Educator Guide

GREGOR MENDEL
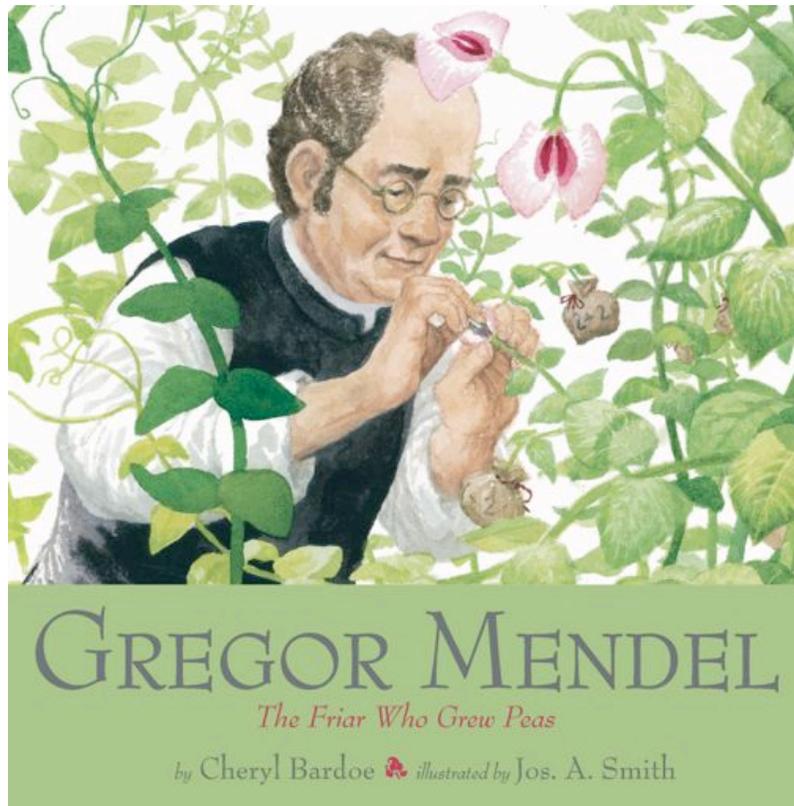*The Friar Who Grew Peas*
by Cheryl Bardoe *illustrated by* Jos. A. Smith

About the Book

How do parents—whether apple trees, sheep, or humans—pass down traits to their children? This question fascinated Gregor Mendel. The world's first geneticist, Mendel overcame poverty and obscurity to discover one of the fundamental aspects of genetic science: that all animals, plants, and people inherit traits through the same process. An Augustinian friar in the 1800s, Gregor Mendel grew 30,000 pea plants over eight years to conduct his great experiment. From observing yellow peas, green peas, smooth peas, and wrinkled peas, Mendel crafted his theory of heredity--years before scientists had any notion of genes. Children will be inspired by Gregor's never-ending search for knowledge. His famous experiments make an easy to understand introduction to genetics.

About the Educator Guide

Gregor Mendel: The Friar Who Grew Peas connects to elementary school standards in science, math, social studies and language arts. It provides a launching point to explore the process of heredity in plants and animals, the scientific method, mathematical patterns, similarities and differences between the lives of modern scientists and those in the 1800s, and writing biography. This guide suggests activities and discussion questions to enrich learning on these subjects.

Vocabulary

- *Dominant trait* – (n) A trait that always shows up when its gene is present. The dominant trait sometimes hides the presence of a gene for recessive trait.

- *Friar* – (n) A man who serves at an Abbey in the Catholic church.

- *Gene* – (n) A segment of DNA on a chromosome that codes for a specific trait.

- *Heredity* – (n) The process by which parents pass down traits to their children.

- *Hybrid* – (n) The offspring produced by breeding together different types of plants or animals, such as two varieties of pea plants.

- *Hypothesis* – (n) A possible explanation for a scientific problem that can be tested by experiment.

- *Offspring* – (n) The child of two parents.

- *Pistil* – (n) The female part of a flower, which contains egg cells.

- *Pollen* – (n) The fine grains of powder that are produced by a flower's stamen.

- *Pollinate* – (v) To transfer pollen from the stamen to the pistil. Pollination fertilizes the egg cells of a flower so that they will turn into seeds.

- *Recessive trait* – (n) A trait that does not appear when its gene is paired with the gene for a dominant trait.

- *Stamen* – (n) The male part of a flower, which produces pollen.

- *Universal Law* – (n) A rule that always holds true, regardless of changing circumstances.

Science Activities

1. Identifying Traits
The handout on page 6 of this guide illustrates six pairs of traits that are common to all people. Have students record the traits they possess.

2. Punnett Square
Read about Gregor Mendel's crossbreeding experiments on pages 16-27 of the book. When Mendel crossbred yellow pea plants with green pea plants, he observed that the green peas disappeared in the first generation of plants, and reappeared in later generations. Mendel called the gene for yellow peas "dominant" because it can hide the presence of the gene for green peas. Mendel called green peas "recessive." Mendel concluded that the gene for green peas can be passed down even in yellow peas.

To see how this works, have students color the Punnett Square worksheet on page 7 of this guide. Using the genes inside the peas, students can predict the color on the outside of the peas. (Answer key provided on page 9 of this guide.)

3. Follow Traits Down a Family Tree

Study the "pea family trees" on pages 25 and 27 of Gregor Mendel: Planting the Seeds of Genetics. Discuss with students how the makeup of the gene pairs determines the color of the peas. Examine the trait family tree on the handout on page 8 of this guide. First have students identify which of the Johnson family members have only recessive genes. Hint #1: If they have no widow's peak (a recessive trait), then they must have two recessive genes. Then have students identify which family members have one recessive gene and one dominant gene. Hint #2: These family members have a widow's peak (a dominant trait) and either a child or a parent who has a recessive trait. Lastly, have students circle the family members for whom we don't have enough information to know what their traits are. Hint: If a person has a dominant trait, they may have a pair of dominant genes, or a one dominant and one recessive gene. We can't tell which pair they have just by looking at the individual, but we may be able to figure it out by looking at the traits of their parents or children. (Answer key provided on page 9 of this guide.)

National Science Education Standards for activities 1-3:
Life Science Content Standard C: Students should develop understanding of the characteristics of organisms, the life cycles of organisms, and organisms and their environment. *(grades K-4)*
Life Science Content Standard C: Students should develop understanding of structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, diversity and adaptations of organisms. *(grades 5-8)*

4. Explore the Scientific Method

Mendel is credited with being the first to apply the scientific method to the natural sciences. Share the steps of the scientific process with your students. Discuss how Mendel fulfilled each step. Students can use these steps to plan their own experiment.

Step 1: Identify a question.

Step 2: Develop a hypothesis.

Step 3: Design an experiment to test the hypothesis. Which elements will stay the same? Which will change? How will the variables be controlled? How will the results be measured? How many times will the experiment need to be repeated?

Step 4: Gather data.

Step 5: Analyze results. What do they results mean? Do they confirm the hypothesis? If not, why? What was discovered?

National Science Education Standards:
- *Science as Inquiry, content standard A*, students should develop abilities necessary to do scientific inquiry and understanding about scientific inquiry. *(grades K-8)*
- *History and Nature of Science, content standard G*, students should develop understanding of science as human endeavor. *(grades K-8)*

Mathematics Activities

1. What Makes a Pattern

Mendel saw a pattern in the results of his pea-breeding experiments. A pattern is a repetitive form, order or arrangement. Patterns can be used to predict what comes next, but only if you understand the rules beneath the pattern. By examining the following sequences, students can identify the rules of these patterns and predict the numbers that come next.

Pattern A: 2, 4, 6, 8, 10, 12, 14, ?, ?, ?...
Answer: Pattern is each even number in sequence.

Pattern B: 1, 4, 7, 10, 13, 16, 19, ?, ?, ?...
Answer: Add three each time. The next numbers in the sequence are 22, 25, 28.

Pattern B: 1, 1, 2, 3, 5, 8, 13, 21, 34…
Answer: Add the previous two numbers to get the next number in the sequence. The next numbers will be 55, 89, 144.

Pattern C: 1, 3, 6, 10, 15, 21, 28, 36…
Answer: The difference increases by 1 each time. So add 1, then add 2, then add 3, then add 4, etc. The next numbers in the sequence are 45, 55, 66.

Standards from National Council of Teachers of Mathematics:
- Understand patterns, relations, and functions (grades K-5)
- Apply and adapt a variety of appropriate strategies to solve problems (grades K-5)
- Compute fluently and make reasonable estimates (grades 3-5)

2. The Rule Behind Gregor Mendel's Pattern

Share with your students a famous rule in mathematics that gives meaning to the pattern that Mendel found in the peas.

As shown in the Punnett Square activity above, Mendel's hybrids fell into three categories. If Mendel sorted his peas into even piles, he would have had:

- one pile of green peas that only produced more green peas

- one pile of yellow peas that only produced more yellow peas

- two piles of yellow peas that produced yellow and green peas.

Mendel wrote his pattern down as 1:1:2. This pattern can be explained with the following mathematical law: When a two-part number is multiplied by itself, the parts mix and match in

the same pattern, regardless of what numbers are used. Think of the number 7 as being made up of two parts, a 5 and a 2. To multiply this number by itself, mathematicians write (5+2) x (5+2). They then work out every combination of the parts.

They multiply:

the first 5 times the last 5…	(5+2) x (5+2)	5x5 = 25
the first 5 times the last 2…	(5+2) x (5+2)	5x2 = 10
the first 2 times the last 5…	(5+2) x (5+2)	5x2 = 10
the first 2 times the last 2…	(5+2) x (5+2)	2x2 = 4

Add these numbers together to get the final answer, 49.

This brainteaser has one set of 5x5, one set of 2x2 and two sets of 5x2.

Gregor had one set of green pea plants, one set of yellow pea plants and two sets of mixed pea plants. He concluded that each trait was made up of two separate and interchangeable parts. Mendel called these parts "elements" and we call them "genes."

Standards from National Council of Teachers of Mathematics:
- ***Understand patterns, relations, and functions***. *(grades 3-5)*
- ***Understand meanings of operations and how they relate to one another***. *(grades 3-5)*
- ***Compute fluently and make reasonable estimates***. *(grades 3-5)*

Social Studies Activities

1. Going to School
Read pages 2-6 of the book to see what sacrifices Mendel and his family made for his education. Discuss the following questions:
- Why was getting an education so difficult?
- What did Mendel and his family do in order for him to continue his schooling? –
- Why was education important to Gregor?
- How does his experience in 19th-century Europe compare to students' experience today?
- Why is education important today?
- What would students sacrifice to pursue their own education?

2. Science Then and Now
As students study the pictures of Mendel at work, have them list the scientific tools that he used. What did Mendel's "lab" look like? Then study the picture of the DNA lab at the end of the book. List the scientific tools that contemporary scientists use. How are modern scientific tools similar to and different from those that Mendel used? For more information on what tools and research of contemporary biologists studying genetics, visit the website for the Pritzker DNA Lab at The Field Museum at www.fieldmuseum.org/research_collections/ pritzker_lab/pritzker/index.html

Identify Your Traits

All people have one trait from each of the pairs below. Look in a mirror or work with a partner to identify which traits you have. Circle your traits.

| no chin cleft (recessive) | chin cleft (dominant) | | no dimple (recessive) | dimple (dominant) |

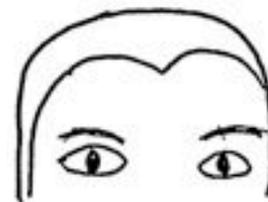| curved thumb (recessive) | straight thumb (dominant) | | straight pinkies (recessive) | bent pinkies (dominant) |

| attached earlobe (recessive) | dangly earlobe (dominant) | | no widow's peak (recessive) | widow's peak (dominant) |

You received one gene for each of these traits from each of your parents. If you circled a recessive trait above, then you must have received two recessive genes from your parents. If you circled a dominant trait above, then you may have received two dominant traits. Or you may have received one dominant gene and one recessive gene.

Having one trait is not any better than having the other. The dominant gene is only called "dominant" because it hides the presence of the other gene.
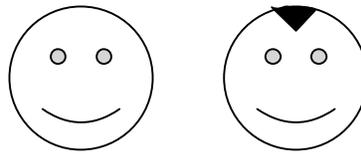
How Parents Pass Traits Down

Color the ⬡G genes green. Color the ⬡Y genes yellow. Mother and Father pea are yellow on the outside. What color will each baby pea be on the outside? Color them either yellow or green.

Mother pea

Father pea

Baby pea 1

Baby pea 2
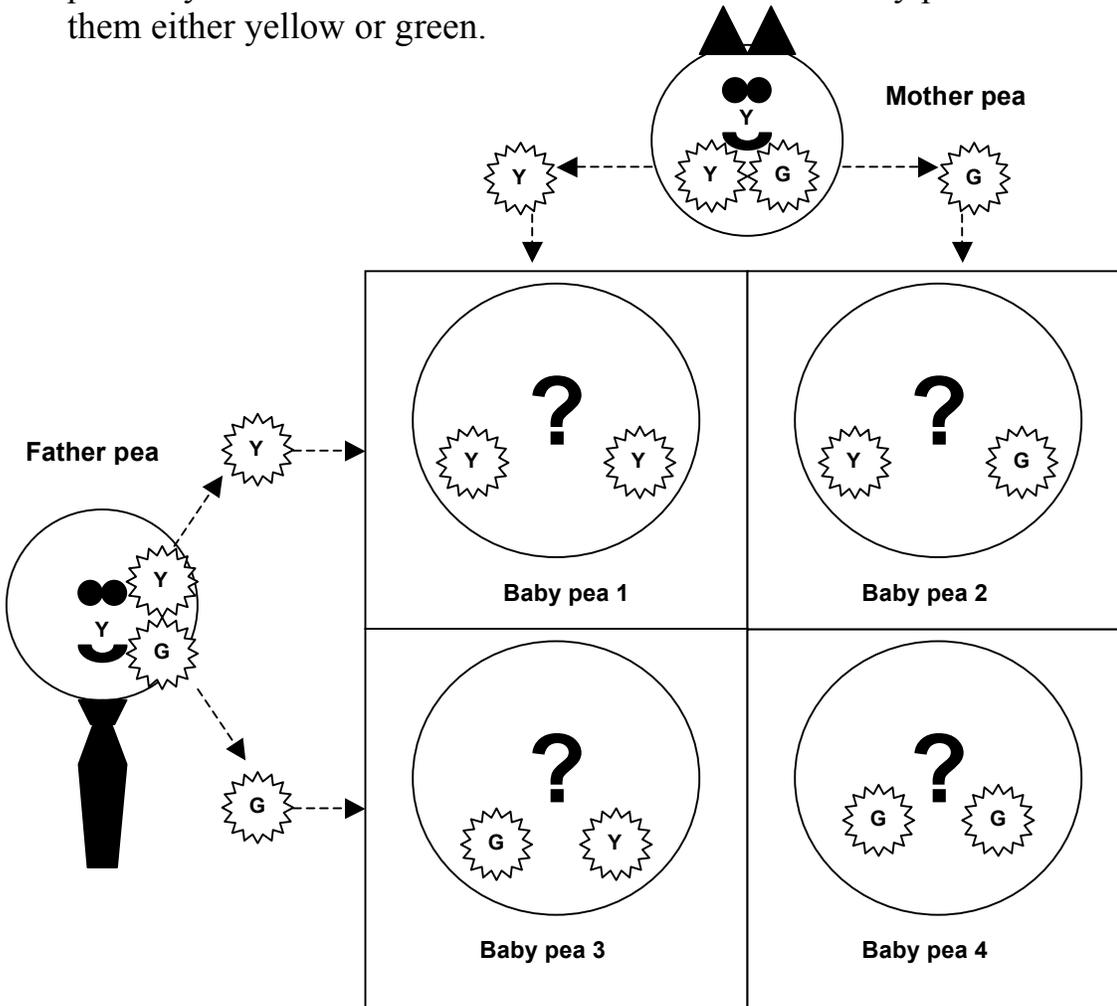
Baby pea 3

Baby pea 4

See Mother and Father pea each give one gene to each baby pea? Even though the parent peas are yellow on the outside, they each have one gene for yellow peas and one gene for green peas on the inside. Notice that parents are just as likely to pass on a green (recessive) gene as they are to pass on a yellow (dominant) gene.

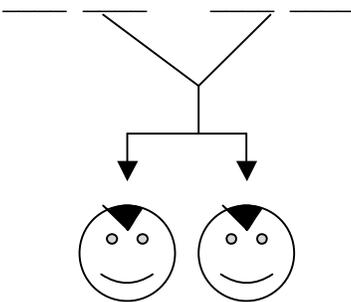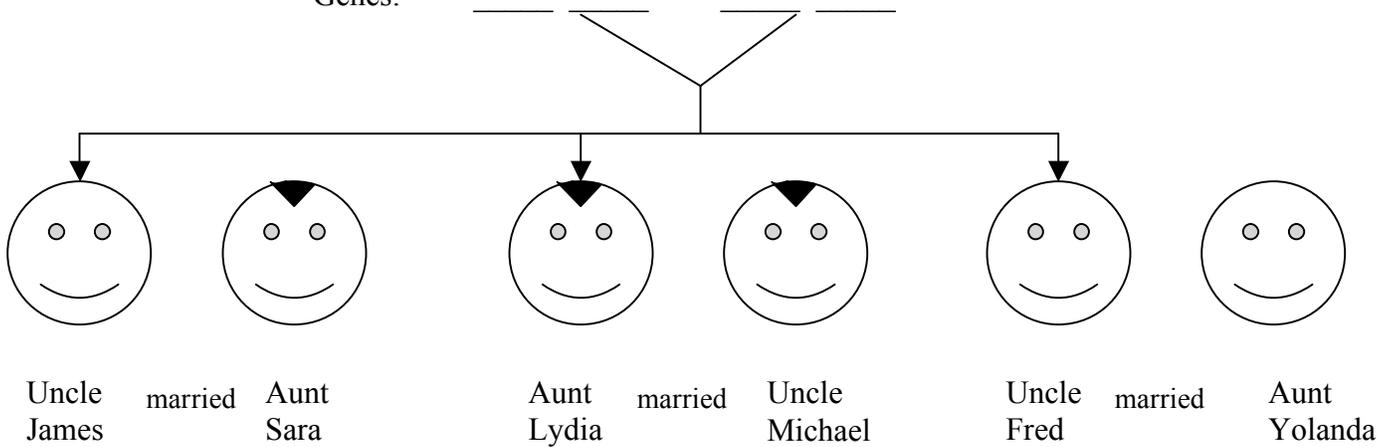**Explain how two yellow pea parents can produce a green pea child?**
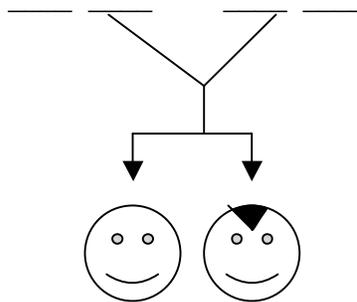
_____

Widow's Peak Trait Family Tree

Grandpa
Edwin

Grandma
Betsy

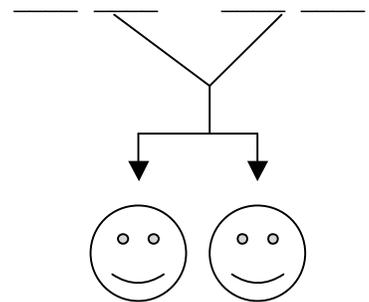Genes: _____ _____   _____ _____

Uncle
James   married   Aunt
Sara

Aunt
Lydia   married   Uncle
Michael

Uncle
Fred   married   Aunt
Yolanda

_____ _____

_____ _____ _____

_____ _____

Jeremy   Evan

John   Jennifer

Brittney   Meghan

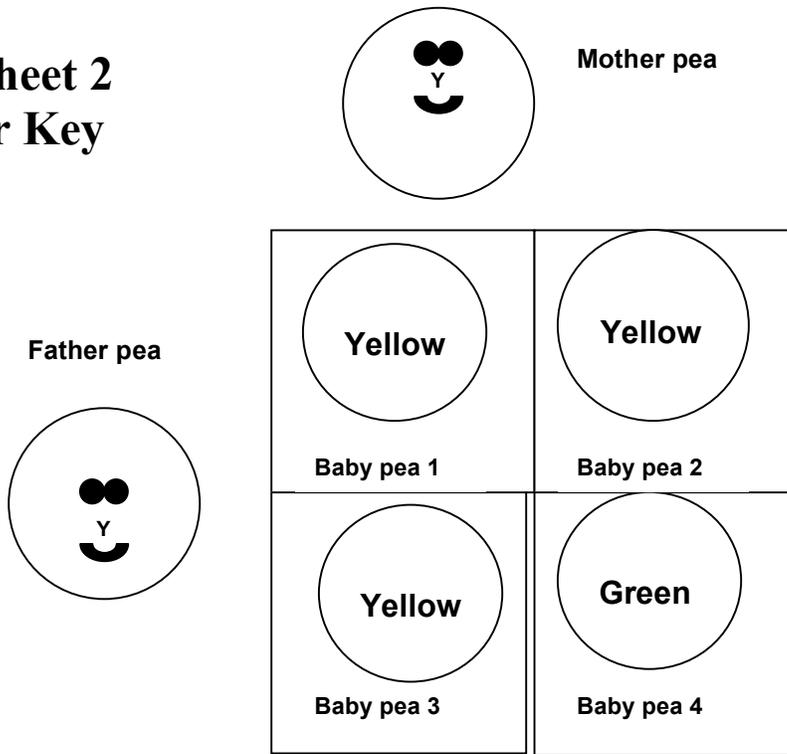_____ _____   _____ _____   _____ _____   _____ _____   _____ _____   _____ _____

Step 1: Identify which family members have only recessive genes. Write NW for "No Widow's Peak" in each of the spaces below.

Step 2: Identify which family members have one recessive gene and one dominant gene. Write W for "Widow's Peak on one line and NW on the other line.

Step 3: Circle the family members for whom you can't tell what their genes are. Maybe

Worksheet 2
Answer Key

Mother pea

Father pea

Yellow	**Yellow**
Baby pea 1	Baby pea 2
Yellow	**Green**
Baby pea 3	Baby pea 4

Worksheet 3
Answer Key

Grandpa Edwin Grandma Betsy

Genes: NW/NW W/NW

Uncle James married Aunt Sara Aunt Lydia married Uncle Michael Uncle Fred married Aunt Yolanda
NW/NW ??? can't tell NW/W W/NW NW/NW NW/NW

Jeremy Evan John Jennifer Brittney Meghan
NW/W NW/W NW/NW ??? can't tell NW/NW NW/NW