Continuous Variables (Chapter 3)

Prof. Joyce Robbins

Continuous Variables

We’re looking for features such as:

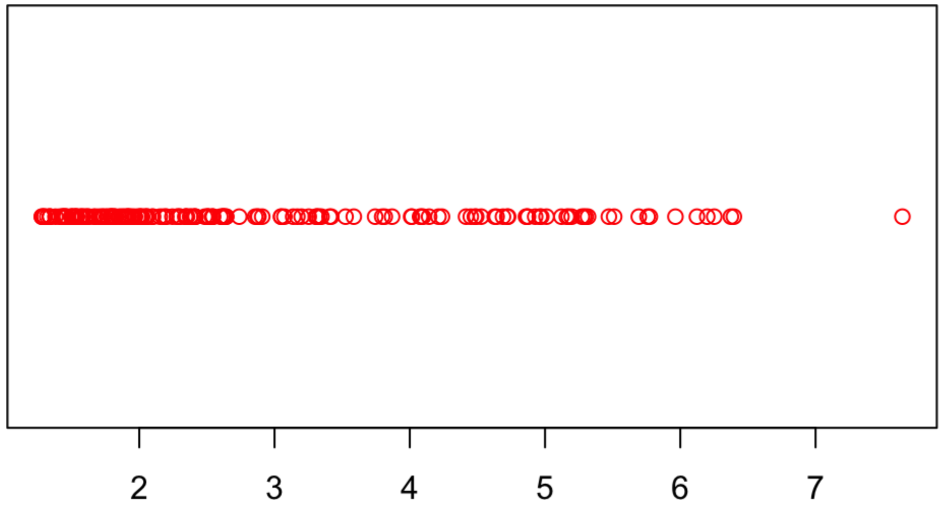
- Asymmetry
- Outliers
- Multimodality
- Gaps
- Heaping
- Rounding
- Impossibilities / Errors

Basic Options

- Stripcharts / rug plot
- Stem and leaf plot
- Dotplots
- Histogram / density curve
- Boxplot

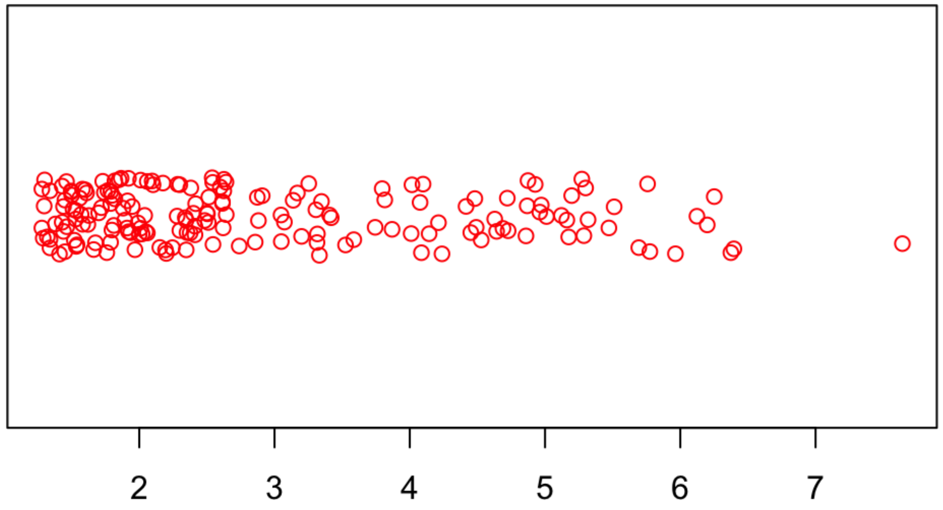
Strip charts

```
par(las = 1) # for all chunks since global.par set to TRUE above
world <- read.csv("countries2012.csv")
stripchart(world$TFR, col = "red", pch = 21)
```



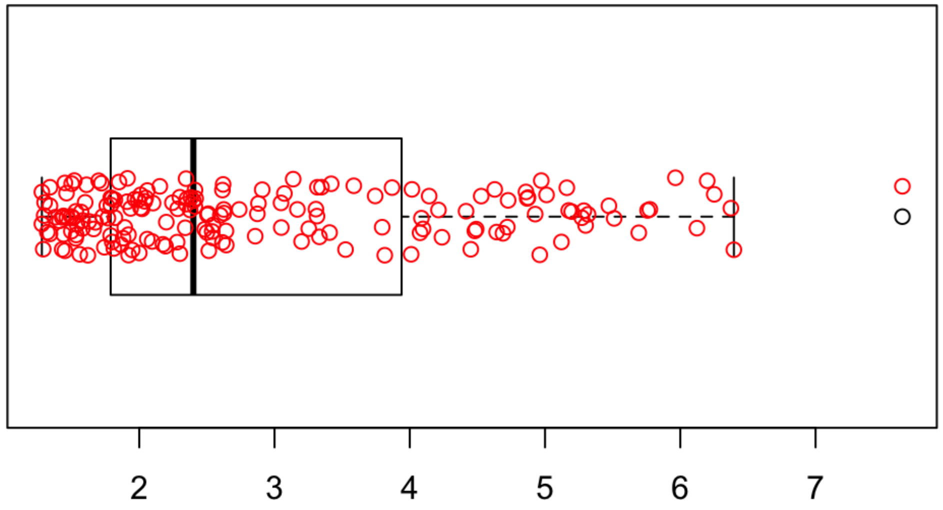
Strip charts

```
stripchart(world$TFR, col = "red", pch = 21,
           method = "jitter")
```



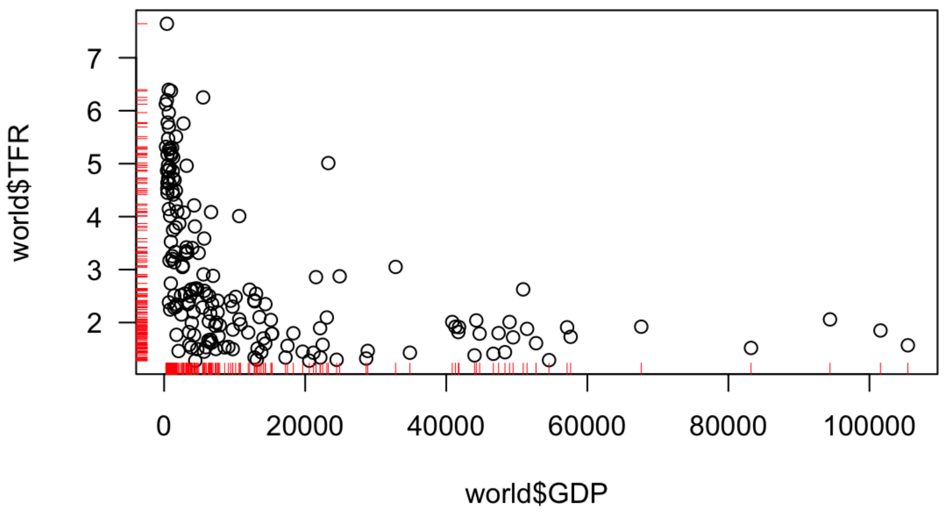
Strip charts w/ boxplot

```
boxplot(world$TFR, horizontal = TRUE)
stripchart(world$TFR, col = "red", pch = 21, add = TRUE, method = "jitter")
```



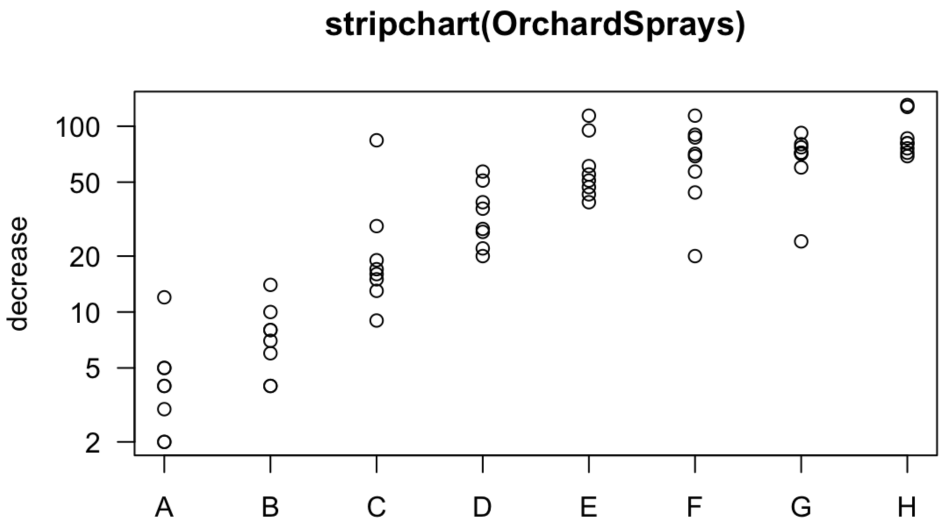
Rug plot

```
plot(world$GDP, world$TFR)
rug(world$GDP, col = "red")
rug(world$TFR, col = "red", side = 2)
```



Strip charts

```
stripchart(decrease ~ treatment,
    main = "stripchart(OrchardSprays)",
    vertical = TRUE, log = "y",
    data = OrchardSprays, pch = 21)
```



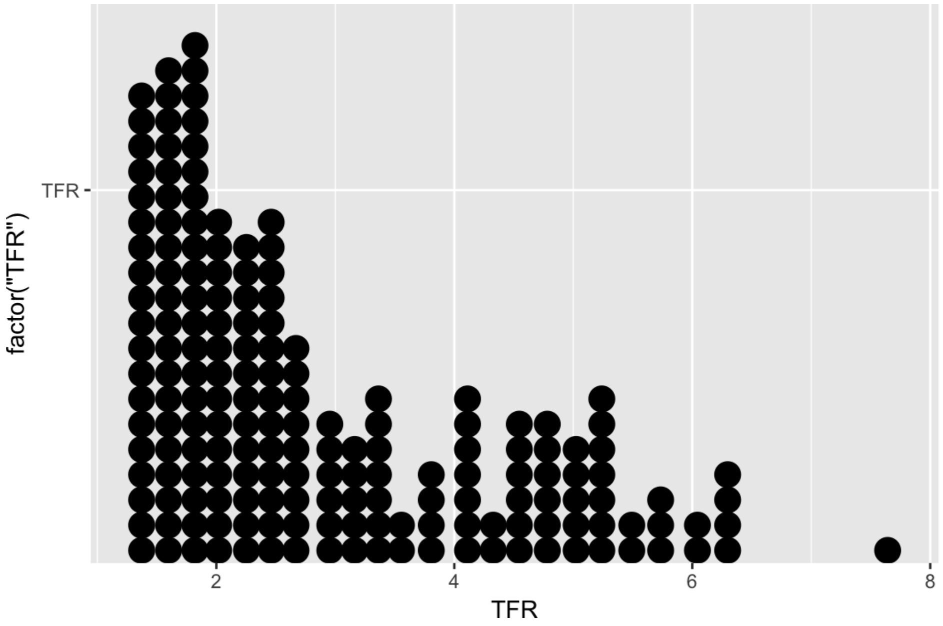
Stem and leaf plot

```r
prices <- c(379, 425, 450, 450, 499, 529, 535, 535, 545, 599, 665, 675, 699, 699, 725, 725, 745, 799)
stem(prices)
```

```
##
##   The decimal point is 2 digit(s) to the right of the |
##
##   3 | 8
##   4 | 355
##   5 | 03445
##   6 | 078
##   7 | 00335
##   8 | 0
```

Dot plot

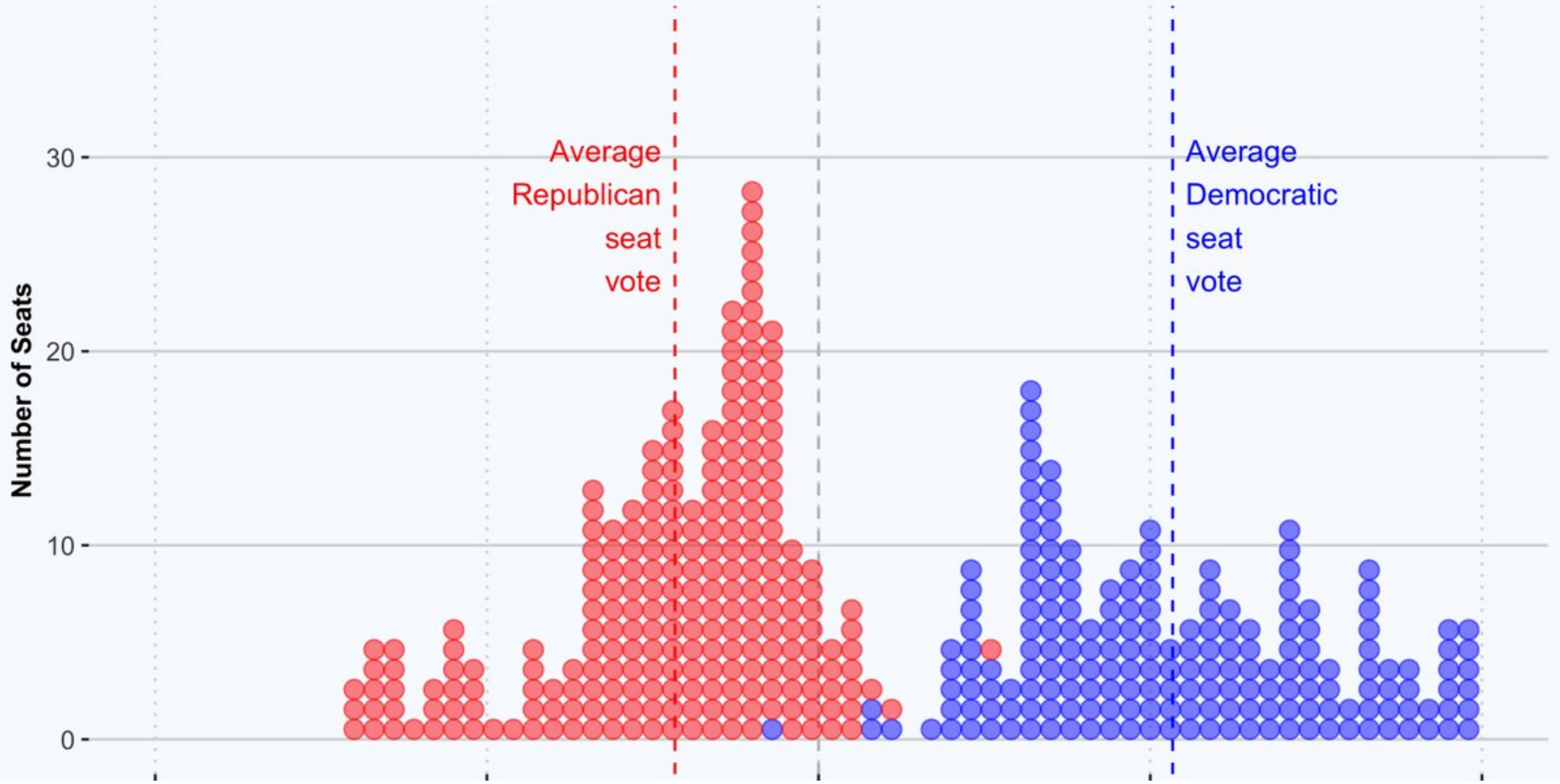
```
library(ggplot2)
ggplot(world, aes(TFR, y = factor("TFR"))) +
    geom_dotplot()
```



2018 Congressional Race

More Republicans than Democrats are Vulnerable in 2018 House Elections

Forecast 2018 House elections show big potential fore Democratic landslide, little for Republicans. If we underestimate Democrats by 3% nationally, they could have an historic wave midterm. But if Republicans overperform by 3%, they gain just 10 seats.



*Forecast comes from thecrosstab.com/2018-midterms-forecast/

@GElliottMorris | TheCrosstab.com | George Elliott Morris

Histograms

- primary tool for continuous data
- boundary issues
- count / relative frequency / density histograms
- unequal binwidth histograms
- importance of binwidth
- using `ggvis` to interactively adjust binwidths

How are histograms created?

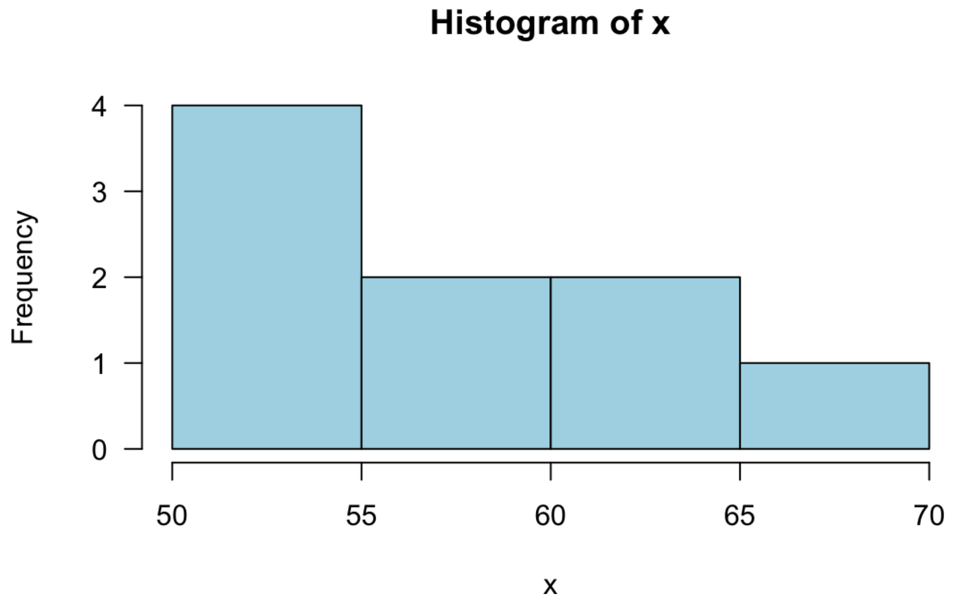
Draw a histogram on paper of the following data.

(use binwidth = 5)

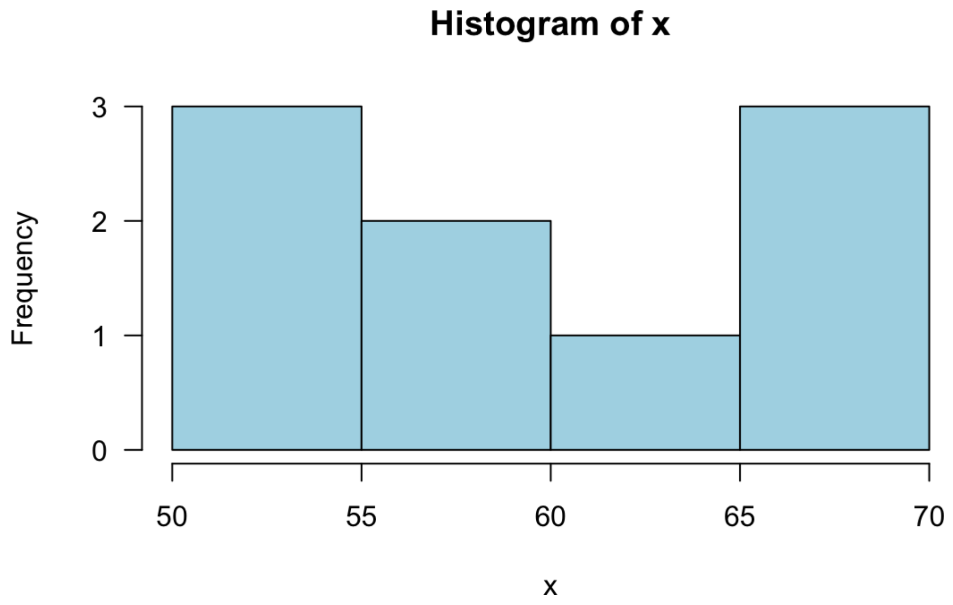
50, 51, 53, 55, 56, 60, 65, 65, 68

How are histograms created?

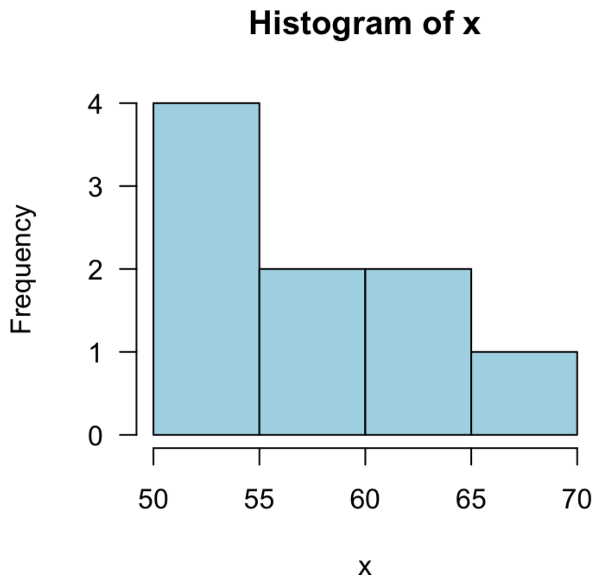
```
par(las = 1)  # opts_knit$set(global.par = TRUE) above
x <- c(50, 51, 53, 55, 56, 60, 65, 65, 68)
hist(x, col = "lightblue")
```

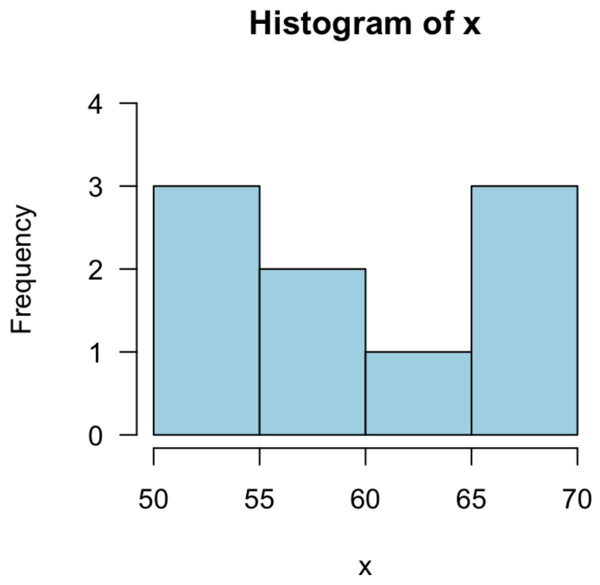


How are histograms created?



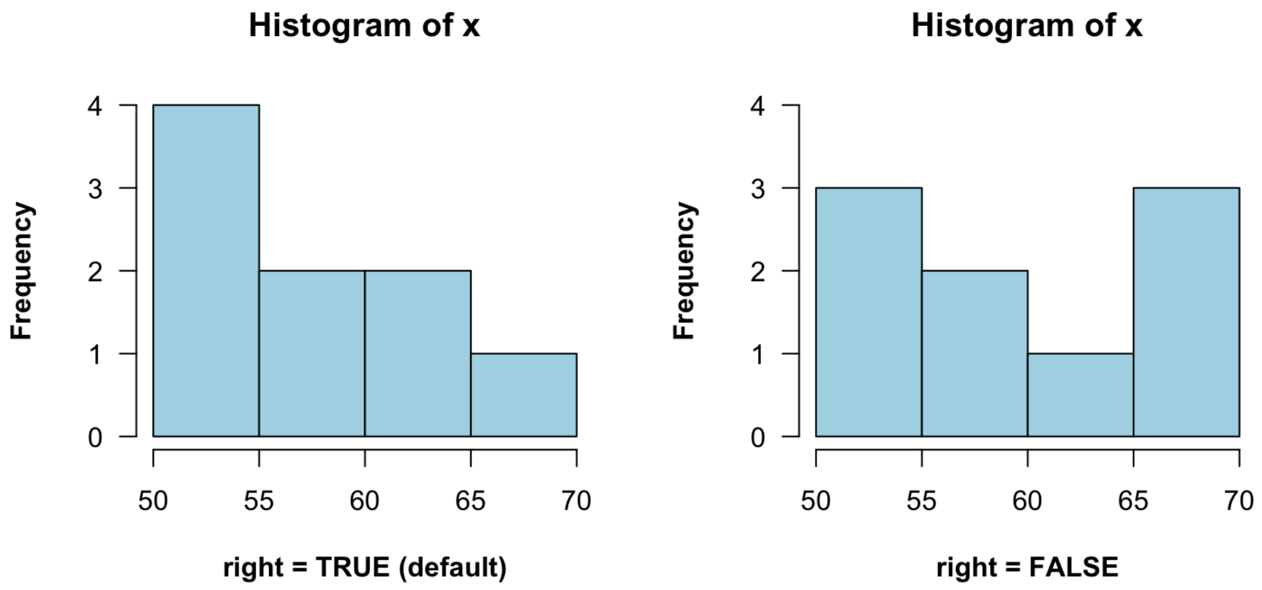
What is causing the difference?





Bin boundaries

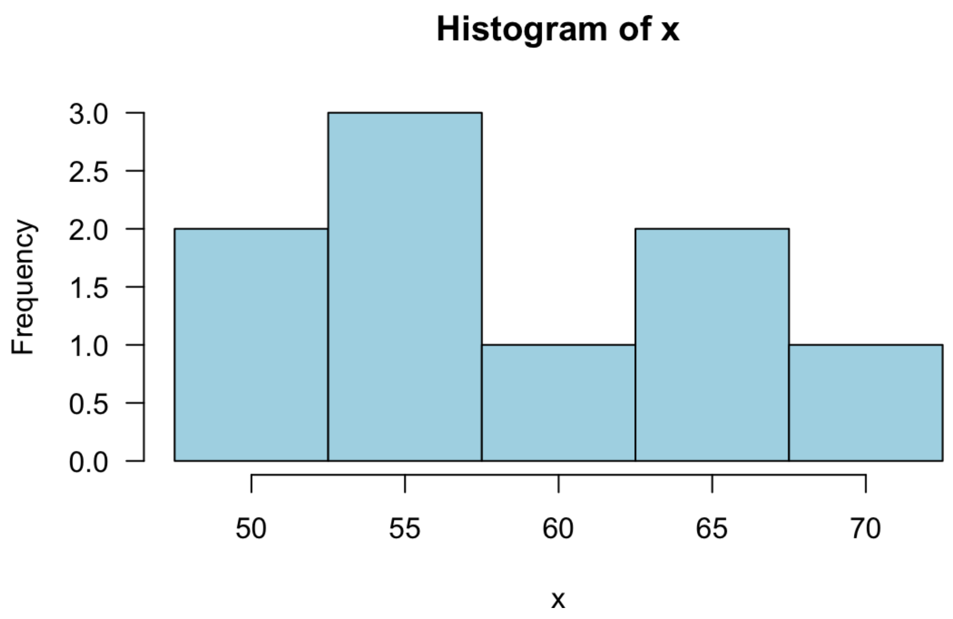
```
op <- par(mfrow = c(1, 2), las = 1)
hist(x, col = "lightblue", ylim = c(0, 4),
     xlab = "right = TRUE (default)", font.lab = 2)
hist(x, col = "lightblue", right = FALSE, ylim = c(0, 4),
     xlab = "right = FALSE", font.lab = 2)
```



```
par(op)
```

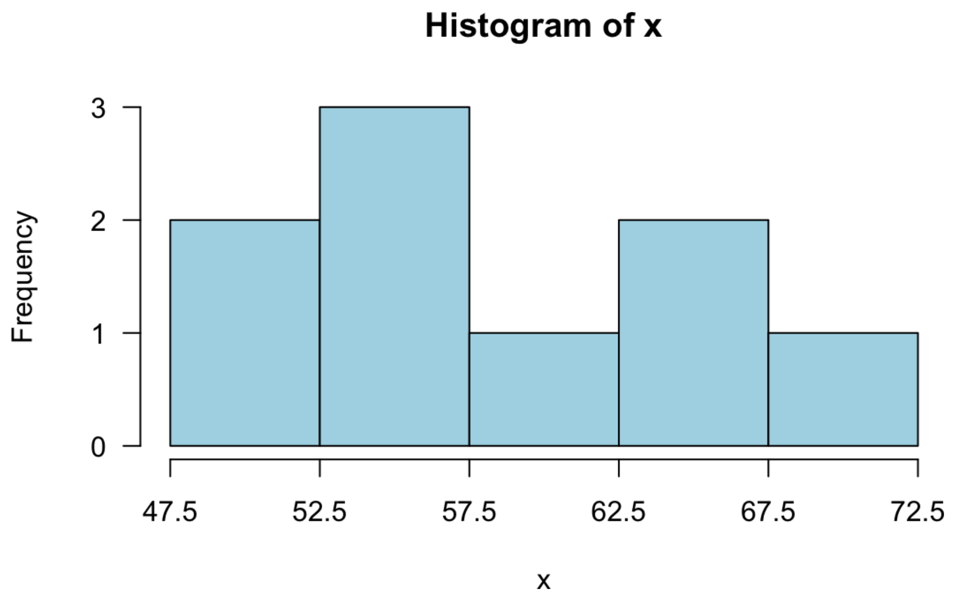
Bin boundaries

```
hist(x, breaks = seq(47.5, 72.5, 5), col = "lightblue")
```



Bin boundaries

```r
# presentation issues
hist(x, breaks = seq(47.5, 72.5, 5), col = "lightblue",
     axes = FALSE)
axis(1, at = seq(47.5, 72.5, 5))
axis(2, at = 0:3)
```



Frequency, Relative Frequency, Density

mids	freq	relfreq	density
350	1	0.05556	0.00056
450	4	0.22222	0.00222
550	5	0.27778	0.00278
650	4	0.22222	0.00222
750	4	0.22222	0.00222

- the sum of relative frequencies is 1
- the sum of densities x binwidth is 1

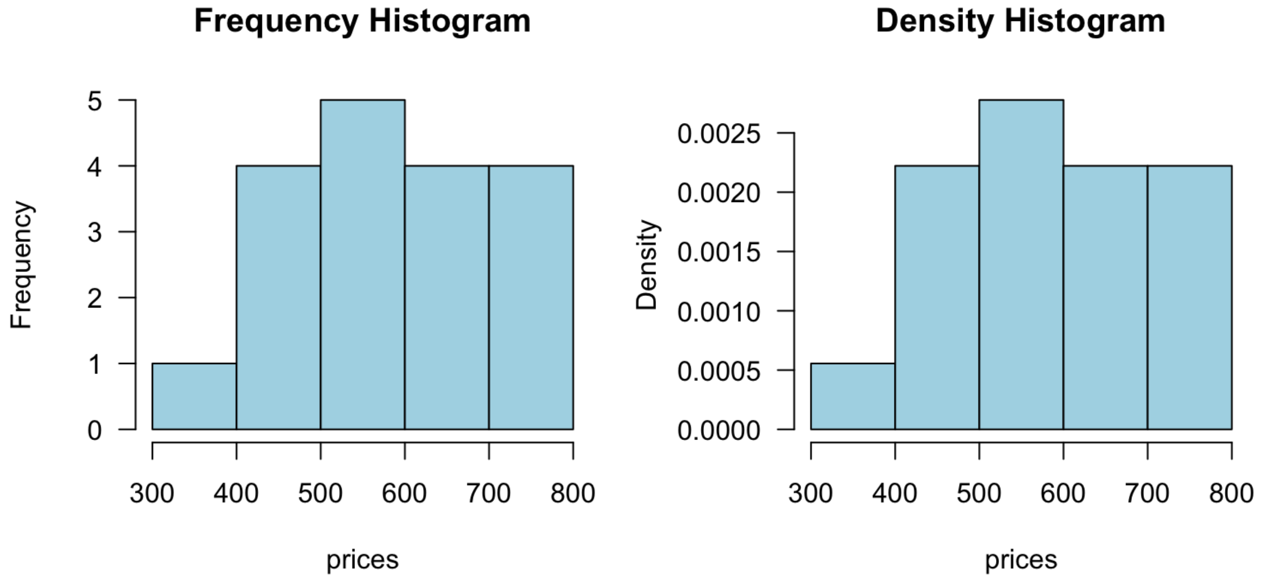
Frequency, Relative Frequency, Density

```
x <- hist(prices, breaks = seq(300, 800, 100), plot = FALSE)
x
```

```
## $breaks
## [1] 300 400 500 600 700 800
##
## $counts
## [1] 1 4 5 4 4
##
## $density
## [1] 0.00055556 0.00222222 0.00277778 0.00222222 0.00222222
##
## $mids
## [1] 350 450 550 650 750
##
## $xname
## [1] "prices"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
```

Frequency vs. Density Histogram (`freq = FALSE`)

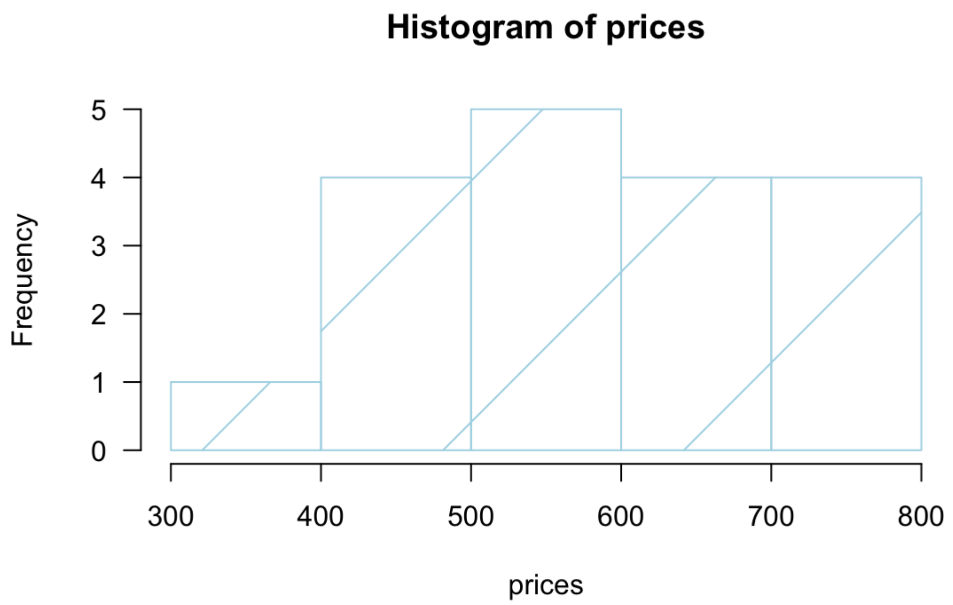
```r
oldpar <- par(mfrow = c(1, 2), las = 1)
hist(prices, breaks = c(300, 400, 500, 600, 700, 800),
     col = "lightblue", main = "Frequency Histogram")
hist(prices, breaks = c(300, 400, 500, 600, 700, 800),
     freq = FALSE, col = "lightblue", ylab = "",
     main = "Density Histogram")
mtext("Density", side = 2, line = 4, las = 3)
```



```r
par(oldpar)
```

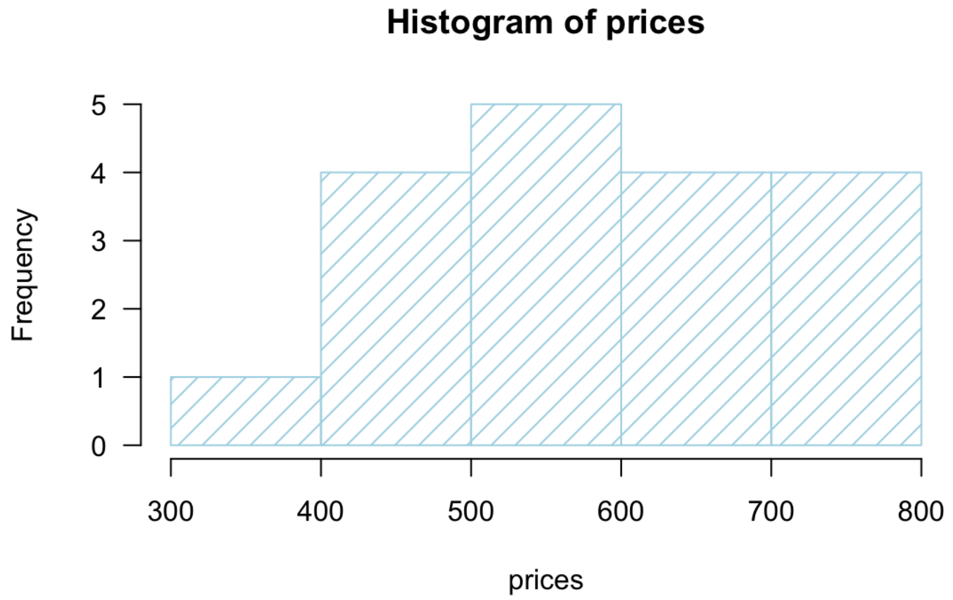
Don’t use `density = TRUE`

```
hist(prices, breaks = seq(300, 800, 100), col = "lightblue",
     density = TRUE)
```



Don’t use `density = TRUE`

```
hist(prices, breaks = seq(300, 800, 100), col = "lightblue",
     density = 10)
```

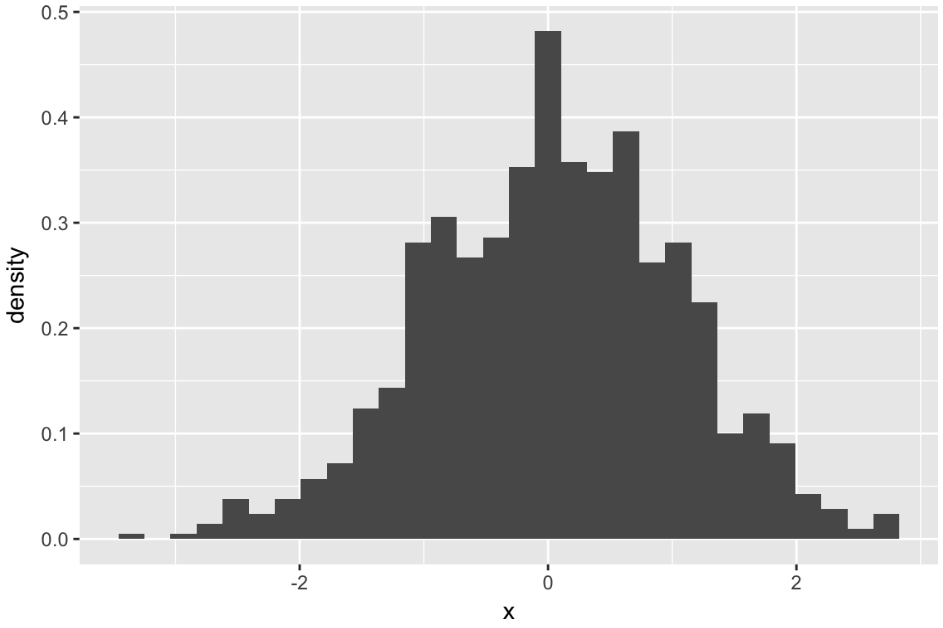


```
sum(TRUE)
```

```
## [1] 1
```

Density histogram `ggplot2`

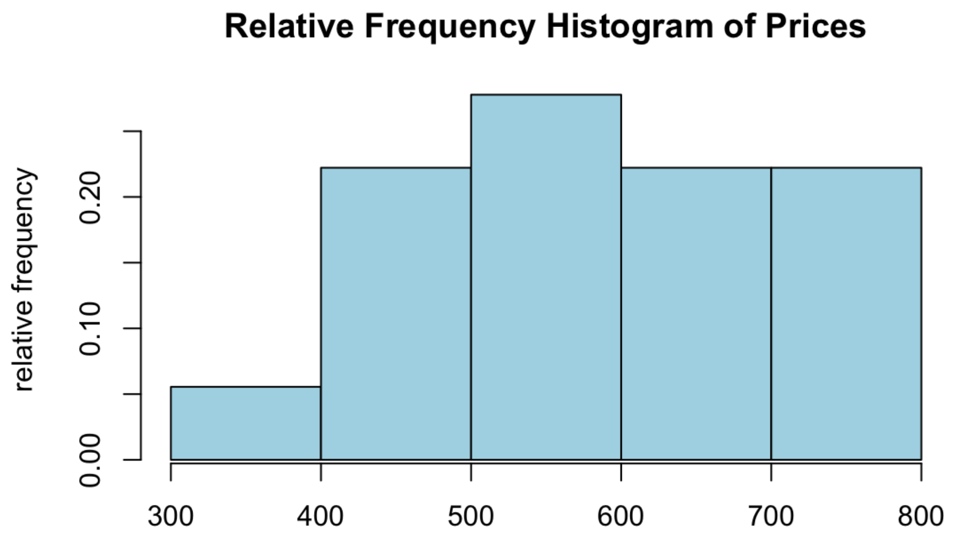
```
df2 <- data.frame(x = rnorm(1000))
ggplot(df2, aes(x, y = ..density..)) + geom_histogram()
```



Relative frequency histogram

Method # 1 Use `barplot()`

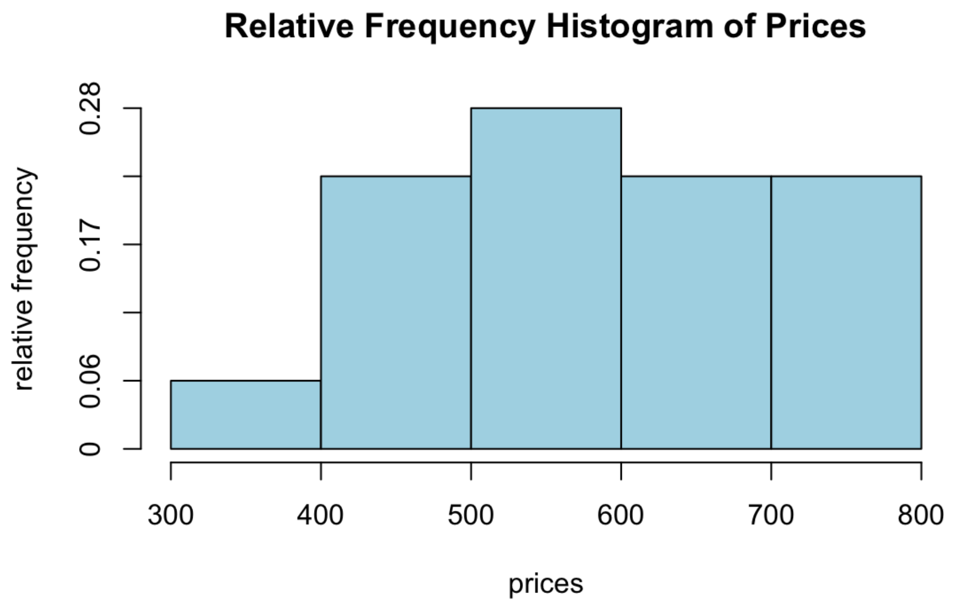
```
x <- barplot(df$relfreq, space = 0, col = "lightblue",
             ylab = "relative frequency")
# axis(1) to see the scale on the x-axis
axis(1, at = 0:5, labels = seq(300, 800, 100))
title("Relative Frequency Histogram of Prices")
```



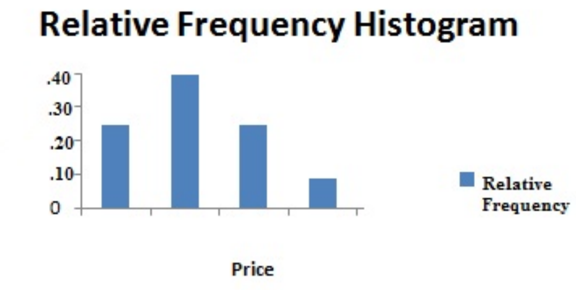
Relative frequency histogram

Method # 2 Use `hist()` and change the y-axis tick mark labels… but be careful!!

```
hist(prices, breaks = c(300, 400, 500, 600, 700, 800),
     col = "lightblue", yaxt = "n",
     ylab = "relative frequency",
     main = "Relative Frequency Histogram of Prices")
axis(2, at = 0:5, labels = round((0:5)/18,2))
```



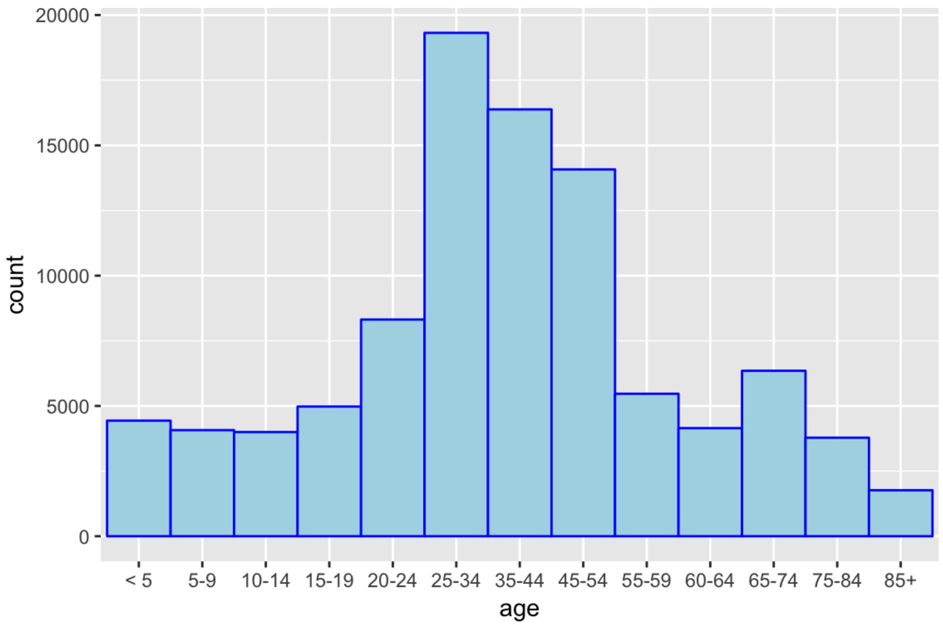
Example from the web



Source: http://www.statisticshowto.com/relative-frequency-histogram-2/

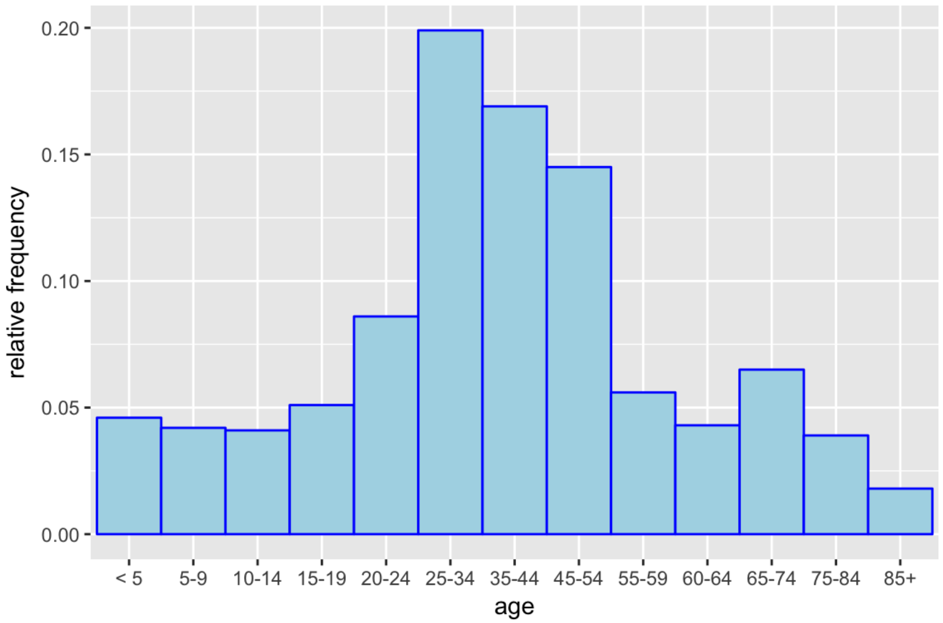
What’s wrong with this histogram?

```
# Use geom_col since we already have frequency counts
# This is an example of what not to do
df <- read.csv("zip10027census2000.csv")
df$age <- factor(df$age, levels = df$age)
g0 <- ggplot(df, aes(x = age, y = pop)) +
    geom_col(width = 1, color = "blue", fill = "lightblue") +
    ylab("count")
g0
```



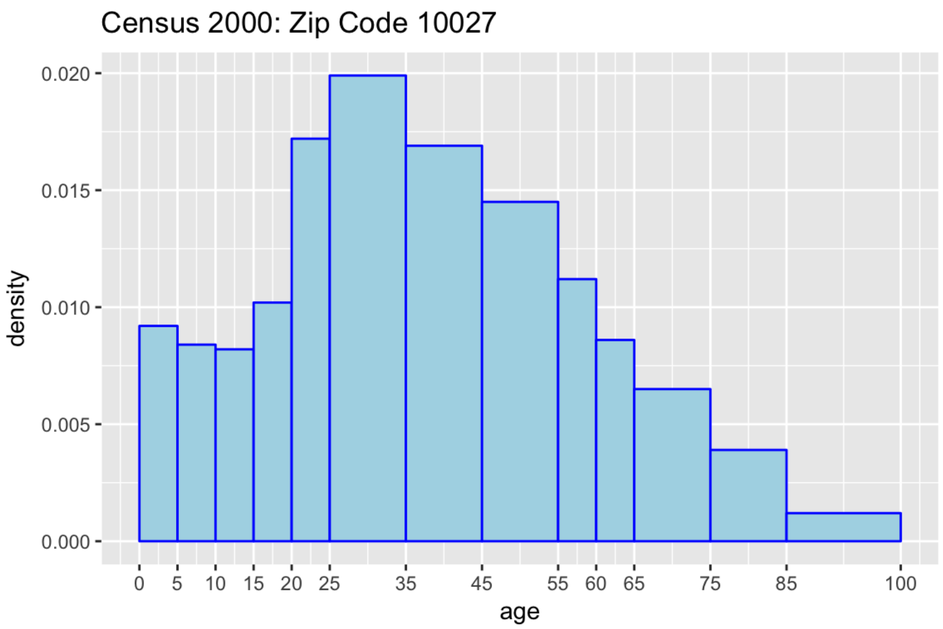
Relative frequency histogram

```
# Doesn't fix the problem
ggplot(df, aes(x = age, y = percent/100)) +
    geom_col(width = 1, color = "blue", fill = "lightblue") +
    ylab("relative frequency")
```



Density histogram with unequal bin (or class) widths

```
g2 <- ggplot(df, aes(x = center, y = percent/(100*binwidth),
               width = binwidth)) +
    geom_col(color = "blue", fill = "lightblue") +
    ylab("density") + xlab("age") +
    scale_x_continuous(breaks = c(0, df$breaks)) +
    ggtitle("Census 2000: Zip Code 10027")
g2
```



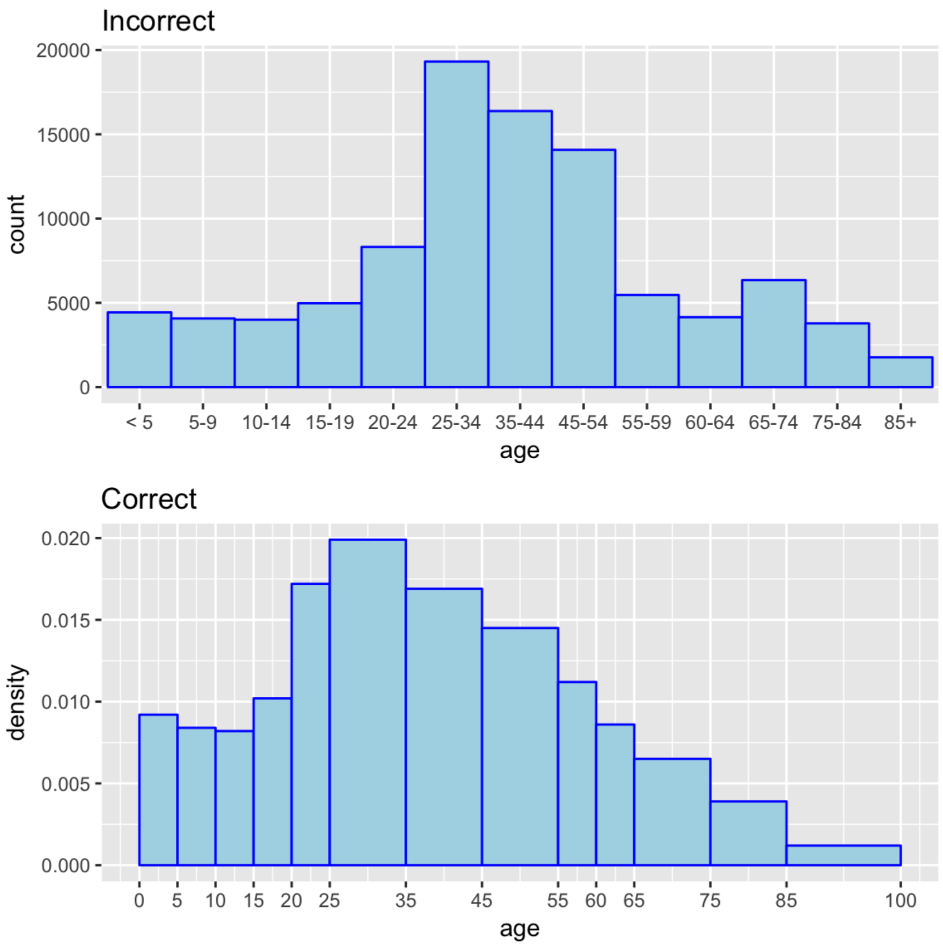
Density = RelFreq / Binwidth

```
library(dplyr)
kdf <- df %>% transmute(Class = age, Frequency = pop,
                        RelFreq = round(pop/sum(pop),3),
                        ClassWidth = binwidth,
                        Density = round(RelFreq/ClassWidth,3))
knitr::kable(kdf)
```

Class	Frequency	RelFreq	ClassWidth	Density
< 5	4435	0.046	5	0.009
5-9	4072	0.042	5	0.008
10-14	3999	0.041	5	0.008
15-19	4977	0.051	5	0.010
20-24	8316	0.086	5	0.017
25-34	19317	0.199	10	0.020
35-44	16380	0.169	10	0.017
45-54	14077	0.145	10	0.014
55-59	5467	0.056	5	0.011
60-64	4148	0.043	5	0.009
65-74	6350	0.065	10	0.007
75-84	3781	0.039	10	0.004
85+	1767	0.018	15	0.001

Compare the histograms

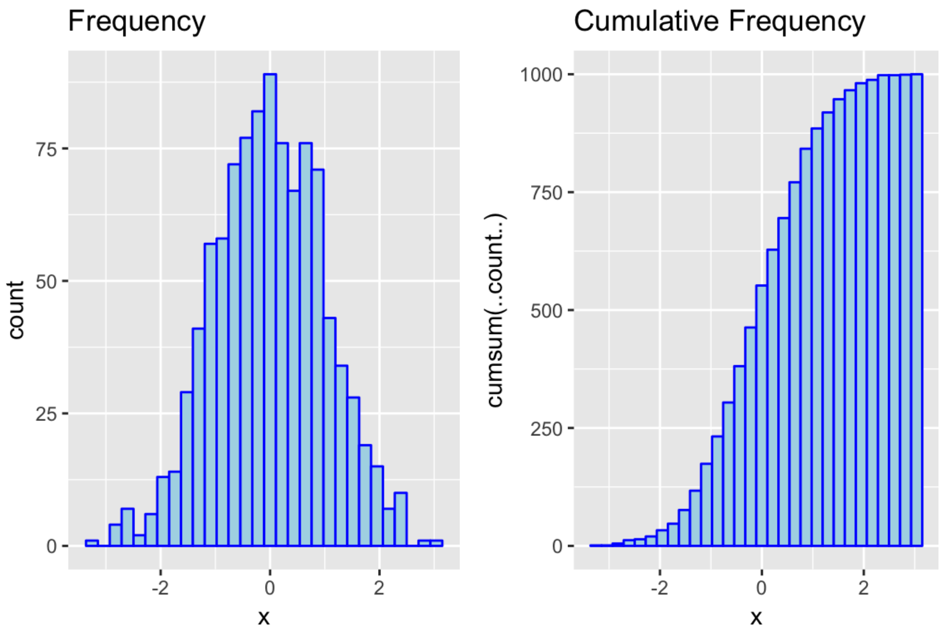
```
library(gridExtra)
grid.arrange(g0 + ggtitle ("Incorrect"),
             g2 + ggtitle ("Correct"))
```



Source: https://factfinder.census.gov/

Cumulative frequency histogram

```
df <- data.frame(x = rnorm(1000))
g1 <- ggplot(df, aes(x = x)) +
    geom_histogram(color = "blue", fill = "lightblue") +
    ggtitle ("Frequency")
g2 <- ggplot(df, aes(x = x)) +
    geom_histogram(aes(y = cumsum(..count..)),
                   color = "blue", fill = "lightblue") +
    ggtitle("Cumulative Frequency")
grid.arrange(g1, g2, nrow = 1)
```

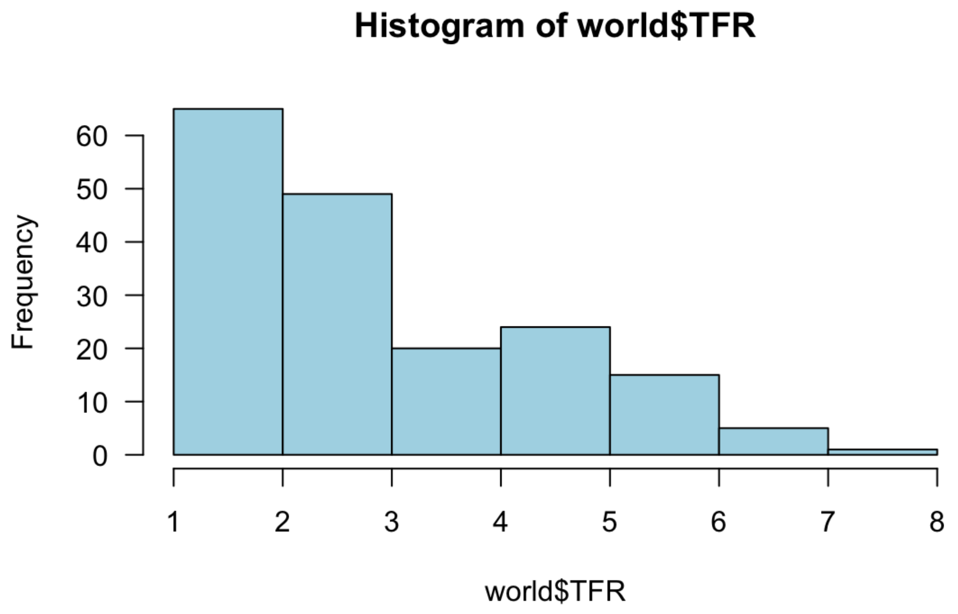


Binwidth

```
  'stat_bin()' using 'bins = 30'. Pick better
  value with 'binwidth'.
```

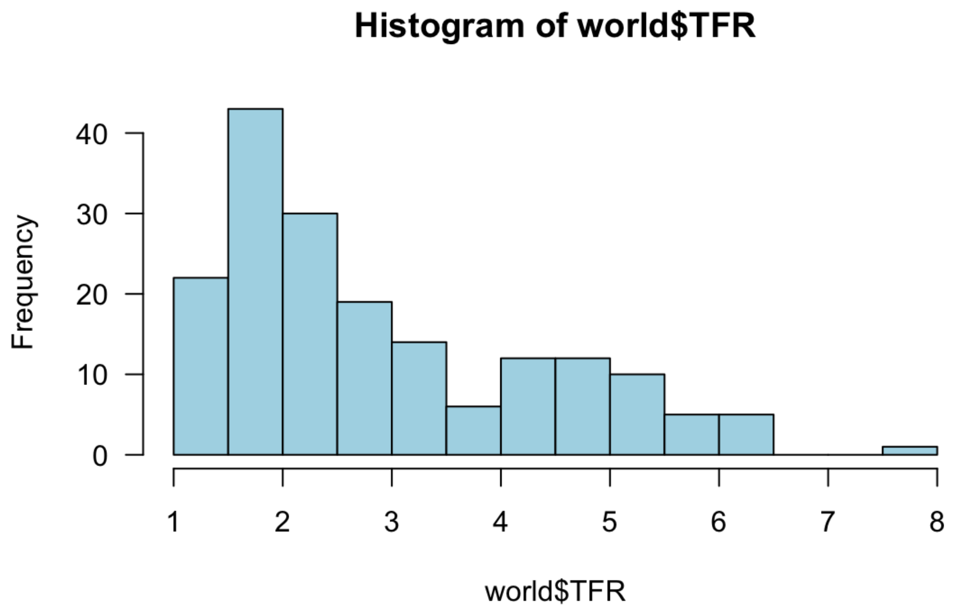
Histograms

```r
hist(world$TFR, col = "lightblue")
```



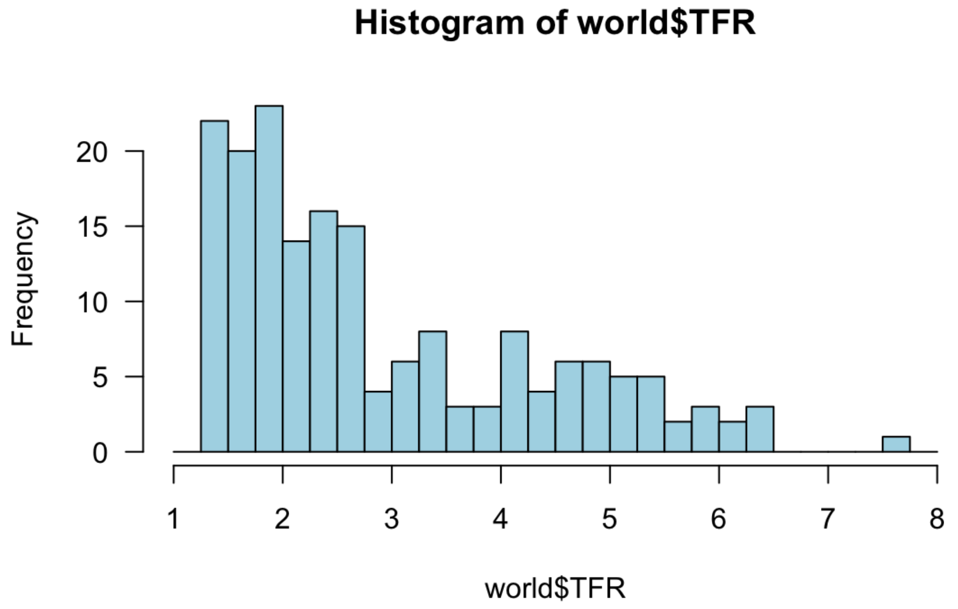
Histograms

```r
hist(world$TFR, col = "lightblue", breaks = 10)
```



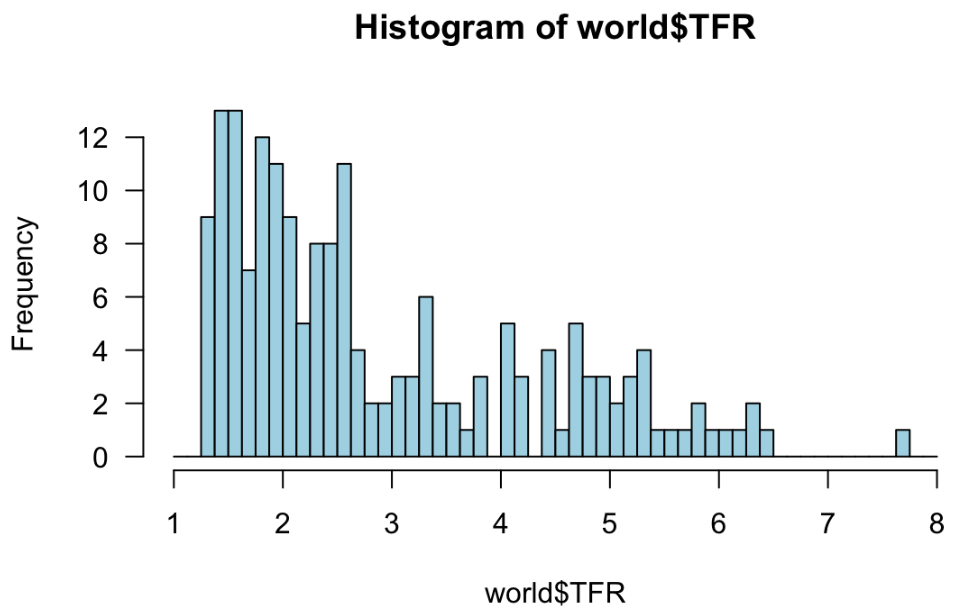
Histograms

```
hist(world$TFR, col = "lightblue",
     breaks = seq(1 , 8, .25))
```



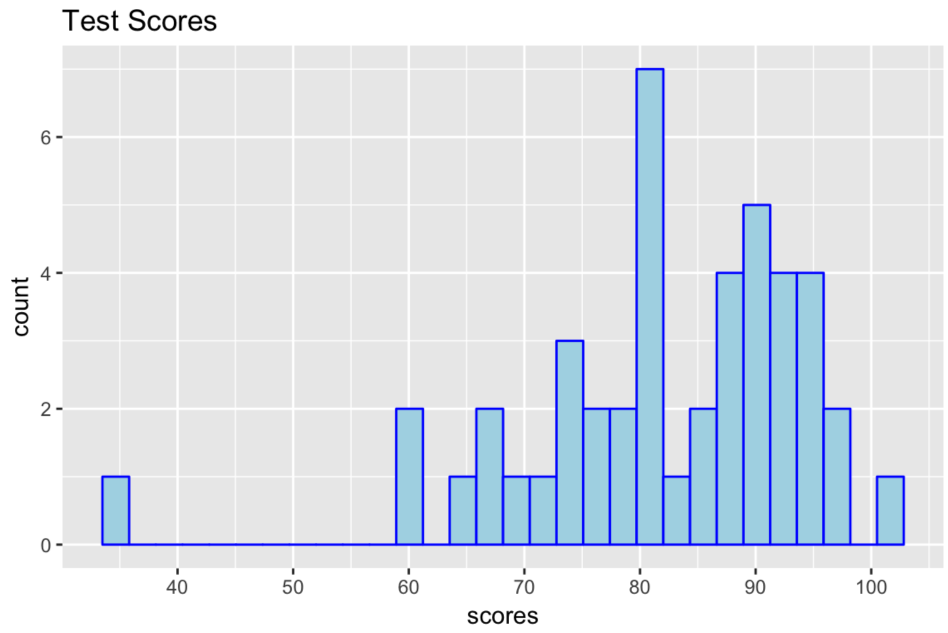
Histograms

```
hist(world$TFR, col = "lightblue",
     breaks = seq(1 , 8, .125))
```



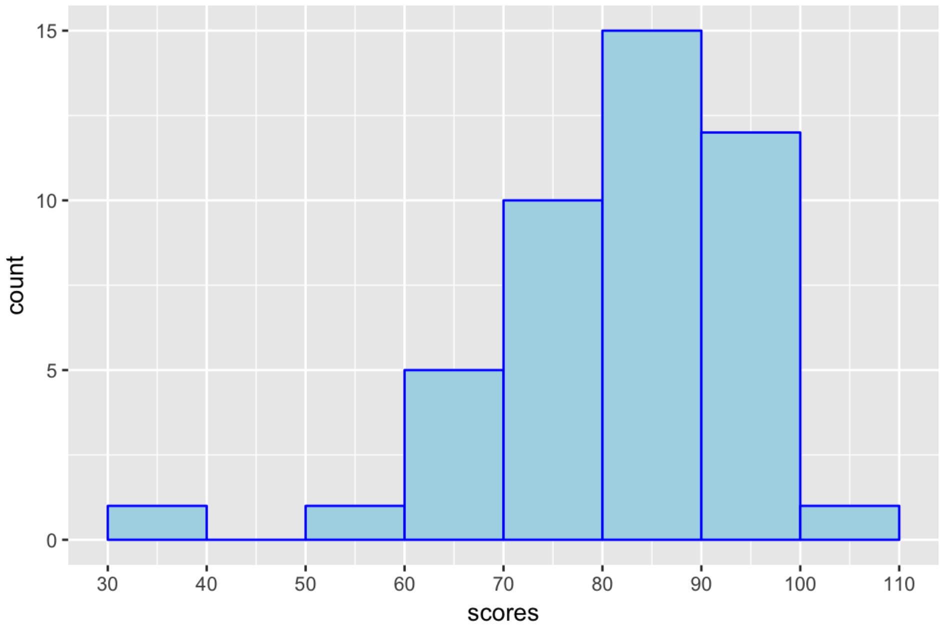
Histograms

```
df <- data.frame(scores = c(35, 59, 61, 64, 66, 66, 70, 72, 73, 74,
                            75, 76, 76, 78, 79, 80, 80, 81, 81, 82,
                            82, 82, 84, 86, 86, 88, 88, 88, 88, 89,
                            89, 90, 91,91, 92, 92, 92, 92, 94, 94,
                            94, 94, 96, 98, 102))
ggplot(df, aes(x = scores)) +
    geom_histogram(color = "blue", fill = "lightblue") +
    scale_x_continuous(breaks = seq(30, 100, 10)) +
    ggtitle("Test Scores")
```



Fewer bins

```
ggplot(df, aes(x = scores)) +
    geom_histogram(color = "blue", fill = "lightblue",
                   breaks = seq(30, 110, 10)) +
        scale_x_continuous(breaks = seq(30, 110, 10))
```



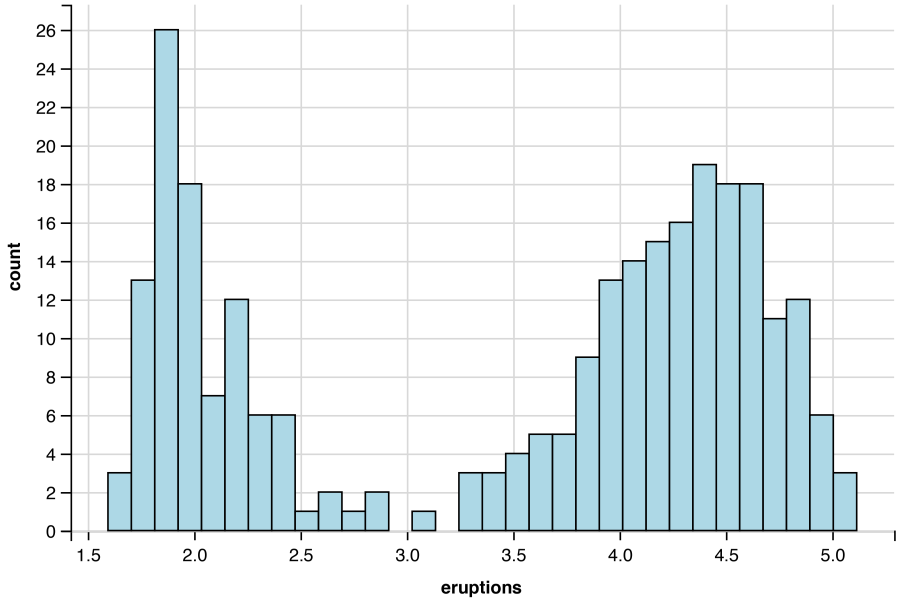
ggvis

- built w/ Vega, Shiny
- Vega <– D3 + …
- Shiny <– R + web (HTML, CSS, SVG, JavaScript)
- code looks like `ggplot2` + `dplyr`
- best use: EDA
- More info, tutorials: https://ggvis.rstudio.com/

ggvis

```
library(ggvis)
faithful %>% ggvis(~eruptions) %>%
    layer_histograms(fill := "lightblue",
                     width = input_slider(0.01, 1,
                                          value = .1,
                                          step = .1,
                                          label = "width"))
```

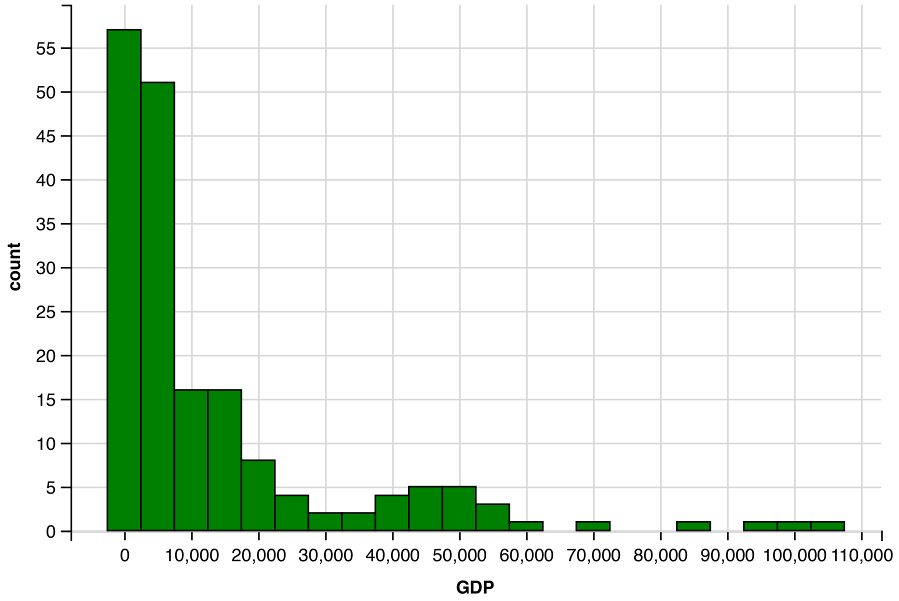
```
## Warning: Can't output dynamic/interactive ggvis plots in a knitr document.
## Generating a static (non-dynamic, non-interactive) version of the plot.
```



GDP

```
df <-read.csv("countries2012.csv")
df %>% ggvis(~GDP) %>%
    layer_histograms(fill := "green",
                     width = input_slider(500, 10000,
                                          value = 5000,
                                          step = 500,
                                          label = "width"))
```

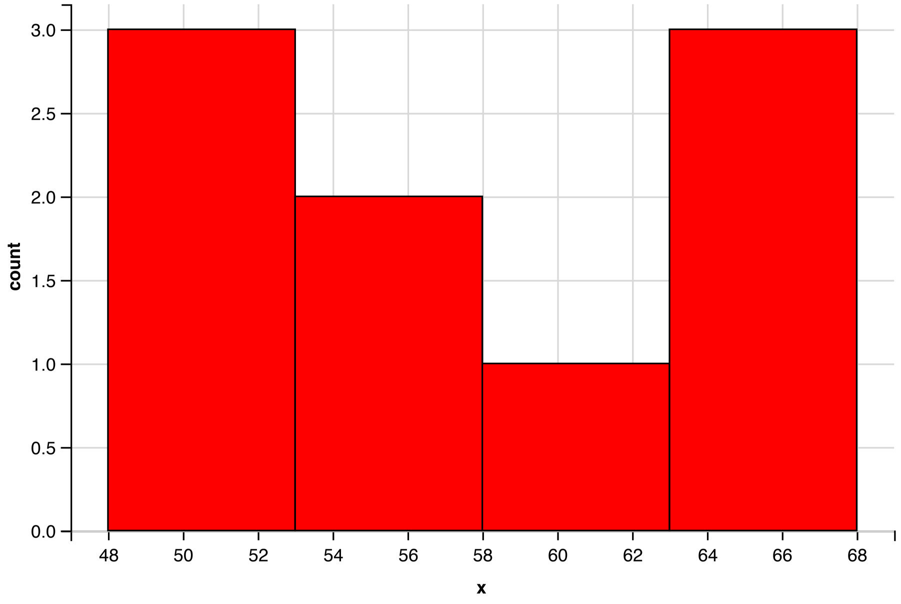
```
## Warning: Can't output dynamic/interactive ggvis plots in a knitr document.
## Generating a static (non-dynamic, non-interactive) version of the plot.
```



Center

```
df <- data.frame(x = c(50, 51, 53, 55, 56, 60, 65, 65, 68))
df %>% ggvis(~x) %>%
    layer_histograms(fill := "red",
                     width = input_slider(1, 10,
                                          value = 5,
                                          step = 1,
                                          label = "width"),
                     center = input_slider(0, 1,
                                           value = .5,
                                           step = .5,
                                           label = "center"))
```

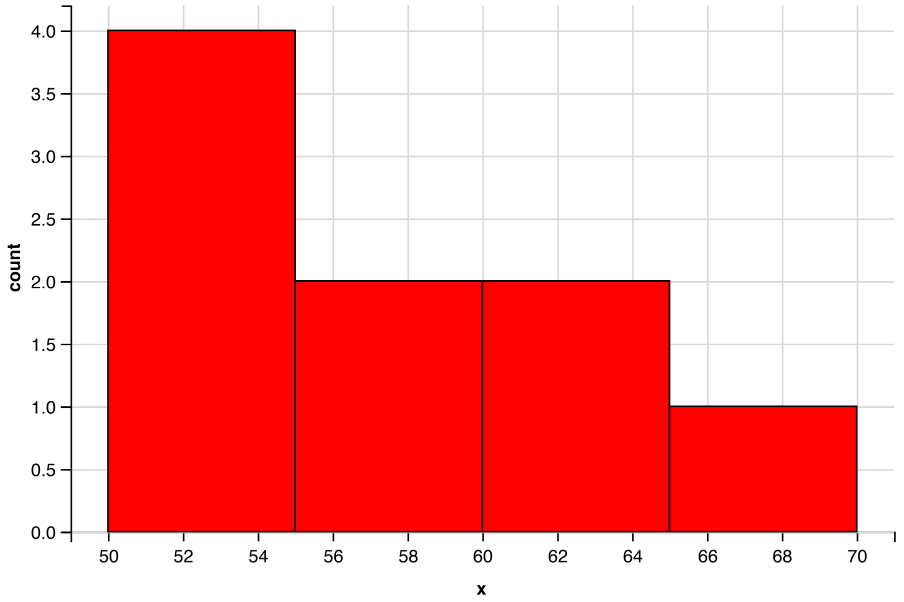
```
## Warning: Can't output dynamic/interactive ggvis plots in a knitr document.
## Generating a static (non-dynamic, non-interactive) version of the plot.
```



Boundary

```
df %>% ggvis(~x) %>%
    layer_histograms(fill := "red",
                     width = input_slider(1, 10,
                                          value = 5,
                                          step = 1,
                                          label = "width"),
                     boundary = input_slider(47.5, 50,
                                           value = 50,
                                           step = .5,
                                           label = "boundary"))
```

```
## Warning: Can't output dynamic/interactive ggvis plots in a knitr document.
## Generating a static (non-dynamic, non-interactive) version of the plot.
```


count
x