AP Biology Workshop
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Woolly Worm Lab[1]

In this lab you will study natural selection. During the exercise you will represent a predacious bird who feeds on woolly worms. The woolly worms are pieces of colored yarn which have been randomly distributed over an area on the school grounds. Some of the wool pieces will blend into the habitat while others will be easy to find. The colored yarn woolly worms that you "eat" will be tallied and recorded, and a Chi-square test will be used to determine if the wool pieces were collected randomly or by a selection process. It is hoped that this lab activity will add to your understanding of natural selection.

PROCEDURES & QUESTIONS:

1. During an 3-4 minute "feeding" period collect as many of the woolly worms as possible in the collection area.

2. Upon returning to the lab tally the number of each kind of worm you "ate" and record the numbers in **Table 1** under Column A (Observed number).

3. Total this column of figures and divide by the number of kinds of worms available. This will give the average number of worms of each kind that you would be expected to find if the collected them randomly. This value would be entered in the B column as the "Expected Number".

4. If the wool pieces were collected randomly, then the number of each color collected should be nearly equal. It follows then that if the collection *was* random any differences between the Observed numbers and the Expected numbers could be attributed to chance. We can propose a *Null Hypothesis* that states that there will be no significant difference in the numbers of each color yarn collected. If the null hypothesis is not supported by the data, then selection of some colors over others must have occurred.

   Use the Chi-square test to examine the differences between the number of worms expected and the actual number you collected. The Chi-square test will tell you if the differences between what you collected and what was expected are too large to be attributed to chance alone. That is, does the variance from the expected fall within statistical limits and still support the null hypothesis? The Chi-square cannot prove or disprove a hypothesis, but it can provide you with a *statement of plausibility* concerning the original null hypothesis.

   Using a calculator, determine the differences between observed and expected values (enter them in Column C), square the differences (enter them in Column D), and divide these squared differences by the expected value (enter them in column E). Total up all the values in Column E to get the Chi-square value.

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[1] Originally conceived and written by Mr. Ken House of New York City and appeared in *American Biology Teacher* magazine in April 1986.

Table 1. Chi-Square Calculations

$$\chi^2 = \sum \frac{(obs.-exp.)^2}{exp.}$$

Color	A. Observed number	B. Expected number	C. Obs.-Exp.	D. (Obs.-Exp.)2	E. (Obs.-Exp.)2 / Exp.
1)					
2)					
3)					
4)					
5)					
6)					
7)					
8)					
9)					
10)					
11)					
12)					
13)					
14)					
15)					
16)					
Grand total =				$\chi^2 = \sum =$	

$\frac{\text{Grand total}}{\text{Number of colors}}$ = Expected number (B) for each color.

Table 2. Chi-Square Distribution

Degrees of Freedom	p = .99	p = .95	p = .50	p = .05	p = .01	p = .001
1	<0.001	0.004	0.455	3.841	6.635	10.827
2	0.020	0.103	1.386	5.991	9.210	13.815
3	0.115	0.352	2.366	7.815	11.345	16.286
4	0.297	0.711	3.357	9.488	13.277	18.465
5	0.554	1.145	4.351	11.070	15.086	20.517
6	0.872	1.635	5.348	12.592	16.812	22.457
7	1.239	2.167	6.346	14.067	18.475	24.322
8	1.646	2.733	7.344	15.507	20.090	26.125
9	2.088	3.325	8.343	16.919	21.666	27.877
10	2.558	3.940	9.342	18.307	23.206	29.588
11	3.053	4.575	10.341	19.675	24.725	31.264
12	3.571	5.226	11.340	21.026	26.217	32.909
13	4.107	5.892	12.340	22.362	27.688	34.528
14	4.660	6.571	13.339	23.685	29.141	36.123
15	5.229	7.261	14.339	24.996	30.578	37.697

Random chance hypothesis acceptable (p = .99 to p = .50) | Random chance hypothesis not acceptable (p = .05 to p = .001)

Total number of events (colors) - 1 = degree of freedom used

p = probability

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5. How much of a variance from the expected can be tolerated before the original null hypothesis can be accepted or rejected? Refer to **Table 2**, the Chi-square Distribution Table. Most biologists agree that Chi-square values above the 0.05, or five percent level of probability, would tend to support the null hypothesis by indicating that the numbers of each color yarn observed does not vary significantly from the expected.

   However, values at or below the 0.05 level of probability suggest that the numbers that you observed are not likely to result form chance factors alone. Therefore, such observed numbers suggest that certain yarn colors are being selected over others. Thus, the original null hypothesis must be rejected.

   Determine the level of probability (p) for your Chi-square value. The degrees of freedom used are always one less than the number of events or colors observed. If you used 11 colors then use 10 degrees of freedom to determine the level of probability.

6. In your write-up, answer the following questions:

   a. Was the original null hypothesis acceptable? Explain.

   b. Which colored worms were subjected to a positive selection and which ones were subjected to a negative selection pressure?

   c. What factors contributed to these selective pressures?

   d. How will gene frequencies which determine woolly worm color be affected from one generation to the next if the environmental factors that existed today during the lab should remain unchanged?

   e. How would the woolly worm population change over the next few years should this selection continue?

   f. What may happen to the woolly worm population if there is an increase in annual rainfall over the next few years in Athens? Think about how their immediate environment would change.

   g. Some animal species are conspicuously colored and contrast sharply with their surroundings. What purposes might this coloration serve, and how are these species able to survive in light of the evidence gathered in this exercise?