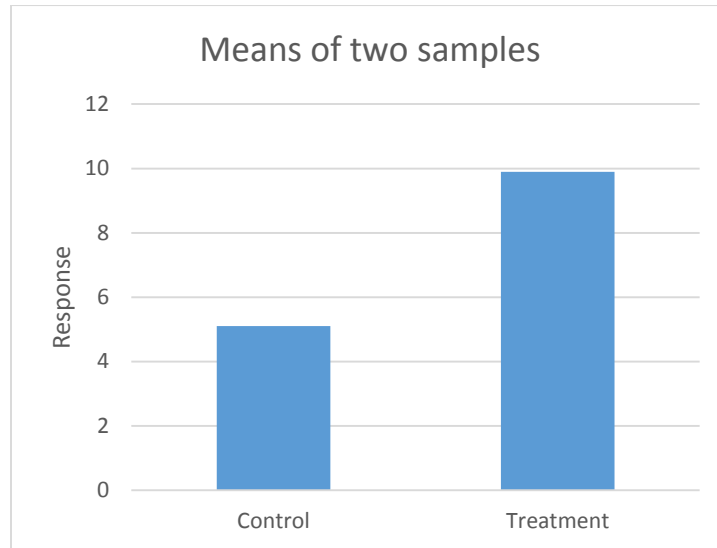
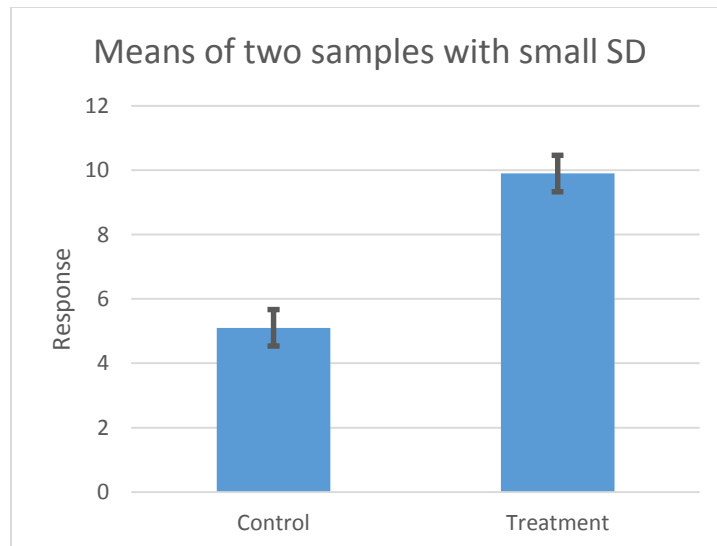


The importance of t-tests

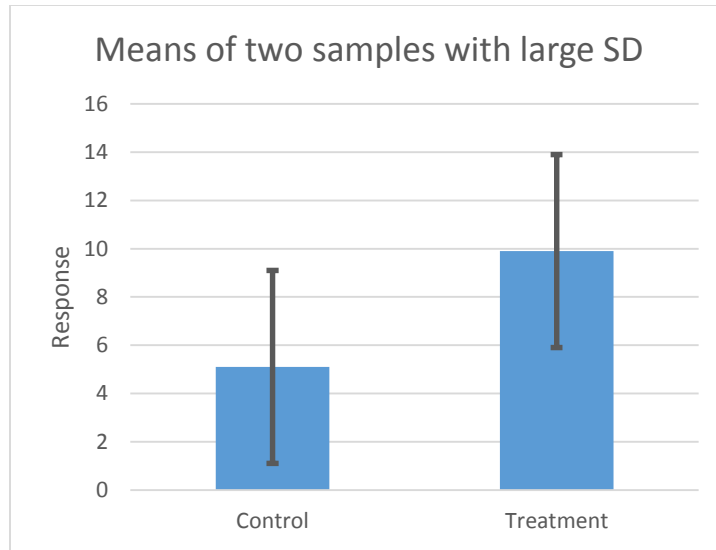
When comparing two samples in an experiment (for example, a response variable in the control vs. the same response variable in the treatment), you will probably first look at the average response of each sample. See the graph below for an example of comparing two means:



By just glancing at that graph, you may conclude that your treatment group had a response twice as large as the control group. What we're forgetting here, however, is the amount of variation we measured in each group. We can visualize the variation in our response variable by adding error bars around the means to show what the range of responses were for each treatment. Commonly, scientists use standard deviation to determine the size of their error bars.



In the above graph with added error bars, the variation and standard deviation of our samples is very small. This means our treatment really *was* different from the control, and a t-test will likely show that the result is significantly different ($p < 0.05$).



The above graph shows a different case where even though the means haven't changed, the standard deviations of each sample are so large that the error bars overlap. This means that the difference in average response was due to random sampling variation, not an effect of the experimental treatment. A t-test in this case will most likely show that $p > 0.05$ and you do *not* have a significant difference.

T-tests help scientists decide if the differences we find in the lab are due to the factors we are experimentally manipulating, or if they are due to random chance instead!

Using formulas to perform t-tests

Start by arranging your data into two continuous groups that are easy to highlight separately. In this case, Sample 1 is all in a single column next to a column containing Sample 2 values.

	A	B	C
1		Sample 1	Sample 2
2		5	15
3		8	17
4		9	19
5		7	17
6		6	18
7		5	13
8			

To get the p-value for your samples, type =T.TEST into an empty cell (the formula =TTEST also works for older versions of Excel).

	A	B	C	D	E	F	G	H	I	J	K
1		Sample 1	Sample 2		T test						
2		5	15		p-value	=T.TEST					
3		8	17		t statistic	T.TEST	Returns the probability associated with a Student's t-Test				
4		9	19								
5		7	17								
6		6	18								
7		5	13								
8											

The first of four arguments required for the formula T.TEST is your first array of data (array1). Highlight your first samples and then type a comma to move on to the next argument.

	A	B	C	D	E	F	G	H
1		Sample 1	Sample 2		T test			
2		5	15		p-value	=T.TEST(B2:B7		
3		8	17		t statistic	T.TEST(array1, array2, tails, type)		
4		9	19					
5		7	17					
6		6	18					
7		5	13					

Highlight your second set of samples for array2.

	A	B	C	D	E	F	G	H
1		Sample 1	Sample 2		T test			
2		5	15		p-value	=T.TEST(B2:B7,C2:C7		
3		8	17		t statistic	T.TEST(array1, array2, tails, type)		
4		9	19					
5		7	17					
6		6	18					
7		5	13					

The next argument tails asks if you are doing a one-tailed or two-tailed t-test. We are using a two-tailed test, so type 2.

The first argument, probability, refers to the p-value we just calculated (p stands for probability!), so highlight the cell you just completed and type a comma.

				=T.INV.2T(F2)				
	A	B	C	D	E	F	G	H
1		Sample 1	Sample 2		T test			
2			5	15	p-value	4.69439E-06		
3			8	17	t statistic	=T.INV.2T(F2)		
4			9	19				
5			7	17				
6			6	18				
7			5	13				

The next argument, degrees of freedom, is equal to $n - 2$. n is the number of samples you have (12 total in this case) minus the number of groups of samples you have (2 groups). So degrees of freedom = 10.

				=T.INV.2T(F2,10)				
	A	B	C	D	E	F	G	H
1		Sample 1	Sample 2		T test			
2			5	15	p-value	4.69439E-06		
3			8	17	t statistic	=T.INV.2T(F2,10)		
4			9	19				
5			7	17				
6			6	18				
7			5	13				
8								

After hitting enter, you have both values for your results!

	A	B	C	D	E	F
1		Sample 1	Sample 2		T test	
2			5	15	p-value	4.69439E-06
3			8	17	t statistic	8.874438355
4			9	19		
5			7	17		
6			6	18		
7			5	13		
8						