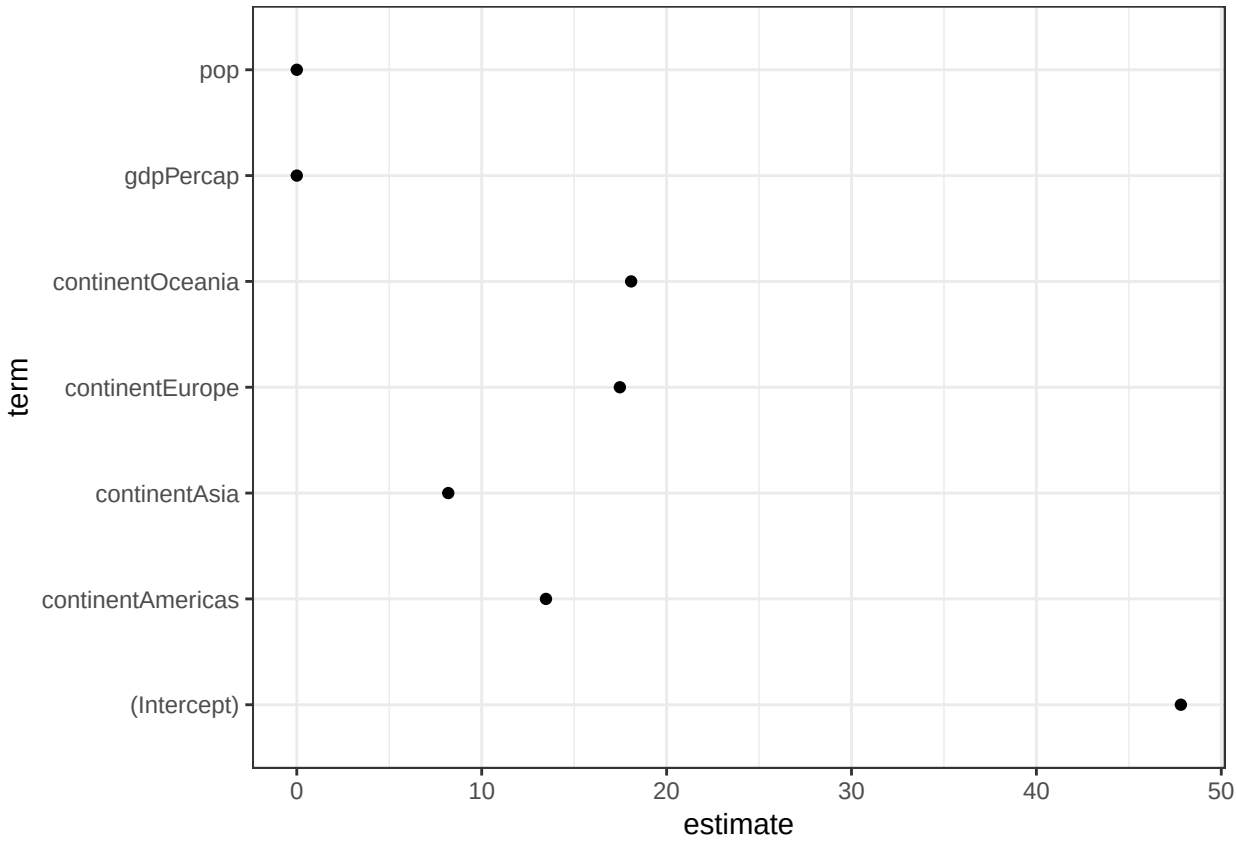
Plotting text

```
gapminder %>%
  filter(continent == "Asia" | continent == "Americas") %>%
  group_by(continent, country) %>%
  summarize(gdp_mean = mean(gdpPercap),
            lifeExp_mean = mean(lifeExp)) %>%
  ggplot(aes(x = gdp_mean, y = lifeExp_mean)) +
  geom_point() +
  geom_text(aes(label = country)) +
  scale_x_log10() +
  facet_grid(~continent)
```

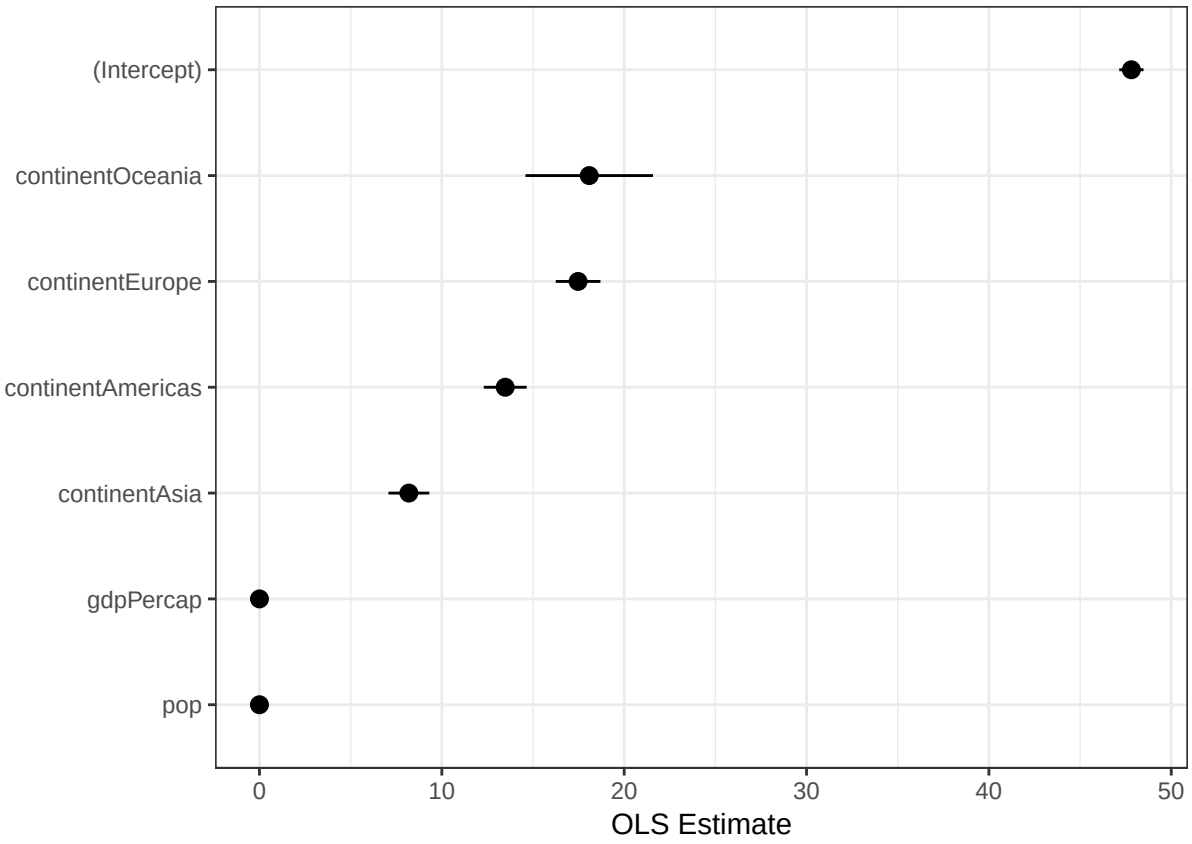


Ploting models

```
# regression model
out <-lm(formula = lifeExp ~ gdpPercap + pop + continent,
          data = gapminder)

# estimates
out_comp <- tidy(out)

p <- out_comp %>%
  ggplot(aes(x = term, y = estimate))

p + geom_point() +
  coord_flip() +
  theme_bw()
```




```
# plus confidence intervals
out_conf <- tidy(out, conf.int = TRUE)

p <- out_conf %>%
  ggplot(aes(x = reorder(term, estimate), y = estimate, ymin = conf.low, ymax = conf.high))

p + geom_pointrange() + coord_flip() + labs(x = "", y = "OLS Estimate") +
  theme_bw()
```


(Intercept)
continentOceania
continentEurope
continentAmericas
continentAsia
gdpPercap
pop
0
10
20
30
40
50
OLS Estimate