Wooly Worms – an Ecology Lab, with a review of the scientific method…

The following lab encourages students to construct a testable hypothesis. The concepts of scientific method, predator-prey relationships, basic ecological principles, and some statistical analyses will all be a part of hypothesis formation and testing. Although the current lab is focused at the college level, it may be modified easily for use with younger students.

1. Wooly worms (caterpillars) are a food source (prey) for a number of bird species (predators). They come in a variety of colors and patterns. Since both birds and humans can see colors, we might be able to predict if some colors might be more or less noticeable than others. Based on our experiences, we might construct a hypothesis regarding which color(s) of wooly worm will be more/most likely caught in a limited time. The hypothesis we propose must be testable. We must conduct an experiment that appropriately tests our hypothesis. The conclusions we draw will be based on an objective, statistical standard (chi-square, χ^2).

2. If it is not raining (too hard), we will spend about 10-15 minutes playing "wooly worm versus predators" in the area immediately in from of the science building. Stakes will show you the boundaries of your "territory". Your instructor will demonstrate the "catching technique" and tell you when to begin and when to stop.

3. Your job as a "predacious bird" is to catch as many wooly worms as possible in your territory. Wooly worms come in all colors (see the front board in the laboratory for examples of woolly worm phenotypes). You may pick up only **ONE** wooly worm at a time **USING THE FORCEPS PROVIDED**. The forceps simulate the action of a bird's beak.

4. Place your captured wooly worm in your collecting bag and mark your tally card as described below. The time it takes for you to place your prey in the bag and mark your card simulates the time it would take a real predator to eat its prey and be ready for the next morsel.

5. You must tally your captured prey according to its color and **KEEP TRACK OF THE ORDER** in which you captured your prey, on the tally card provided. List the first worm caught as 1; second, 2; etc. Upon returning to the classroom, total the number of each color caught and the total number of worms caught (as illustrated below).

EXAMPLE:

Tally Card	Order Number	Total
1. Red	1, 4, 5, 6	4
2. White	3, 11	2
3. Yellow	-	0
4. Purple	2, 10	2
5. Black	8	1
6. Green	9	1
7. Blue	7	1
TOTAL:		**11**

6. Be aware, however, that while pursuing your prey, you must be careful not to become prey yourself for there are, circling in your territory, large predators (your instructor and/or TA) that love **STUDENT** prey. If you are tagged by the instructor with a water gun, you are **DEAD** and out of the game of life. There will be a small safe area you can hide in for a short period of time and not be tagged. A maximum of two prey organisms can be in the safe area for not more than one minute at a time and can only use the safe area twice during the game. After you have been in the safe area once, there must be at least one minute pass before you can return to the safe area.

7. After all cards are in, the instructor will total the numbers for each category as well as the total number caught. These figures will be placed on the board. Please copy these figures down on the "**Class Tally Card**" (see below) so that you can complete the rest of the exercise.

Worksheet: The Wooly Worm

1. Fill in the chart below (using class totals which we will calculate in class).

CLASS TALLY CARD		
	Actual Number	**Expected Number**
1. Red		
2. White		
3. Yellow		
4. Purple		
5. Black		
6. Green		
7. Blue		
TOTAL:		

2. Chi-square (χ^2) is a "goodness of fit" test based on whether or not expected and actual data (fairly) closely agree. Chi-square is based on *probabilities* of detecting agreement between expected and actual data. As our sample size increases, our probability of coming closer to "the truth" of the matter increases. The parameters for a given Chi-square test are based on the **degrees of freedom** (the total number of options available to us minus one) and the **confidence level** chosen (the degree of certainty that one wishes to use). The confidence level (= a) indicates how likely it is that a correct hypothesis will be detected.

As an example, let's begin setting up the situation we have with wooly worms. We construct a hypothesis:

Hypothesis: *There is an equal chance of any one color of wooly worm being caught.*

Is the hypothesis reasonable? Or is there a better hypothesis to test? Is the hypothesis testable? It is, ***if*** we have an **objective standard** (in this case mathematical) to which we can compare our results. In order to accept or reject our hypothesis, we must:

1) calculate a Chi-square value based on expected and actual data values and

2) compare our calculated Chi-square to a standardized Chi-square distribution (see chart on last page of this exercise).

Use the data from the chart (#1, above) to calculate a Chi-square (χ^2) value:

$$\chi^2 = \Sigma[(A_i - E_i)^2/E_i]$$

$$= (A1-E1)^2/E1 + (A2-E2)^2/E2 + (A3-E3)^2/E3 + (A4-E4)^2/E4 + (A5-E5)^2/E5 + (A6-E6)^2/E6 + (A7-E7)^2/E7$$

where **A** is the **actual value** the class found for a given color of worm when doing the experiment, and **E** is the **expected value** *if there is an equal chance of any one color… being caught*.

Work Area:

3. Conclusion
   a. What were the degrees of freedom used in this exercise? _____

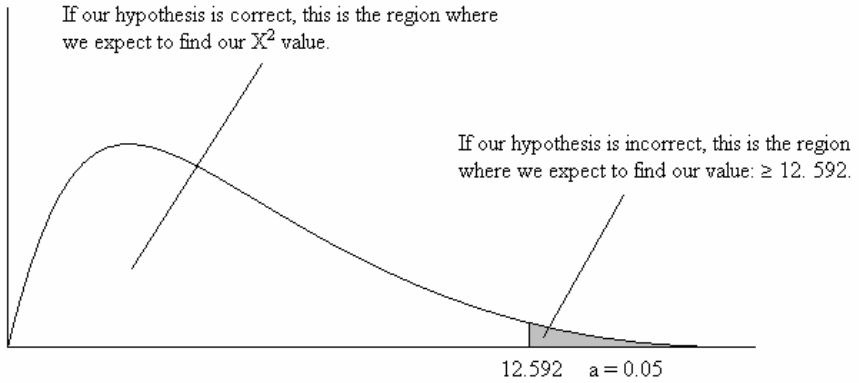
   b. What confidence level should we use when calculating our chi-square value? (use the table below)

   c. What is the calculated chi-square (χ^2) value? _____

   d. Do your results indicate that it was chance alone that caused the unequal numbers of capture wooly worm phenotypes? Explain.

   e. What do these results indicate might happen over time to this wooly worm population?

If we have seven color choices (options), our degrees of freedom = 7 – 1 = 6. A confidence level of 0.05 is often considered reasonable. Essentially, when we specify a confidence level of 0.05 we are saying that we would reject a **valid** hypothesis only 5% of the time. Stated another way, by choosing a confidence level of 0.05 (or 5%), **we are saying that if our number falls below the Chi-square value, we are 95% certain that our hypothesis is correct** (see distribution, below).



Critical value of Chi-square distribution for a = 0.05 and df = 6

We then go to a chart which lists confidence levels and degrees of freedom for Chi-square distribution (see chart below). The intersection of the a = 0.05 column, and df = 6 gives us a Chi-square value of 12.592. To determine whether we should accept or reject our hypothesis, we compare our calculated value to the value published in the chart (below). If the calculated value is **less than** 12. 592, we accept our hypothesis. If the calculated value is **equal to, or greater than**, 12.592, we **reject** the hypothesis.

Chi-Square (χ^2) Distribution										
Degrees of Freedom	**0.995**	**0.99**	**0.975**	**0.95**	**0.90**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**
1	-	-	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	**12.592**	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589