Use these tasks to check your understanding & skills for the this subtopic.

	Assessment Statement	Obj.
1.1.1	**State** that error bars are a graphical representation of the variability of data. ❑ *These can show range or standard deviation* ❑ *95% confidence intervals can be presented as error bars to suggest significance of differences*	1
1.1.2	**Calculate** the mean and standard deviation of a set of values. ❑ *Using your TI Inspire OR TI84 (for the exam)* ❑ *Using Excel (for labs)*	2
1.1.3	**State** that the term standard deviation is used to **summarize the spread of values around the mean**, and that **68% of the values** fall within ± one standard deviation of the mean	1
1.1.4	**Explain** how the standard deviation is useful for comparing the means and the spread of data between two or more samples. ❑ *A greater standard deviation means a greater spread of data around the mean.* ❑ *This can be used to infer variability.*	3
1.1.5	**Deduce** the significance of the difference between two sets of data using calculated values for *t* and the appropriate tables. ***State*** *whether we accept or reject the Null Hypothesis (H_0).* ❑ Use the value of t (given) from a table, comparing it to critical values & interpret the results ❑ Use the =TTEST function in Excel to get to the P value & interpret the results	3
1.1.6	**Explain** that the existence of a correlation does not establish that there is a causal relationship between two variables.	3

❑ Complete *Quia Quiz 1.1 Statistical Analysis*

The table the right shows the critical values for values of t.

In Biology, we will usually use a **P-value of 0.05**. This means that we are 95% sure that differences in results are real, not due to chance (there is 5% or less overlap in data).

- ❑ **Identify** the column that shows the values for P=0.05. **Highlight** this column.
- ❑ **Draw** an arrow above the table to show the direction in which we become 'more confident' in our results.

"DF" means "**degrees of freedom**" - the **total sample size** (adding both groups together) **minus two**.

- ❑ **State** the degrees of freedom in these tests:

A. There are 20 samples in total. DF= _____
B. Group A has 16 samples, Group B has 10. DF= _____
C. 11 *before* and 11 *after* samples are taken. DF= _____

The critical value is found by cross-referencing the DF with the P=0.05 column. Find the critical values for the samples above.

A. cv = _____ B. cv = _____ C. cv = _____

A **t-value** is calculated from the sample data. We do not need to know how to do this. We do need to know how to determine significance by comparing 't' to the critical value.

Table from: http://www.medcalc.org/manual/t-distribution.php

DF	A P	0.80 0.20	0.90 0.10	0.95 0.05	0.98 0.02
1		3.078	6.314	12.706	31.820
2		1.886	2.920	4.303	6.965
3		1.638	2.353	3.182	4.541
4		1.533	2.132	2.776	3.747
5		1.476	2.015	2.571	3.365
6		1.440	1.943	2.447	3.143
7		1.415	1.895	2.365	2.998
8		1.397	1.860	2.306	2.897
9		1.383	1.833	2.262	2.821
10		1.372	1.812	2.228	2.764
11		1.363	1.796	2.201	2.718
12		1.356	1.782	2.179	2.681
13		1.350	1.771	2.160	2.650
14		1.345	1.761	2.145	2.625
15		1.341	1.753	2.131	2.602
16		1.337	1.746	2.120	2.584
17		1.333	1.740	2.110	2.567
18		1.330	1.734	2.101	2.552
19		1.328	1.729	2.093	2.539
20		1.325	1.725	2.086	2.528
21		1.323	1.721	2.080	2.518
22		1.321	1.717	2.074	2.508
23		1.319	1.714	2.069	2.500
24		1.318	1.711	2.064	2.492
25		1.316	1.708	2.060	2.485
26		1.315	1.706	2.056	2.479
27		1.314	1.703	2.052	2.473
28		1.313	1.701	2.048	2.467
29		1.311	1.699	2.045	2.462
30		1.310	1.697	2.042	2.457
31		1.309	1.695	2.040	2.453
32		1.309	1.694	2.037	2.449

Deducing <u>significance</u> by comparing calculated values of t with the t-table.
In a test for significance we set out our working like this. Use this as an example for your work.

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H_0 (Null hypothesis):
"There is no significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

H_1 (Alternate hypothesis)
"There is a significant difference."

If t < cv, we accept H_0.
If t > cv, we reject H_0.

Conclusion: There <u>is / is not</u> a significant difference between the results.

.....

How does this work? *Check your understanding.*

- ❑ As we become more confident in our data, the P value decreases.
  - ❑ The corresponding critical values increase.
  - ❑ So if the t-value is larger than the critical value, we are more confident in the results.

Practice Questions

1. A researcher measures the wing-spans of 12 red-throat and 13 broad-billed hummingbirds. The t-value is calculated as 2.15. **Deduce** the significance of the difference between the two types of birds.

H_0 (Null hypothesis):
"There is no significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

H_1 (Alternate hypothesis)
"There is a significant difference."

If t < cv, we accept H_0.
If t > cv, we reject H_0.

Conclusion: There <u>is / is not</u> a significant difference between the results.

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2. A student measures the shells of 16 snails on the north side of an island and 15 on the south. The t-value is calculated as 1.61. **Deduce** the significance of the difference between the two types of snails.

H_0 (Null hypothesis):
"There is no significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

H_1 (Alternate hypothesis)
"There is a significant difference."

If t < cv, we accept H_0.
If t > cv, we reject H_0.

Conclusion: There <u>is / is not</u> a significant difference between the results.

.....

3. Quick practice: **determine** the significance of these differences.

	Group A	Group B	DF	t =	cv =	Accept or Reject H_0?	Significant difference?
3a	n = 5	n = 7		2.405			
3b	n = 12	n = 12		2.029			

More practice

4. 15 students take a quiz before and after a set of lessons and the results compared. The t-value is calculated as 1.94. **Deduce** the significance of the difference between the results before and after.

H_0 (Null hypothesis):
"There is no significant difference."

H_1 (Alternate hypothesis)
"There is a significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

If t < cv, we accept H_0.
If t > cv, we reject H_0.

Conclusion: There is / is not a significant difference between the results.

.....

5. In a test of a heart medication, a control group of 11 patients was compared to the test group of 14 patients. The t-value is calculated as 2.225. **Deduce** the significance of the difference between the results of the control and the test group.

H_0 (Null hypothesis):
"There is no significant difference."

H_1 (Alternate hypothesis)
"There is a significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

If t < cv, we accept H_0.
If t > cv, we reject H_0.

.....

6. The weights of 12 babies were measured before and after a treatment of anti-parasite medication. The t-value is calculated as 3.112. **Deduce** the significance of the difference between the results of the control and the test group.

H_0 (Null hypothesis):
"There is no significant difference."

H_1 (Alternate hypothesis)
"There is a significant difference."

Degrees of freedom = _____ P = 0.05

t = _____ critical value = _____

If t < cv, we accept H_0.
If t > cv, we reject H_0.

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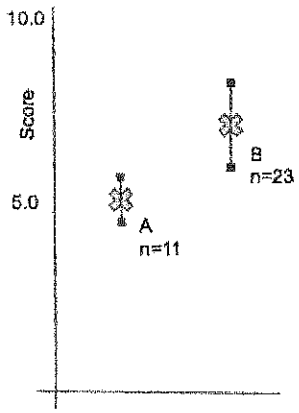
7. In this graph, two means are compared. Error bars show **standard deviation**.



State the mean of each population. A = _____ B = _____

Compare the standard deviations of each group.

Can we tell from the error bars whether the two groups are significantly different?

The t-value of of the data is calculated as 2.025.
What conclusion can be drawn from these data?

8. **Experimental Design.** How would you design an investigation into whether students are more alert in the morning or after lunch?

- ❑ What data might you collect?
- ❑ How would this be processed, graphed and analysed?
- ❑ What statistical test would you use?

EXIT TICKET: 2-minute Essay

Before you leave, **summarise** your learning on statistical analysis. Include:

- ❑ Importance of standard deviation & uses of error bars
- ❑ Function of t-tests
- ❑ Correlation and causation

Name: _____