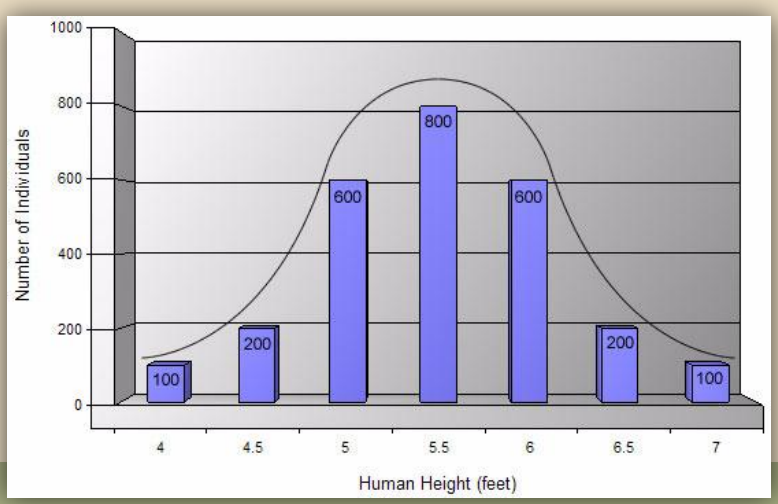
AP Biology Intro to Statistic

Statistics

- Statistical analysis is used to collect a sample size of data which can infer what is occurring in the general population
  - More practical for most biological studies
  - Requires math and graphing data
- Typical data will show a normal distribution (bell shaped curve).
  - Range of data



Statistical Analysis

- Two important considerations
  - How much variation do I expect in my data?
  - What would be the appropriate sample size?

Measures of Central Tendencies

- Mean
  - Average of data set
- Median
  - Middle value of data set
  - Not sensitive to outlying data
- Mode
  - Most common value of data set

Measures of Average

- Mean: average of the data set
  - Steps:
    - Add all the numbers and then divide by how many numbers you added together

$$\bar{\mathbf{x}} = \frac{1}{n}\sum_{i=1}^{n} \mathbf{x}_i. \quad = \quad \bar{x} = \frac{x_1 + x_2 + x_3 + \ldots\ldots\ldots + x_n}{n}$$

Example: 3, 4, 5, 6, 7

3+4+5+6+7= 25
25 divided by 5 = 5
The mean is 5

Measures of Average

- Median: the middle number in a range of data points
  - Steps:
    - Arrange data points in numerical order. The middle number is the median
    - If there is an even number of data points, average the two middle numbers
- Mode: value that appears most often

Example: 1, 6, 4, 13, 9, 10, 6, 3, 19

1, 3, 4, 6, 6, 9, 10, 13, 19

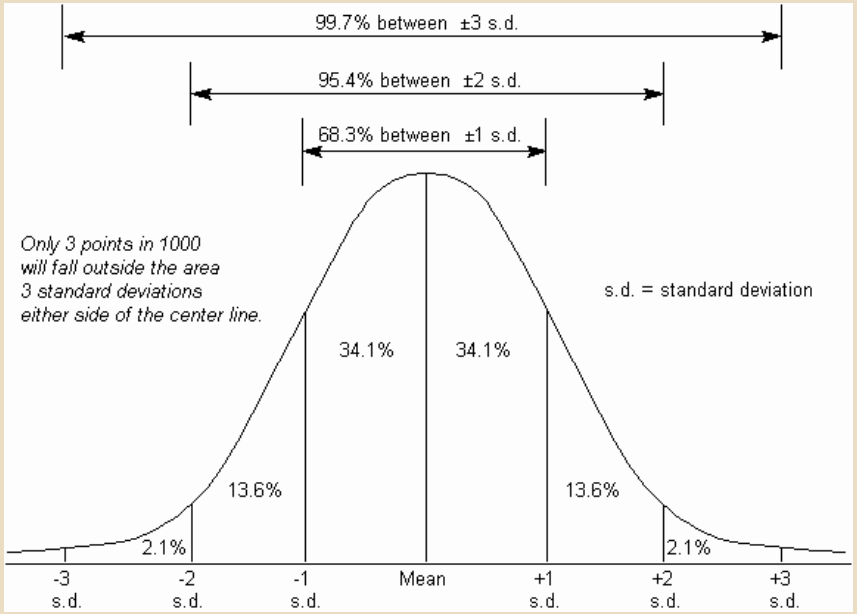
Median = 6

Mode = 6

Measures of Variability

- Standard Deviation
  - In normal distribution, about 68% of values are within one standard deviation of the mean
  - Often report data in terms of +/- standard deviation
- It shows how much variation there is from the "average" (mean).
  - If data points are close together, the standard deviation with be small
  - If data points are spread out, the standard deviation will be larger

Standard Deviation



- 1 standard deviation from the mean in either direction on horizontal axis represents 68% of the data
- 2 standard deviations from the mean and will include ~95% of your data
- 3 standard deviations form the mean and will include ~99% of your data

- Bozeman video: Standard Deviation

Calculating Standard Deviation

Calculation of the standard deviation of a list of numbers can be made easier by using a table:

Difference between measured value and mean
2 - 6.4 = -4.4

Square of number in previous column
-4.4 x -4.4 = 19.6

Measure number	Measured value, x	$(x - \bar{X})$	$(x - \bar{X})^2$
1	2	-4.4	19.36
2	5	-1.4	1.96
3	12	5.6	31.36
60	7	0.6	0.36
61	4	-2.4	5.76
Total:	392	Total:	199.66
Mean, $\bar{X}$	6.4	Std. Dev.:	1.82

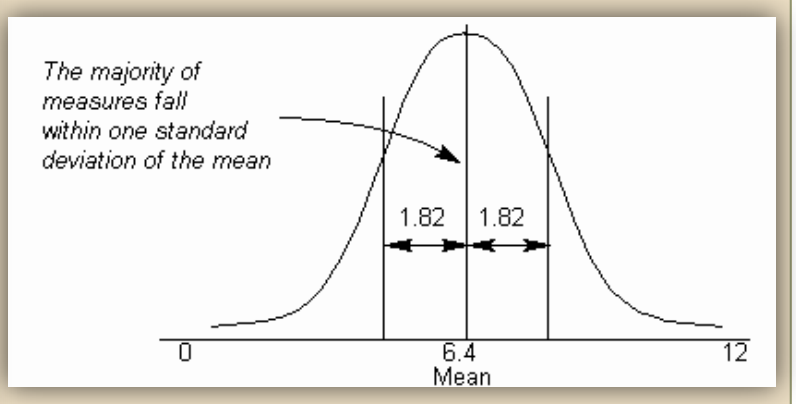
Total number of measurements made, n

Sum of column: $\sum (x - \bar{X})^2$

Average of measured values
$\frac{392}{61} = 6.4$

Standard Deviation = $\sqrt{\frac{\sum (x - \bar{X})^2}{n - 1}} = \sqrt{\frac{199.66}{61 - 1}} = 1.82$

$$s = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$



Calculating Standard Deviation

Grades from recent quiz in AP Biology:

96, 96, 93, 90, 88, 86, 86, 84, 80, 70

1st Step:

find the mean ($\overline{X}$)

$$s = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Measure Number	Measured Value x	$(x - \overline{X})$	$(x - \overline{X})^2$
1	96	9	81
2	96	9	81
3	92	5	25
4	90	3	9
5	88	1	1
6	86	-1	1
7	86	-1	1
8	84	-3	9
9	80	-7	49
10	70	-17	289
TOTAL	868	TOTAL	546
Mean, X	87	Std Dev	

Calculating Standard Deviation

2nd Step:

determine the deviation from the mean for each grade then square it

$$\sum (X - \overline{X})^2$$

$$s = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Measure Number	Measured Value x	$(x - \overline{X})$	$(x - \overline{X})^2$
1	96	9	81
2	96	9	81
3	92	5	25
4	90	3	9
5	88	1	1
6	86	-1	1
7	86	-1	1
8	84	-3	9
9	80	-7	49
10	70	-17	289
TOTAL	868	TOTAL	546
Mean, $\overline{X}$	87	Std Dev	

Calculating Standard Deviation

Measure Number	Measured Value x	$(x - \overline{X})$	$(x - \overline{X})^2$
1	96	9	81
2	96	9	81
3	92	5	25
4	90	3	9
5	88	1	1
6	86	-1	1
7	86	-1	1
8	84	-3	9
9	80	-7	49
10	70	-17	289
TOTAL	868	TOTAL	546
Mean, $\overline{X}$	87	Std Dev	

Step 3:

Calculate degrees of freedom (n-1)

where n = number of data values

So, 10 – 1 = 9

$$s = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Calculating Standard Deviation

Measure Number	Measured Value x	$(x - \overline{X})$	$(x - \overline{X})^2$
1	96	9	81
2	96	9	81
3	92	5	25
4	90	3	9
5	88	1	1
6	86	-1	1
7	86	-1	1
8	84	-3	9
9	80	-7	49
10	70	-17	289
TOTAL	868	TOTAL	546
Mean, $\overline{X}$	87	Std Dev	8

Step 4:

Put it all together to calculate S

$S = \sqrt{(546/9)}$

$= 7.79$

$= 8$

$$s = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Calculating Standard Error

- So for the class data:
  - Mean = 87
  - Standard deviation (S) = 8

- 1 s.d. would be (87 – 8) thru (87 + 8) or 81-95
  - So, 68.3% of the data should fall between 81 and 95
- 2 s.d. would be (87 – 16) thru (87 + 16) or 71-103
  - So, 95.4% of the data should fall between 71 and 103
- 3 s.d. would be (87 – 24) thru (87 + 24) or 63-111
  - So, 99.7% of the data should fall between 63 and 111

Measures of Variability

- Standard Error of the Mean (SEM)
  - Accounts for both sample size and variability
  - Used to represent uncertainty in an estimate of a mean
  - As SE grows smaller, the likelihood that the sample mean is an accurate estimate of the population mean increases

Calculating Standard Error

Using the same data from our Standard Deviation calculation:

Mean = 87

S = 8

n = 10

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

$SE_X = 8/\sqrt{10}$

$= 2.52$

$= 2.5$

Bozeman video: Standard Error

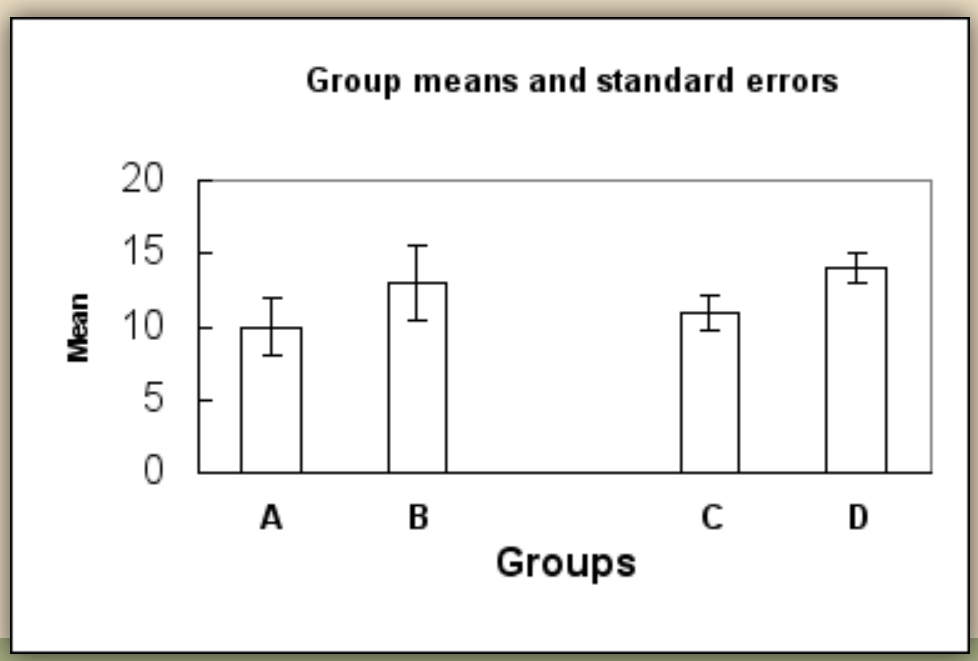
This means the measurements vary by $\pm$ 2.5 from the mean

Graphing Standard Error

- Common practice to add standard error bars to graphs, marking one standard error above & below the sample mean (see figure below). These give an impression of the precision of estimation of the mean, in each sample.

Which sample mean is a better estimate of its population mean, B or C?

Identify the two populations that are most likely to have statistically significant differences?



Additional youtube videos

- Standard Deviation Standard Error of a Sample