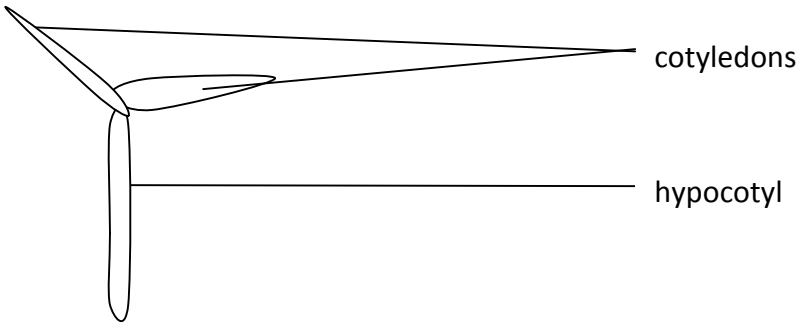
Chi Squared Test χ^2



To carry out a Chi-Squared Test fill in the table below

	Green Cotyledon Purple Hypocotyl	*Green Cotyledon Green Hypocotyl*	*Golden Cotyledon Green Hypocotyl*	*Golden Cotyledon Purple Hypocotyl*	*Total*
observed number (O)					
expected number (E)					
$O-E$					
$(O-E)^2$					
$\frac{(O-E)^2}{E}$					

χ^2 =

Chi Squared Test χ^2

A Chi Squared test is a simple and valuable way of analysing discrete data. It is a way of exploring whether differences between observed and expected data are significant, or not.

An example

Let's say we have a sample of 48 Eu-Sol Tomato seeds. We would expect a 9:3:3:1 ratio in these seeds.

27 9 9 3

However, when the seeds are grown we observe the following numbers

25 18 4 1

Is this significant? Do the seeds have a 9:3:3:1 ratio and our sample doesn't reflect this or is there, in fact, a different ratio in the seeds other than 9:3:3:1?

A Chi Squared test can help us decide.

Firstly we assume that the seeds do, indeed, have a 9:3:3:1 ratio. This is called a *null hypothesis*. This is what we are trying to prove.

Then we look for a value for χ^2. This value will tell us whether, or not, we reject the null hypothesis. To reject the null hypothesis would mean that the seeds do not, in fact, have a 9:3:3:1 ratio. We will compare our value for χ^2 to values in a table to decide whether, or not, we reject our null hypothesis.

To find a value for χ^2 we fill out the following table.

	Green Cotyledon Purple Hypocotyl	*Green Cotyledon Green Hypocotyl*	*Golden Cotyledon Green Hypocotyl*	*Golden Cotyledon Purple Hypocotyl*	Total
observed number (O)	25	18	4	1	48
expected number (E)	27	9	9	3	48
$O-E$	-2	9	-5	-2	0
$(O-E)^2$	4	81	25	4	114
$\frac{(O-E)^2}{E}$	0.15	9	2.78	1.33	13.26

So we get a value of **13.26**. Now we need to analyse this figure.

We need to compare our χ^2 value with those from a chi squared table. There is a chi squared table at the end of this document.

The table shows 'degrees of freedom' against 'probability, *p*'.

The 'degrees of freedom' is the number of variables minus 1. We have 4 variables (different possibilities of seedling) to observe, so we need to look at the row with degrees of freedom = 3.

Degrees of Freedom	**Probability, *p***				
	0.99	**0.95**	**0.05**	**0.01**	**0.001**
1	0.000	0.004	3.84	6.64	10.83
2	0.020	0.103	5.99	9.21	13.82
3	0.115	0.352	7.82	11.35	16.27
4	0.297	0.711	9.49	13.28	18.47
5	0.554	1.145	11.07	15.09	20.52

Different probabilities give us different values. These are interpreted as follows.

> To reject our null hypothesis at a probability of 0.05 we need a chi squared value of at least 7.82
>
> To reject our null hypothesis at a probability of 0.01 we need a chi squared value of at least 11.35
>
> To reject our null hypothesis at a probability of 0.001 we need a chi squared value of at least 16.27

Our value was **13.26**.

Therefore we would conclude that we **reject our null hypothesis** at probabilities of 0.05 and 0.01 and that the seeds do not have a 9:3:3:1 ratio.

But, at a probability of 0.001 we would **not reject the null hypothesis** and would conclude there was not sufficient evidence to suggest that our seeds did not have a 9:3:3:1 ratio.

Chi Squared table χ^2

Degrees of Freedom	Probability, *p*				
	0.99	**0.95**	**0.05**	**0.01**	**0.001**
1	0.000	0.004	3.84	6.64	10.83
2	0.020	0.103	5.99	9.21	13.82
3	0.115	0.352	7.82	11.35	16.27
4	0.297	0.711	9.49	13.28	18.47
5	0.554	1.145	11.07	15.09	20.52
6	0.872	1.635	12.59	16.81	22.46
7	1.239	2.167	14.07	18.48	24.32
8	1.646	2.733	15.51	20.09	26.13
9	2.088	3.325	16.92	21.67	27.88
10	2.558	3.940	18.31	23.21	29.59
11	3.05	4.58	19.68	24.73	31.26
12	3.57	5.23	21.03	26.22	32.91
13	4.11	5.89	22.36	27.69	34.53
14	4.66	6.57	23.69	29.14	36.12
15	5.23	7.26	25.00	30.58	37.70
16	5.81	7.96	26.30	32.00	39.25
17	6.41	8.67	27.59	33.41	40.79
18	7.02	9.39	28.87	34.81	42.31
19	7.63	10.12	30.14	36.19	43.82
20	8.26	10.85	31.41	37.57	45.32
21	8.90	11.59	32.67	38.93	46.80
22	9.54	12.34	33.92	40.29	48.27
23	10.20	13.09	35.17	41.64	49.73
24	10.86	13.85	36.42	42.98	51.18
25	11.52	14.61	37.65	44.31	52.62