STATISTICS FOR DATA SCIENCE

Data Visualization and Interpretation

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Data Visualization and Interpretation – Histogram

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Data Visualization

Data visualization is a **BIG buzz word** these days, but what does it actually mean ????

At a basic level, data is just information — **facts, figures, words, percentages, measurements, and observations**, but it's just computerized information.

In order for you to make it useful, you need to **find creative ways** to **make it user friendly** for your audience.

This is where the art of **data visualization** comes in!

Source: nutsandboltspeedtraining.com

Data Visualization

Data visualization is the **secret art** of **turning data** into **visual graphics** that people can understand (**graphs, charts, info graphics**, etc.).

Words may be mightier than the sword, but in a battle for our brains, **visual images win every time**. - Colin Ware.

Source: nutsandboltspeedtraining.com

Types of Visualizations

- Histogram
- Box plot
- Scatter plot
- Bar chart
- Heat map

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Data Distribution

- To understand some of the fundamental concepts of statistical analysis, it is important to **appreciate** the **importance** of the **distribution of data points** in the sample.
- **Data type** and the **distribution pattern** of their values **influence** the **choice of appropriate statistical tests**.
- Emphasis will be placed on the **normal, or Gaussian, distribution.**
- This is an important distribution to understand because the **assumption of this distribution** underlies the **use of many** common **statistical tests**.

Source: Sciencedirect.com

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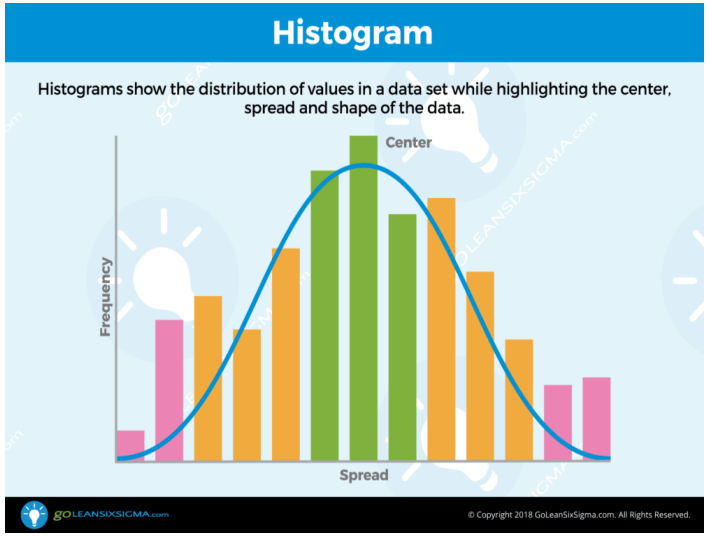
Histogram

- **Histograms** show the **distribution of data values** in a data set while highlighting the **center, spread and shape** of the data.
- Histograms, also known as **Frequency Plots**, are a visual displays of **how much variation exists** in a process.
- They highlight the **center of the data** measured as the **mean, median and mode.**
- They highlight the **distribution of the data** measured as the **range and standard deviation.**
- The **shape of a Histogram** indicates whether the distribution is **normal, bi-modal, or skewed.**



Source: goLEANSIXSIGMA.com

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Histogram

A histogram is used to **summarize discrete or continuous data.**

In other words, it provides a visual interpretation of numerical data by showing the **number of data points** that fall within a specified range of values (called "**bins**").

It is similar to a vertical bar graph.

However, a histogram, unlike a vertical bar graph, shows **no gaps between the bars.**

Importance of Histogram

A histogram is a **graphical display of data** using bars of different heights.

In a histogram, each bar groups **numbers into ranges**.

Taller bars show that **more data falls** in that **range.**

A histogram displays the **shape and spread** of **continuous** sample data.

A histogram is used to **summarize discrete or continuous data.**

Example – Construction of Histogram for PM emissions of 62 Vehicles

Class Interval	Frequency	Relative Frequency	Density
1 - 3	12	0.1935	0.0968
3 – 5	11	0.1774	0.0887
5 – 7	18	0.2903	0.1452
7 – 9	9	0.1452	0.0726
9 – 11	5	0.0806	0.0403
11 – 13	1	0.0161	0.0081
13 – 15	2	0.0323	0.0161
15 – 17	0	0.0000	0.0000
17 – 19	2	0.0323	0.0161
19 – 21	1	0.0161	0.0081
21 – 23	0	0.0000	0.0000
23 - 25	1	0.0161	0.0081

Example – Class Intervals

The intervals in the left-hand column are called **class intervals.**

They divide the sample into groups.

For most histograms, the class intervals all have the same width. In the example all classes have width 2.

The notation 1–< 3, 3–< 5, and so on, indicates that a point on the boundary will go into the class on its right.

For example, a sample value equal to 3 will go into the class 3–< 5, not 1–< 3.

Example – Width of Class Intervals

There is no hard-and-fast rule as to how to choose the endpoints of the class intervals.

It is good to have more intervals rather than fewer, but it is also good to have large numbers of sample points in the intervals.

When the number of observations n is large (several hundred or more), some have suggested that reasonable starting points for the number of classes may be $\log_2 n$ or $2n^{1/3}$.

When the number of observations is smaller, more classes than these are often needed.

Example – Frequency and Relative Frequency

The column labeled “Frequency” in Table presents the numbers of data points that fall into each of the class intervals.

The column labeled “Relative Frequency” presents the frequencies divided by the total number of data points, which for these data is 62.

The relative frequency of a class interval is the proportion of data points that fall into the interval.

Note that since every data point is in exactly one class interval, the relative frequencies must sum to 1.

Example - Density

Finally, the column labeled “Density” presents the relative frequency divided by the class width.

In this case all classes have width 2, so the densities are found by dividing the relative frequencies by 2.

Note that when the classes are of equal width, the frequencies, relative frequencies, and densities are proportional to one another.

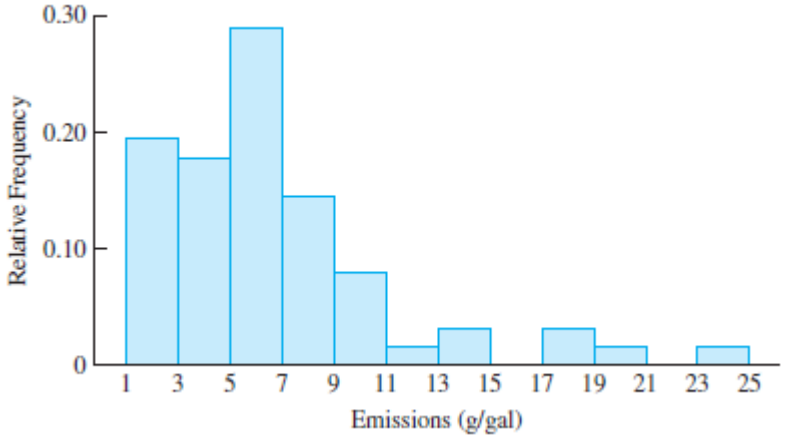
Example – Interpretation of Histogram

The units on the horizontal axis are the units of the data, in this case grams per gallon.

Each class interval is represented by a rectangle.

When the class intervals are of equal width, the heights of the rectangles may be set equal to the frequencies, the relative frequencies, or the densities.

Since these three quantities are proportional, the shape of the histogram will be the same in each case.



Bins in Histogram

Histograms are based on area, not height of bars.

In a histogram, it is the area of the bar that indicates the frequency of occurrences for each bin.

In statistics, the Freedman – Diaconis rule can be used to select the size of the bins to be used in a histogram

$$\text{Bin size} = 2\frac{\text{IQR}(x)}{\sqrt[3]{n}}$$

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Equal Bins / Class Widths

Suppose we are looking at the history grades of students in 10th grade and have the classes corresponding to letter grades: A, B, C, D, F. The number of each of these grades gives us a frequency for each class:

- 7 students with an F
- 9 students with a D
- 18 students with a C
- 12 students with a B
- 4 students with an A

Frequency

To determine the relative frequency for each class we first add the total number of data points: $7 + 9 + 18 + 12 + 4 = 50$. Next we, divide each frequency by this sum 50.

- 0.14 = 14% students with an F
- 0.18 = 18% students with a D
- 0.36 = 36% students with a C
- 0.24 = 24% students with a B
- 0.08 = 8% students with an A

Relative Frequency

Source: www.thoughtco.com

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Unequal Bin / Class Widths

Histograms are drawn with class intervals of differing widths rarely.

When the **class intervals** are of **unequal widths**, the **heights** of the **rectangles or bars** must be set equal to the densities.

Compute the **density** for each class, according to the formula,

$$\text{Density} = \frac{\text{Relative Frequency}}{\text{Class Width}}$$

The **areas of the rectangles** will then be the **relative frequencies**.

Parts of Histogram

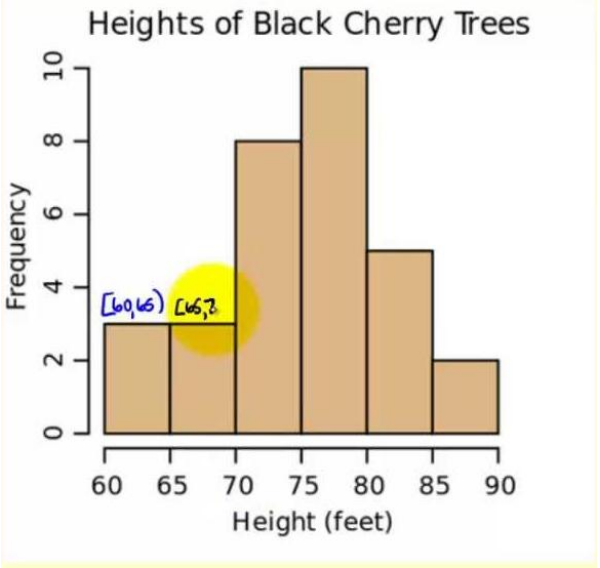
The title: The title **describes the information** included in the histogram.

X-axis: The X-axis are intervals that show the **scale of values** which the measurements fall under.

Y-axis: The Y-axis shows the **number of times** that the values occurred within the intervals set by the X-axis.

The bars: The **height of the bar** shows the **number of times** that the values occurred within the interval, while the **width** of the bar shows the **interval that is covered**.

For a histogram with **equal bins**, the **width** should be the **same** across all bars.



Source: Mathispower4u

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Distributions of a Histogram – Normal Distribution

A normal distribution:

In a normal distribution, points on one side of the average are as likely to occur as on the other side of the average.

Source: corporatefinanceinstitute.com

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Distributions of a Histogram – Bimodal Distribution

A bimodal distribution: In a bimodal distribution, there are two peaks.

In a bimodal distribution, the data should be separated and analyzed as separate normal distributions.

Source: corporatefinanceinstitute.com

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Distributions of a Histogram – Right-Skewed Distribution

A right-skewed distribution: A right-skewed distribution is also called a positively skewed distribution.

In a right-skewed distribution, a large number of data values occur on the left side with a fewer number of data values on the right side.

A right-skewed distribution usually occurs when the data has a range boundary on the left-hand side of the histogram. For example, a boundary of 0.

Source: corporatefinanceinstitute.com

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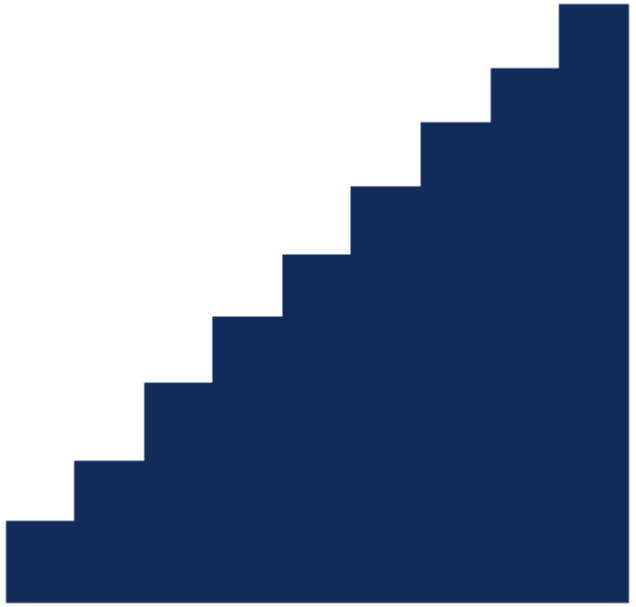
Distributions of a Histogram – Left-Skewed Distribution

A left-skewed distribution: A left-skewed distribution is also called a negatively skewed distribution.

In a left-skewed distribution, a large number of data values occur on the right side with a fewer number of data values on the left side.

A right-skewed distribution usually occurs when the data has a range boundary on the right-hand side of the histogram. For example, a boundary such as 100.



Source: corporatefinanceinstitute.com

Distributions of a Histogram – Random Distribution

A random distribution:

A random distribution lacks an apparent pattern and has several peaks.

In a random distribution histogram, it can be the case that different data properties were combined.

Therefore, the data should be separated and analyzed separately.

Source: corporatefinanceinstitute.com

Summary

Choose boundary points for the class intervals.

Compute the frequency and relative frequency for each class.

Compute the density for each class, according to the formula

$$\text{Density} = \frac{\text{Relative Frequency}}{\text{Class Width}}$$

Draw a rectangle for each class. If the classes all have the same width, the heights of the rectangles may be set equal to the frequencies, the relative frequencies, or the densities.

If the classes do not all have the same width, the heights of the rectangles must be set equal to the densities.

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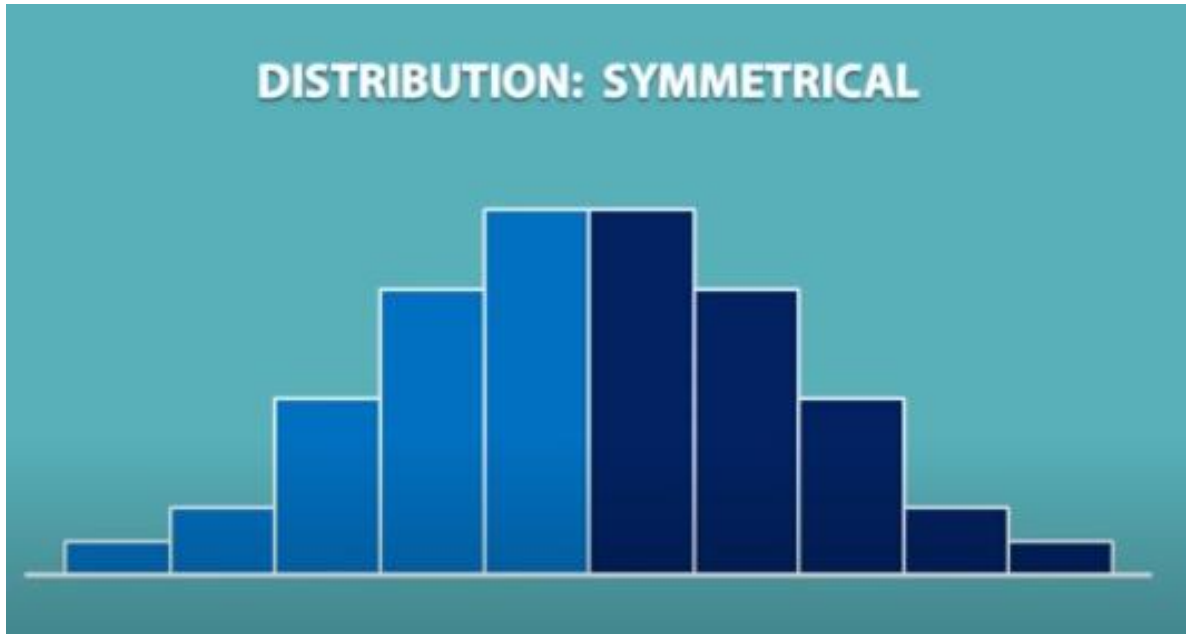
Symmetry

A distribution is said to be symmetrical if it can be divided into two equal sizes of the same shape.



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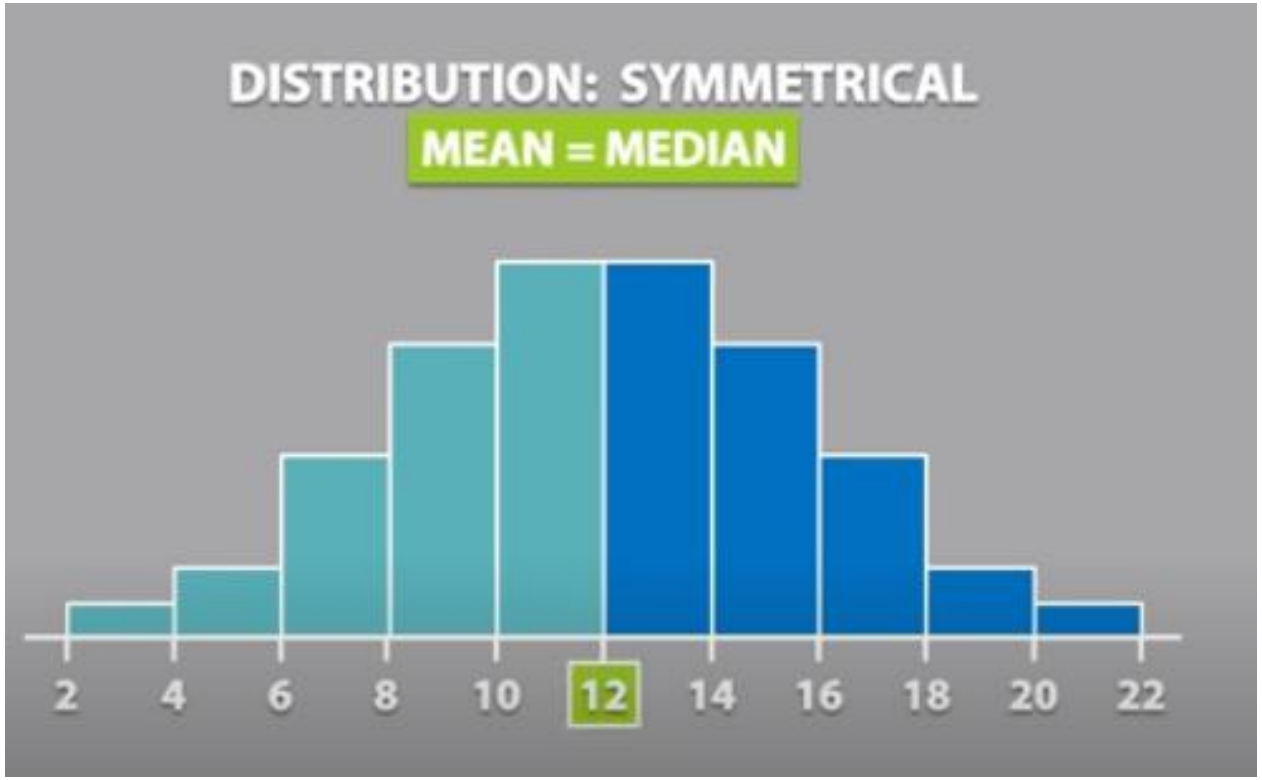
Distribution - Symmetry

When a histogram is roughly **symmetric**, the mean and the median are approximately equal.



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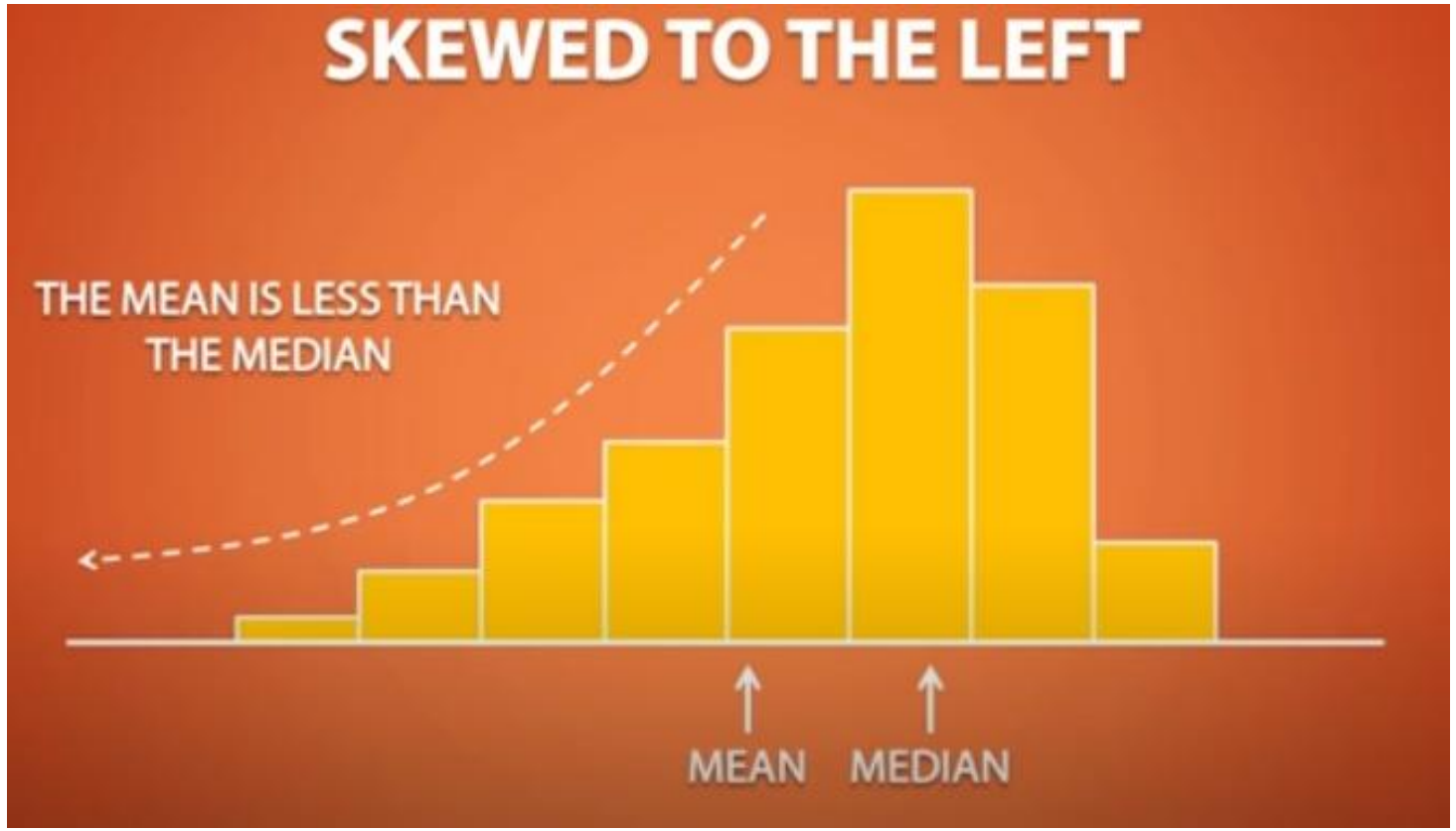
Distribution – Left Skewed

When a histogram is **left-skewed**, the mean is less than the median.



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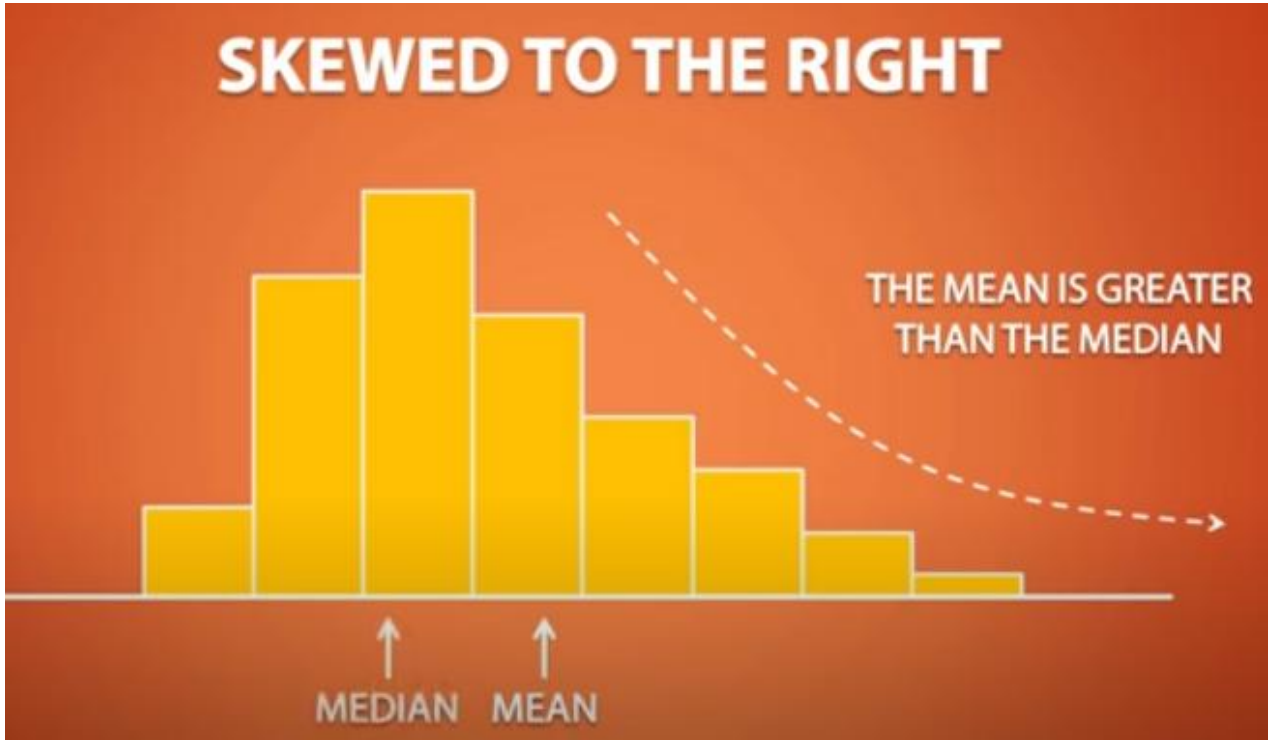
Distribution – Right Skewed

When a histogram is **right-skewed**, the mean is greater than the median.



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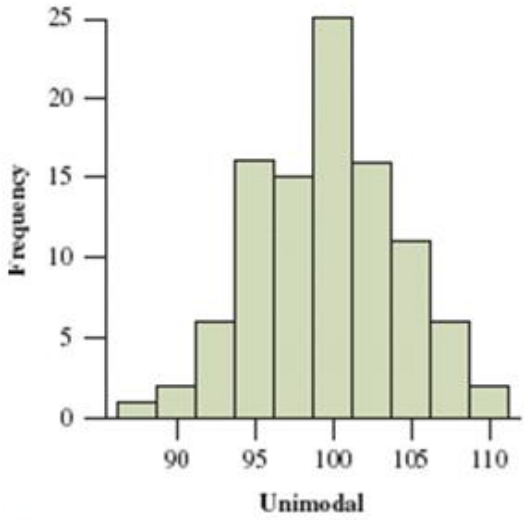
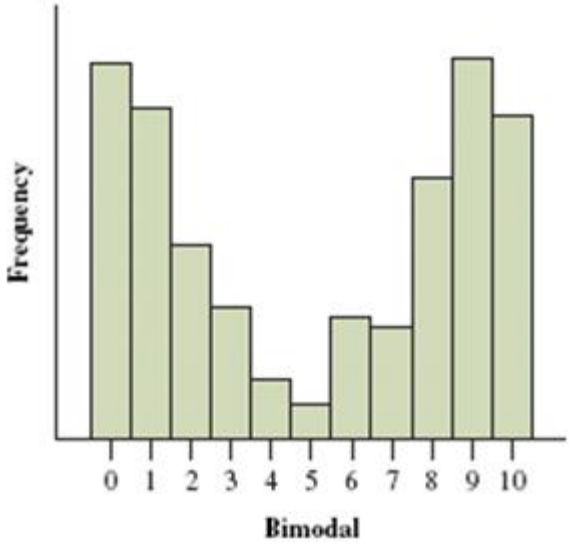
Unimodal and Bimodal Histogram

A histogram with only one peak is what we call **unimodal**.

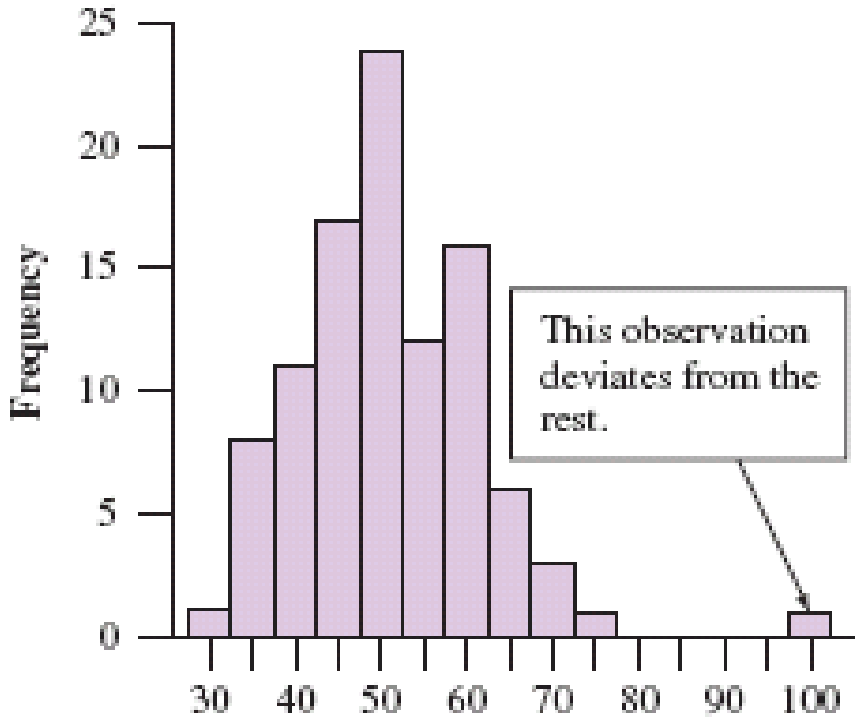


If a histogram has two peaks then we say that it is **bimodal**.



Outlier

An outlier falls far from the rest of the data.



THANK YOU

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