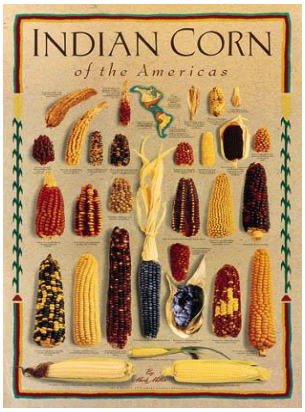
Class Activity

INDIAN CORN: HOW DOES INDIAN CORN ILLUSTRATE MENDEL'S LAW?



INTRODUCTION

In the 1869's, an Austrian monk named Gregor Mendel published papers on the inheritance traits in the garden pea. Forty years later, at the turn of the 20th century, three scientists rediscovered his publications which were long forgotten and ignored. Today, you will examine some patterns of inheritance which Mendel elucidated many years ago. Instead of using garden peas, we are using maize or corn. We will look at the inheritance of kernel color and of wrinkled or smooth texture. (The texture is actually an indication of the presence of an enzyme involved in the production of starch.) By observing the appearance, the **PHENOTYPE**, of the kernels, we will try to deduce their gene combinations, the **GENOTYPE**.

STUDENT OBJECTIVES

1. Observe a biological specimen showing various combinations of traits.
2. Calculate the genotype from the counted phenotype using chi-square statistics.

PRE-ACTIVITY QUESTIONS

1. A white fruited squash plant when crossed with a yellow fruited one produces offspring about half of which are white and half yellow. What are the genotypes of the parents?

MATERIALS

Maize cobs of different inheritance patterns (cob #1-monohybrid cross: cob #2-dihybrid cross)
charts of corn kernel types,
calculators (optional)

PROCEDURES

Work in pairs.

I. Single Gene Inheritance – The Laws of Dominance and Segregation

1. Review the laws of inheritance with your teacher.
2. **Observe Cob #1**. Note the color of the kernels. A corn plant **pure** for yellow color was crossed with a plant **pure** for purple color. The cobs produced in the children, the **F1 GENERATION**, were all purple. Their genotypes are **HYBRID**. The F1 corn plants were self-pollinated and the cob you are now observing represents their children, the **F2 GENERATION**. Determine the dominant color.
3. Start at the red dot which marks the beginning of a row of kernels. One person should count the kernels of each color. The other person should enter the information on the chart below. Repeat for ten rows.
4. **Observe Cob #2.** Note the color and the texture of the kernels. A plant pure for yellow color and wrinkled texture was crossed with a plant pure for purple color and smooth texture. The F1 kernels were all purple and smooth. Their genotypes are **DIHYBRID**. The F□ plants were self-fertilized and the cob you are now observing represents their progeny, the F_2 generation. Determine if wrinkled or smooth is dominant.
5. Start at the red dot made to mark the beginning of a row of kernels. One person counts the kernels of each combination of traits. The other person should enter the information on the **DATA TABLE** on the lab report. Continue counting for ten rows.

II. How Do Scientists Use Statistics to Predict the Results of Genetic of Genetics Crosses?

The CHI SQUARE TEST for Goodness of Fit

How do scientists know if their data fits the results suggested by their hypothesis? Some people make a guess ("Looks good to me!"). Fortunately, there are methods available, which are more reliable and systematic. One such

method is the statistical "tool" called the **CHI-SQUARE TEST**. This test is used when we expect a specific number of items in specific "classes", such as in genetics experiments.

This method makes use of a very logical assumption: the smaller the difference between the observed results and the expected results, the more confidence we can have that our original hypothesis is correct. Deviations between the observed and the expected results are due to chance or to the wrong hypothesis. As the deviations become larger, at what point do we begin to doubt our hypothesis? The Chi-Square test can help us make that decision if there is any difference between our observed data and the data we expect.

Calculation of CHI-SQUARE VALUES
We always start with a **NULL HYPOTHESIS**: There is no difference between the observed data and the expected data.

The following is the equation for determining the Chi-Square value.

$$X^2 = \sum \frac{(\text{Observed result} - \text{Expected result})^2}{\text{Expected result}}$$

The symbol Σ = summation of all individual values. The expected result can be determined by multiplying the total # of offspring by the expected ratio for that phenotype. Do not round off to the nearest whole number.

FOR TWO ALTERNATIVE CLASSES (or, in our case, for the monohybrid cross): The X^2 value was obtained from the X^2 table!

** If X^2<= 3.84, we can say that our hypothesis is **SUPPORTED** by our data and we **ACCEPT** the **NULL HYPOTHESIS**. Differences between observed and expected results are due only to chance.
** If X^2> 3.84, we can say that our original hypothesis is **NOT** supported by our data and we must **REJECT** the **NULL HYPOTHESIS**. The differences are not due to chance and we must rethink our understanding of the problem.

FOR FOUR ALTERNATIVE CLASSES (or, in our case, for the dihybrid cross): Use 7.815 as a cut-off for four classes
IMPORTANT NOTE: REMEMBER, A CHI-SQUARE VALUE MAY SUPPORT OUR HYPOTHESIS. IT DOES NOT PROVE IT.
** This is a very limited description of the Chi-Square test. If you would like to know more or if you would like to use it for your own research, please see your teacher.
SAMPLE CALCULATION
Two hundred and seven (207) offspring are produced from a cross of two mice. Of these, 144 are black and 63 are white. The data suggests that the parents are hybrid black. You can do a Chi-Square test to determine if the offspring data is consistent with the hybrid nature of the parents. If the parents are hybrid, ¾ (0.75) of the offspring will be black and ¼ (0.25) will be white.
NULL HYPOTHESIS = There is **NO DIFFERENCE** between the observed and expected data.

	Observed	**Expected**
Purple	144	(207)(0.75) = 155.28
White	63	(207)(0.25) = 51.75
Total	207	207.00

Set up the Chi-Square equation: Review the equation from the previous page

$$X^2 = \frac{(\text{Observed purple} - \text{Expected purple})^2}{\text{Expected purple}} + \frac{(\text{Observed white} - \text{Expected white})^2}{\text{Expected white}}$$

$$= \frac{(144 - 155.25)^2}{155.25} + \frac{(63 - 51.75)^2}{51.75} = 0.82 + 2.45 = 3.27$$

A Chi-Square Table

	Probability				
Degrees of Freedom	**0.9**	**0.5**	**0.1**	**0.05**	**0.01**
1	0.02	0.46	2.71	3.84	6.64
2	0.21	1.39	4.61	5.99	9.21
3	0.58	2.37	6.25	7.82	11.35
4	1.06	3.36	7.78	9.49	13.28
5	1.61	4.35	9.24	11.07	15.09

Since Chi-Square (3.27 from above) is less than 3.84, we have confidence that the parents are hybrid black. **We accept the null hypothesis.**

* A Chi-Square for 4 genes will require 4 sets of Chi-Square calculations added together with a cut-off point of 7.815. If the Chi-Square is less than 7.815, we have confidence that the offspring are in a 9:3:3:1 ratio. We accept the null hypothesis.