APES
Ms. Jacobson
Lab: Using Wooly Worms to Model Natural Selection

Name: ___________________________________

Date: ____________

Background Information:

Wooly worms are pieces of yarn of various colors distributed in a random manner over a designated area of your schoolyard. You will simulate the feeding by predators who like wooly worms as part of their diets. You will feed on (collect) as many worms in a timed session as you can. The collected worms are counted and recorded and a **Chi-square test** is used to determine if the yarn pieces were collected randomly or by a selection process.

Since worms of certain colors are best fitted to survive in their environment, certain variations are more favorable to the individual and the species than others. These favorable variations are termed **adaptations**. Adaptations increase an organism's chances of survival and subsequent ability to reproduce and pass on its traits (favorable genes) to its offspring. An example of adaptation is **cryptic coloration**, whereby an organism blends into its environment so well that it is difficult to detect. Cryptic coloration can help animals escape predators or catch unsuspecting prey. This **"survival of the fittest"** concept is supported by **Darwin's Theory of Natural Selection**.

As with many other worms, the wooly worms in this lab activity represent or simulate insect larvae in a natural habitat. They will complete their metamorphosis into adult insects, so long as they survive. Predation places a selection pressure on certain colors of wooly worms; those who exhibit favorable adaptations (i.e. remain hidden by their cryptic appearance and thus escape predation) are positively selected for. Those who contrast with their surroundings are easy prey for the predatory birds, and are said to be selected against. The gene frequencies for wooly worm coloration will change - such changes illustrate the dynamics of natural selection. Drastic and sudden changes in the environment may lead to extinctions, but this is not common in nature.

Background on Random Numbers and Selection:

The different colors of yarn distributed randomly on school grounds represent the different color variations of wooly worms. If these yarn pieces are collected randomly, the number of worms of each color should be nearly equal. If, however, the data does not support this hypothesis, then selection of certain colors must have occurred. A **null hypothesis** (H_0) is proposed for these circumstances, something to the effect that the color of the wooly worms will have no effect on the numbers of each color collected. If you can reasonably show that this is not the case through a statistical process, then selection must have occurred.

The **Chi-square test** is used to test the null hypothesis by comparing the expected number of worms of each color against the observed numbers actually collected. A variance between the expected and the observed numbers is likely in any chance event. The Chi-square test will determine if this variance is within acceptable statistical limits to support the original null hypothesis. The Chi-square test will reveal how likely it is that the worms were collected randomly.

Materials:

- 9 different colors of yarn
- Individual Data Table

APES Name: ______________________________

Ms. Jacobson

Lab: Using Wooly Worms to Model Natural Selection Date: __________

- Chi-Square probability table
- Class Chi-Square Calculations Data Table
- calculator (don't get used to it! :-))

Procedure:

Before Feeding Frenzy:

1. Develop the null hypothesis.

H_0: ____

____

H_A: ____

____

During Feeding Frenzy:

1. At the signal, engage in a feeding frenzy until told to stop. Collect as many worms as you can.
2. After the feeding period, return to the classroom with your worms. Refer to the Class Data Table on the board and determine the number of each color of worms you collected.

After Feeding Frenzy:

1. Write down class data on your copy of the Chi-Square Calculations Table. The class data should be recorded in the column labeled "Observed Number" (A).

2. The "Expected Number" (B) for each color is determined by dividing the total number observed by the number of different colors.

$$\frac{Total\ Number\ of\ Worms}{Number\ of\ Colors} = Expected\ number\ of\ worms$$

3. Subtract the expected number from the observed number. The answer may be positive or negative. Write your answer for each color in the column labeled "Obs. - Exp." (C):

   Column C = (Observed Number) - (Expected Number)
4. Square the number obtained for Column C (this should make all of your negative numbers positive). Write your answer for each color in the column labeled $(\text{Obs. - Exp.})^2$ (D):

   Column D = (Answer in Column C)^2
5. Divide the answer obtained for Column D by the Expected number. Write your answer for each color in the column labeled $(\text{Obs. - Exp.})^2/\text{Exp.}$ (E):

$$\textbf{Column E} = \frac{(Observed - Expected)^2}{Expected}$$

6. Add up all of the numbers in Column E to get your Chi-square value.
7. Determine the degrees of freedom to be used. The degrees of freedom will always be one less than the total) events (colors) observed.

   Degrees of Freedom = (Number of Colors) - 1
8. Determine the probability that the Chi-square value you obtained is caused by chance factors or by selection. The columns with the decimals refer to the probability (p) levels of the Chi-square numbers

listed. The rows on the Chi-Square chart are your degrees of freedom. Anything less than p = 0.05 is considered significant.

Data:

Individual Data Table

Color	Observed
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8	
9	

Class Chi-Square Calculations Data Table

Color	A. Observed	B. Expected	C. Obs. - Exp.	D. $(\text{Obs.} - \text{Exp.})^2$	E. $(\text{Obs.} - \text{Exp})^2/\text{Exp.}$
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8					
9					

Total Column E = Chi-Square = ________________

APES
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Chi-Square Probability Table

Degrees of Freedom (*df*)	Probability ()p										
.	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	13.28	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
11	5.58	5.58	6.99	8.15	10.34	12.90	24.73	17.28	19.68	24.73	31.26
12	6.30	6.30	7.81	9.03	11.34	14.01	26.22	18.55	21.03	26.22	32.91
13	7.04	7.04	8.63	9.93	12.34	15.12	27.69	19.81	22.36	22.69	34.53
14	7.79	7.79	9.47	10.82	13.34	16.22	29.14	21.06	23.69	29.14	36.12
Nonsignificant									Significant ⟶		

Data Analysis:

1. Do you think that the null hypothesis is acceptable or unacceptable? What factors influenced your decision?
2. Which colors of worms were subjected to a positive selection pressure? Which colors of worms were subjected to a negative selection pressure? Explain.
3. Consider feeding times, feeding habits, ability to see color, vision acuity, and other possible characteristics of predatory birds in nature. How might such characteristics determine selection of certain colors?
4. Consider the school grounds upon which you fed on your wooly worms. If this particular environment remained unchanged over a very long period of time, how would gene frequency be affected in future generations?
5. Suppose the school grounds upon which you fed experienced a decrease in rain over a very long period of time. What might happen to the gene frequency of the different colors of the wooly worm population in the future?
6. How would the results be affected if red or white worms were poisonous?
7. Explain the connection between Darwin's Theory of Natural Selection and change in gene (allele) frequencies.

Conclusion-- What did you learn in this lab about mimicry, natural selection and chi-square probability tests?

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