Mendel's Groundwork for Genetics

One of the most important outcomes of sexual reproduction is the variety in traits that results from a shuffling of genes. These traits are distinguishing characteristics that are inherited. Scientists have known for a long time that traits in organisms vary. Scientists also saw that offspring often looked similar to their parents, but not always. What remained a mystery was *why* traits vary.

FIGURE 2: These cats show a variety of inherited traits.

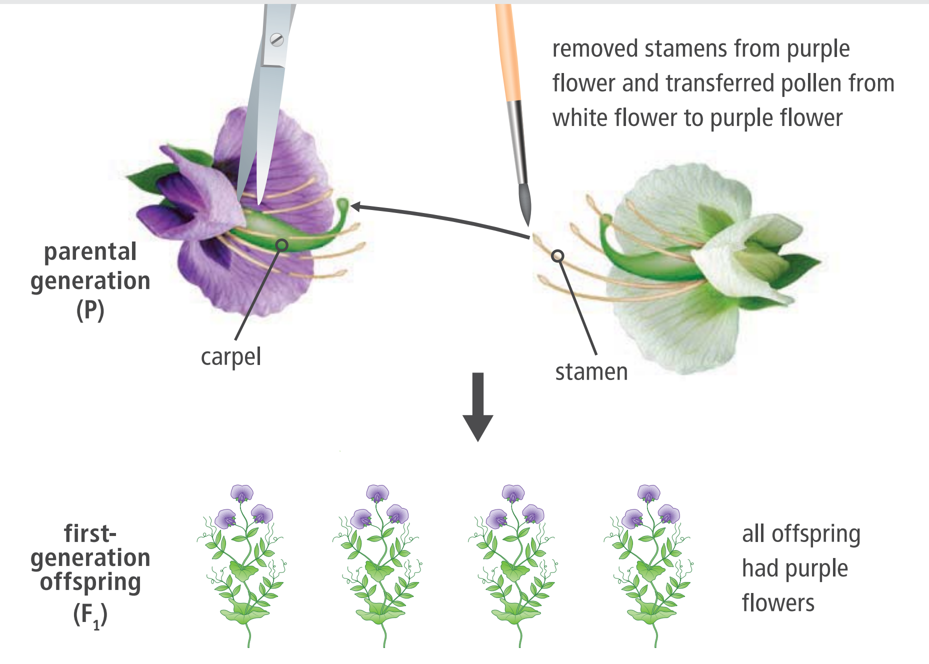
Collaborate With a partner, identify at least three traits that vary among the cats shown in Figure 2.

Mendel's Experimental Design

Our current understanding of heredity comes from a foundation laid in the mid-1800s by an Austrian monk named Gregor Mendel. Mendel's detailed experiments using pea plants led to some important changes in the way scientists viewed the transmission of traits. Scientists of the time commonly thought that parents' traits were blended in offspring, like mixing two colors of paint. However, this idea failed to explain how specific traits on one end of the trait spectrum are observed throughout many successive generations, without all being blended or "diluted."

Mendel chose to work with pea plants based on their fast rate of reproduction and the fact that he could easily control their pollination. He began with purebred plants as the parent generation. Purebred means, for example, that a purple flowering pea plant only produces offspring that have purple flowers when allowed to self-fertilize. During his experiments, Mendel prevented self-fertilization by controlling which plants were able to reproduce. He crossed plants with specific traits by interrupting the self-fertilization process. He then observed the results of each cross. Mendel also used mathematics to analyze the experimental data gathered from hundreds of pea plant crosses.

FIGURE 3: Mendel removed the male parts of flowers and then fertilized the female parts with pollen from a different plant.



Explore Online

Hands-On Lab

Investigating Traits and Heredity Plan and conduct an investigation to determine how albinism is inherited in tobacco plants.

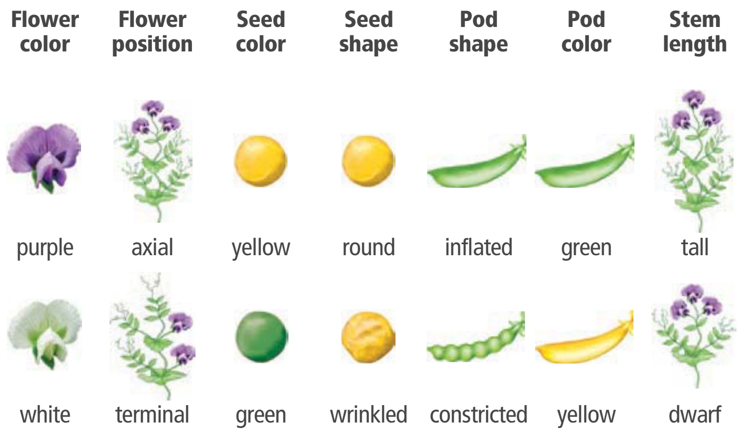
Analyze Why did Gregor Mendel pollinate the plants himself rather than let the plants self-fertilize?

Mendel's Observations

During his experiments, Mendel observed seven traits in the pea plants. We now know that these specific traits are associated with genes on different chromosomes or are far enough apart on the same chromosome to allow for crossing over. However, Mendel did not know this. The traits Mendel studied are shown in Figure 4. Each trait shows a simple "either-or" characteristic; they do not show an intermediate form. For example, the plant is either tall or short, but not medium in height. The selection of these traits that occur in the "either-or" fashion played a crucial role in helping Mendel identify the patterns he observed. Had he chosen different traits or a different species for his experiments, he may not have come to the same conclusions.

Explain Figure 4 shows the characteristics that Mendel noticed before he set up his experiments. What is one question you would ask about how these traits are passed down from one plant generation to the next?

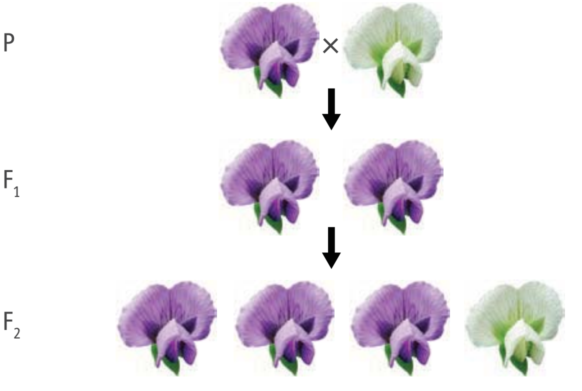
FIGURE 4: Mendel worked with seven traits in pea plants for his experiments.



A genetic cross is the mating of two organisms. When Mendel pollinated a specific female flower of a plant with the pollen from another plant, he carried out a cross. Through his experiments, Mendel was able to observe the results of specific crosses.

Two of Mendel's experimental crosses are shown in Figure 5. In the first experiment, he crossed a purebred white-flowered pea plant with a purebred purple-flowered pea plant. These original plants are the parents—or P—generation. The offspring that result from such a cross are called the first filial—or F_1—generation. In the second experiment, Mendel let the F_1 generation self-fertilize, meaning he did not control their pollination himself. Recall that both F_1 plants had purple flowers. The offspring from these crosses, referred to as the F_2 generation, showed a different set of traits.

FIGURE 5: Purebred white and purple plants were crossed to make the F_1 generation. F_1 plants then self-fertilized, making F_2 plants.



Collaborate Discuss these questions with a partner.

1. What pattern occurred when the P generation was crossed?
2. What patterns occurred when the F_1 generation was crossed?
3. What questions do you think Mendel would have asked after seeing these results?

Mendel performed similar crosses with F_1 generation plants, which are monohybrids. A monohybrid results from crossing two parents with different variations of a trait. He observed the original traits in the F_2 plants. In all cases, the offspring of these crosses showed many plants with one version of a trait and some plants with the alternate version. The results of his crosses are shown in Figure 6.

Data Analysis

Mendel's Data

FIGURE 6: Mendel allowed the F_1 hybrid plants to self-fertilize, resulting in the reappearance of some previously hidden traits.

Mendel's Monohybrid Cross Results			
F_1 Traits	Dominant	Recessive	Ratio
Pea shape	5474 round	1850 wrinkled	2.96:1
Pea color	6020 yellow	2001 green	3.01:1
Flower color	705 purple	224 white	3.15:1
Pod shape	882 inflated	299 constricted	2.95:1
Pod color	428 green	152 yellow	2.82:1
Flower position	651 axial	207 terminal	3.14:1
Plant height	787 tall	277 short	2.84:1

Analyze Answer the following questions about Mendel's data.

1. What patterns do you notice in the data?
2. What questions might Mendel have asked after seeing this data?

Mendel's Conclusions

After making careful observations of his experiments and reviewing the data, Mendel realized that certain traits, such as white flowers, had not disappeared; they were just temporarily masked. They also had not been altered by other traits or blended to form a new trait. Mendel concluded that traits are inherited as discrete "factors" that pass from the parental generation to the offspring.

Gather Evidence What forms of evidence offer support for Mendel's conclusion that traits are inherited as discrete units from the parental generation?

Recall that each gamete of a diploid organism has only one version of a gene, because gametes are haploid, or have half the number of chromosomes as body cells. During meiosis, homologous chromosomes separate and are deposited into gametes. Two gametes fuse during fertilization, so the resulting organism has two copies of each gene, one from each parent. This knowledge, unknown to Mendel, parallels his experimental results and his conclusions about inheritance. The separation of alleles during gamete formation became known as the Law of Segregation.

Explain During anaphase I of meiosis, copies of the same gene are separated as homologous chromosomes move to opposite sides of the cell. These chromosomes may or may not contain the same genetic information. Use evidence from meiosis to explain how gene separation occurs and why gametes only have one copy of each gene. How does the process of meiosis support the Law of Segregation?

FIGURE 7: Anaphase I