Dealing with datasets- Understanding Tidyverse package in R- Part 1

Dr Ebin Deni Raj

28/01/2022

Contents

1. Session Description

This document is prepared for First semester students of Mtech in AI and Data Science. This document gives an introductory taste to the programming language R, focused on a powerful set of tools known as the Tidyverse. The document is focused on the intertwined processes of data manipulation and visualization using the tools *dplyr* and *ggplot2.* You'll learn to manipulate data by filtering, sorting, and summarizing a real dataset of historical country data in order to answer exploratory and interesting questions. You'll then learn to turn this processed data into informative line plots, bar plots, histograms, and more with the ggplot2 package.

Kindly install the following before the session

1. **install.packages("dplyr")**
2. **install.packages("gapminder")**
3. **install.packages("ggplot2")**

2. Starting with packages

dplyr is a grammar of data manipulation, providing a consistent set of verbs that help you solve the most common data manipulation challenges:

- mutate() adds new variables that are functions of existing variables.
- select() picks variables based on their names.
- filter() picks cases based on their values.
- summarise() reduces multiple values down to a single summary.
- arrange() changes the ordering of the rows.

2.1 Load the gapminder package

```
library(gapminder)
```

2.2 Load the dplyr package

```
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
```

2.3 Understanding gapminder dataset

```
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
```

If you hit enter after correctly typing this, your R script is executed and the output is shown in the R Console.

2.3.1 Understanding a data frame

Now that you've loaded the gapminder dataset, you can start examining and understanding it.We've already loaded the gapminder and dplyr packages. *Can you look and tell, how many observations (rows) are in the dataset?*
Ans:1704

Let us start working on this dataset:

2.3.2 Filtering

The *filter* verb extracts particular observations based on a condition. In this exercise you'll filter for observations from a particular year.
Add a *filter()* line after the pipe *(%>%)* to extract only the observations from the year 1957. Remember that you use == to compare two values.

```
# Filter the gapminder dataset for the year 1957
gapminder %>%
  filter(year==1957)
```

```
## # A tibble: 142 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1957    30.3  9240934      821.
##  2 Albania     Europe     1957    59.3  1476505     1942.
##  3 Algeria     Africa     1957    45.7 10270856     3014.
##  4 Angola      Africa     1957    32.0  4561361     3828.
##  5 Argentina   Americas   1957    64.4 19610538     6857.
##  6 Australia   Oceania    1957    70.3  9712569    10950.
##  7 Austria     Europe     1957    67.5  6965860     8843.
##  8 Bahrain     Asia       1957    53.8   138655    11636.
##  9 Bangladesh  Asia       1957    39.3 51365468      662.
## 10 Belgium     Europe     1957    69.2  8989111     9715.
```

```
## # ... with 132 more rows
```

2.3.3 Filtering for one country and one year

You can also use the *filter()* verb to set two conditions, which could retrieve a single observation.
Just like in the last exercise, you can do this in two lines of code, starting with *gapminder %>%* and having the *filter()* on the second line. Keeping one verb on each line helps keep the code readable. Note that each time, you'll put the pipe *%>%* at the end of the first line (like gapminder %>%); putting the pipe at the beginning of the second line will throw an error. * Filter the gapminder data to retrieve only the observation from China in the year 2002. *Ans*

```
# Filter for China in 2002
gapminder%>%
   filter(country=="China")%>%filter(year==2002)
```

```
## # A tibble: 1 x 6
##   country continent  year lifeExp        pop gdpPercap
##   <fct>   <fct>     <int>   <dbl>      <int>     <dbl>
## 1 China   Asia       2002    72.0 1280400000     3119.
```

2.3.4 Arranging observations by life expectancy

You can use *arrange()* to sort observations in ascending or descending order of a particular variable. In this case, you can sort the dataset based on the lifeExp variable.
* Sort the gapminder dataset in ascending order of life expectancy (lifeExp).
* Sort the gapminder dataset in descending order of life expectancy.

```
# Sort in ascending order of lifeExp
gapminder%>%
  arrange(lifeExp)
```

```
## # A tibble: 1,704 x 6
##    country      continent  year lifeExp     pop gdpPercap
##    <fct>        <fct>     <int>   <dbl>   <int>     <dbl>
##  1 Rwanda       Africa     1992    23.6 7290203      737.
##  2 Afghanistan  Asia       1952    28.8 8425333      779.
##  3 Gambia       Africa     1952    30    284320      485.
##  4 Angola       Africa     1952    30.0 4232095     3521.
##  5 Sierra Leone Africa     1952    30.3 2143249      880.
##  6 Afghanistan  Asia       1957    30.3 9240934      821.
##  7 Cambodia     Asia       1977    31.2 6978607      525.
##  8 Mozambique   Africa     1952    31.3 6446316      469.
##  9 Sierra Leone Africa     1957    31.6 2295678     1004.
## 10 Burkina Faso Africa     1952    32.0 4469979      543.
## # ... with 1,694 more rows
```

```
# Sort in descending order of lifeExp

gapminder%>%
  arrange(desc(lifeExp))
```

```
## # A tibble: 1,704 x 6
##    country          continent  year lifeExp       pop gdpPercap
##    <fct>            <fct>     <int>   <dbl>     <int>     <dbl>
##  1 Japan            Asia       2007    82.6 127467972    31656.
```

```
##  2 Hong Kong, China Asia       2007    82.2   6980412    39725.
##  3 Japan           Asia       2002    82   127065841    28605.
##  4 Iceland         Europe     2007    81.8    301931    36181.
##  5 Switzerland     Europe     2007    81.7   7554661    37506.
##  6 Hong Kong, China Asia      2002    81.5   6762476    30209.
##  7 Australia       Oceania    2007    81.2  20434176    34435.
##  8 Spain           Europe     2007    80.9  40448191    28821.
##  9 Sweden          Europe     2007    80.9   9031088    33860.
## 10 Israel          Asia       2007    80.7   6426679    25523.
## # ... with 1,694 more rows
```

2.3.5 Filtering and arranging

You'll often need to use the pipe operator *(%>%)* to combine multiple dplyr verbs in a row. In this case, you can combine a *filter()* with an *arrange()* to find the highest populous countries in a particular year.

*Use filter() to extract observations from just the year 1957, then use arrange() to sort in descending order of population (pop).

```
# Filter for the year 1957, then arrange in descending order of population
gapminder%>%
   filter(year==1957)%>%
   arrange(desc(pop))
```

```
## # A tibble: 142 x 6
##    country        continent  year lifeExp       pop gdpPercap
##    <fct>          <fct>     <int>   <dbl>     <int>     <dbl>
##  1 China          Asia       1957    50.5 637408000      576.
##  2 India          Asia       1957    40.2 409000000      590.
##  3 United States  Americas   1957    69.5 171984000    14847.
##  4 Japan          Asia       1957    65.5  91563009     4318.
##  5 Indonesia      Asia       1957    39.9  90124000      859.
##  6 Germany        Europe     1957    69.1  71019069    10188.
##  7 Brazil         Americas   1957    53.3  65551171     2487.
##  8 United Kingdom Europe     1957    70.4  51430000    11283.
##  9 Bangladesh     Asia       1957    39.3  51365468      662.
## 10 Italy          Europe     1957    67.8  49182000     6249.
## # ... with 132 more rows
```

2.3.6 Using mutate to change or create a column

Suppose we want life expectancy to be measured in months instead of years: you'd have to multiply the existing value by 12. You can use the *mutate()* verb to change this column, or to create a new column that's calculated this way.

1. Use mutate() to change the existing *lifeExp* column, by multiplying it by 12:-> 12 *lifeExp.
2. Use mutate() to add a new column, called *lifeExpMonths*, calculated as 12*lifeExp.

```
# Use mutate to change lifeExp to be in months
gapminder%>%
    mutate(lifeExp=12*lifeExp)
```

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
```

```
##  1 Afghanistan Asia       1952    346.  8425333      779.
##  2 Afghanistan Asia       1957    364.  9240934      821.
##  3 Afghanistan Asia       1962    384. 10267083      853.
##  4 Afghanistan Asia       1967    408. 11537966      836.
##  5 Afghanistan Asia       1972    433. 13079460      740.
##  6 Afghanistan Asia       1977    461. 14880372      786.
##  7 Afghanistan Asia       1982    478. 12881816      978.
##  8 Afghanistan Asia       1987    490. 13867957      852.
##  9 Afghanistan Asia       1992    500. 16317921      649.
## 10 Afghanistan Asia       1997    501. 22227415      635.
## # ... with 1,694 more rows
```

```
# Use mutate to create a new column called lifeExpMonths
gapminder%>%
    mutate(lifeExpMonths=12*lifeExp)
```

```
## # A tibble: 1,704 x 7
##    country     continent  year lifeExp      pop gdpPercap lifeExpMonths
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>          <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.           346.
##  2 Afghanistan Asia       1957    30.3  9240934      821.           364.
##  3 Afghanistan Asia       1962    32.0 10267083      853.           384.
##  4 Afghanistan Asia       1967    34.0 11537966      836.           408.
##  5 Afghanistan Asia       1972    36.1 13079460      740.           433.
##  6 Afghanistan Asia       1977    38.4 14880372      786.           461.
##  7 Afghanistan Asia       1982    39.9 12881816      978.           478.
##  8 Afghanistan Asia       1987    40.8 13867957      852.           490.
##  9 Afghanistan Asia       1992    41.7 16317921      649.           500.
## 10 Afghanistan Asia       1997    41.8 22227415      635.           501.
## # ... with 1,694 more rows
```

2.3.7 Combining filter, mutate, and arrange

In this exercise, you'll combine all three of the verbs you've learned in this chapter, to find the countries with the highest life expectancy, in months, in the year 2007.

In one sequence of pipes on the gapminder dataset: * *filter()* for observations from the *year* 2007, * *mutate()* to create a column lifeExpMonths, calculated as 12 * *lifeExp*, and * *arrange()* in descending order of that new column

```
# Filter, mutate, and arrange the gapminder dataset
gapminder%>%
filter(year==2007)%>%
mutate(lifeExpMonths=12*lifeExp)%>%
arrange(desc(lifeExpMonths))
```

```
## # A tibble: 142 x 7
##    country          continent  year lifeExp       pop gdpPercap lifeExpMonths
##    <fct>            <fct>     <int>   <dbl>     <int>     <dbl>          <dbl>
##  1 Japan            Asia       2007    82.6 127467972    31656.           991.
##  2 Hong Kong, China Asia       2007    82.2   6980412    39725.           986.
##  3 Iceland          Europe     2007    81.8    301931    36181.           981.
##  4 Switzerland      Europe     2007    81.7   7554661    37506.           980.
##  5 Australia        Oceania    2007    81.2  20434176    34435.           975.
##  6 Spain            Europe     2007    80.9  40448191    28821.           971.
```

```
##  7 Sweden           Europe     2007    80.9   9031088    33860.          971.
##  8 Israel           Asia       2007    80.7   6426679    25523.          969.
##  9 France           Europe     2007    80.7  61083916    30470.          968.
## 10 Canada           Americas   2007    80.7  33390141    36319.          968.
## # ... with 132 more rows
```

2.4 Data Visualization

2.4.1 Variable assignment

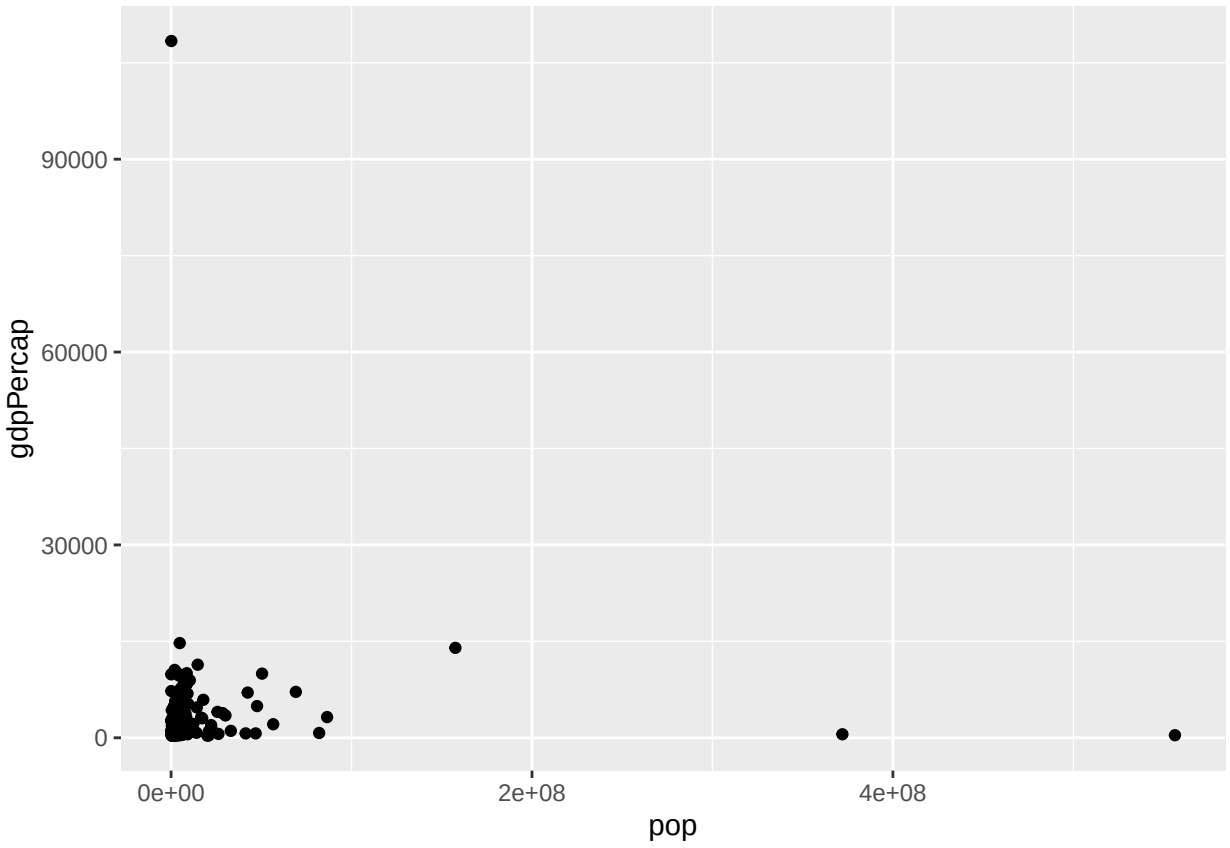
Throughout the exercises from this point, you'll be visualizing a subset of the gapminder data from the year 1952. First, you'll have to load the ggplot2 package, and create a gapminder_1952 dataset to visualize.

```
# Load the ggplot2 package as well
library(gapminder)
library(dplyr)
library(ggplot2)

# Create gapminder_1952
gapminder_1952 <- gapminder%>%filter(year==1952)
```

###2.4.2 Comparing population and GDP per capita

Use ggplot to plot population *(pop)* on x- axis and GDP per capita *(gdpPercap)* on y axis

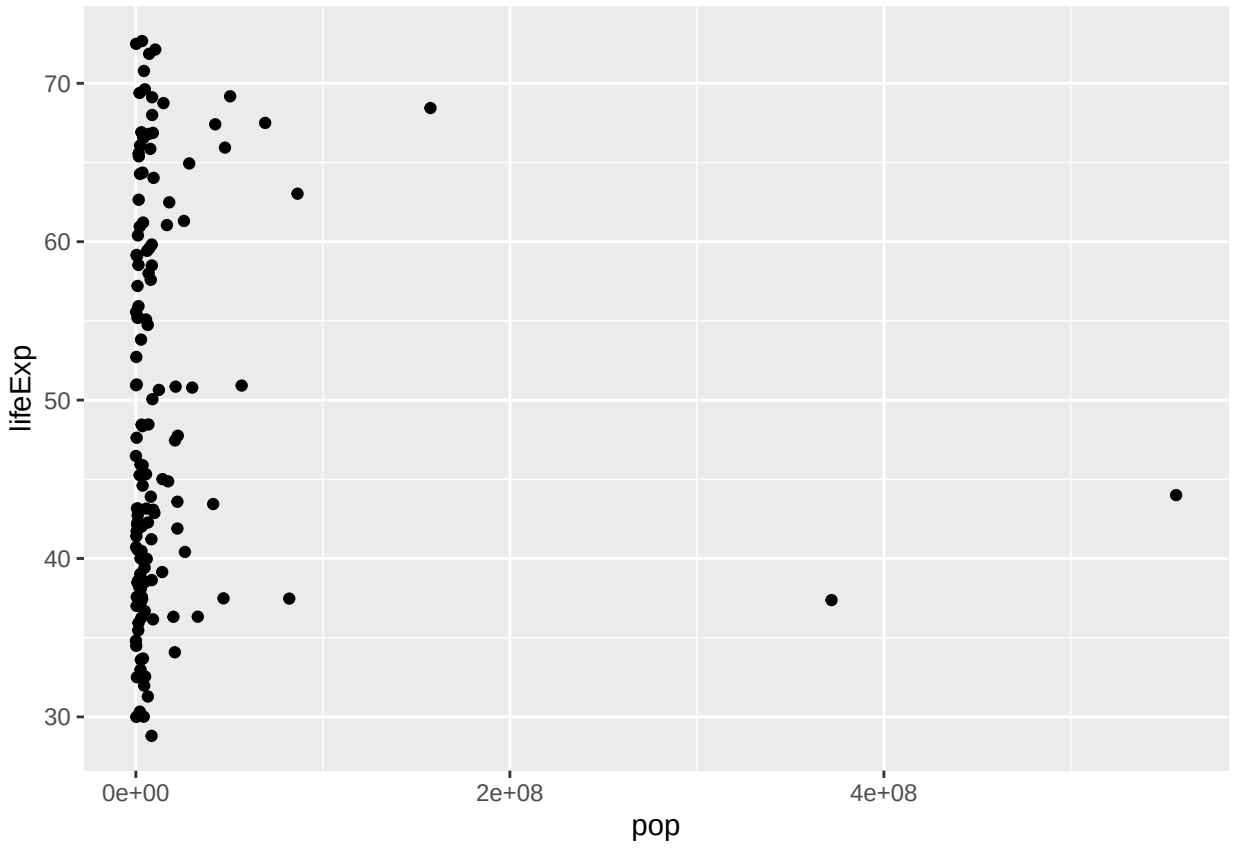
```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# put pop on the x-axis and gdpPercap on the y-axis
ggplot(gapminder_1952, aes(x = pop, y = gdpPercap)) +
  geom_point()
```



2.4.3 Comparing population and life expectancy

Create a scatter plot from scratch, to compare each country's population with its life expectancy in the year 1952.

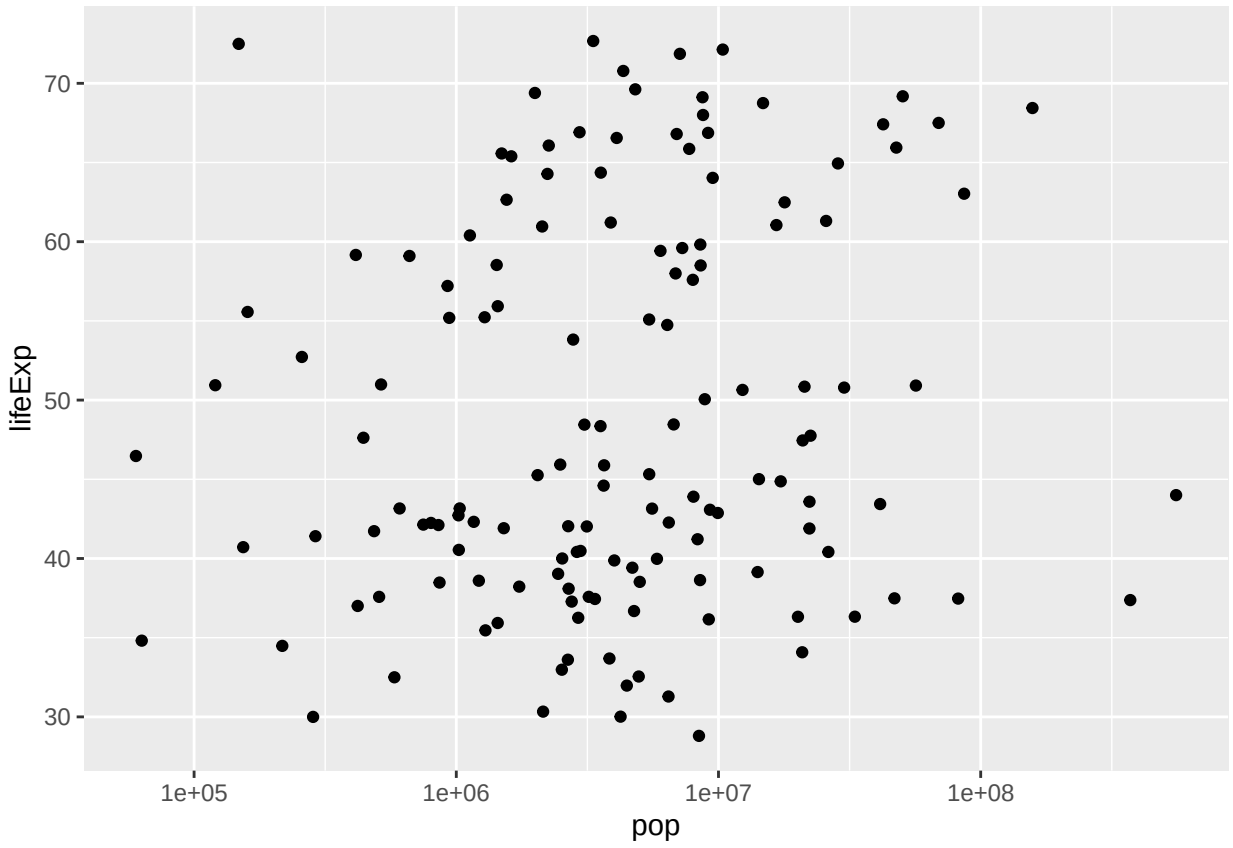
```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Create a scatter plot with pop on the x-axis and lifeExp on the y-axis
ggplot(gapminder_1952,aes(x=pop,y=lifeExp))+ geom_point()
```



2.4.4 Putting the x-axis on a log scale

You have previously created a scatter plot with population on the x-axis and life expectancy on the y-axis. Since population is spread over several orders of magnitude, with some countries having a much higher population than others, it's a good idea to put the x-axis on a log scale.
* Change the existing scatter plot to put the x-axis (representing population) on a log scale.

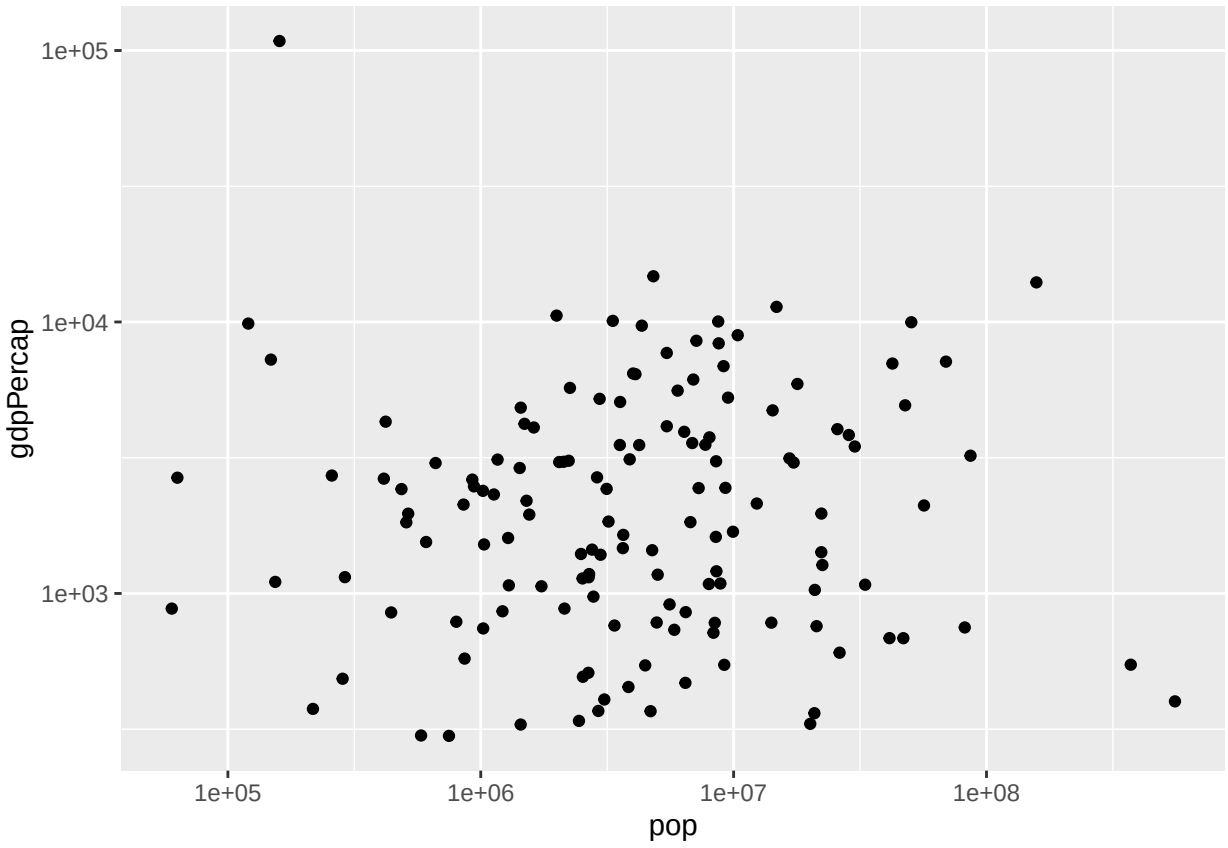
```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Change this plot to put the x-axis on a log scale
ggplot(gapminder_1952, aes(x = pop, y = lifeExp)) +
  geom_point()+scale_x_log10()
```



2.4.5 Putting the x- and y- axes on a log scale

Suppose you want to create a scatter plot with population on the x-axis and GDP per capita on the y-axis. Both population and GDP per-capita are better represented with log scales, since they vary over many orders of magnitude.
* Create a scatter plot with population (pop) on the x-axis and GDP per capita (gdpPercap) on the y-axis. Put both the x- and y- axes on a log scale.

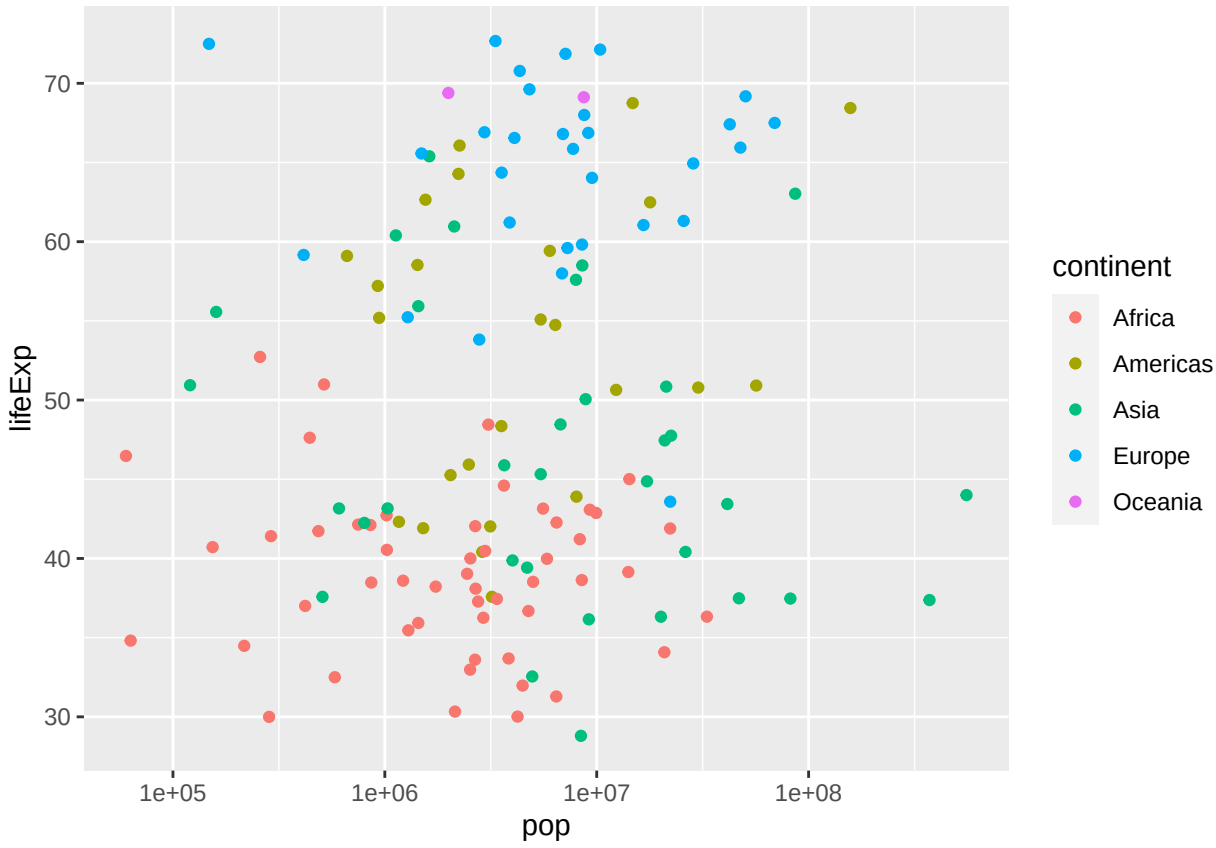
```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Scatter plot comparing pop and gdpPercap, with both axes on a log scale
ggplot(gapminder_1952,aes(x=pop,y=gdpPercap))+ geom_point() + scale_x_log10()+ scale_y_log10()
```



2.4.6 Adding color to a scatter plot

We will see how to use the color aesthetic, which can be used to show which continent each point in a scatter plot represents.
* Create a scatter plot with population *(pop)* on the x-axis, life expectancy *(lifeExp)* on the y-axis, and with continent *(continent)* represented by the color of the points. Put the x-axis on a log scale.

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Scatter plot comparing pop and lifeExp, with color representing continent
ggplot(gapminder_1952, aes(x=pop,y=lifeExp, color=continent))+ geom_point() + scale_x_log10()
```

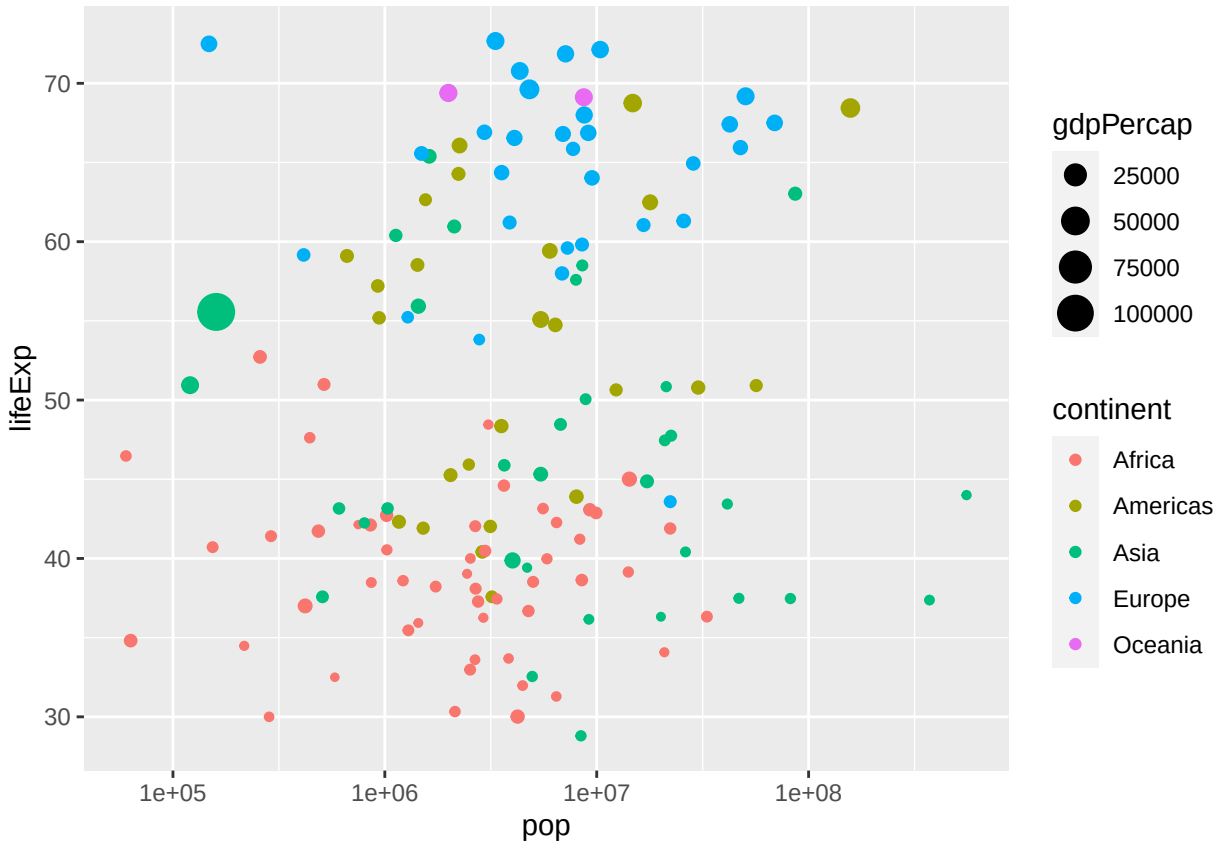


2.4.7 Adding size and color to a plot

In the last exercise, you created a scatter plot communicating information about each country's population, life expectancy, and continent. Now we will use the size of the points to communicate even more.

- Modify the scatter plot so that the size of the points represents each country's GDP per capita *(gdpPercap)*.

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Add the size aesthetic to represent a country's gdpPercap
ggplot(gapminder_1952, aes(x = pop, y = lifeExp, color = continent,size=gdpPercap)) +
  geom_point() +
  scale_x_log10()
```

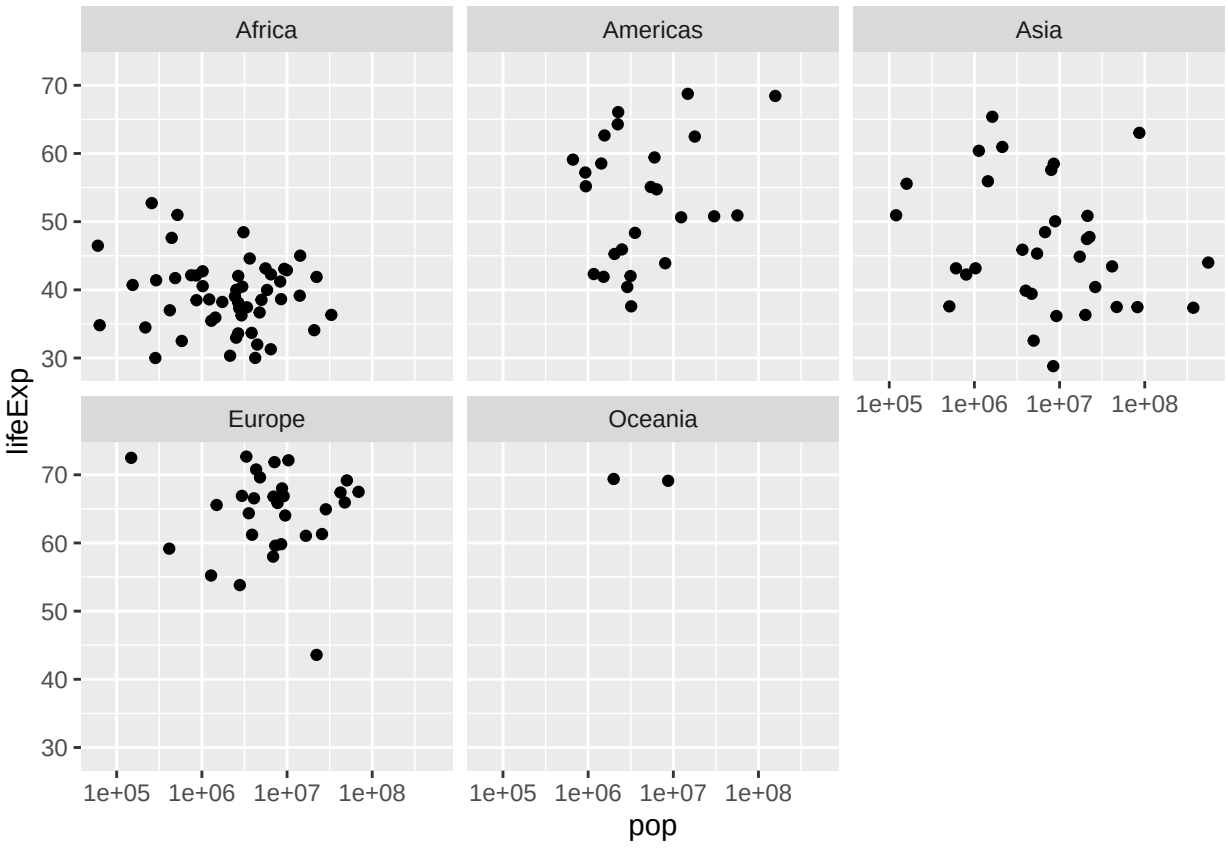


2.4.8 Creating a subgraph for each continent

The facet approach partitions a plot into a matrix of panels. Each panel shows a different subset of the data. We will try to to use faceting to divide a graph into subplots based on one of its variables, such as the continent.

*Create a scatter plot of gapminder_1952 with the x-axis representing population (pop), the y-axis representing life expectancy (lifeExp), and faceted to have one subplot per continent (continent). Put the x-axis on a log scale.

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Scatter plot comparing pop and lifeExp, faceted by continent
ggplot(gapminder_1952, aes(x=pop,y=lifeExp)) +geom_point()+ scale_x_log10()+facet_wrap(~continent)
```

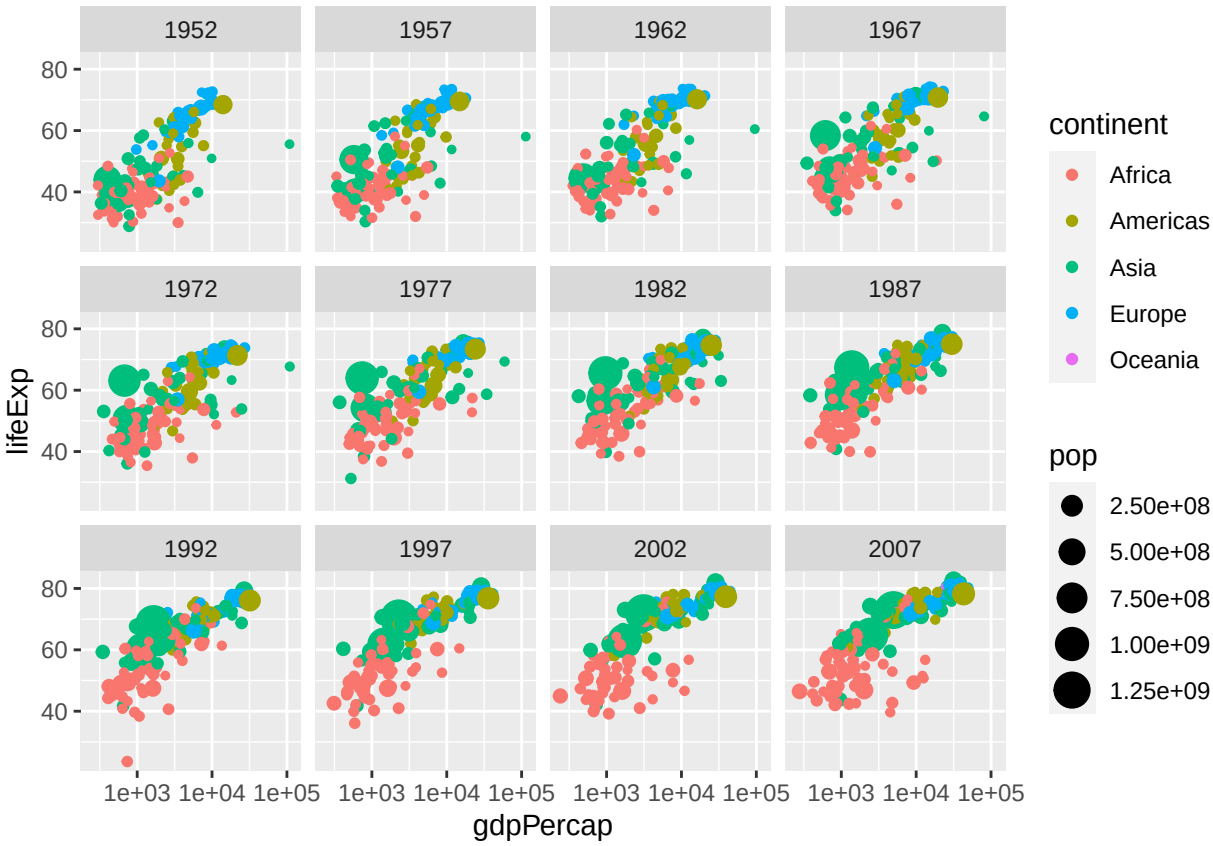


2.4.9 Faceting by year

All of the graphs we have seen so far have been visualizing statistics within one year. Now that you're able to use faceting, however, you can create a graph showing all the country-level data from 1952 to 2007, to understand how global statistics have changed over time.

- Create a scatter plot of the gapminder data:
- Put GDP per capita (gdpPercap) on the x-axis and life expectancy (lifeExp) on the y-axis, with continent (continent) represented by color and population (pop) represented by size.
- Put the x-axis on a log scale
- Facet by the year variable

```
# Scatter plot comparing gdpPercap and lifeExp, with color representing continent
# and size representing population, faceted by year
ggplot(gapminder,aes(x=gdpPercap,y=lifeExp,color=continent,size=pop))+
  geom_point()+
  scale_x_log10()+ facet_wrap(~year)
```



3. Grouping and Summarizing

3.1 Summarizing the median life expectancy

We have sean seen how to find the mean life expectancy and the total population across a set of observations, but *mean()* and *sum()* are only two of the functions R provides for summarizing a collection of numbers. Here, we will learn to use the *median()* function in combination with summarize().
* Use the *median()* function within a *summarize()* to find the median life expectancy.
* Save it into a column called medianLifeExp.

```
library(gapminder)
library(dplyr)

# Summarize to find the median life expectancy
gapminder%>%summarize(medianLifeExp=median(lifeExp))
```

```
## # A tibble: 1 x 1
##   medianLifeExp
##           <dbl>
## 1          60.7
```

3.2 Summarizing the median life expectancy in 1957

Rather than summarizing the entire dataset, find the median life expectancy for only one particular year. In this case, you'll find the median in the year 1957.

- Filter for the year 1957, then use the *median()* function within a *summarize()* to calculate the median life expectancy into a column called *medianLifeExp*.

```
# Filter for 1957 then summarize the median life expectancy
gapminder%>%
 filter(year==1957)%>%summarize(medianLifeExp=median(lifeExp))
```

```
## # A tibble: 1 x 1
##   medianLifeExp
##           <dbl>
## 1          48.4
```

3.3 Summarizing multiple variables in 1957

The *summarize()* verb allows you to summarize multiple variables at once. In this case, you'll use the *median()* function to find the median life expectancy and the *max()* function to find the maximum GDP per capita. * Find both the median life expectancy *(lifeExp)* and the maximum GDP per capita *(gdpPercap)* in the year 1957, calling them *medianLifeExp* and *maxGdpPercap* respectively. You can use the *max()* function to find the maximum.

```
# Filter for 1957 then summarize the median life expectancy and the maximum GDP per capita
gapminder %>%
filter(year == 1957) %>%
summarize(medianLifeExp = median(lifeExp),
maxGdpPercap= max(gdpPercap))
```

```
## # A tibble: 1 x 2
##   medianLifeExp maxGdpPercap
##           <dbl>        <dbl>
## 1          48.4      113523.
```

3.4 Summarizing by year

In a previous exercise, you found the median life expectancy and the maximum GDP per capita in the year 1957. Now, you'll perform those two summaries within each year in the dataset, using the group_by verb. * Find the median life expectancy *(lifeExp)* and maximum GDP per capita *(gdpPercap)* within each year, saving them into *medianLifeExp* and *maxGdpPercap*, respectively.

```
# Find median life expectancy and maximum GDP per capita in each year
gapminder %>%
group_by(year) %>%
summarize(medianLifeExp = median(lifeExp),
maxGdpPercap = max(gdpPercap))
```

```
## # A tibble: 12 x 3
##     year medianLifeExp maxGdpPercap
##    <int>         <dbl>        <dbl>
##  1  1952          45.1      108382.
##  2  1957          48.4      113523.
##  3  1962          50.9       95458.
##  4  1967          53.8       80895.
##  5  1972          56.5      109348.
##  6  1977          59.7       59265.
##  7  1982          62.4       33693.
##  8  1987          65.8       31541.
```

```
##  9  1992          67.7       34933.
## 10  1997          69.4       41283.
## 11  2002          70.8       44684.
## 12  2007          71.9       49357.
```

3.5 Summarizing by continent

You can group by any variable in your dataset to create a summary. Rather than comparing across time, you might be interested in comparing among continents. You'll want to do that within one year of the dataset: let's use 1957.

- Filter the gapminder data for the year 1957. Then find the median life expectancy *(lifeExp)* and maximum GDP per capita *(gdpPercap)* within each continent, saving them into *medianLifeExp* and *maxGdpPercap*, respectively.

```
# Find median life expectancy and maximum GDP per capita in each continent in 1957
gapminder%>% filter(year==1957)%>%
group_by(continent) %>%
summarize(medianLifeExp = median(lifeExp),
maxGdpPercap = max(gdpPercap))
```

```
## # A tibble: 5 x 3
##   continent medianLifeExp maxGdpPercap
##   <fct>             <dbl>        <dbl>
## 1 Africa             40.6        5487.
## 2 Americas           56.1       14847.
## 3 Asia               48.3      113523.
## 4 Europe             67.6       17909.
## 5 Oceania            70.3       12247.
```

3.6 Summarizing by continent and year

Instead of grouping just by year, or just by continent, can you now group by both continent and year to summarize within each.

- Find the median life expectancy *(lifeExp)* and maximum GDP per capita *(gdpPercap)* within each combination of continent and year, saving them into *medianLifeExp* and *maxGdpPercap*, respectively.

```
# Find median life expectancy and maximum GDP per capita in each continent/year combination
gapminder %>%
group_by(year, continent) %>%
summarize(medianLifeExp = median(lifeExp),
maxGdpPercap = max(gdpPercap))
```

```
## `summarise()` has grouped output by 'year'. You can override using the `.groups` argument.
```

```
## # A tibble: 60 x 4
## # Groups:   year [12]
##     year continent medianLifeExp maxGdpPercap
##    <int> <fct>             <dbl>        <dbl>
##  1  1952 Africa             38.8        4725.
##  2  1952 Americas           54.7       13990.
##  3  1952 Asia               44.9      108382.
##  4  1952 Europe             65.9       14734.
##  5  1952 Oceania            69.3       10557.
##  6  1957 Africa             40.6        5487.
```

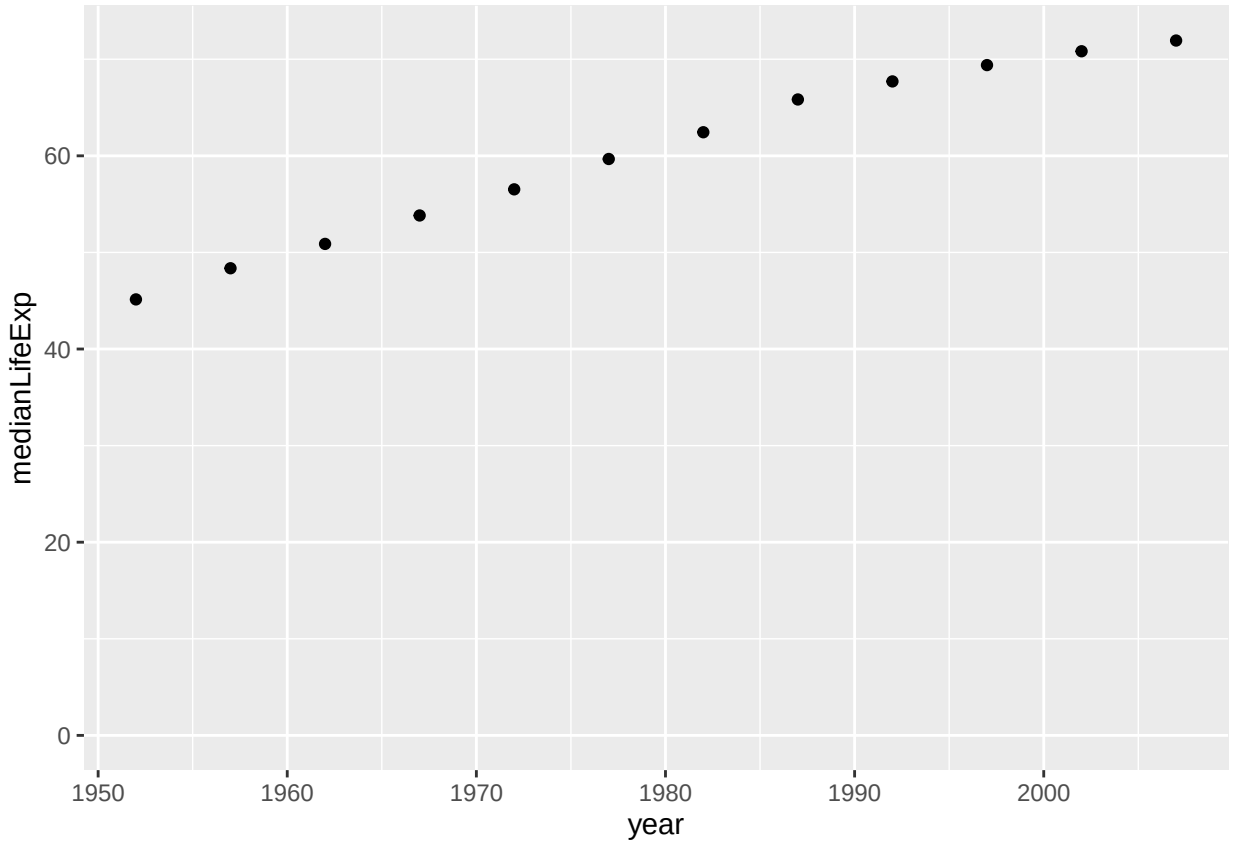
```
##  7  1957 Americas           56.1       14847.
##  8  1957 Asia               48.3      113523.
##  9  1957 Europe             67.6       17909.
## 10  1957 Oceania            70.3       12247.
## # ... with 50 more rows
```

3.7 Visualizing median life expectancy over time

can you use the ggplot2 package to turn this into a visualization of changing life expectancy over time?

- Use the *by_year* dataset to create a scatter plot showing the change of median life expectancy over time, with *year* on the x-axis and *medianLifeExp* on the y-axis. Be sure to add *expand_limits(y = 0)* to make sure the plot's y-axis includes zero.

```
by_year <- gapminder %>%
  group_by(year) %>%
  summarize(medianLifeExp = median(lifeExp),
            maxGdpPercap = max(gdpPercap))

# Create a scatter plot showing the change in medianLifeExp over time
ggplot(by_year, aes(x =year , y = medianLifeExp)) +
geom_point()+
expand_limits(y = 0)
```



3.8 Visualizing median GDP per capita per continent over time

In the last exercise you were able to see how the median life expectancy of countries changed over time. Now you'll examine the median GDP per capita instead, and see how the trend differs among continents.

- Summarize the gapminder dataset by continent and year, finding the median GDP per capita *(gdpPercap)* within each and putting it into a column called *medianGdpPercap*. Use the assignment operator <- to save this summarized data as *by_year_continent*.
- Create a scatter plot showing the change in *medianGdpPercap* by continent over time. Use color to distinguish between continents, and be sure to add *expand_limits(y = 0)* so that the y-axis starts at zero.

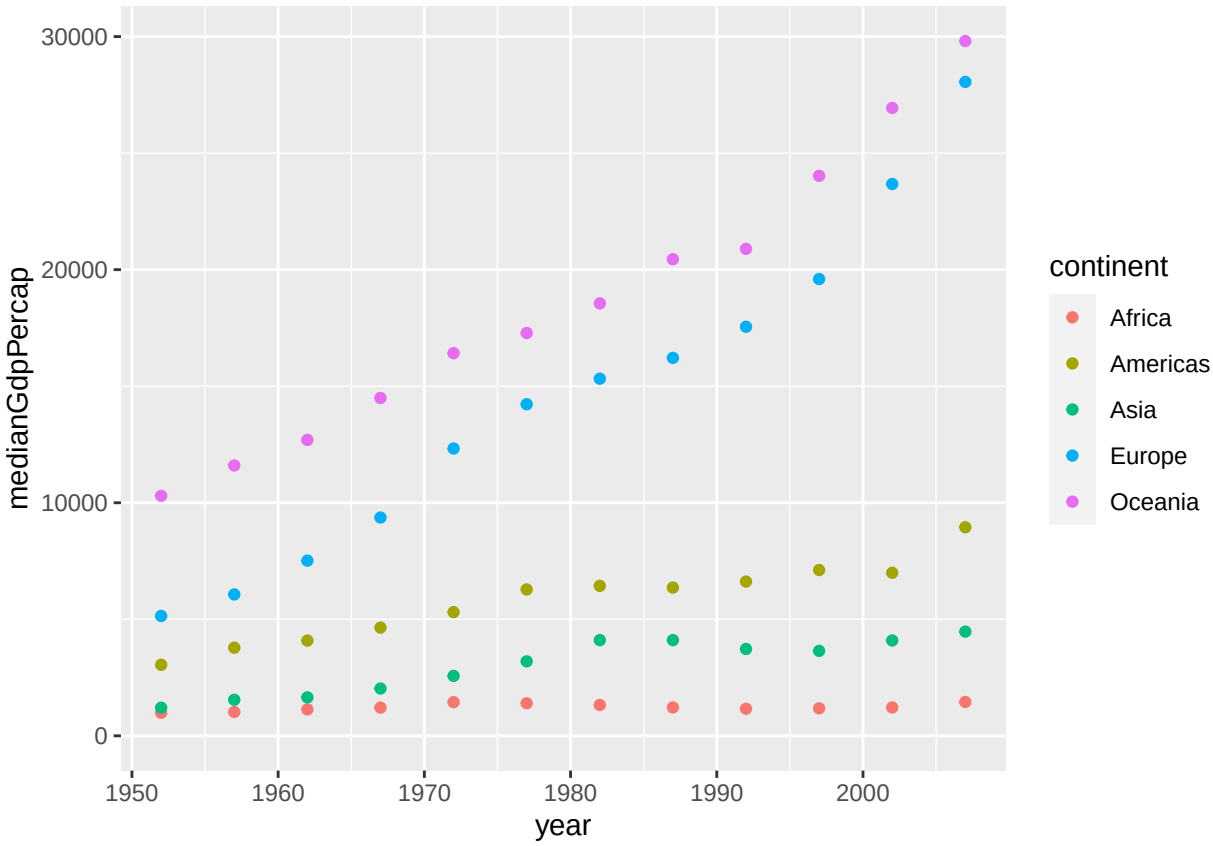
```
# Summarize medianGdpPercap within each continent within each year: by_year_continent
by_year_continent <- gapminder %>%
group_by(year, continent) %>%
summarize(medianGdpPercap = median(gdpPercap))
```

```
## `summarise()` has grouped output by 'year'. You can override using the `.groups` argument.
```

```
by_year_continent
```

```
## # A tibble: 60 x 3
## # Groups:   year [12]
##     year continent medianGdpPercap
##    <int> <fct>               <dbl>
##  1  1952 Africa               987.
##  2  1952 Americas            3048.
##  3  1952 Asia                1207.
##  4  1952 Europe              5142.
##  5  1952 Oceania            10298.
##  6  1957 Africa              1024.
##  7  1957 Americas            3781.
##  8  1957 Asia                1548.
##  9  1957 Europe              6067.
## 10  1957 Oceania            11599.
## # ... with 50 more rows
```

```
# Plot the change in medianGdpPercap in each continent over time
ggplot(by_year_continent, aes(x=year,y=medianGdpPercap,color=continent))+geom_point()+expand_limits(y =
```



3.9 Comparing median life expectancy and median GDP per continent in 2007

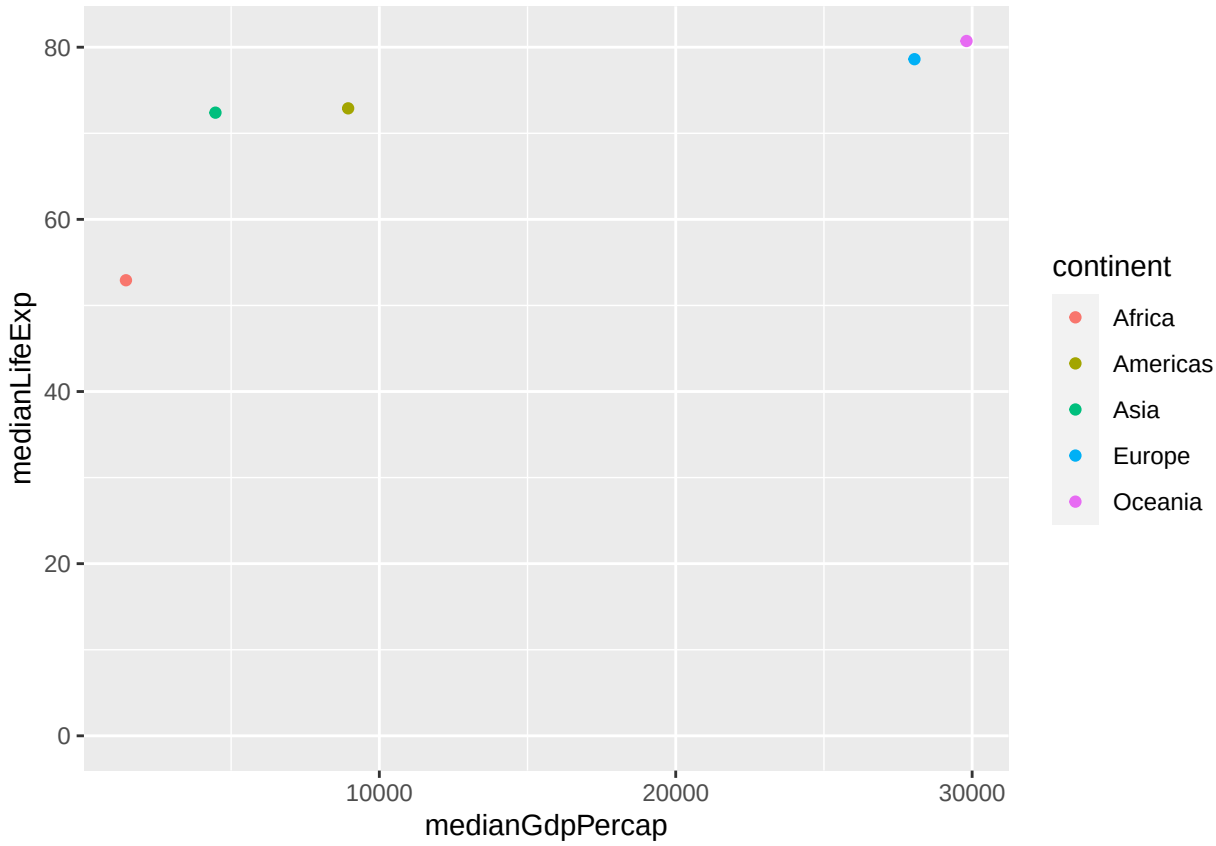
In these exercises you've generally created plots that show change over time. But as another way of exploring your data visually, you can also use ggplot2 to plot summarized data to compare continents within a single year.

- Filter the gapminder dataset for the year 2007, then summarize the median GDP per capita and the median life expectancy within each *continent*, into columns called *medianLifeExp* and *medianGdpPercap*. Save this as *by_continent_2007*.

- Use the *by_continent_2007* data to create a scatterplot comparing these summary statistics for continents in 2007, putting the median GDP per capita on the x-axis to the median life expectancy on the y-axis.

- Color the scatter plot by continent. You don't need to add expand_limits(y = 0) for this plot.

```
# Summarize the median GDP and median life expectancy per continent in 2007
by_continent_2007<-gapminder%>% filter(year==2007)%>%
group_by(continent)%>%
summarize(medianLifeExp=median(lifeExp),medianGdpPercap=median(gdpPercap))
# Use a scatter plot to compare the median GDP and median life expectancy
ggplot(by_continent_2007,aes(x=medianGdpPercap,y=medianLifeExp,color=continent))+
  geom_point()+expand_limits(y=0)
```



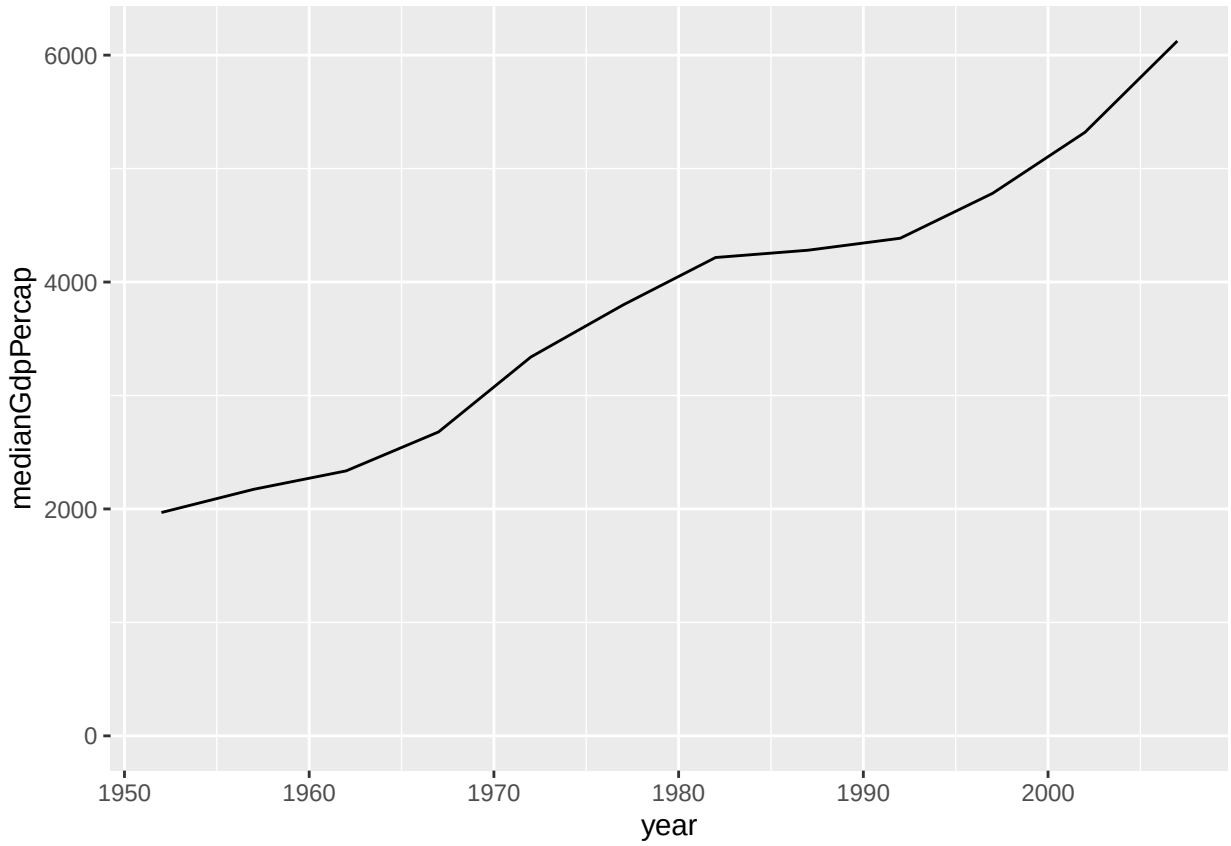
4 Types of Visualization

4.1 Visualizing median GDP per capita over time using Line plot

A line plot is useful for visualizing trends over time. In this exercise, you'll examine how the median GDP per capita has changed over time.
* Use *group_by()* and *summarize()* to find the median GDP per capita within each year, calling the output column *medianGdpPercap*. Use the assignment operator <- to save it to a dataset called by_year.

- Use the *by_year* dataset to create a line plot showing the change in median GDP per capita over time. Be sure to use *expand_limits(y = 0)* to include 0 on the y-axis.

```
# Summarize the median gdpPercap by year, then save it as by_year
by_year<-gapminder%>%group_by(year)%>%
summarize(medianGdpPercap=median(gdpPercap))

# Create a line plot showing the change in medianGdpPercap over time
ggplot(by_year,aes(x=year,y=medianGdpPercap))+geom_line()+expand_limits(y = 0)
```



4.2 Visualizing median GDP per capita by continent over time

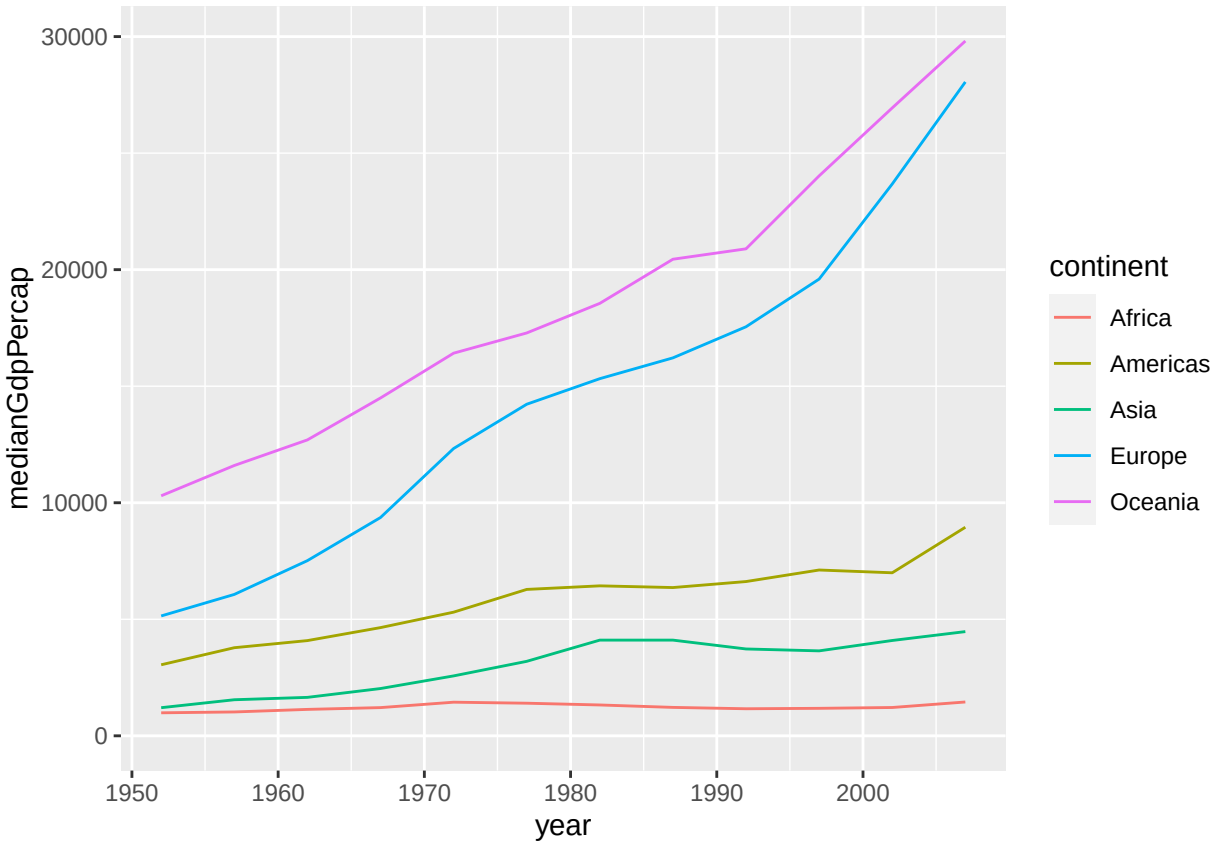
In the last exercise you used a line plot to visualize the increase in median GDP per capita over time. Now you'll examine the change within each continent.

- Use group_by() and summarize() to find the median GDP per capita within each year and continent, calling the output column medianGdpPercap. Use the assignment operator <- to save it to a dataset called by_year_continent.
- Use the by_year_continent dataset to create a line plot showing the change in median GDP per capita over time, with color representing continent. Be sure to use expand_limits(y = 0) to include 0 on the y-axis.

```
# Summarize the median gdpPercap by year & continent, save as by_year_continent
by_year_continent<-gapminder%>%group_by(year,continent)%>%summarize(medianGdpPercap=median(gdpPercap))
```

```
## `summarise()` has grouped output by 'year'. You can override using the `.groups` argument.
```

```
# Create a line plot showing the change in medianGdpPercap by continent over time
ggplot(by_year_continent, aes(x=year,y=medianGdpPercap,color=continent))+geom_line()+expand_limits(y = 0
```

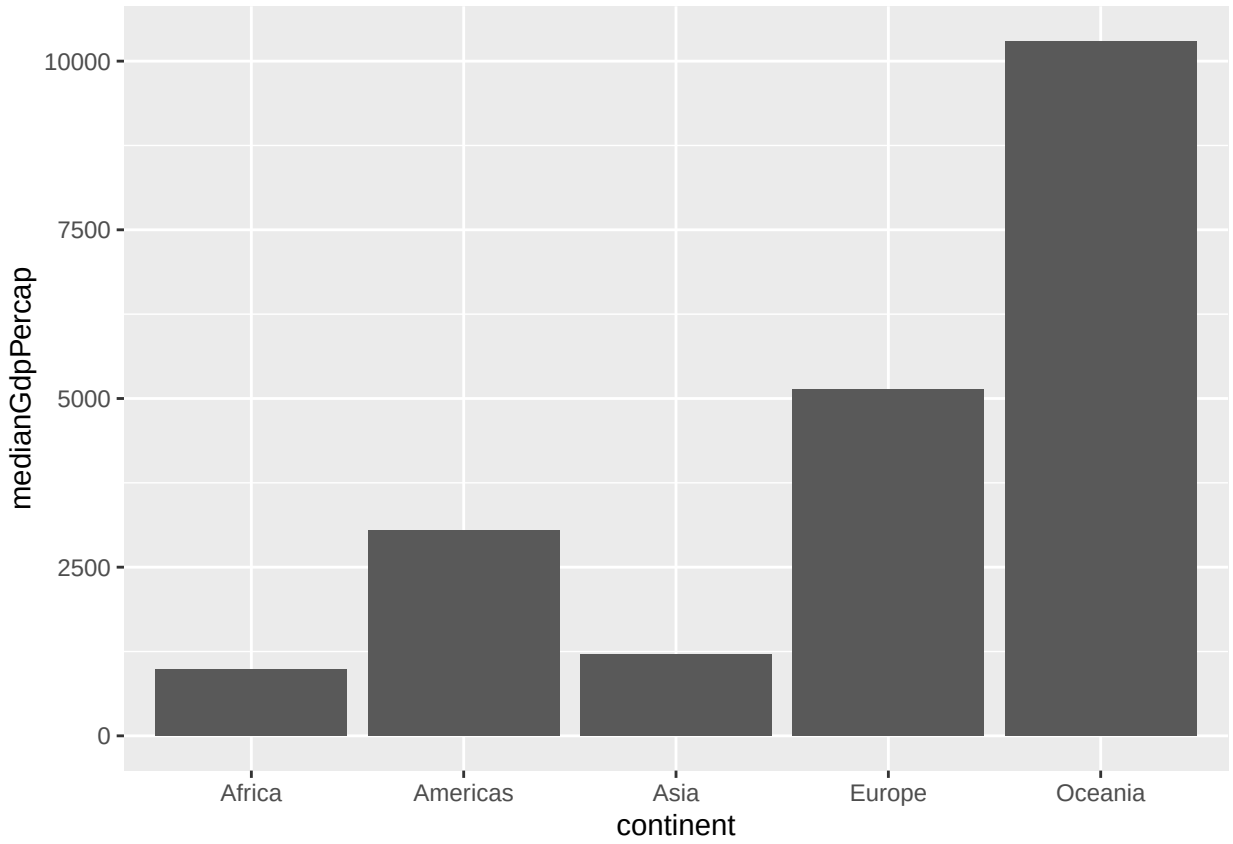


4.3 Visualizing median GDP per capita by continent

A bar plot is useful for visualizing summary statistics, such as the median GDP in each continent.

- Use group_by() and summarize() to find the median GDP per capita within each continent in the year 1952, calling the output column medianGdpPercap. Use the assignment operator <- to save it to a dataset called by_continent.
- Use the by_continent dataset to create a bar plot showing the median GDP per capita in each continent.

```
# Summarize the median gdpPercap by continent in 1952
by_continent<-gapminder%>%group_by(continent)%>%filter(year==1952)%>%
summarize(medianGdpPercap=median(gdpPercap))
# Create a bar plot showing medianGdp by continent
ggplot(by_continent, aes(x = continent, y = medianGdpPercap)) +
geom_col()
```



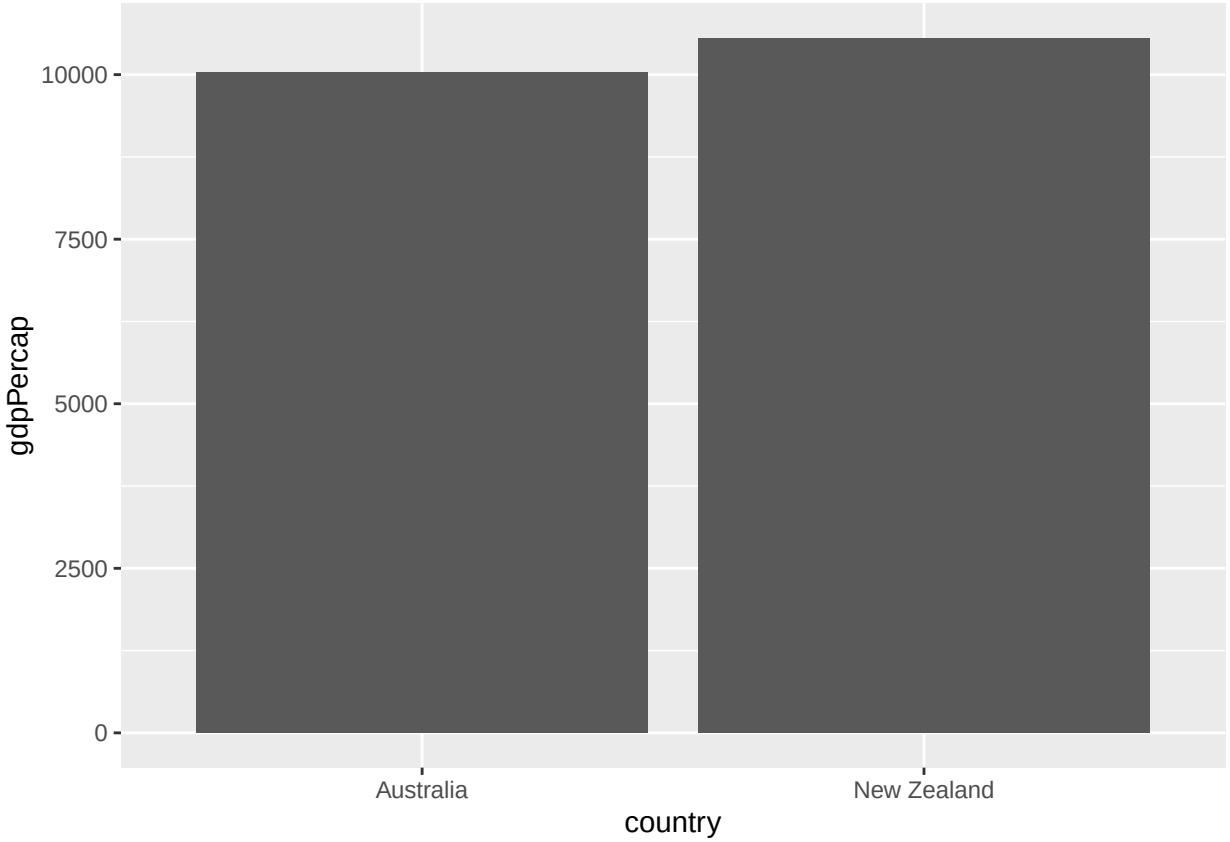
4.4 Visualizing GDP per capita by country in Oceania

You've created a plot where each bar represents one continent, showing the median GDP per capita for each. But the x-axis of the bar plot doesn't have to be the continent: you can instead create a bar plot where each bar represents a country.

In this exercise, you'll create a bar plot comparing the GDP per capita between the two countries in the Oceania continent (Australia and New Zealand).

- Filter for observations in the Oceania continent in the year 1952. Save this as oceania_1952.
- Use the oceania_1952 dataset to create a bar plot, with country on the x-axis and gdpPercap on the y-axis.

```
# Filter for observations in the Oceania continent in 1952
oceania_1952<- gapminder%>% filter(year==1952,continent=="Oceania")

# Create a bar plot of gdpPercap by country
ggplot(oceania_1952,aes(x=country,y=gdpPercap))+geom_col()
```

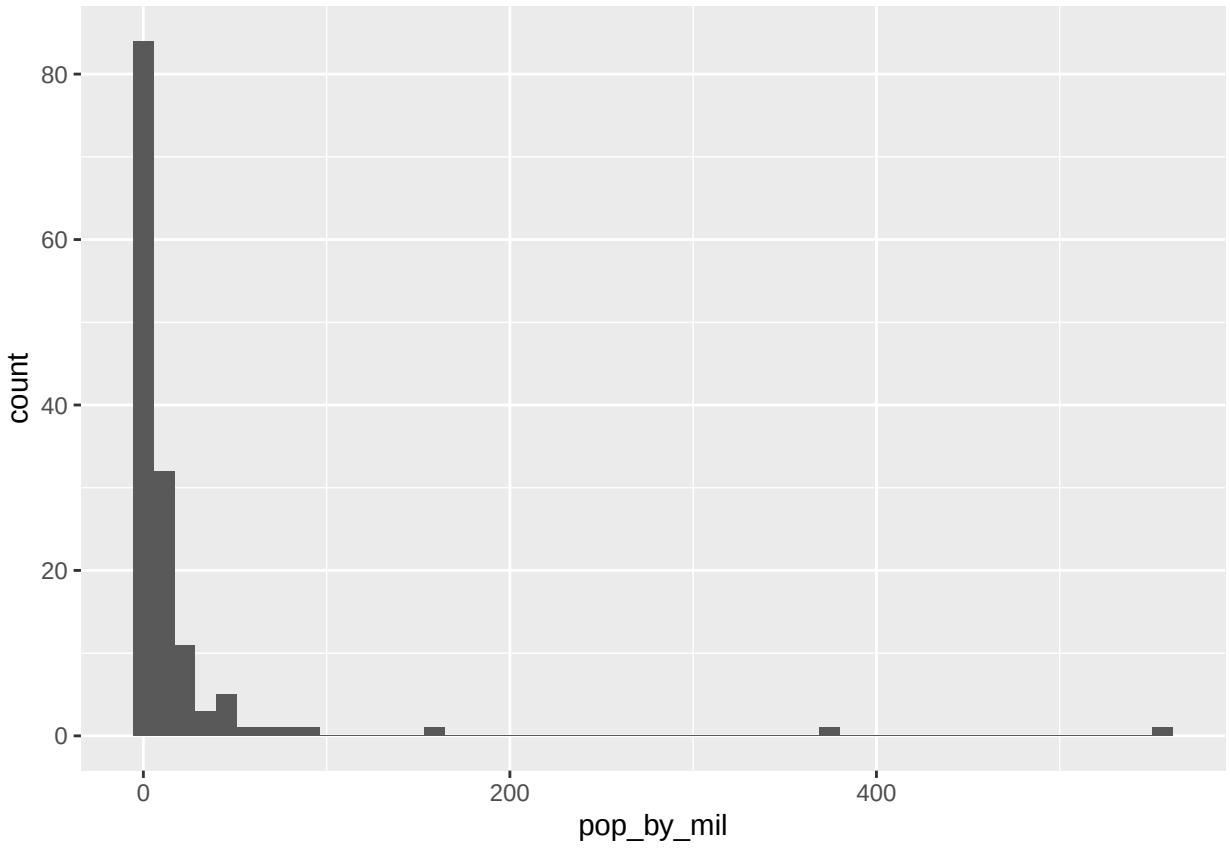


4.5 Visualizing population

A histogram is useful for examining the distribution of a numeric variable. In this exercise, you'll create a histogram showing the distribution of country populations (by millions) in the year 1952.

- Use the gapminder_1952 dataset to create a histogram of country population (pop_by_mil) in the year 1952. Inside the histogram geom, set the number of bins to 50.

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952) %>%
  mutate(pop_by_mil = pop / 1000000)

# Create a histogram of population (pop_by_mil)
ggplot(gapminder_1952, aes(x = pop_by_mil)) +
geom_histogram(bins = 50)
```

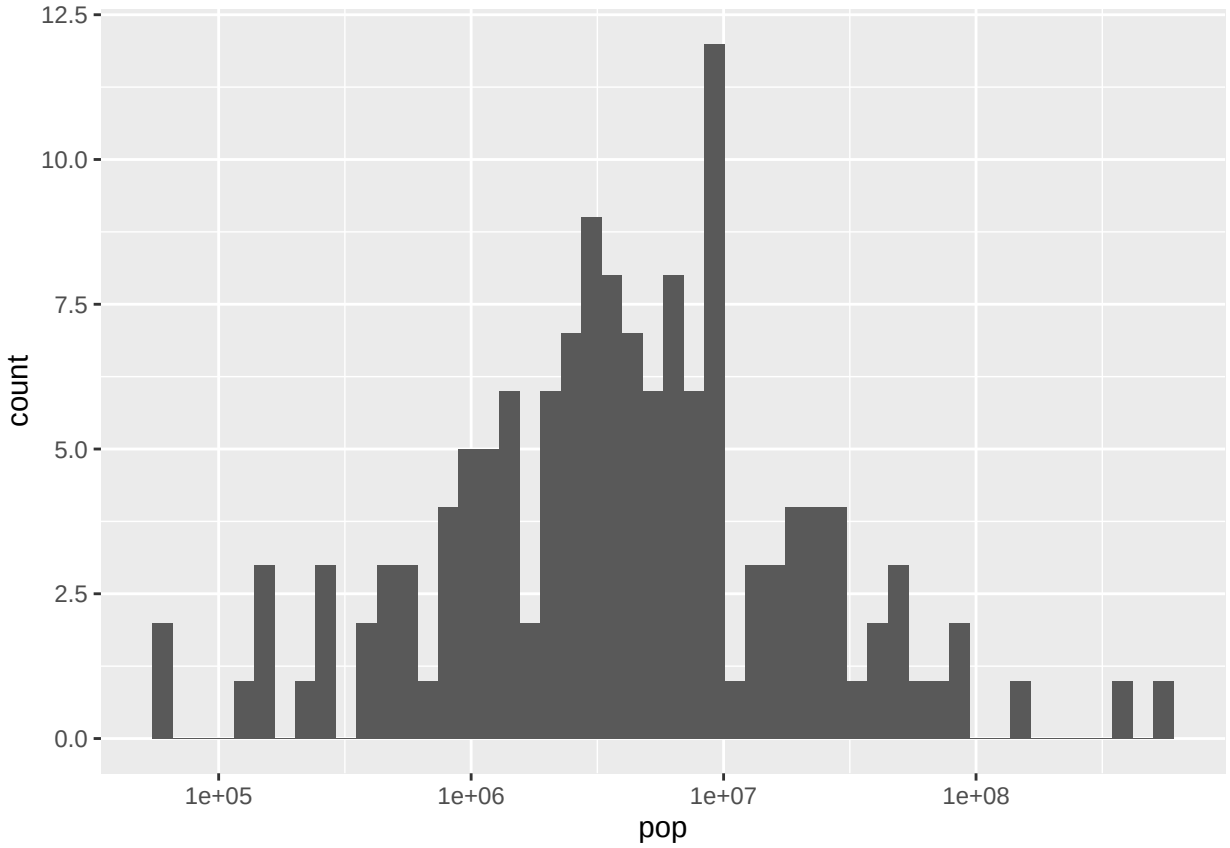


4.6 Visualizing population with x-axis on a log scale

In the last exercise you created a histogram of populations across countries. You might have noticed that there were several countries with a much higher population than others, which causes the distribution to be very skewed, with most of the distribution crammed into a small part of the graph. (Consider that it's hard to tell the median or the minimum population from that histogram).

To make the histogram more informative, you can try putting the x-axis on a log scale. * Use the gapminder_1952 dataset (code is provided) to create a histogram of country population (pop) in the year 1952, putting the x-axis on a log scale with scale_x_log10().

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Create a histogram of population (pop), with x on a log scale
ggplot(gapminder_1952, aes(x = pop)) +
geom_histogram(bins = 50)+scale_x_log10()
```

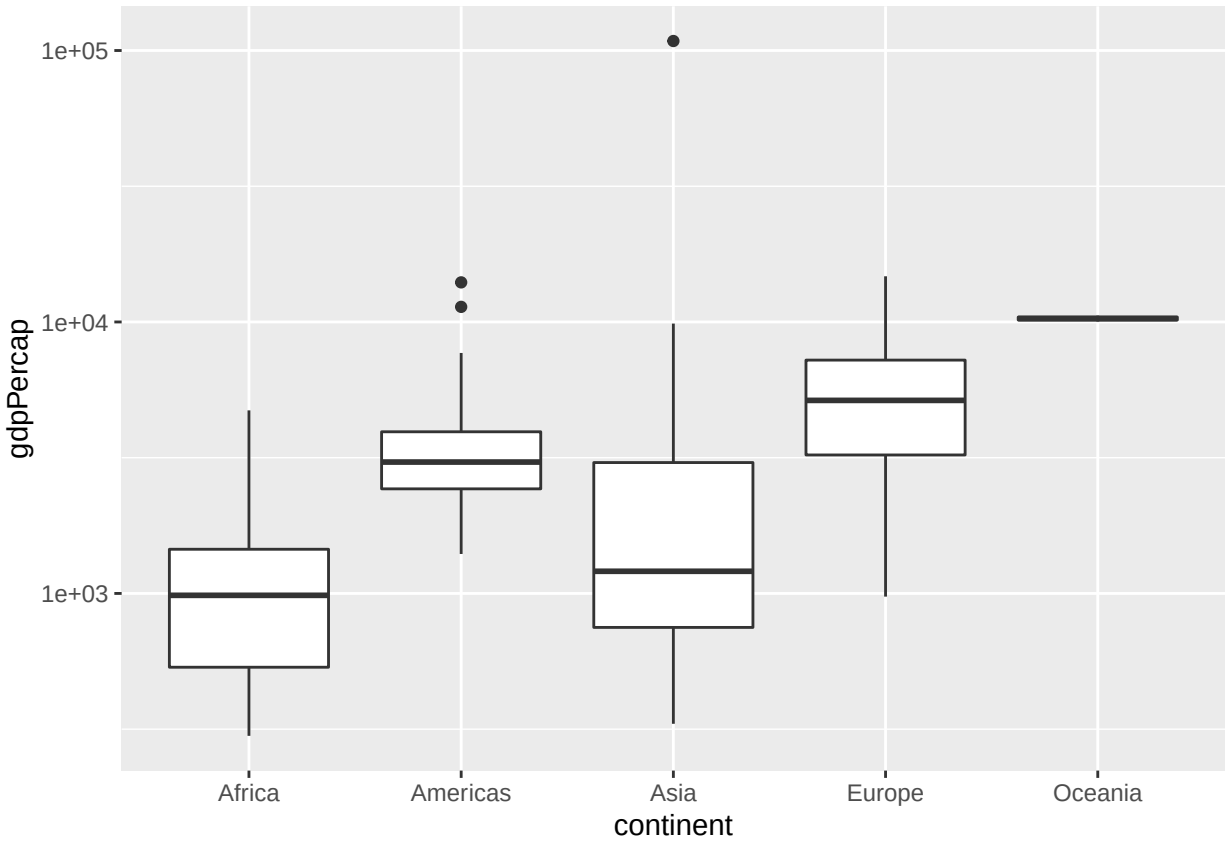


4.7 Comparing GDP per capita across continents

A boxplot is useful for comparing a distribution of values across several groups. In this exercise, you'll examine the distribution of GDP per capita by continent. Since GDP per capita varies across several orders of magnitude, you'll need to put the y-axis on a log scale.

- Use the gapminder_1952 dataset to create a boxplot comparing GDP per capita (gdpPercap) among continents. Put the y-axis on a log scale with scale_y_log10().

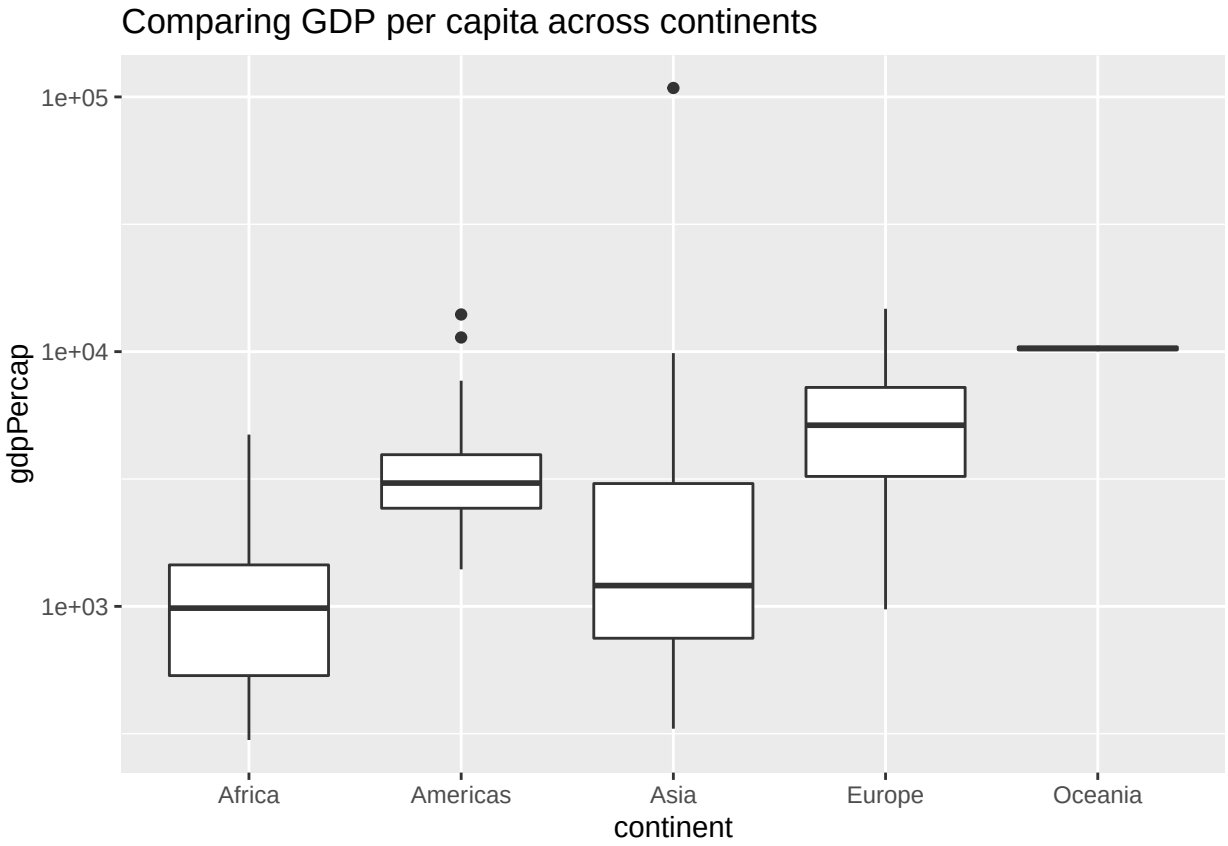
```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Create a boxplot comparing gdpPercap among continents
ggplot(gapminder_1952, aes(x = continent, y = gdpPercap)) +
geom_boxplot()+scale_y_log10()
```



Can you try adding a title to the Graph??

Here we go:

```
gapminder_1952 <- gapminder %>%
  filter(year == 1952)

# Add a title to this graph: "Comparing GDP per capita across continents"
ggplot(gapminder_1952, aes(x = continent, y = gdpPercap)) +
  geom_boxplot() +
  scale_y_log10()+ ggtitle("Comparing GDP per capita across continents")
```


Comparing GDP per capita across continents
1e+05
1e+04
1e+03
gdpPercap
Africa
Americas
Asia
Europe
Oceania
continent