<u>*FUN*</u>damentals of Biostatistics (Lectures 1-4)

BIOSTAT 201A Fall 2025

Discussion 2 – October X, 2025

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Outline

1. Lecture 1: Biostatistics, Inference, and Data
    1. Population vs. Sample, Parameter vs. Statistic
    2. Types of Data
2. Lecture 2: Parameters vs. Statistics, Summary Statistics, and Data Visualization (See Problem 1)
    1. Measures of Location
    2. Measures of Spread
    3. Describing a Distribution
    4. Data Visualization - Boxplots
3. Lecture 3: Probability, Conditioning, and Independence (see Problems 2 and 3)
4. Lecture 4: Random Variables, Sampling, and The Central Limit Theorem
    1. Discrete Random Variables
    2. Properties of the Normal Distribution
    3. Central Limit Theorem

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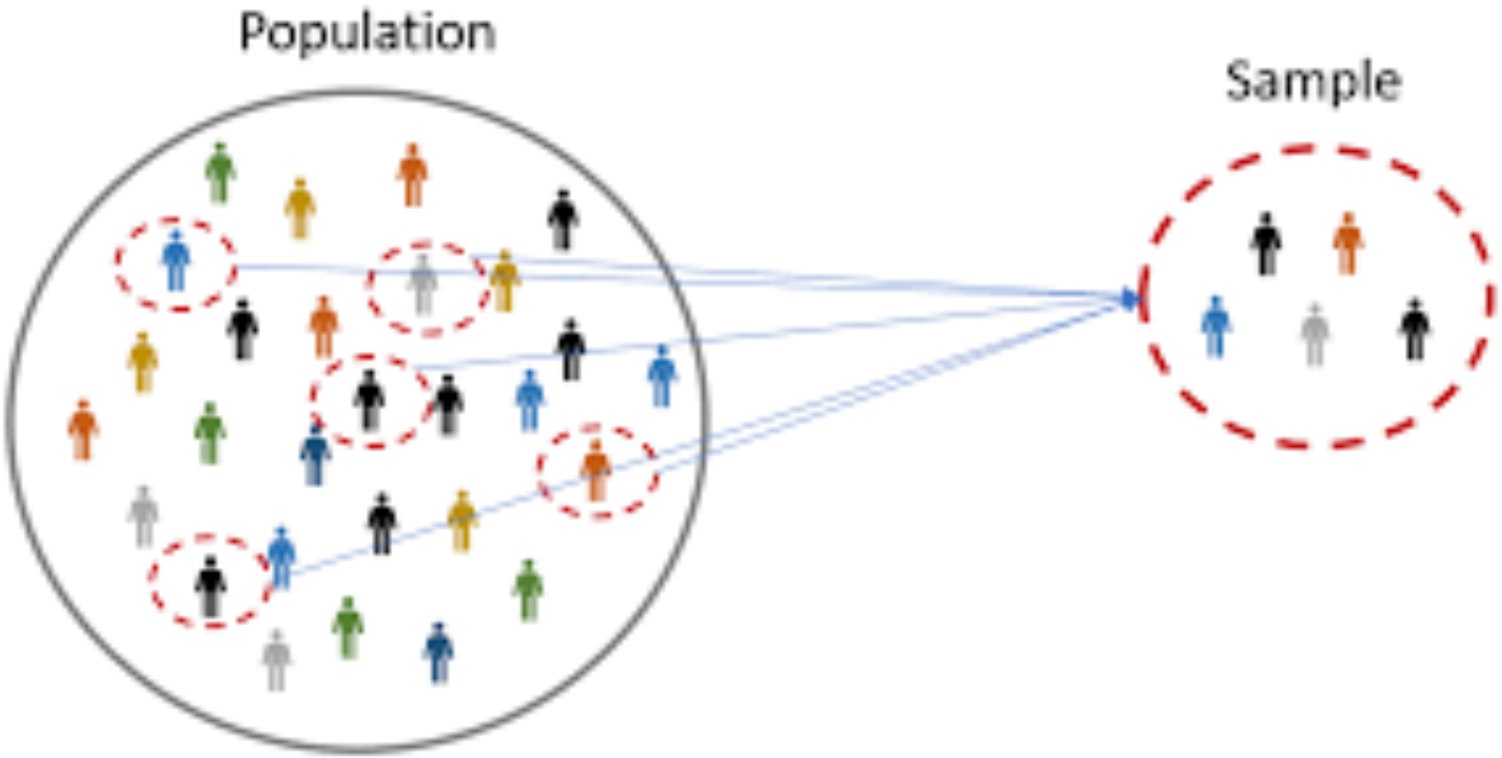
1.1 Population vs. Sample, Parameter vs. Statistic



1.2 Types of Data

(1) **Quantitative (“Quantifiable”)** – discrete or continuous response of measurable magnitude
  - Continuous – can take on an uncountable set of values
  - Discrete – can take on a limited, and often fixed number of possible values

(2) **Qualitative –** no corresponding set of numbers

Can you produce some examples of each type of data?

1.2 Types of Data

- Stevens' Scale of Data Classification

	Categorical	Order	Equal Spacing	True Zero	Examples
Nominal – categorical data without any sensible ordering of values	X				
Ordinal – categorical or discrete data with a natural ranking/ordering relationship	X	X			
Interval – has a notion of distance, defined by measurement units of equal size	X	X	X		
Ratio – has a notion of magnitudes or "x times greater"	X	X	X	X	

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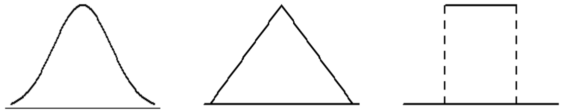
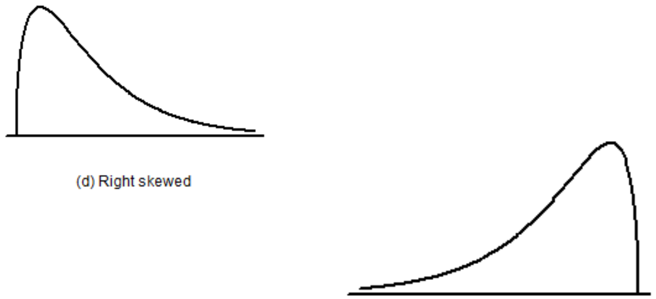
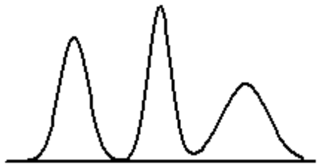
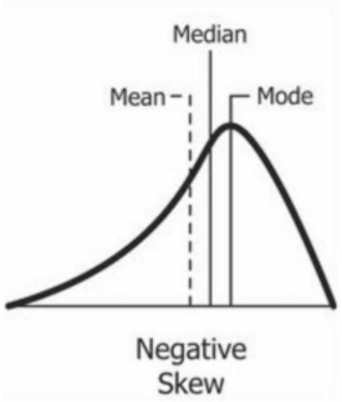
2.1 Measures of Location

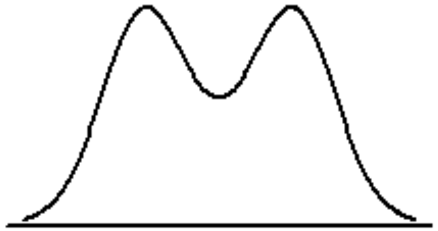
	Formula/How to Calculate it	What the Data Looks Like
Mean	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$	 (a) Bell shaped (b) Triangular (c) Uniform (retangular)
Median	Let observations $x_1, \ldots, x_n$ be ordered such that $x_1 \leq x_2 \leq \cdots \leq x_n$ where x_1 is the minimum and x_n is the maximum If n is even, the median is the average of $x_{\frac{n}{2}}$ and $x_{\frac{n+1}{2}}$ If n is odd, the median is $x_{\frac{n+1}{2}}$	 (d) Right skewed (e) Left skewed
Mode	Most common value	 (i) Multi-modal

2.2 Measures of Spread

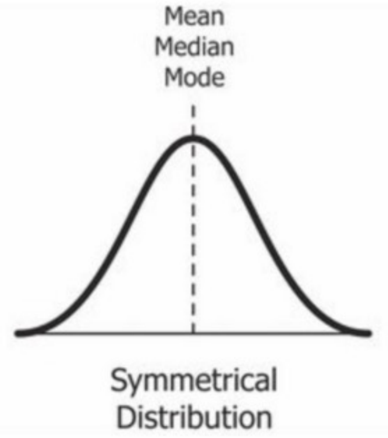
	Formula/How to Calculate it
Range	Range = $x_{max} - x_{min}$
Interquartile Range (IQR)	IQR = $x_{75th\ percentile} - x_{25th\ percentile} = Q3 - Q1$
Sample Variance/Standard deviation ($\sqrt{s^2}$)	$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$

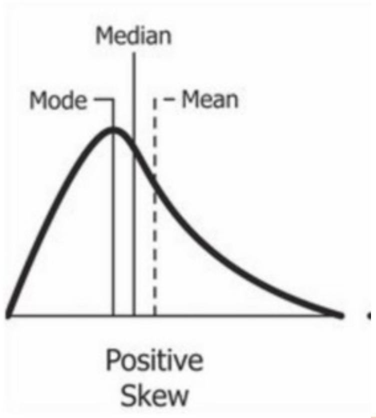
2.3 Describing a Distribution



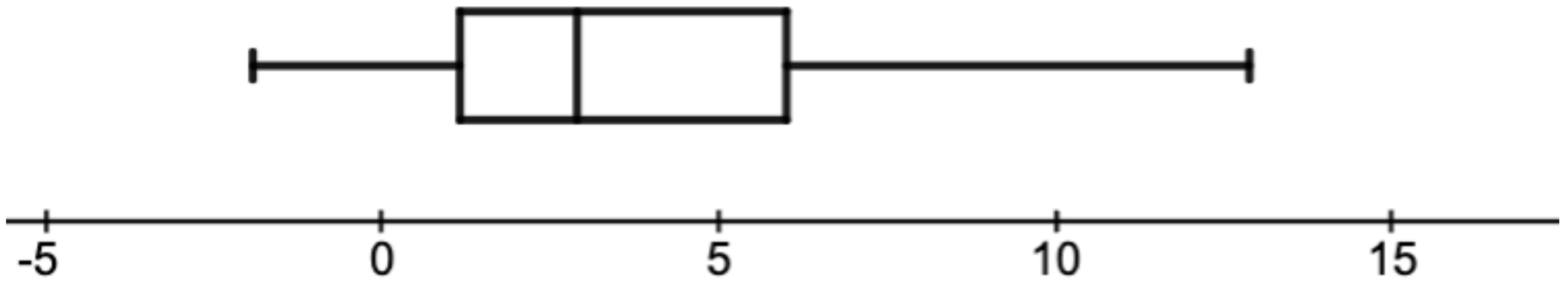


(h) Bimodal





2.4 Data Visualization - Boxplots



2.4 Data Visualization – Stem and Leaf

15, 16, 21, 23, 23, 31, 35, 39, 40, 41, 46, 55, 56

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Some general probability rules

- Complements: $\mathrm{P}(\overline{\mathrm{E}}) = 1 - \mathrm{P}(\mathrm{E})$
- Independence of Events:
  (1) Event A is independent of Event B if the joint probability of A and B can be expressed as:
  $$\mathrm{P}(\mathrm{A} \cap \mathrm{B}) = \mathrm{P}(\mathrm{A})\mathrm{P}(\mathrm{B})$$
  (2) Event A is independent of Event B is the following conditional holds:
  $$\mathrm{P}(\mathrm{A}|\mathrm{B}) = \mathrm{P}(\mathrm{A}),\ \mathrm{P}(\mathrm{B}) > 0$$
- Conditional Probability: $\mathrm{P}(\mathrm{A}|\mathrm{B}) = \frac{\mathrm{P}(\mathrm{A} \cap \mathrm{B})}{\mathrm{P}(\mathrm{B})} = \frac{\mathrm{P}(\mathrm{A}|B)P(B)}{\mathrm{P}(\mathrm{B})}$
- Rule of Total Probability: $\mathrm{P}(\mathrm{A}) = \mathrm{P}(\mathrm{A}|\mathrm{B})\mathrm{P}(\mathrm{B}) + \mathrm{P}(\mathrm{A}|\overline{\mathrm{B}})\mathrm{P}(\mathrm{B})$

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4.1 Discrete Random Variables - Example

Probability Mass Function (PMF) – probability distribution for a discrete variable

Value	**1**	**2**	**4**	**6**
Probability	0.2	0.1	0.4	0.3

Exercise. Compute

(a) Expected Value of X:

(b) Variance of X:

(c) Construct the cumulative distribution function (cdf)

Expected Value of a Discrete RV:

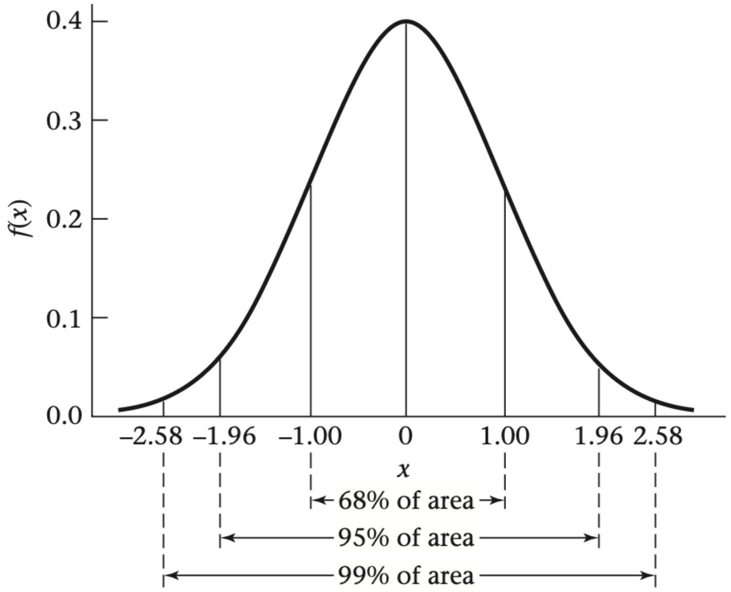
$$\mathbb{E}(X) = \sum_{i=1}^{n} x_i \Pr(X = x_i)$$

Variance of a Discrete RV:

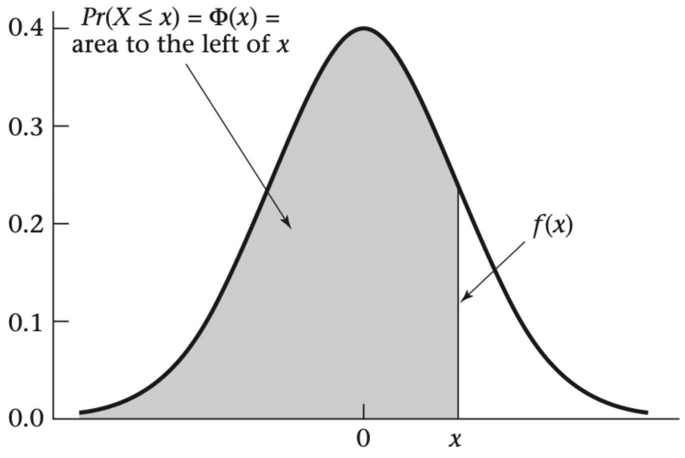
$$Var(X) = \mathbb{E}(X - \mu)^2 = \sum_{i=1}^{n} x_i^2 \Pr(X = x_i) - \mu^2$$

4.2 Properties of the Normal Distribution – The Empirical Rule and CDF

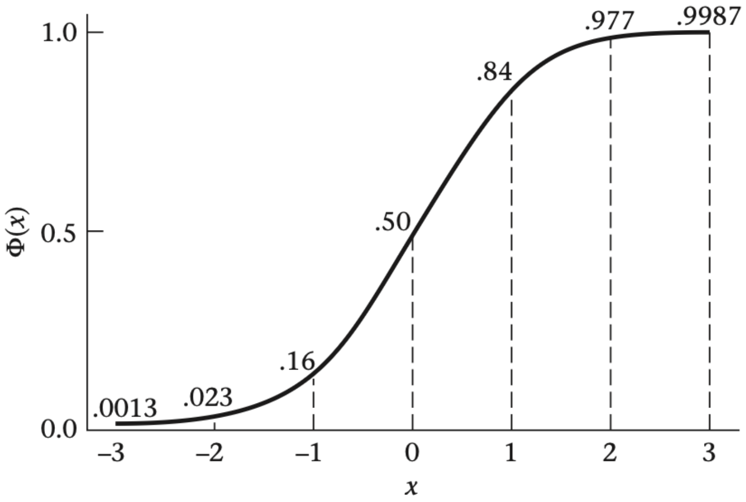
Empirical properties of the standard normal distribution



The cdf [Φ(x)] for a standard normal distribution



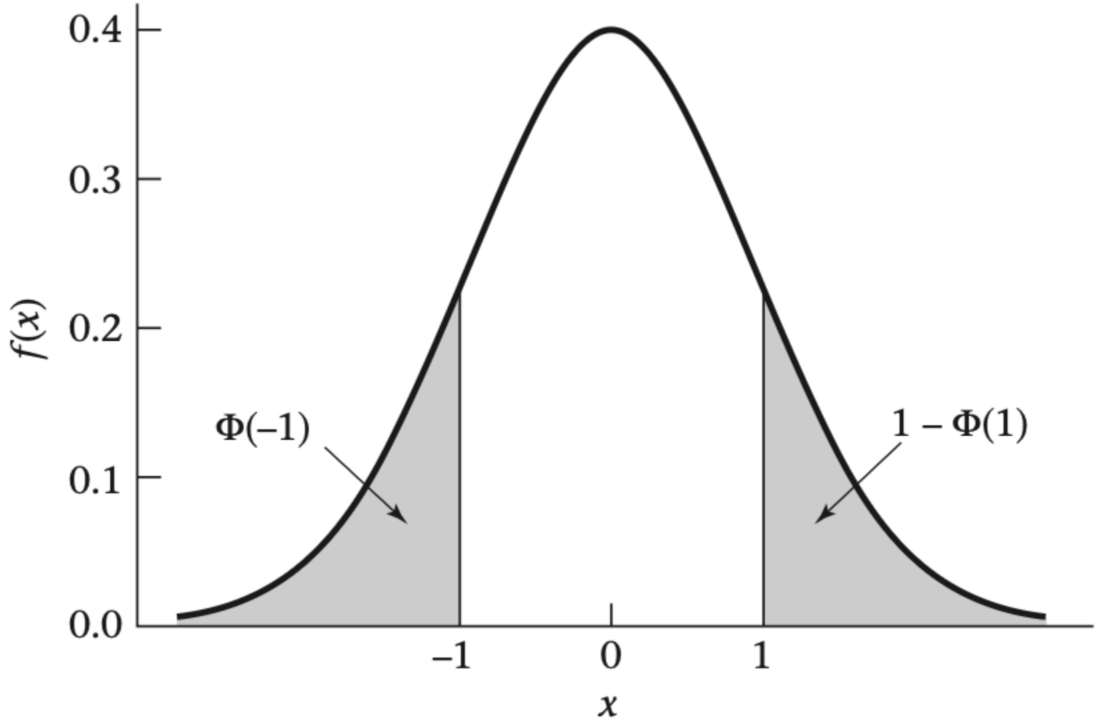
The cdf for a standard normal distribution [Φ(x)]



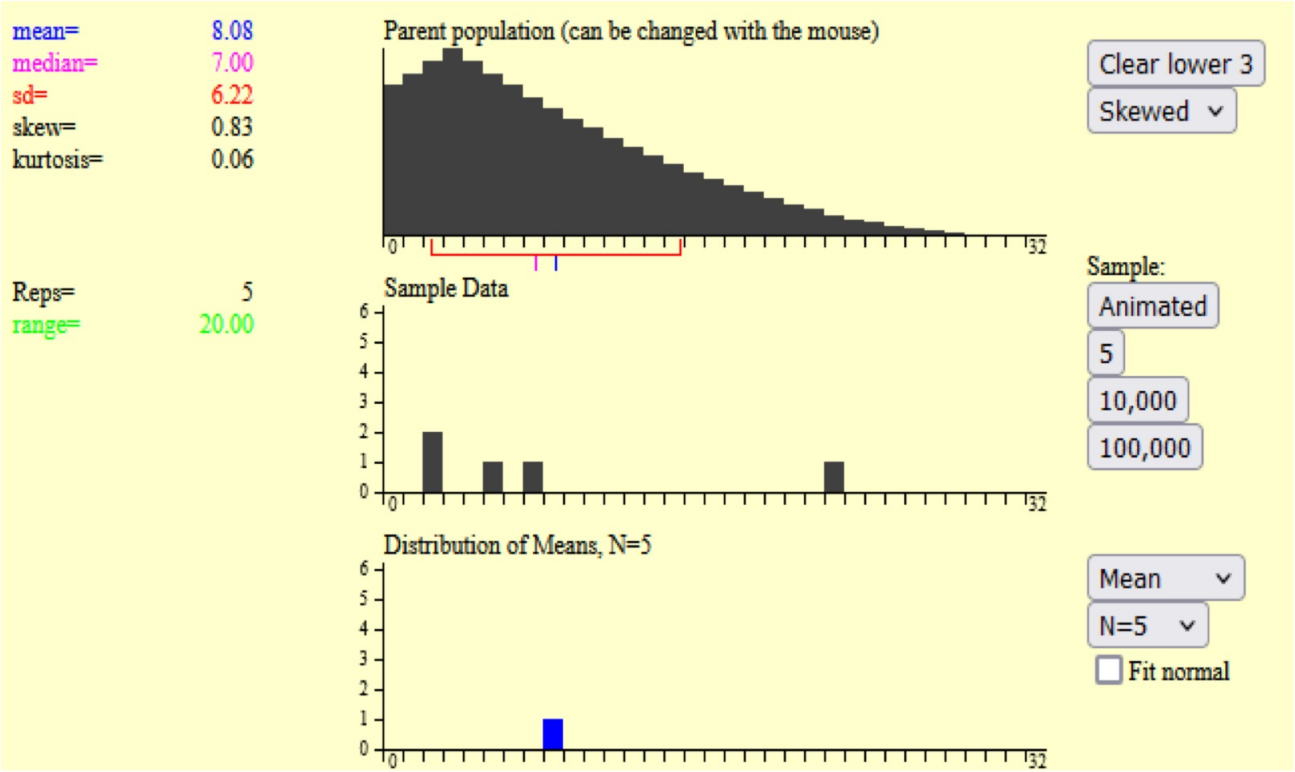
4.2 Properties of the Normal Distribution - Symmetry

$$\Phi(-x) = 1 - \Pr(X \leq x) = 1 - \Phi(\mathrm{x})$$

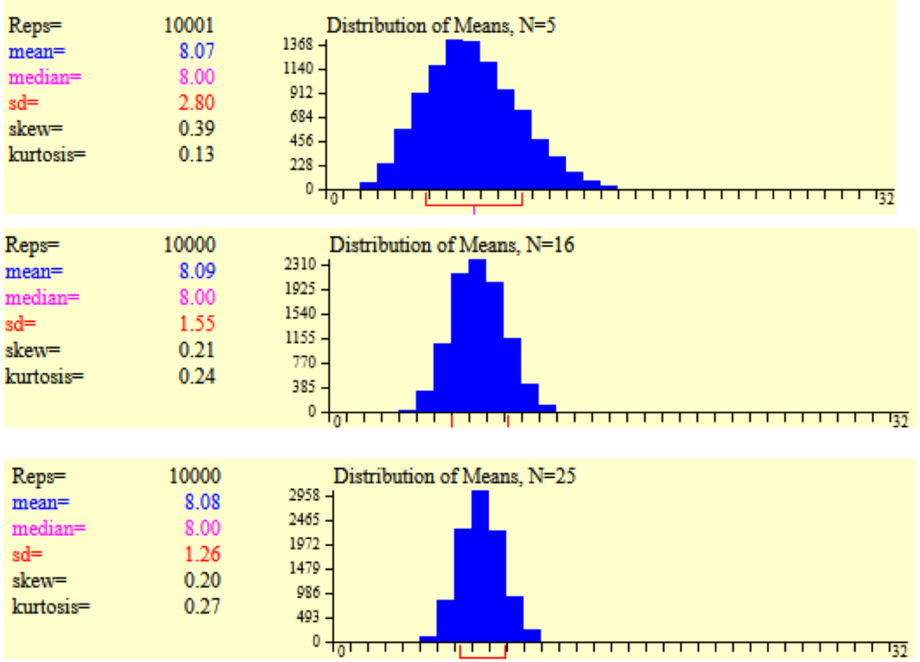
Illustration of the symmetry properties of the normal distribution



4.3 Central Limit Theorem - Illustration



10,000 iterations later…



What do you notice?

- About the Shape?
- What happens as we increase the sample size?

Simulation Link: https://onlinestatbook.com/stat_sim/sampling_dist/