

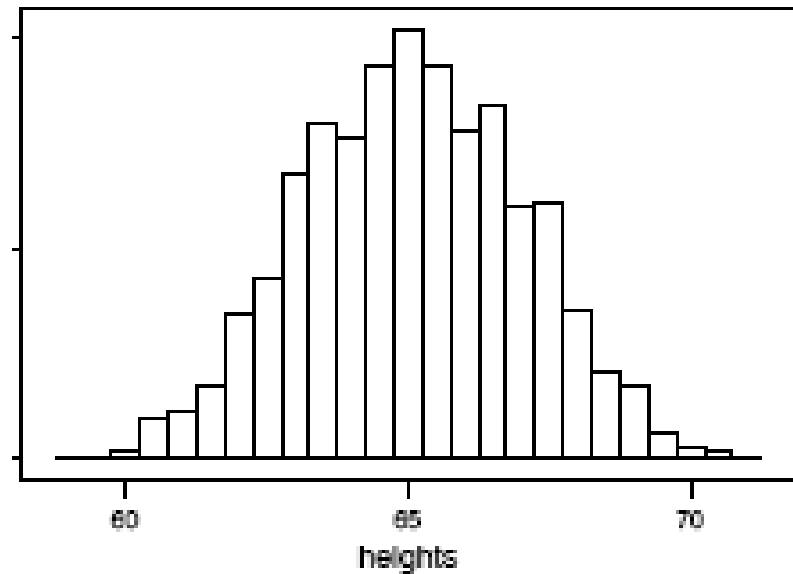
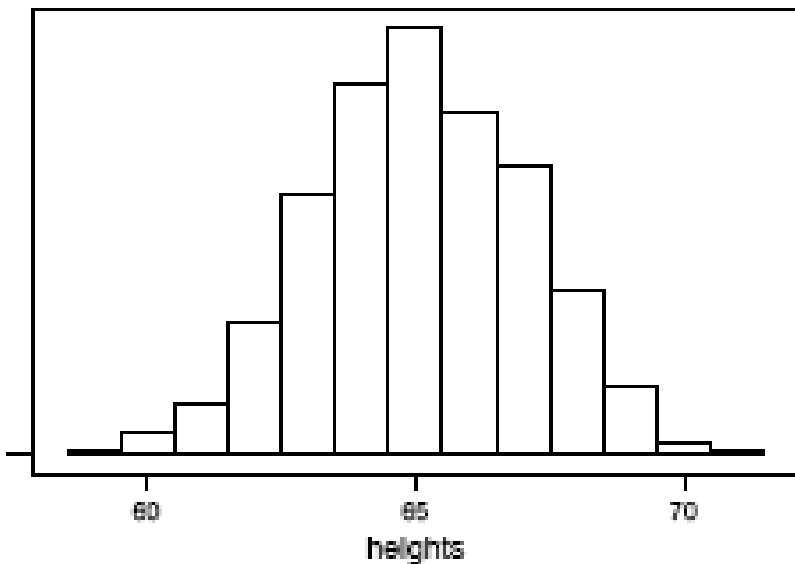
Lecture 10/Chapter 8

Bell-Shaped Curves & Other Shapes

- From a Histogram to a Frequency Curve
- Standard Score
- Using Normal Table
- Empirical Rule

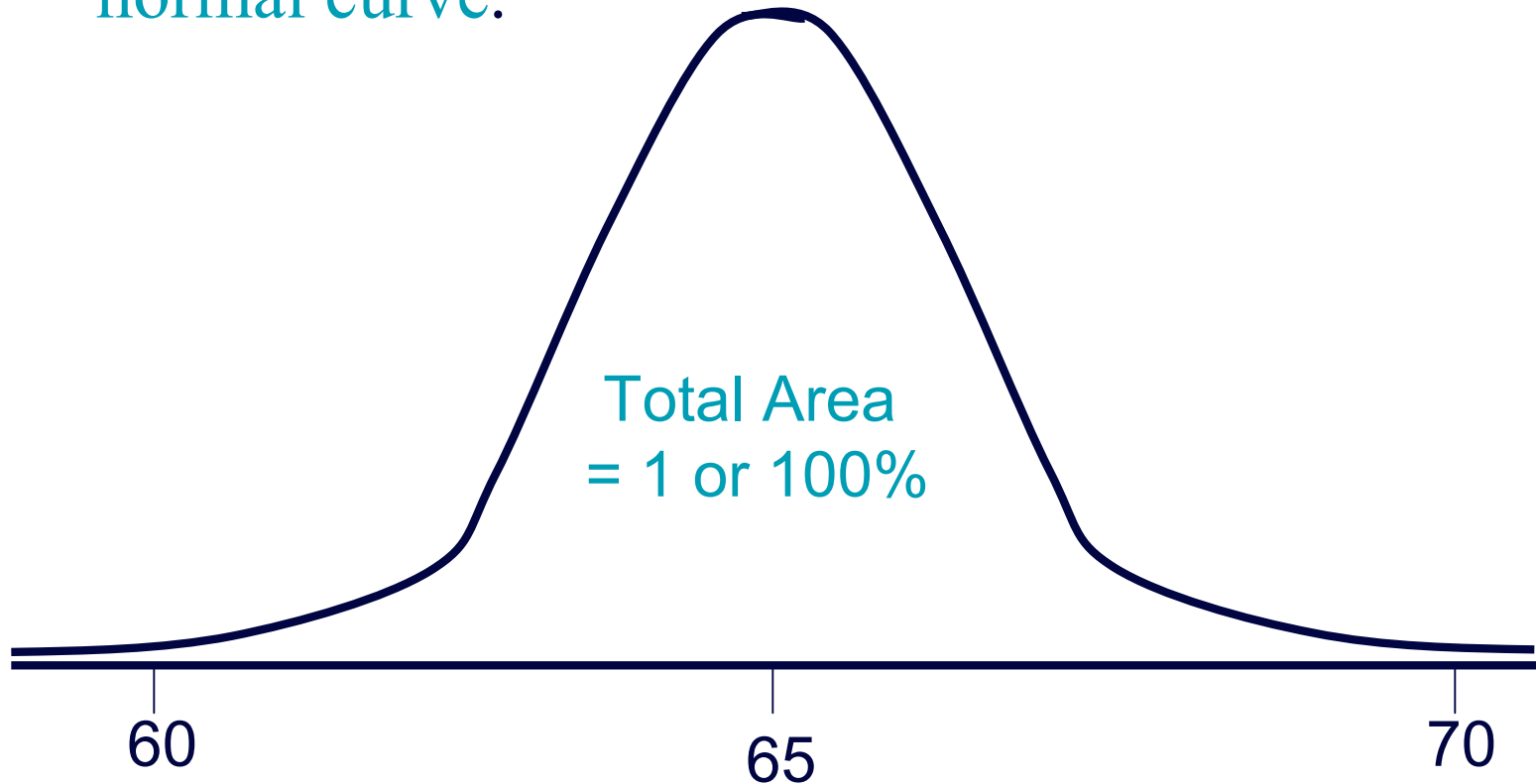
From Histogram to Normal Curve

- Start: sample of female hts to nearest inch (left)
- Fine-tune: sampled hts to nearest 1/2-inch (right)



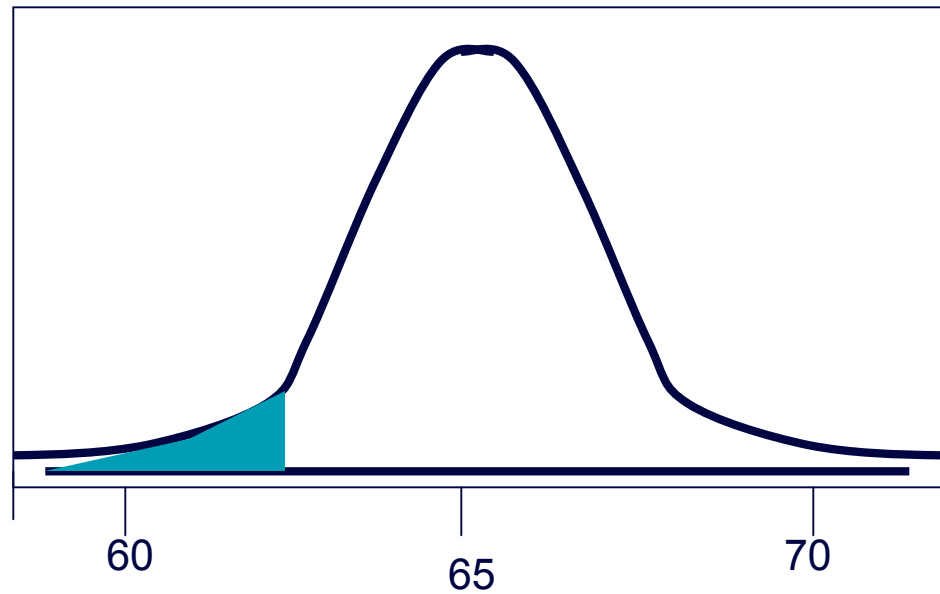
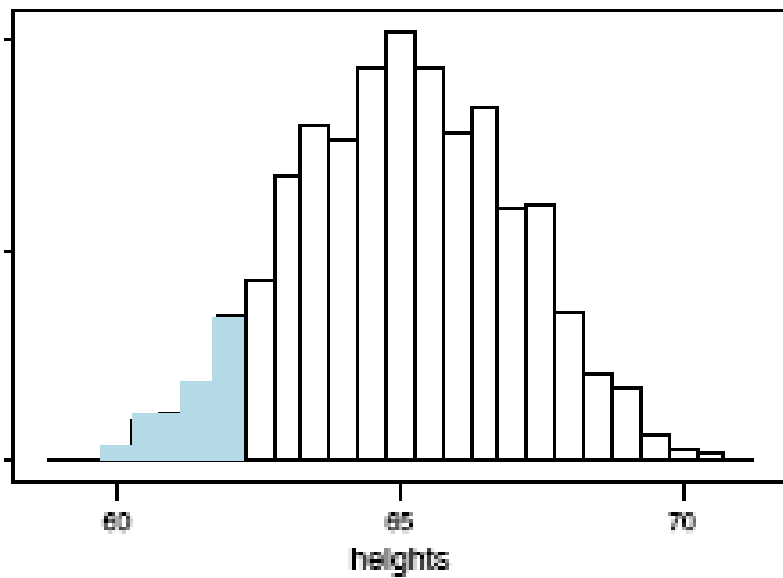
From Histogram to Normal Curve

- Idealize: Population of infinitely many hts over continuous range of possibilities modeled with normal curve.

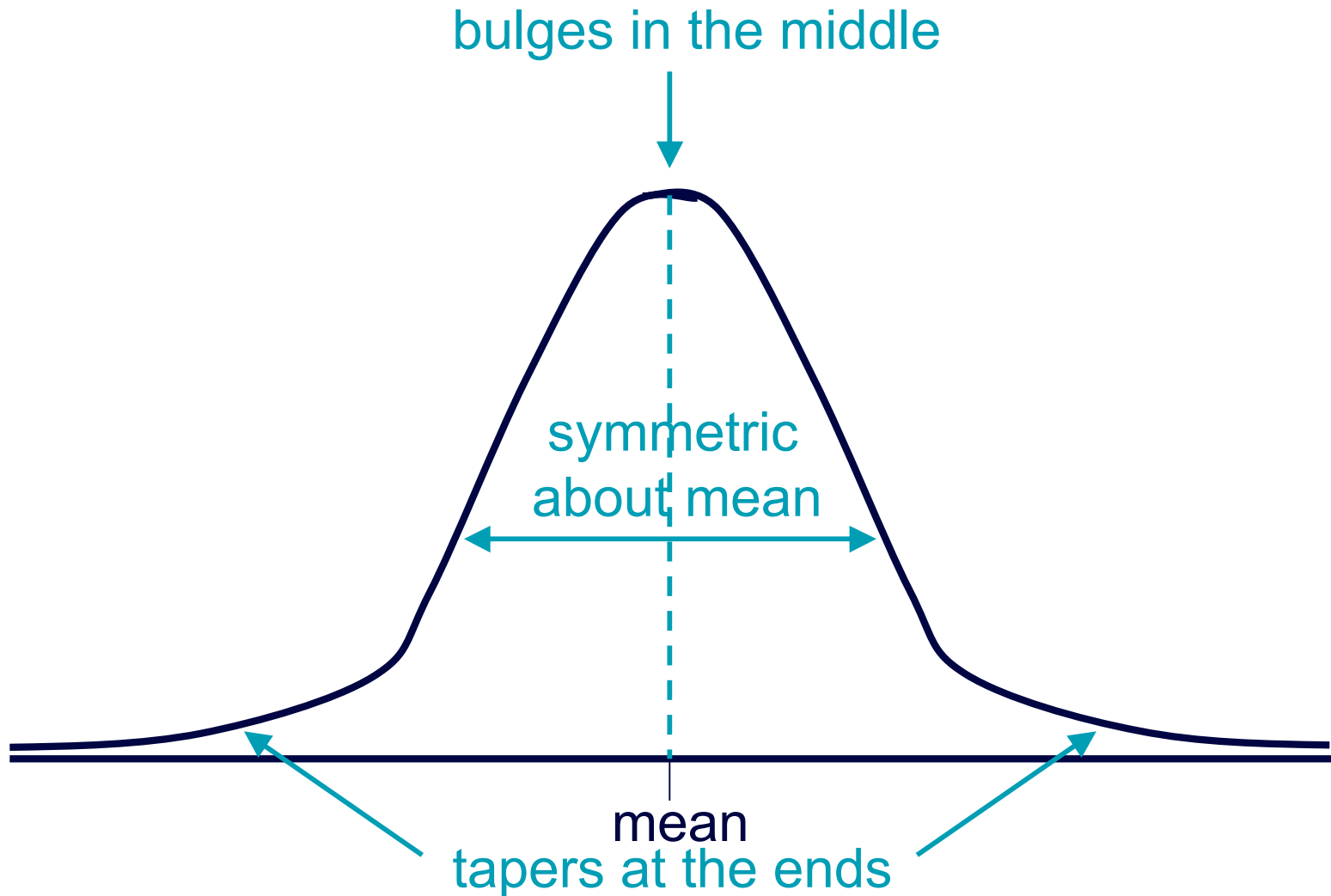


How Areas Show Proportions

- Area of histogram bars to the left of 62 shows proportion of **sampled** heights below 62 inches.
- Area under curve to the left of 62 shows proportion of all heights in **population** below 62 inches.



Properties of Normal Curve





Background of Normal Curve

Karl Friedrich Gauss (1777-1855) was one of the first to explore normal distributions.

Many distributions--such as test scores, physical characteristics, measurement errors, etc.--naturally follow this particular pattern.

If we know the shape is normal, and the value of the mean and standard deviation, we know exactly how the distribution behaves.

There are infinitely many normal curves possible.



Standardizing Values of Normal Distribution

Put a value of a normal distribution into perspective by **standardizing** to its z-score:

$$z = \frac{\text{observed value} - \text{mean}}{\text{standard deviation}}$$



Example: *Sign of z*

- **Background:** A person's z -score for height is found; its sign is negative.
- **Question:** What do we know about the person's height?
- **Response:**



Example: *What z Tells Us*

- **Background:** Heights of women (in inches) have mean 65, standard deviation 2.5. Heights of men have mean 70, standard deviation 3.
- **Question:** Who is taller relative to others of their sex: Jane at 71 inches or Joe at 76 inches?
- **Response:** Jane has $z =$ _____
Joe has $z =$ _____



Example: *More about What z Tells Us*

- **Background:** Jane's z-score for height is +2.4 and Joe's is +2.0.
- **Question:** How do their heights relate to the averages, respectively, for women and men?
- **Response:** Jane's height is

Joe's height is



Example: *Finding a Proportion, Given z*

- **Background:** Jane's z -score for height is $+2.4$ and Joe's is $+2.0$, so the proportion of women shorter than Jane is more than the proportion of men shorter than Joe.
 - **Question:** What are the proportions? *Sketch #1*
 - **Response:** (*See table p. 157.*) The proportion below $z=+2.4$ is about _____; the proportion below $z=+2.0$ is about _____.
- (Jane is in the _____th percentile; Joe is in the _____th.)

Example: Finding %, Given Original Value

- **Background:** Verbal SAT scores for college-bound students are approximately normal with mean 500, standard deviation 100.
- **Question:** If a student scored 450, what percentage scored less than she did? *Sketch #2*
- **Response:** $z = (\text{value} - \text{mean}) / \text{sd} =$
= _____
[450 is _____ stan. deviation below mean]
Table shows _____% are below this.

Example: *Finding Percentage Above*

- **Background:** Verbal SAT scores for college-bound students are approximately normal with mean 500, standard deviation 100.
 - **Question:** If a student scored 400, what percentage scored *more* than he did? **Sketch #3**
 - **Response:** $z = (\text{value} - \text{mean}) / \text{sd} = \underline{\hspace{2cm}}$
 $= \underline{\hspace{1cm}}$ [400 is $\underline{\hspace{1cm}}$ stan. deviation below mean]
- Table shows $\underline{\hspace{2cm}}$ % are *below* this so
 $\underline{\hspace{2cm}}$ % are *above* this.

Example: *Finding z, Given Percentile*

- **Background:** Verbal SAT scores for college-bound students are approximately normal with mean 500, standard deviation 100.
- **Question:** A student scored in the 90th percentile; what was her score? Sketch #4
- **Response:** Table shows 90th percentile has $z = \underline{\hspace{2cm}}$: her score is $\underline{\hspace{2cm}}$ sds above the mean, or $\underline{\hspace{4cm}}$

Example: *Finding z, Given Percentile*

- **Background:** Verbal SAT scores for college-bound students are approximately normal with mean 500, standard deviation 100.
- **Question:** What is the cutoff for top 5%? *Sketch #5*
- **Response:** Proportion above = 0.05 →
proportion below = _____ → $z =$ _____ →
the value is _____ stan. deviations above mean
→ the value is _____.



Example: *Finding Proportion between Scores*

- **Background:** Verbal SAT scores for college-bound students are approximately normal with mean 500, standard deviation 100.
- **Question:** What proportion scored between 425 and 633? *Sketch #6*
- **Response:** 425 has $z = \underline{\hspace{2cm}}$; prop. below = $\underline{\hspace{2cm}}$
633 has $z = \underline{\hspace{2cm}}$; proportion below = $\underline{\hspace{2cm}}$
Prop. with z bet. -0.75 and +1.33 is $\underline{\hspace{2cm}}$

Example: *Proportion within 1 sd of Mean*

- **Background:** *Table 8.1 p. 157* Sketch #7
- **Question:** What proportion of normal values are within 1 standard deviation of the mean?
- **Response:** Proportion below -1 is _____; proportion below $+1$ is _____, so _____ are between -1 and $+1$.



Example: *Proportion within 2 sds of Mean*

- **Background:** *Table 8.1 p. 157* Sketch #8
- **Question:** What proportion of normal values are within 2 standard deviations of the mean?
- **Response:** Proportion below -2 is _____; proportion below $+2$ is _____ →
_____ are between -2 and $+2$.

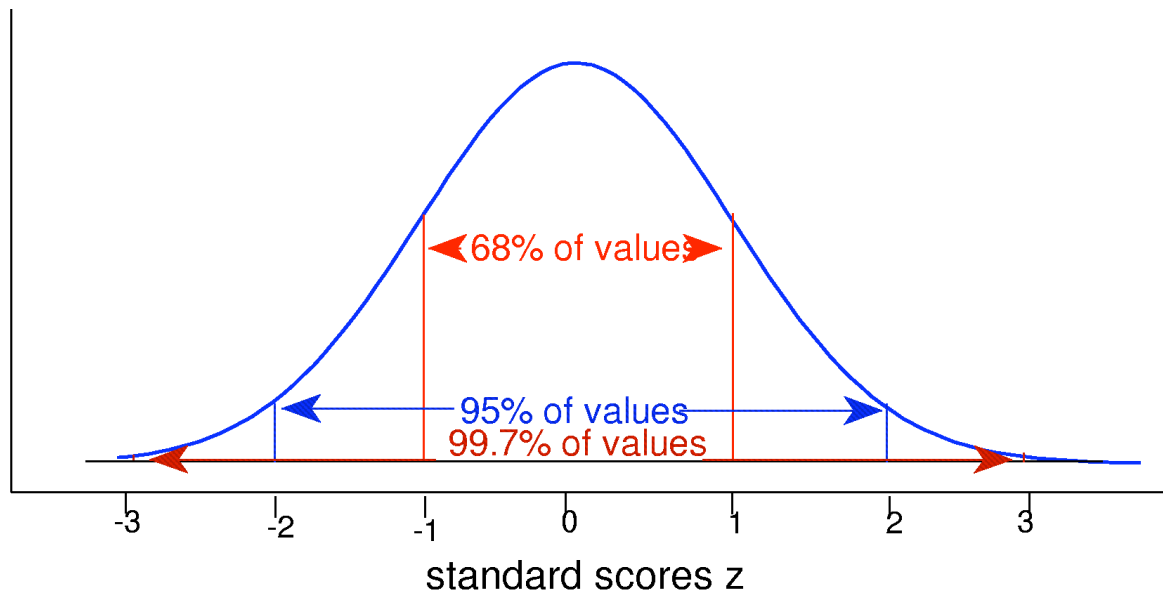
Example: *Proportion within 3 sds of Mean*

- **Background:** *Table 8.1 p. 157* Sketch #9
- **Question:** What proportion of normal values are within 3 standard deviations of the mean?
- **Response:** Proportion below -3 is _____
proportion below $+3$ is _____ →
_____ are between -3 and $+3$.

Empirical Rule (68-95-99.7 Rule)

For any normal curve, approximately

- 68% of values are within 1 sd of mean
- 95% of values are within 2 sds of mean
- 99.7% of values are within 3 sds of mean





Example: *Applying Empirical Rule*

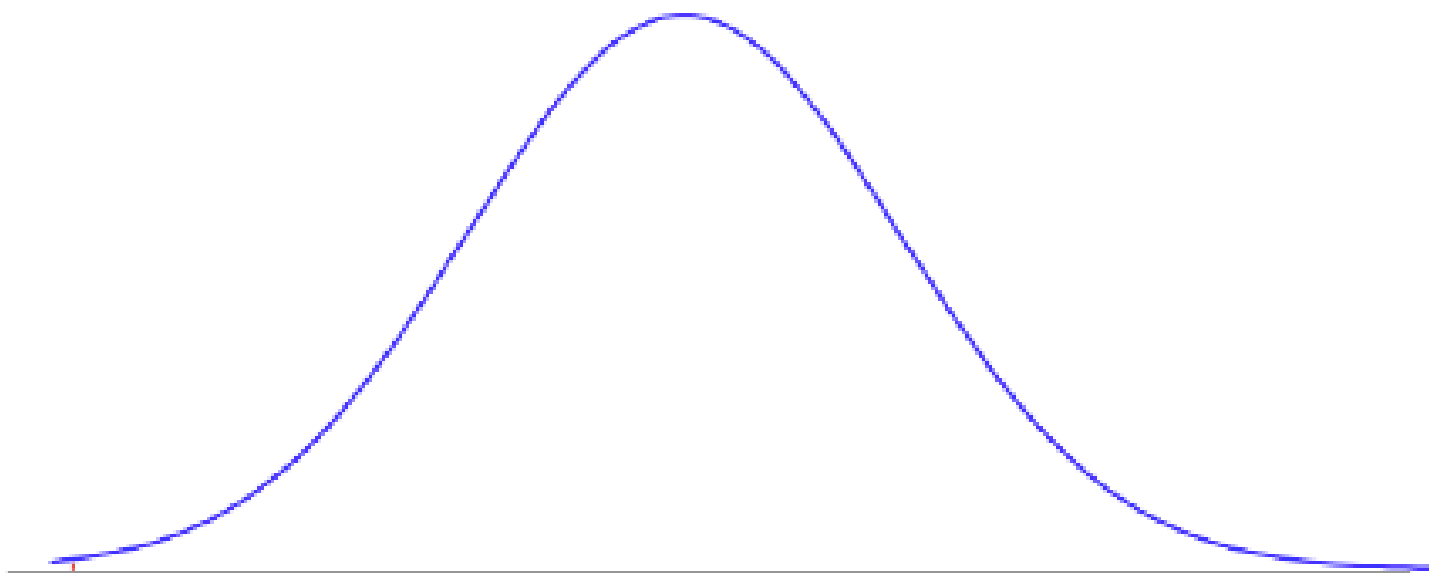
- **Background:** IQ scores normal with mean 100, standard deviation 15.
- **Question:** What does Empirical Rule tell us?
- **Response:**
 - 68% of IQ scores are between _____ and _____
 - 95% of IQ scores are between _____ and _____
 - 99.7% of IQ scores are between _____ and _____



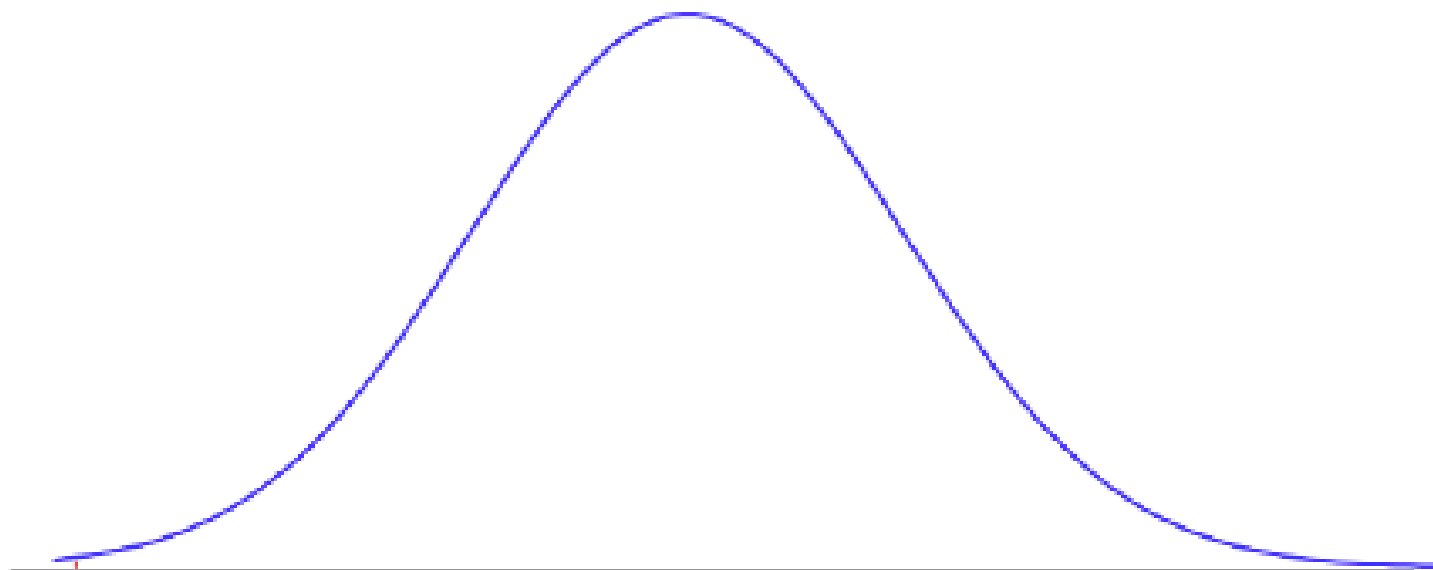
Example: *Applying Empirical Rule?*

- **Background:** Earnings for a large group of students had mean \$4000, stan. dev. \$6000.
 - **Question:** What does Empirical Rule tell us?
 - **Response:**
 - 68% of earnings are between -\$2000 and \$10,000?
 - 95% of earnings are between -\$8000 and \$16,000?
 - 99.7% of earnings between -\$14,000 and \$22,000?
-

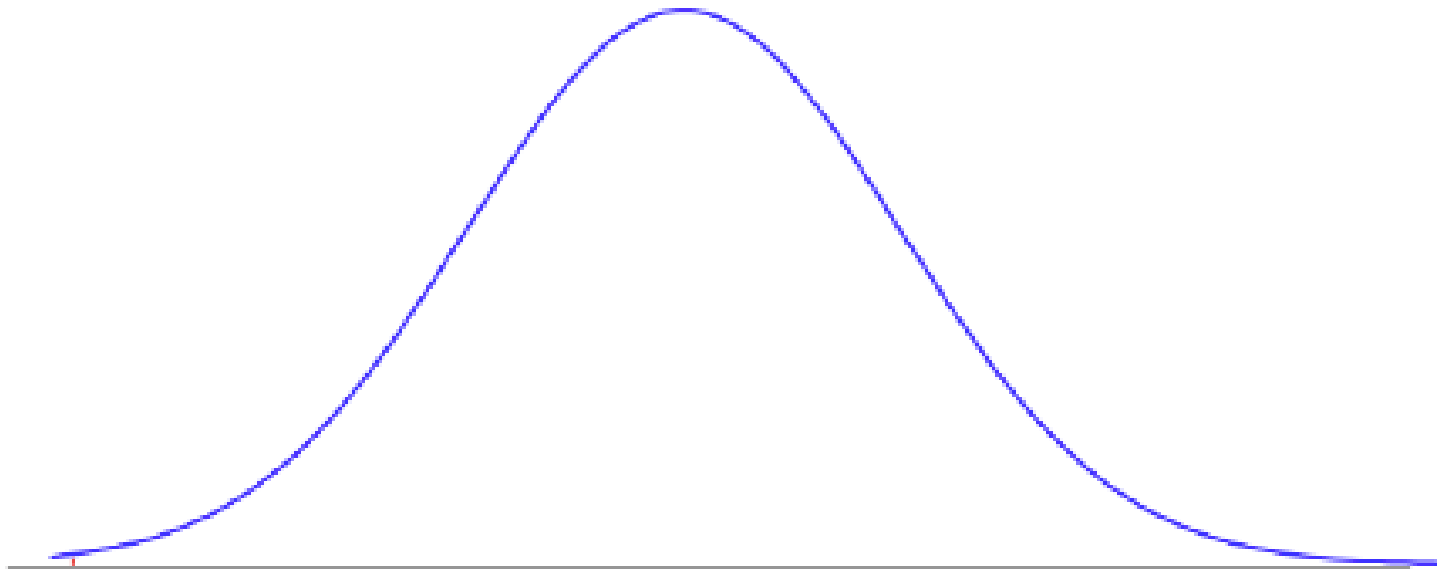
Sketch #1



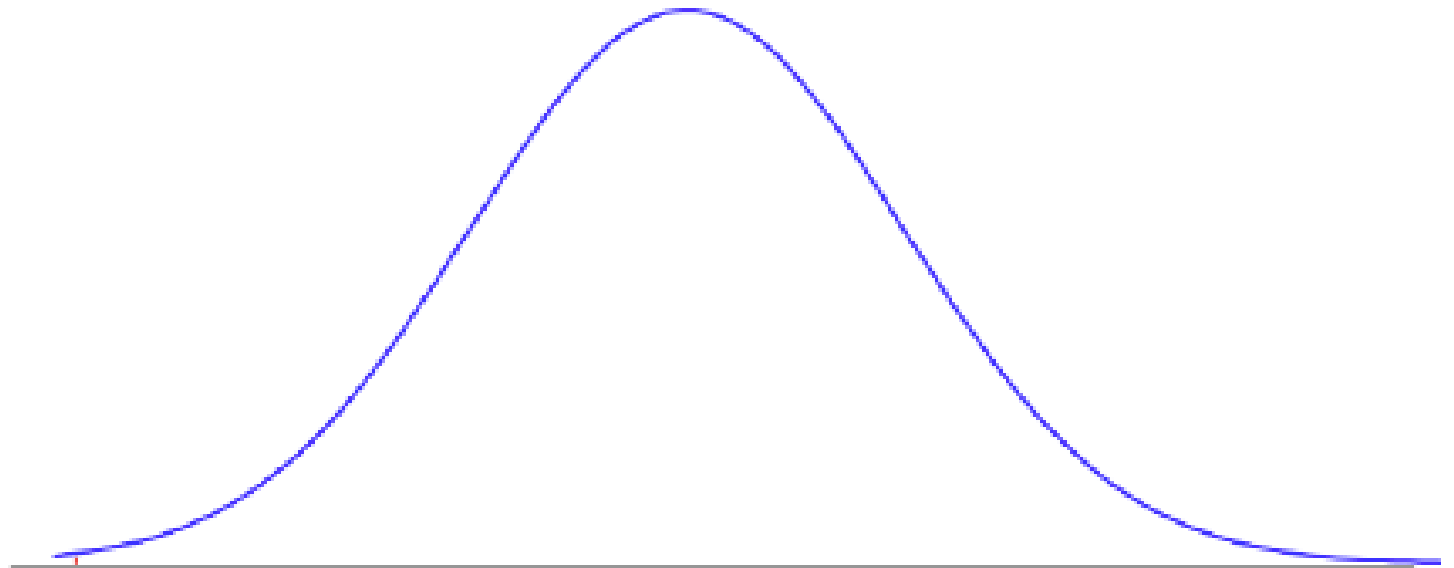
Sketch #2



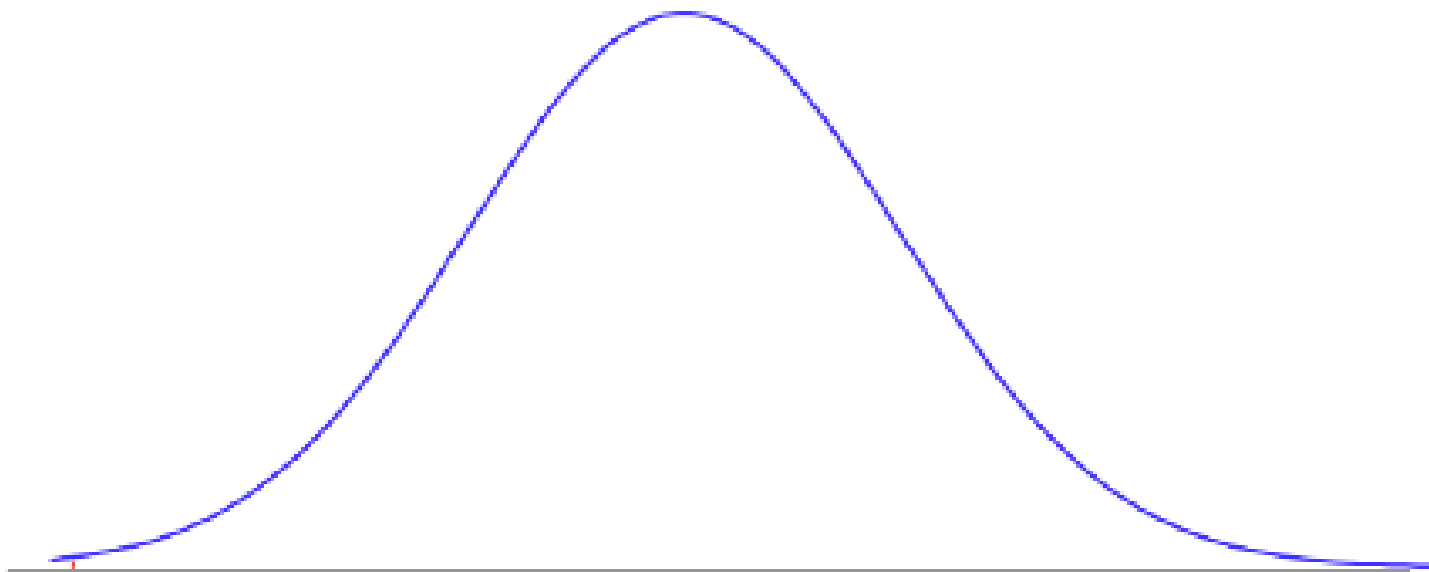
Sketch #3



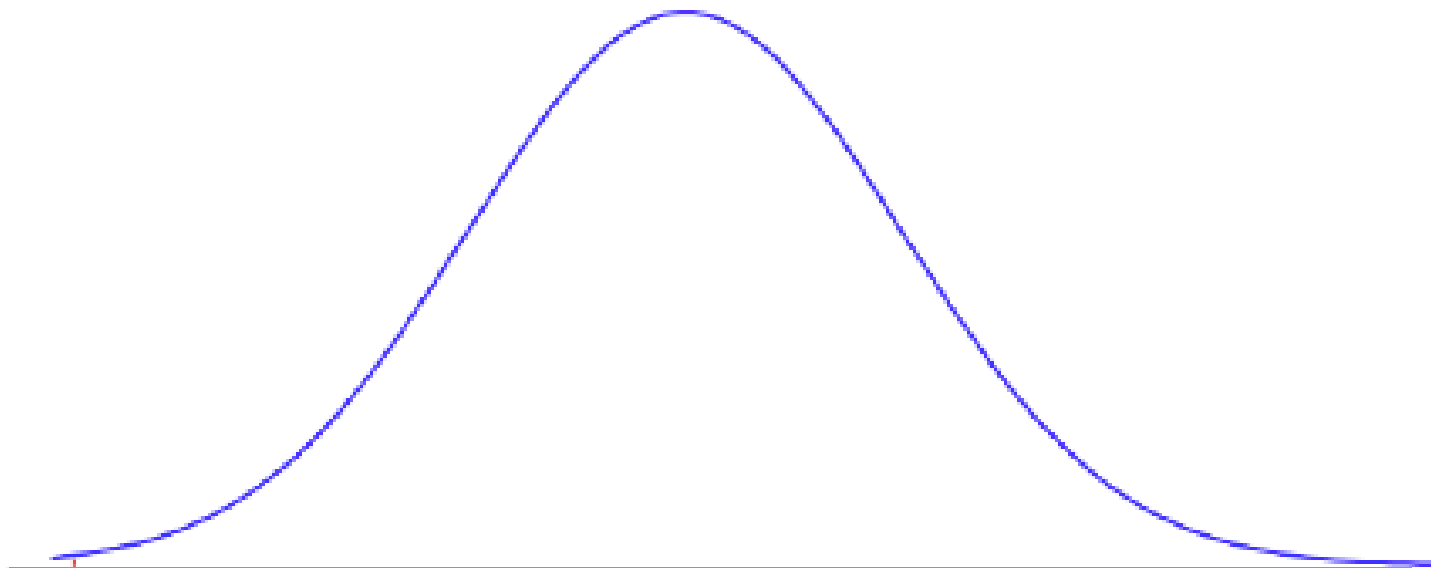
Sketch #4



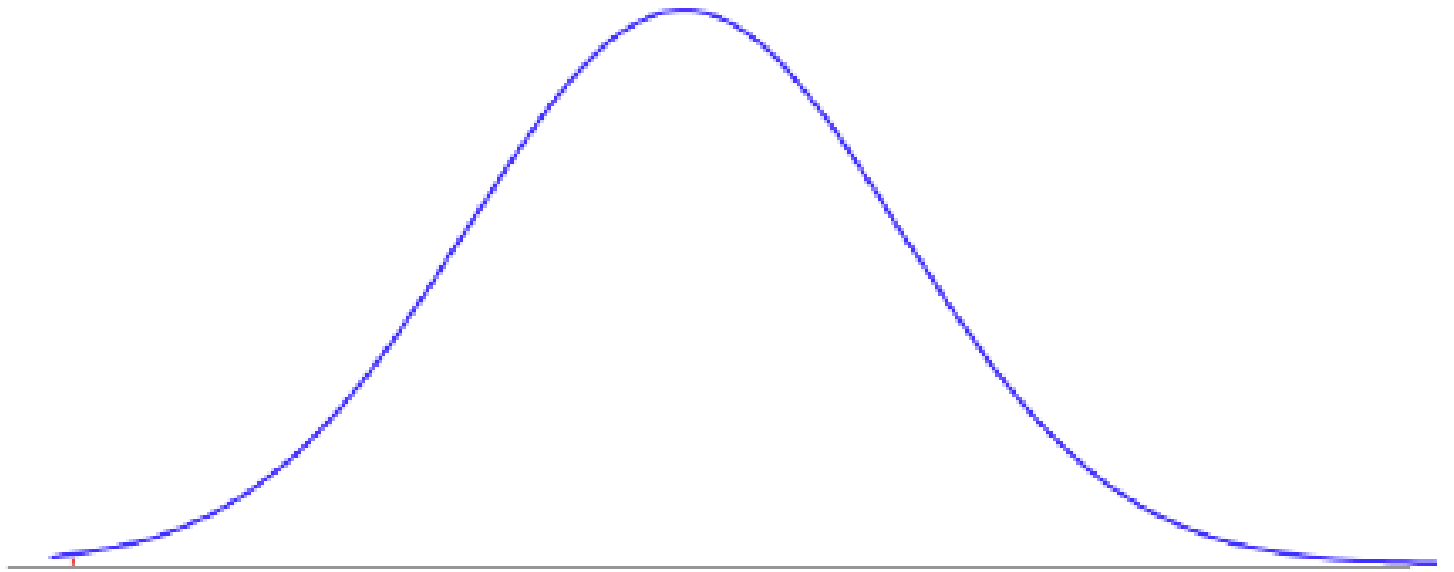
Sketch #5



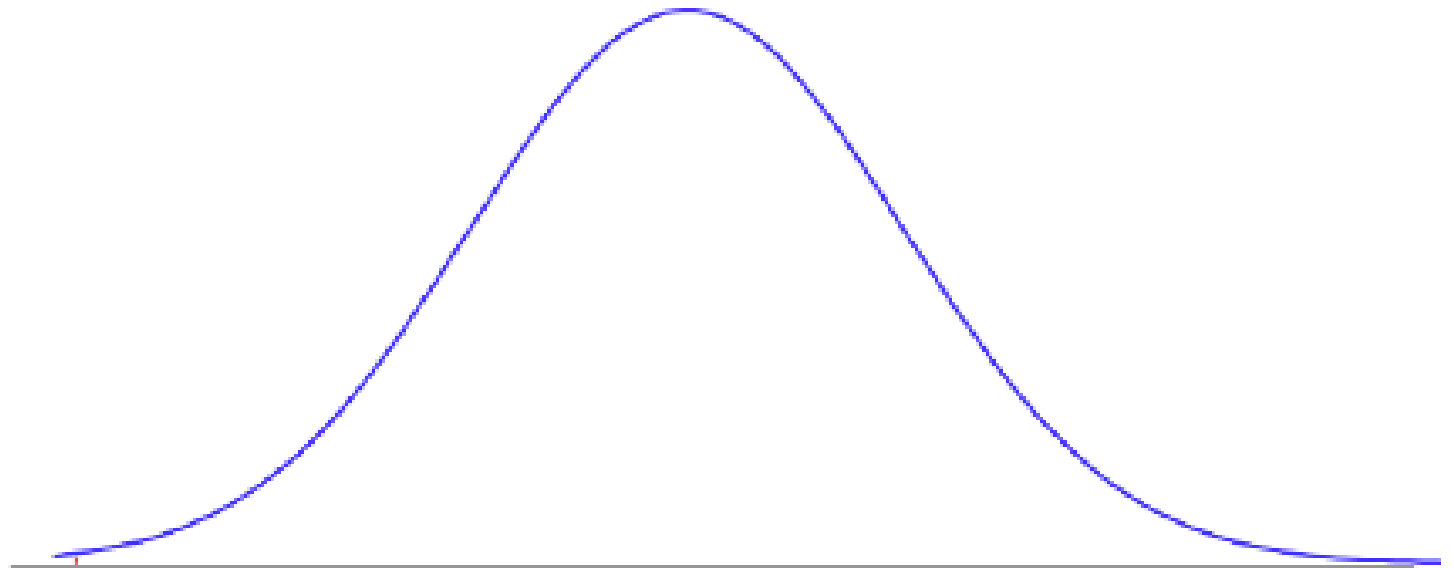
Sketch #6



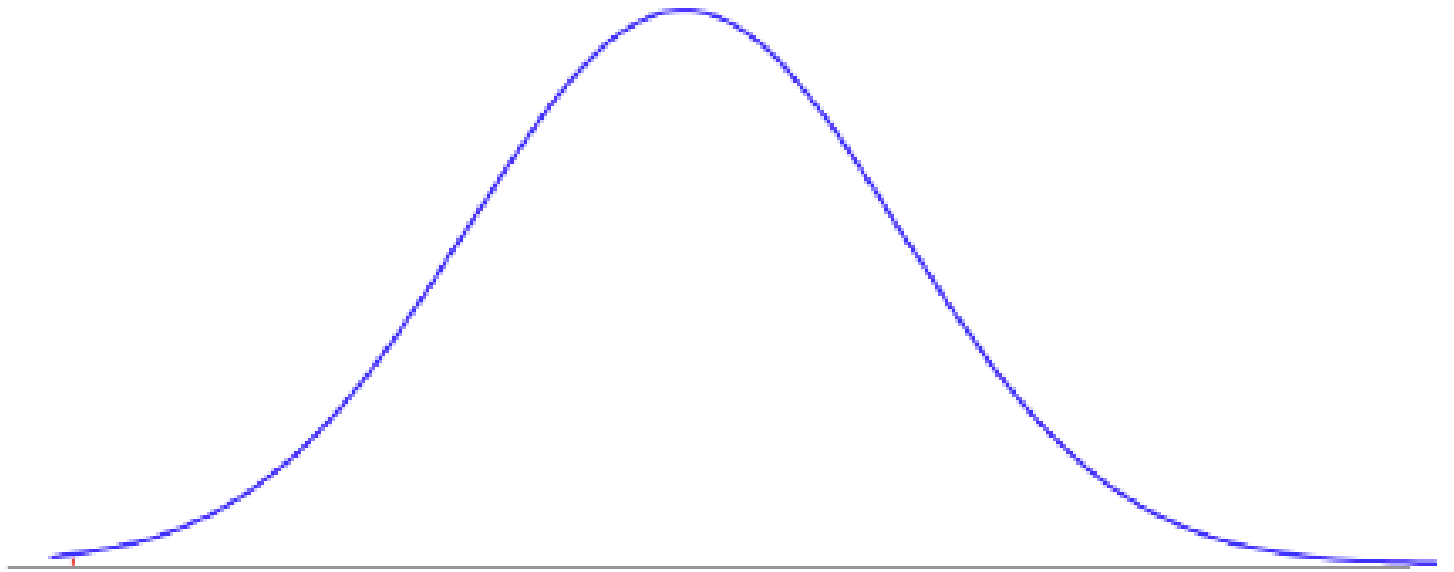
Sketch #7



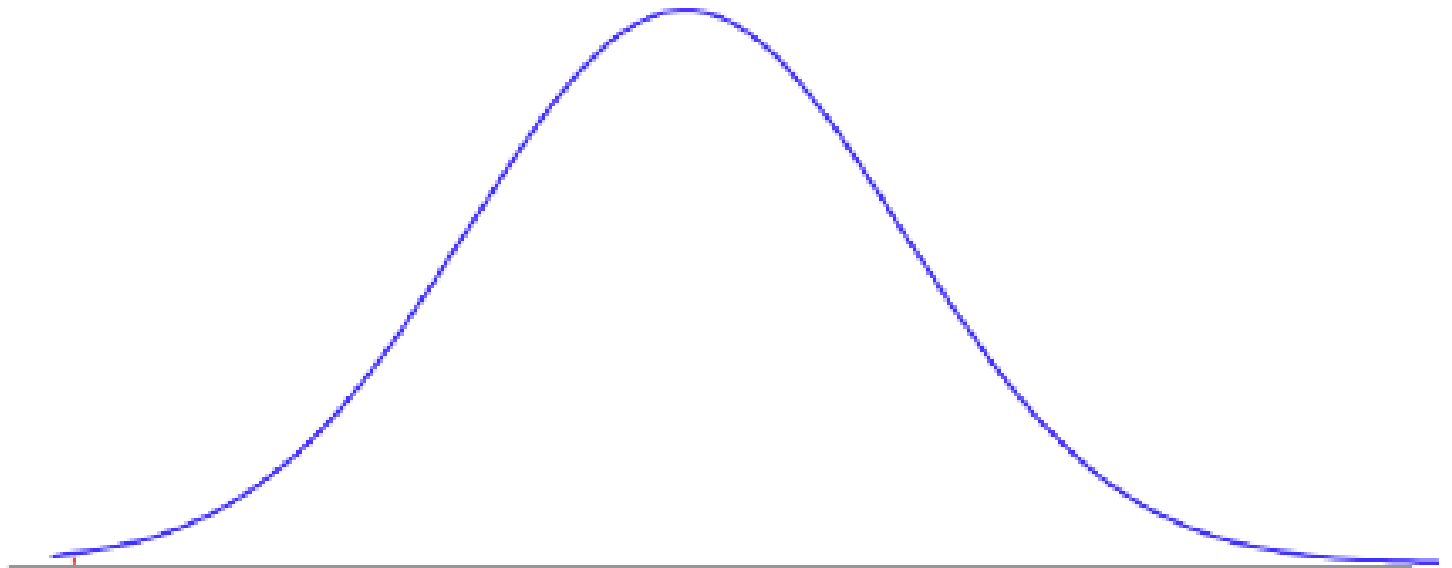
Sketch #8



Sketch #9



Sketch #10





Normal Practice Exercises

Try all the exercises in Lecture 11 before next class; we'll discuss the solutions in lecture.