Teacher Guide: Mouse Genetics (One Trait)

Learning Objectives

Students will…

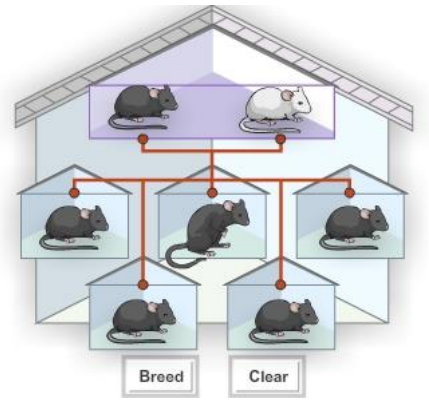
- Define gene, trait, and allele.
- Discover how genes are passed down from parents to offspring.
- Distinguish between dominant and recessive traits.
- Use a Punnett square to predict the results of a genetic cross.

Vocabulary

allele, DNA, dominant allele, gene, genotype, heredity, heterozygous, homozygous, hybrid, inheritance, phenotype, Punnett square, recessive allele, trait

Lesson Overview

In 1865, an Austrian monk named Gregor Mendel presented a paper on pea plant inheritance to the Natural History Society of Brünn. The paper was received politely but generated little interest, and it was virtually ignored for 30 years. Years after Mendel's death, several biologists independently discovered similar patterns of inheritance, and Mendel's work was rediscovered. These patterns became the basis for a new branch of biology: genetics.



A black and white parent yield black offspring

The *Mouse Genetics (One Trait)* Gizmo™ allows students to conduct breeding experiments similar to Mendel's pea plant experiments. Along the way they will discover how traits are passed down from parents to offspring.

The Student Exploration sheet contains three activities:

- Activity A – Students breed mice and observe the phenotypes of the offspring.
- Activity B – Students observe how alleles are passed down from parent to offspring.
- Activity C – Students use Punnett squares to predict the percentages of black and white offspring of a particular parent pair.

Suggested Lesson Sequence

1. **Pre-Gizmo activity** (60 minutes)
   A current trend in dog breeding is to mix two pure breeds to create a hybrid that combines the desirable traits of each parent. Examples are Goldendoodles, Cockapoos, and Snorkies. (See the **Selected Web Resources** below.) You and your students can make up a fun game of "match the parents to the offspring." Have each student print out pictures of two parent dogs of different breeds, and a picture of their hybrid offspring. Put each parent pair in a row on the wall, and place the offspring in random order below. Challenge your students to a fun contest: Who can do the best job of matching parents to their offspring?

2. **Prior to using the Gizmo** (10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:

   - If two parents of the same color are bred together, do all of their offspring always have that color? (Which situation is an exception to that rule?)
   - How do you know that the trait for white fur is still present in a black-fur hybrid?
   - Why is it impossible to see a hybrid (or heterozygous) white mouse?
   - A black mouse is bred to a white mouse, producing 2 black and 1 white offspring. What is the genotype of the black mouse?
   - A black mouse is bred to a white mouse. They produce three black offspring. What is the genotype of the black parent? [Note: This is a trick question! The genotype of the black parent cannot be determined from this information, although as more black offspring are produced, the probability of *FF* increases.]
   - An *Ff* mouse is bred repeatedly to an *ff* mouse, producing 500 total offspring. In theory, 250 offspring should be black and 250 should be white, but the actual numbers are 237 black and 263 white. Why does this happen?

5. **Follow-up activity** (30 – 45 minutes)
Model the inheritance of alleles with a simple experiment. Each student will need a paper bag and two "alleles." You can use any material for the alleles: paper, marbles, blocks, coins, etc. Assign each student a genotype for fur color (*FF*, *Ff*, or *ff*), and ask them to label their alleles appropriately.

   To model reproduction, have the students work in pairs. Each student closes her eyes and draws an allele from her bag. The offspring genotype is recorded, and the alleles are replaced in the bags. Repeat this experiment 9 times and record the results. Ask students to switch partners (or even alleles) several times so that they can see a variety of results.

   When all the data has been collected, tally the results for each combination of parents on the board. How close were these results to the ratios predicted by Mendel's Laws?

   Finally, introduce Mendel's actual results for his pea plants. (See the **Selected Web Resources**.) Mendel looked at about 29,000 pea plants, so his data set was very large. How close were Mendel's own results to the predicted ratios? (Note: Some scientists think that Mendel's results were *too* good—he may have fudged some of his numbers!)

Scientific Background

All inherited traits are encoded in an organism's DNA. Located within the cell nucleus, DNA is a long molecule that resembles a twisted ladder. The "rungs" of the ladder, called *base pairs*, encode the actual genetic information. A *gene* is a sequence of several thousand base pairs. Many genes give instructions for building a particular protein. These proteins help to determine the traits of the organism. Some genes play a regulatory role by producing proteins that turn other genes "on" or "off."

DNA

Most genes occur in two or more varieties, called *alleles*. Each allele codes for a particular trait. Dominant alleles are alleles that are always expressed when present. Recessive alleles are alleles that are only expressed when the dominant allele is absent. In the *Mouse Genetics* Gizmo, the allele for black fur (*F*) is dominant and the allele for white fur (*f*) is recessive. A *heterozygous* mouse (*Ff*) will have black fur because the black fur allele is dominant.

Each organism has two copies of each gene, one inherited from its mother, and one from its father. During sexual reproduction, each parent passes one copy of each gene to their offspring. For example, an *Ff* parent will pass down either the *F* or *f* allele to each offspring. If the other parent is also *Ff* for fur color, then that parent will also pass down either an *F* or an *f* to each offspring. As a result, ¼ of the offspring will be *FF*, ½ will be *Ff*, and ¼ will be *ff*.

Historical connection: Gregor Mendel, the father of genetics

The patterns of inheritance shown by the *Mouse Genetics (One Trait)* Gizmo were originally discovered by Gregor Mendel, an Austrian monk with a rare scientific bent. Born in 1822, Mendel grew up in a farming family. Unlike his contemporary Charles Darwin, Mendel had few financial resources, and he entered the monastery in 1841. Mendel worked as a science teacher for many years, although he twice failed to pass the state teaching exam. (It is thought that he suffered from debilitating test anxiety.)

After attending the University of Vienna for two years, Mendel became interested in the mystery of inheritance. He originally wanted to breed mice, but the local bishop decided this was not a suitable activity in a monastery, so Mendel turned to pea plants instead. It was a fortuitous choice, because pea plants have many traits that are easy to observe and are determined by a single gene. After years of experiments, Mendel discovered two remarkable patterns: the hybrid offspring of two pure parents (such as a tall plant and a short plant) all resemble one parent (in this case, the tall parent). If two of the hybrid offspring are bred, three-quarters of their offspring show the dominant trait (tall), while one-quarter shows the recessive trait (short). These patterns helped Mendel create his theory of inheritance and found the modern science of genetics.

Selected Web Resources

Hybrid dog breeds: http://dogs.thefuntimesguide.com/2006/09/hybrid_mixed_dog_breeds.php
Mendel biography: http://www.strangescience.net/mendel.htm
Mendel's original paper: http://www.mendelweb.org/Mendel.html
Probability and Inheritance: http://anthro.palomar.edu/mendel/mendel_2.htm

Related Gizmos
Inheritance: http://www.explorelearning.com/gizmo/id?657
Mouse Genetics (Two Traits): http://www.explorelearning.com/gizmo/id?382
Chicken Genetics: http://www.explorelearning.com/gizmo/id?453