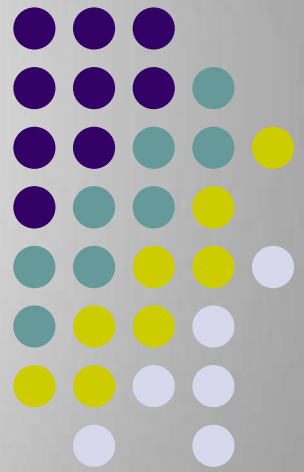
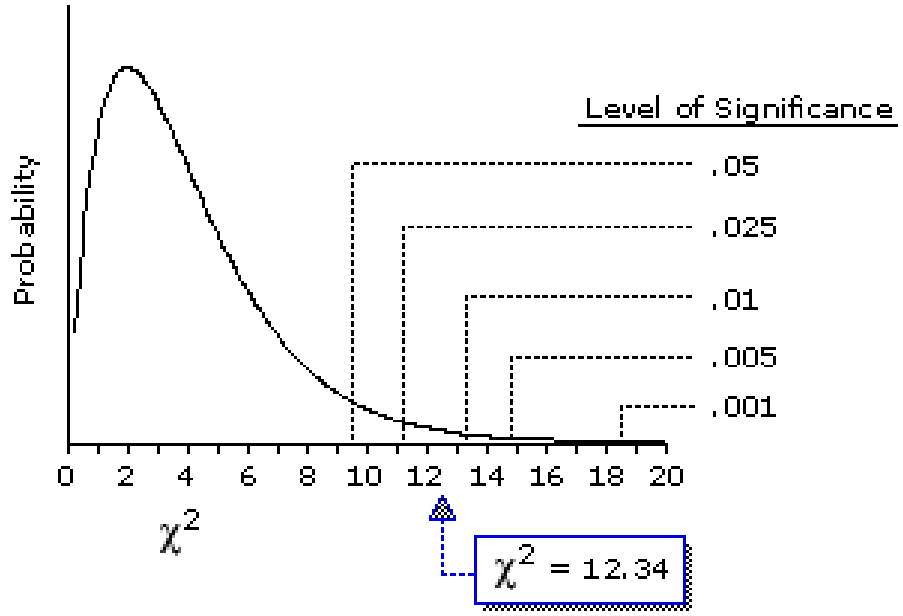
Chi-Square Analysis

AP Biology



UNIT 7: MENDELIAN GENETICS

CHI SQUARE ANALYSIS



Level of Significance (non-directional test)

df	.05	.025	.010	.005	.001
4	9.49	11.14	13.28	14.86	18.47

critical values of chi-square for **df** = 4

$$X^2 = \sum \frac{(o-e)^2}{e}$$

where

X^2 is Chi-squared,
$\sum$ stands for summation,
o is the observed values, and
e is the expected values.

AP BIOLOGY

CHI SQUARE ANALYSIS:

- The chi square analysis allows you to use statistics to determine if your data is “good” or “non-biased” or if the data is “bad” or “biased”
- If statistics show the data is biased this means that somehow the data is far different from what you expected and something is causing the difference beyond just normal chance occurrences.

CHI SQUARE FORMULA:

Observed individuals with a given phenotype

Expected individuals with a given phenotype

Greek letter "chi"

$$X^2 = \sum \frac{(o-e)^2}{e}$$

Summation => add together a term for each condition

NULL HYPOTHESIS:

- The hypothesis is termed the null hypothesis which states
  - **That there is NO substantial statistical deviation (difference) between observed values and the expected values.**
- In other words, the results or differences that do exist between observed and expected are totally random and occurred by chance alone.

CHI SQUARE VALUE:

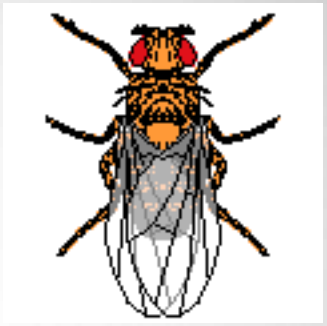
- **If the null hypothesis is supported by analysis**
  - **The assumption is that mating is random and normal gene segregation and independent assortment occurred.**
  - **Note: this is the assumption in all genetic crosses! This is normal meiosis occurring and we would expect random segregation and independent assortment.**
- **If the null hypothesis is not supported by analysis**
  - **The deviation (difference) between what was observed and what the expected values were is very far apart…something non-random must be occurring….**
  - **Possible explanations: Genes are not randomly segregating because they are sex-linked or linked on the same chromosome and inherited together.**

DF VALUE:

- In order to determine the probability using a chi square chart you need to determine the **degrees of freedom** (DF)
- **DEGREES OF FREEDOM:** is the number of phenotypic possibilities in your cross minus one.
  - **DF = # of groups (phenotype classes) – 1**
- Using the DF value, determine the probability or distribution using the Chi Square table
- If the level of significance read from the table is greater than **0.05** or **5%** then the null hypothesis is accepted and the results are due to chance alone and are unbiased.

EXAMPLE:
DIHYBRID FRUIT FLY CROSS

X



Black body - eyeless

Wild type

F1: all wild type

F1 CROSS PRODUCED THE FOLLOWING OFFSPRING

5610

Wild type

1881

Normal body - eyeless

1896

Black body - eyeless

622

Black body

ANALYSIS OF THE RESULTS:

- Once the total number of offspring in each class is counted, you have to determine the expected value for this dihybrid cross.
- What are the expected outcomes of this typical dihybrid cross? **(9:3:3:1)**
  - **9/16 should be wild type**
  - **3/16 should be normal body eyeless**
  - **3/16 should be black body wild eyes**
  - **1/16 should be black body eyeless.**

NOW CONDUCT THE ANALYSIS:

Phenotype	Observed	Hypothesis
Wild	5610	
Eyeless	1881	
Black body	1896	
Eyeless, black body	622	
Total	10009	

To compute the expected value multiply the expected 9/16:3/16:3/16:1/16 ratios by 10,009

CALCULATING EXPECTED VALUES:

- **To calculate the expected value:**
  - **Multiply the total number of offspring times the expected fraction for each phenotype class**
- **TOTAL = 10,009**
  - **Wild-type expected value: 9/16 x 10,009 = 5634**
  - **Eyeless expected value: 3/16 x 10,009 = 1878**
  - **Black body expected value: 3/16 x 10,009 = 1878**
  - **Black body & Eyeless expected value: 1/16 x 10,009 = 626**

NOW CONDUCT THE ANALYSIS:

Phenotype	Observed	Hypothesis
Wild	5610	5634
Eyeless	1881	1878
Black body	1896	1878
Eyeless, black body	622	626
Total	10009	

Null hypothesis: The two traits (black body and eyeless) are not linked and therefore randomly segregate & assort independently of each other during gamete formation. The differences between the expected values and observed values are due to chance alone.

CALCULATING X^2:

- Using the chi square formula compute the chi square total for this cross:
  - $(5610 - 5630)^2 / 5630 = 0.07$
  - $(1881 - 1877)^2 / 1877 = 0.01$
  - $(1896 - 1877)^2 / 877 = 0.20$
  - $(622 - 626)^2 / 626 = 0.02$
  - $x^2 = 0.30$
- How many degrees of freedom?
  - 4 phenotype classes – 1 = 3 degrees of freedom

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

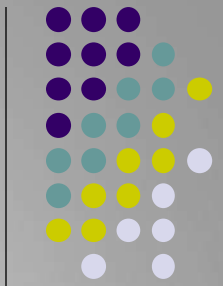
χ^2 = the test statistic $\sum$ = the sum of

O = Observed frequencies E = Expected frequencies

CHI SQUARE TABLE:

ACCEPT NULL HYPOTHESIS *RESULTS ARE RANDOM*								REJECT HYPOTHESIS *RESULTS ARE NOT RANDOM*		
Probability (p)										
Degrees of Freedom	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.38	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59

ANALYSIS QUESTIONS:



- Looking this statistic up on the chi square distribution table tells us the following:
  - **The P value read off the table places our chi square number of 0.30 with 3 degrees of freedom closer to 0.95 or 95%**
- This means that greater than 95% of the time when our observed data is this close to our expected data, the deviation from expected value is due to random chance and not something else!
  - **We therefore fail to reject our null hypothesis.**

ANALYSIS QUESTIONS:

- What is the critical value at which we would reject the null hypothesis?
  - For three degrees of freedom this value for our chi square is > 7.815
- What if our chi square value was 8.0 with 4 degrees of freedom, do we fail to reject or reject the null hypothesis?
  - Fail to reject, since the critical value is >9.48 with 4 degrees of freedom.

HOW TO WRITE YOUR RESULTS:

- When reporting chi square data use the following formula sentence….
  - **With _____ degrees of freedom, my chi square value is _____, which gives me a p value between _____% and _____%, I therefore _____ (accept/reject) my null hypothesis.**
- Use this sentence for your results section of your lab write-up.
- Your explanation of what the significance of this data means goes in your conclusion.