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# K-12 Partnership Lesson Plan

# Bonnie McGill

# *The Chi-Square Goodness of Fit Test*

# *Application for testing genetic inheritance hypotheses*

## Overview

The Chi-square goodness of fit test can be used to test whether observed data are different from expected values based on a hypothesis. This test and lesson is a good introduction to statistical analysis of biological data for high school students. They will test their hypotheses with data and make scientifically rigorous conclusions.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Formulate a hypothesis to test.
* Calculate expected values to test based on their hypothesis.
* Calculate the Chi-square value using a Chi-square table.
* Find the probability range for their Chi-square value and decide to support or reject their hypothesis based on the probability range.

**Length of Lesson**

1.5 hours

**Grade Levels**

AP Biology (10-12)

**Standards covered (NGSS)**

Disciplinary Core Ideas:

* **HS-LS3-3**: apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population

Cross Cutting Concepts:

* Patterns
* Scale, proportion, and quantity

Science and Engineering Practices

* Asking question and defining problems
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

***Chi-square goodness of fit tests are also listed in AP Biology Quantitative Skills Guide***

**Materials**

* Calculators (1 per student)
* Powerpoint presentation
* Student worksheet packet (1 per student)
* Teacher key to packet (all supplemental materials found on the “The Chi-square goodness of fit test: applications…” lesson page on the KBS GK-12 website)

**Background**

Before this lesson, it is important that students have studied inheritance genetics and gene linkage. They will need to be able to predict phenotypic ratios of offspring for different types of crosses (AaBb x AaBb; AaBb x aabb) if genes are linked or not linked (i.e. Chapter 12 “Genetics” in Campbell & Reece Biology AP edition).

In the lesson you will explain why scientists need to do statistical tests, what a “significant” difference means, and under what conditions the Chi-square test is the appropriate test. You will discuss how to translate a hypothesis into a fraction or percentage and then how the Chi-square test uses these expected values to compare to your observed values. You will introduce them to the Chi-square formula and the Chi-square table that breaks down the formula, step by step. Then you have three example problems to work through with the students. Do the first example together as a class. Take the results from the Chi-square table and walk through the probability table. Show them how the probability range tells you whether to support or reject your hypothesis and how to translate this into a conclusion based on your hypothesis and the context of the problem.

The powerpoint presentation and the worksheet packet work in tandem. Hand out the packet before you start the presentation and instruct students to answer the questions in the packet as you go along. The packet is also meant to be a guide for them to be able to refer back to on their own in the future.

### Activities of the session

1. Hand out the worksheet packet before you start your presentation.
2. Instruct the students to follow along in their packet and answer the questions in it.
3. Do example problem 1 as a class.
4. Have the students work in small groups on example problem 2. Then come together as a class to go over the answers.
5. Have the students work in small groups on example problem 3. Then come together as a class to go over the answers. Compare results between groups who tested the different hypotheses.

**Resources**

* Powerpoint, student packet, and teacher answer key listed on the “The chi-square goodness of fit test: applications…” lesson page on the KBS GK-12 website

**Extensions and Modifications**

Skip example problem 2 or 3, and assign it as homework. This might allow you to finish the lesson in 1 hour.

Add in Cara Krieg’s Chi-square worksheet dealing with bird songs: http://kbsgk12project.kbs.msu.edu/blog/2013/12/19/chi-square-tests-when-and-how-to-use/

Have the students analyze data from their own experiment or lab activity.

**Assessment**

Give the students a hypothesis and Chi-square test results and have them find the probability range and decide whether to support or reject the hypothesis. Possible examples included on the student worksheet or in an additional lesson, “Chi-square tests: when and how to use” on the KBS GK-12 website.