Visualizing Data and Summary Statistics

Introduction to Evolution and Scientific Inquiry

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Quantitative vs. Categorical variables

- Quantitative variables are described by data as *numbers*
  - Height of a plant
  - Number of legs on an octopus
  - Length of gestation time

- Categorical variables are described by data as *categories*
  - Colors
  - Species names
  - iPhone models

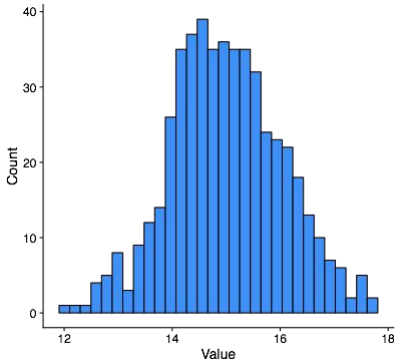
There are two types of quantitative data

- Continuous
  - Any real-number value within some range
  - Example: height, weight,
  - If it can be a decimal, it is continuous

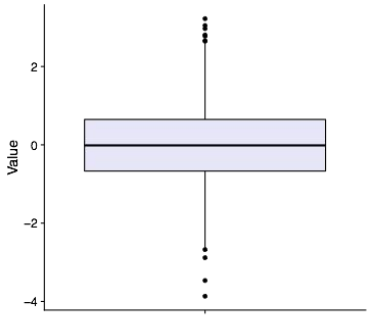
- Discrete (also known as discontinuous in book)
  - Values are in indivisible units, i.e. whole or counting numbers
  - "Count data"
  - If it can NOT have a decimal (i.e. there are not 2.5 people), it is discrete
- Note: discreet is different.

How we represent data depends on what kind it is

Visualize quantitative data

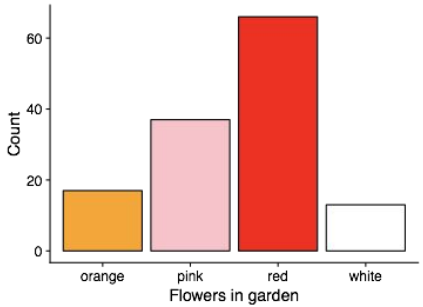


Histogram



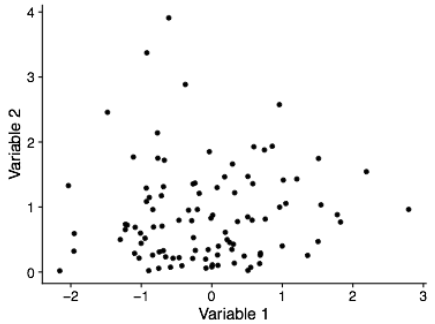
Boxplot

Visualize categorical data*



Bar plot

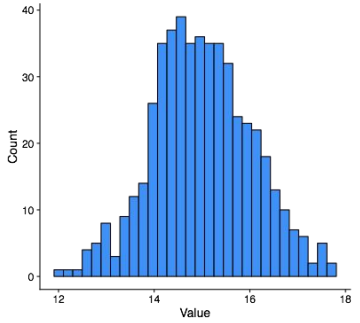
Visualize how **two quantitative** variables relate

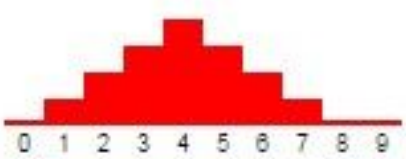


Scatterplot

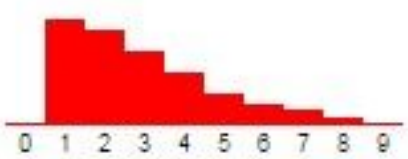
*Commonly used for quantitative data as well, but it “shouldn’t be”

Histograms

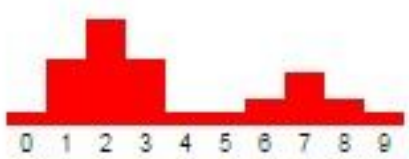




Symmetric, unimodal, bell-shaped

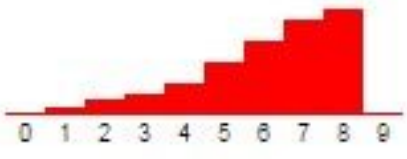


Skewed right

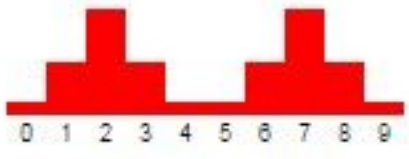


Non-symmetric, bimodal

Uniform

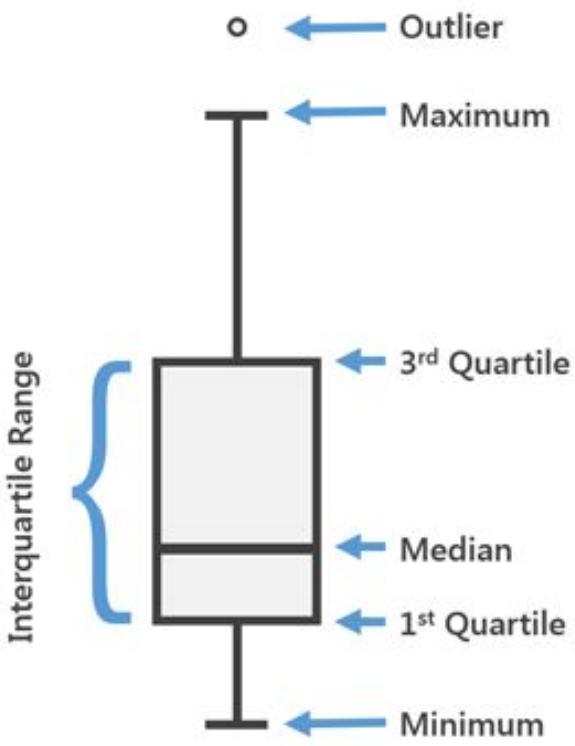


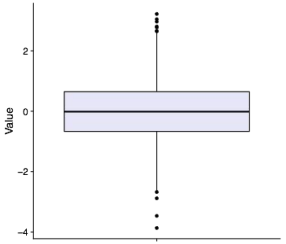
Skewed left

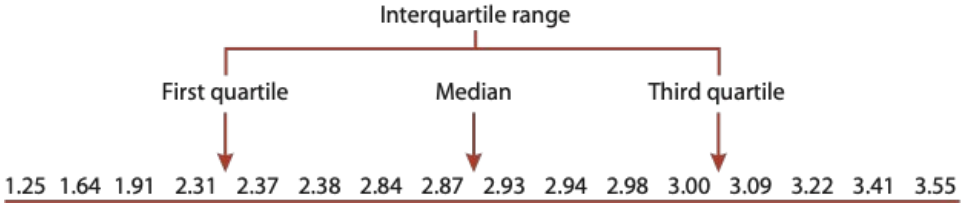


Symmetric, bimodal

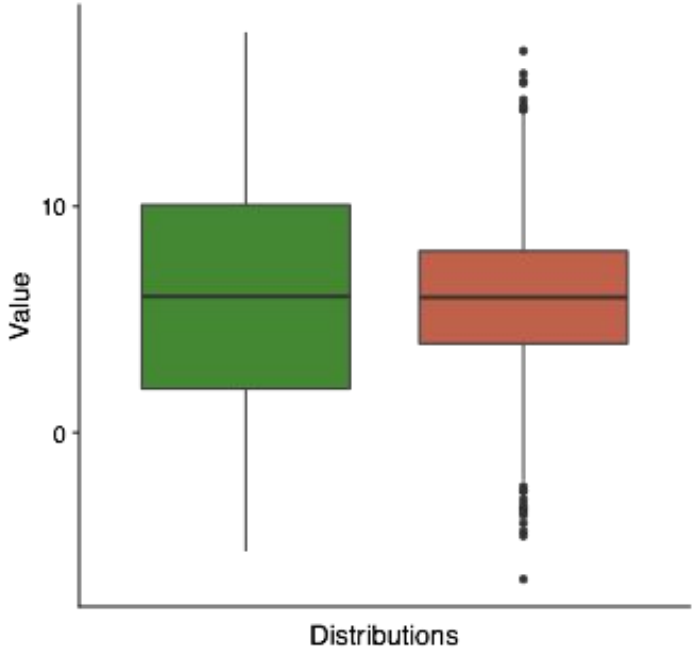
Boxplots

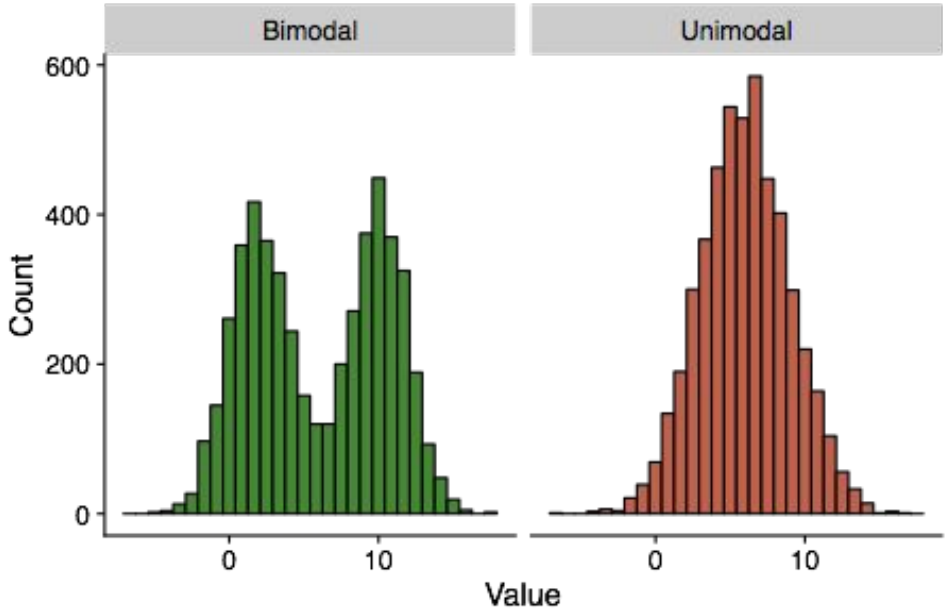

Outlier
Maximum
3rd Quartile
Median
1st Quartile
Minimum
Interquartile Range


Value
2
0
-2
-4


Interquartile range
First quartile
Median
Third quartile
1.25 1.64 1.91 2.31 2.37 2.38 2.84 2.87 2.93 2.94 2.98 3.00 3.09 3.22 3.41 3.55

Boxplots vs. histograms

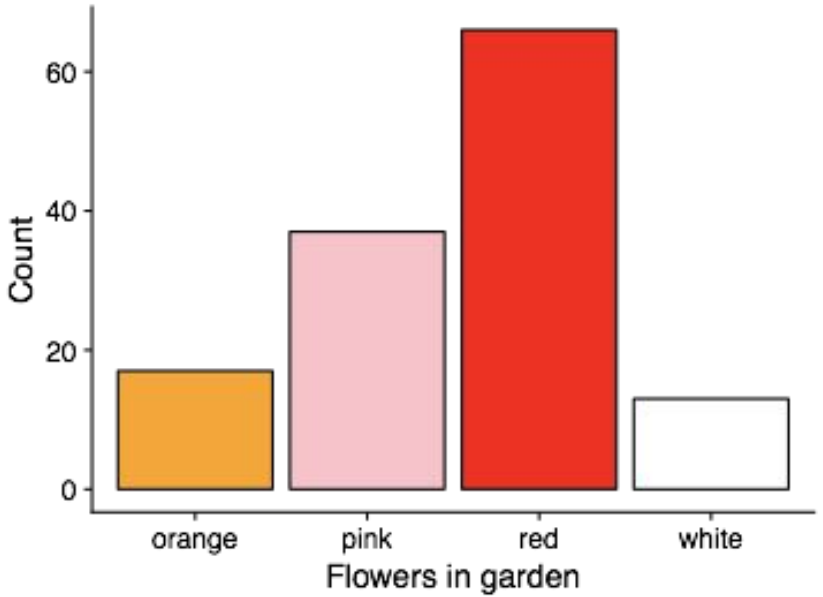




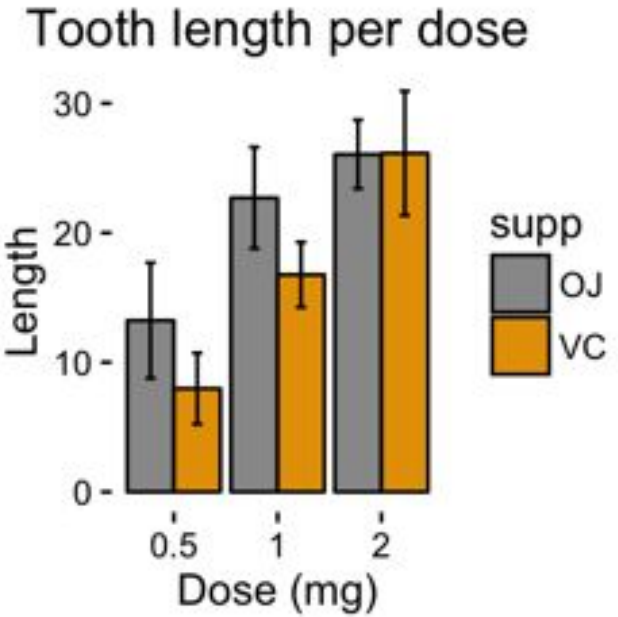
Barplots

In my garden, there are...

- 18 orange flowers
- 37 pink flowers
- 62 red flowers
- 15 white flowers



Barplots for quantitative data

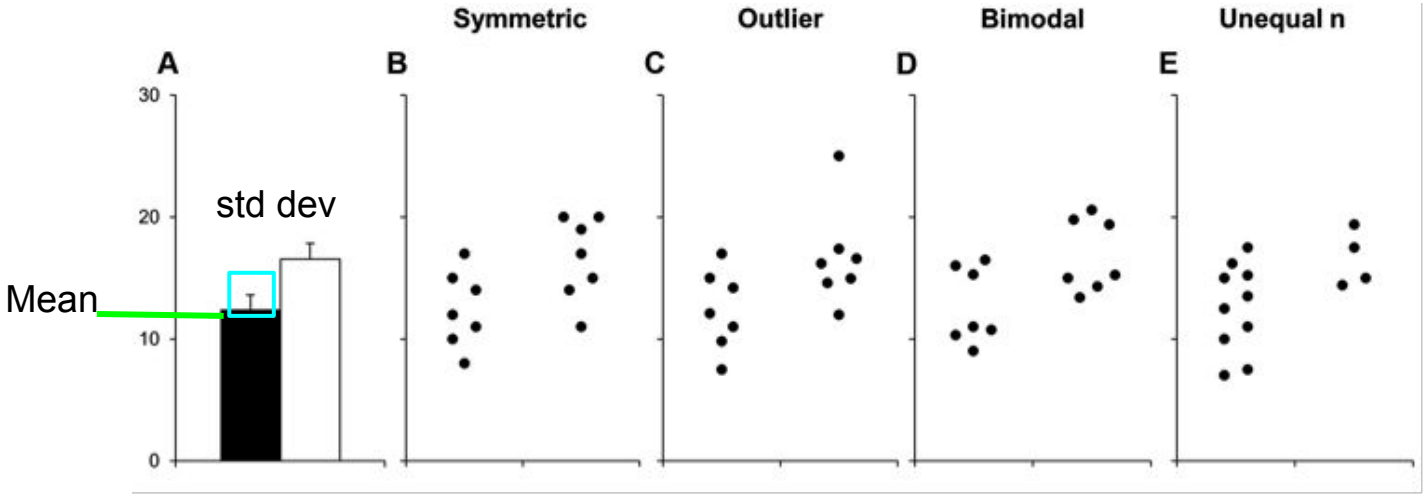


Each animal received one of three dose levels of vitamin C (0.5, 1, and 2 mg/day) by one of two delivery methods, orange juice or ascorbic acid (a form of vitamin C and coded as ‘VC’).

The response is the length of odontoblasts (cells responsible for tooth growth) in 60 guinea pigs.

Height of bar = **mean**
Length of tick = **2*standard deviation** (usually!)

Barplots can be very misleading though!

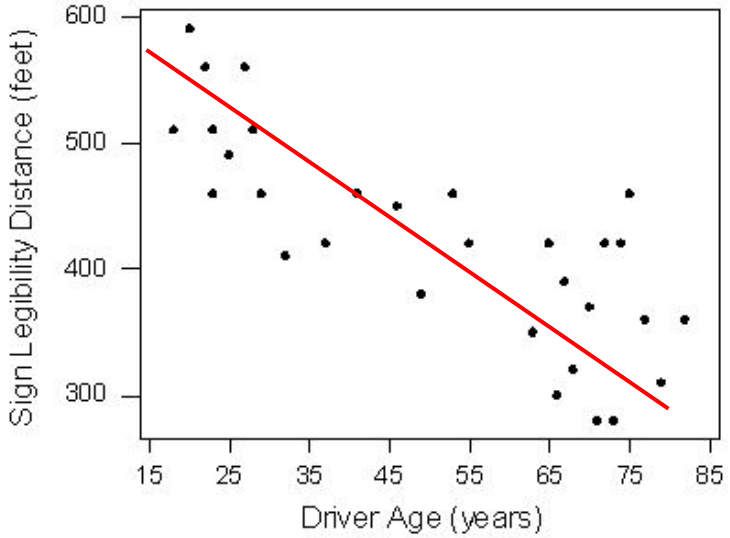


http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002128

Scatterplots

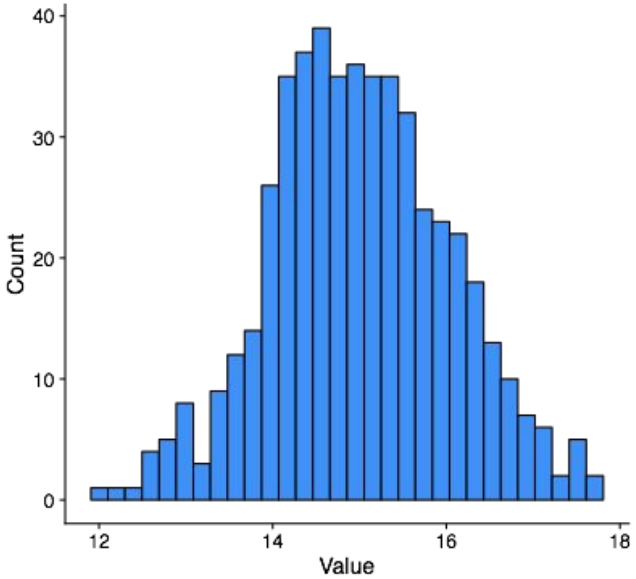
- X-axis shows **independent variable**

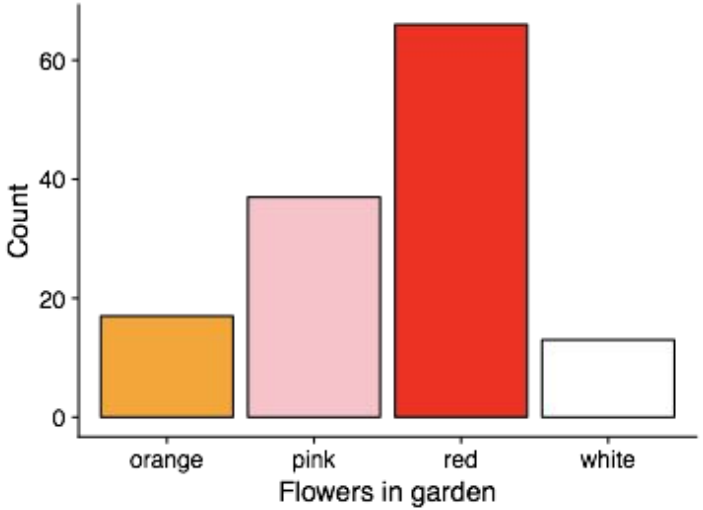
- Y-axis shows **dependent (response) variable**



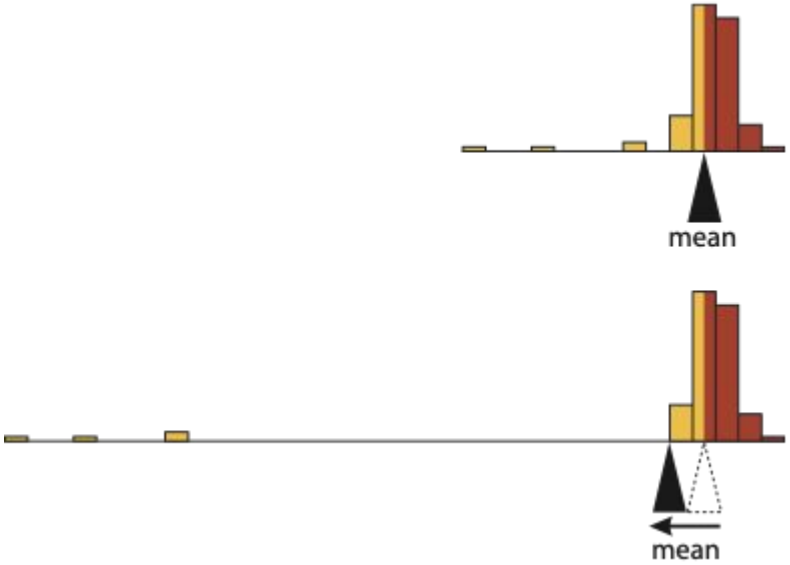
Describing the location of a distribution

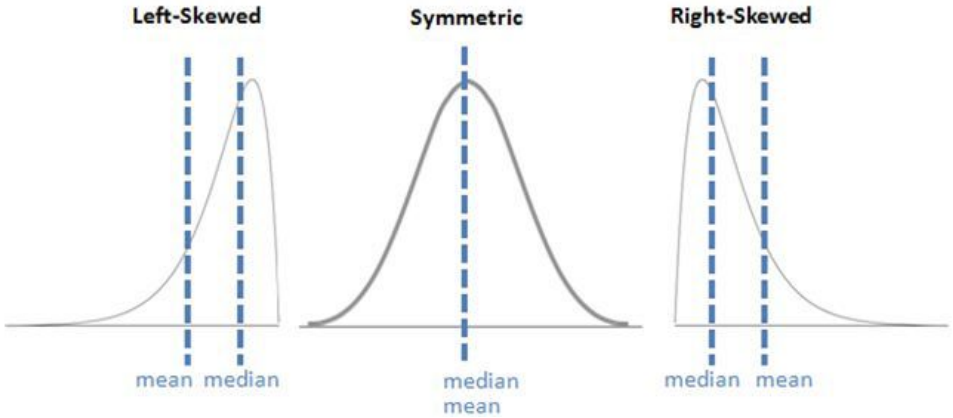
- Location is a fancy word for “center”
  - Mean and median for quantitative data
  - Mode for categorical data





Mean vs median: Mean is **not robust** to outliers





Describing the spread of a distribution

- Range
  - 1, 2, 3, 7, 9 → **8**
  - 1, 2, 3, 7, 9, 500 → **499**
- Standard deviation
  - Variance = s^2

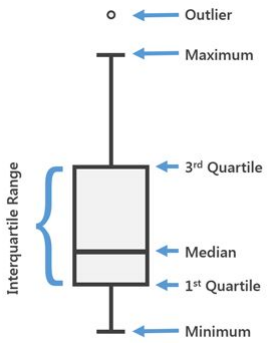
$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

n = The number of data points

$\bar{x}$ = The mean of the x_i

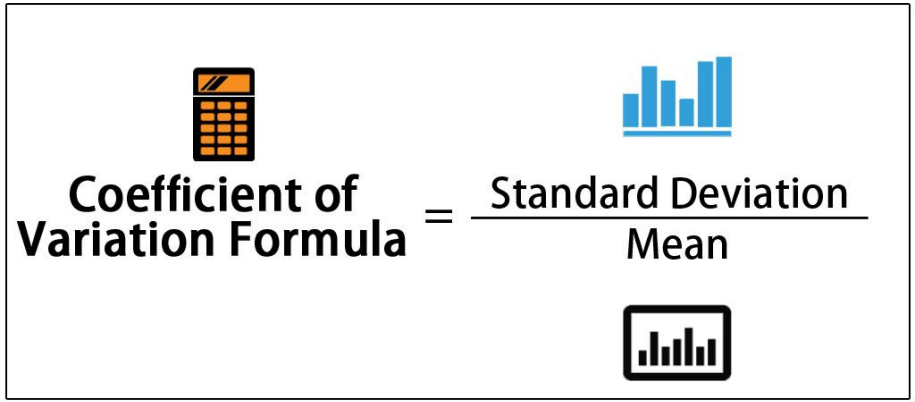
x_i = Each of the values of the data

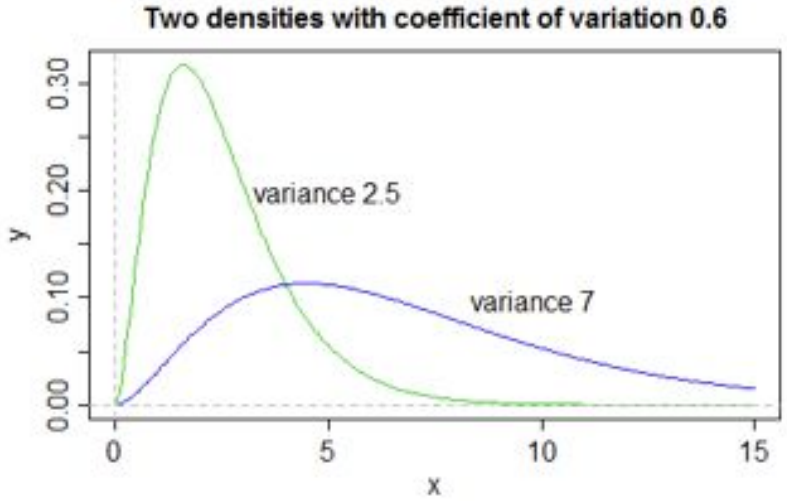
- Interquartile Range (IQR)
  - Middle 50% of the numbers (goes with median)



Comparing spreads of two different distributions

We use the *coefficient of variation* (COV)



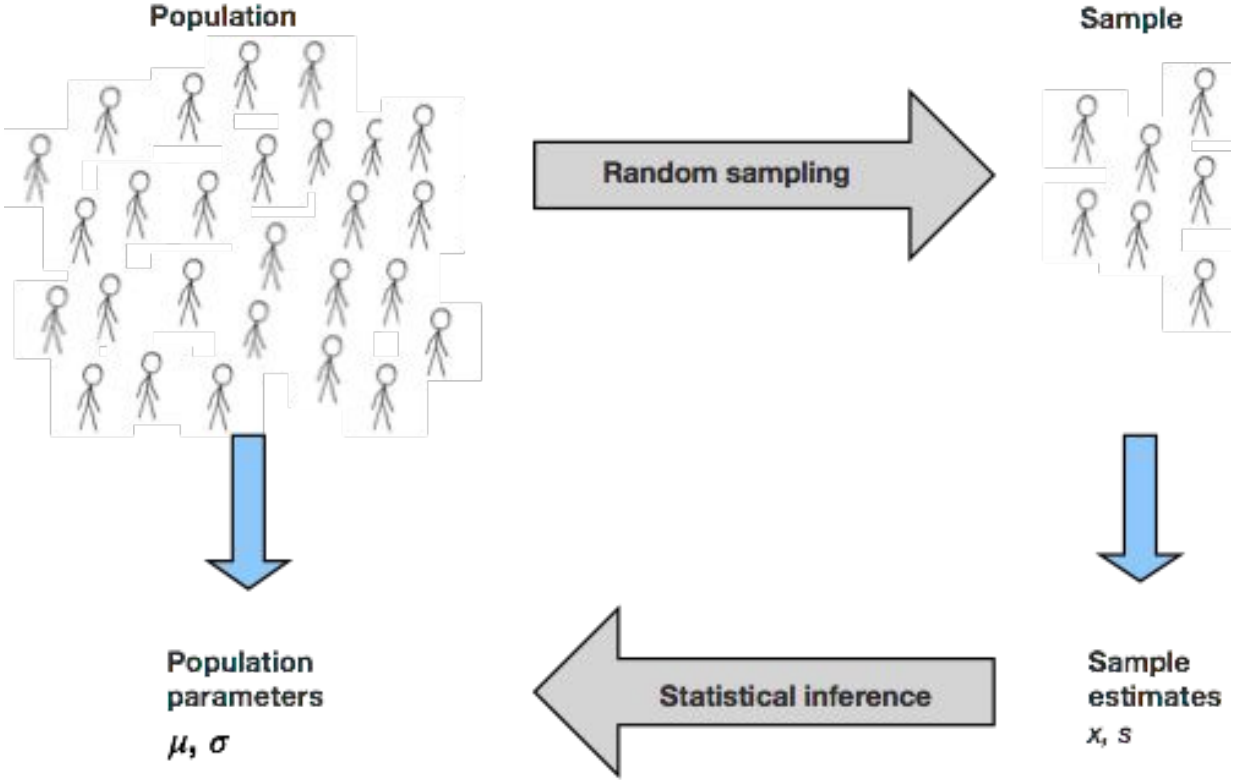


A note on the word population

- In **biology**, a population is group of organisms of a single species who live around the same area

- In **statistics**, a population is total set of observations, data points, etc. that can be made
    - Except in a few cases, we generally never know the population

Statistical Inference: Does my sample represent the true population?



How well does my sample represent the population?

- Standard Error: The distance between my measured statistic and the true population parameter

- **SEM = Standard Error of the Mean**

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

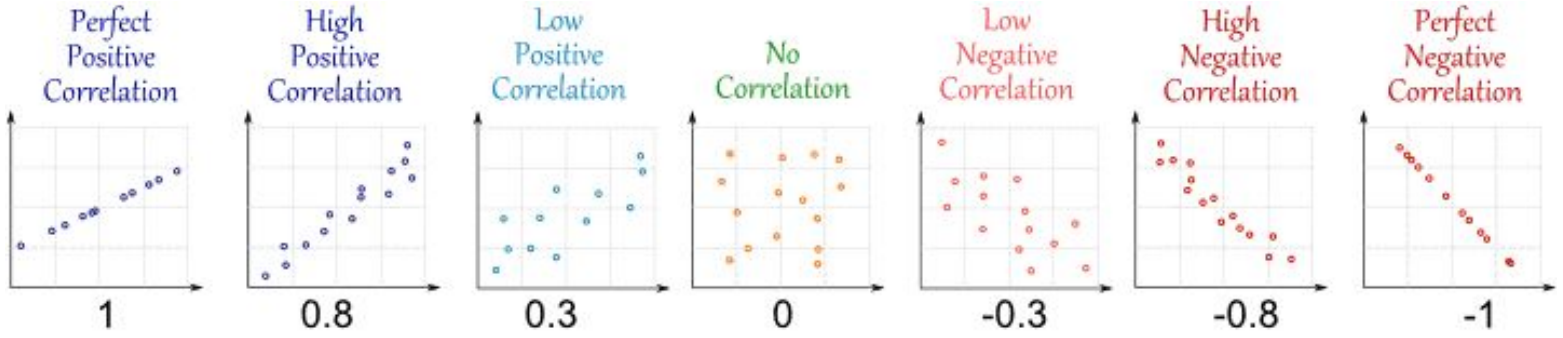
Standard deviation vs standard error

- Standard Deviation: how does the sample vary around the *sample* mean?
  - Low SD = very narrow
  - High SD = lots of spread

- Standard error of the mean: how does the sample mean compare to the *population* mean?
  - Low SEM: sample mean is very close to “true” mean
  - High SEM: sample mean is very far from “true” mean
  - Generally larger sample size yields lower SEM

Describing relationships between quantitative variables

- One common measure is *correlation*
- The Pearson Correlation Coefficient: **-1 <= r <= 1**



Major Correlation Caveats

- *Linear relationship only!* (for now)
  - Curves use different types of *correlation coefficients*

- **CORRELATION 👏 IS 👏 NOT 👏 CAUSATION 👏**
  - http://www.tylervigen.com/spurious-correlations

Explore quantitative data visualization

https://sjspielman.shinyapps.io/plot-iris/

http://guessthecorrelation.com/