Why don't children look exactly like their parents?

DONG! DONG! DONG! The bells pealed early one summer morning in 1856. In the city of Brno, a dark-robed friar hurried to the garden of the Abbey of St. Thomas. Had his peas bloomed? He leaned down to check.

Yes! A white flower!

If not for his long robes, Brother Gregor Mendel might have danced a jig. These pea plants came from the seeds of purple-flowered plants. But as he'd predicted, some of the new plants bloomed white.

How could seeds from purple-flowered plants grow white flowers? With the help of his peas, Gregor Mendel was about to crack the secret of heredity, how traits are passed from parents to children to grandchildren.

Brother Gregor's Garden

It was an exciting time for science. In England, the naturalist Charles Darwin was just finishing a new book that would explain how species evolved and changed. But even Darwin was puzzled by exactly how parents passed traits, like height or eye color, on to their children. And why do traits sometimes skip a generation? It was a mystery.

The Probability of Purple Peas

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art by Marta Antelo

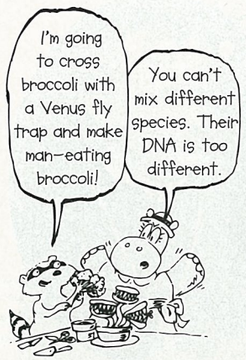
Ask the peas.

Gregor Mendel was born on a small farm in Moravia, now part of the Czech Republic. Like most farmers, Mendel knew that seeds from purple-flowering pea plants grow new plants with purple flowers. Seeds from white-flowering plants grow plants with white flowers.

But what would happen if he cross-bred purple-flowered peas with white ones? Mendel decided to find out.

Brother Gregor

Mendel, originally named Johann, was a poor farmer's son who loved science and math. He liked plants, but he didn't want to farm. When he couldn't afford to pay for college, a teacher suggested that he become an Augustinian friar—a member of a religious community, sworn to poverty, prayer, and service. The church took care of friars' needs and paid for their education. Mendel took the name "Gregor" and joined the Abbey of St. Thomas, in what is now the city of Brno, in the Czech Republic. The friars of St. Thomas lived and studied together. Mendel grew peas and taught school. In his later years, Mendel led the abbey as its abbot.



With a small paintbrush, he took grains of pollen from purple pea flowers and put them on the pollen-collectors of white flowers. He also put pollen from white pea flowers onto purple flowers. Then he covered the blossoms with small bags to make sure no other pollen got in. The pollen fertilized the blossoms, making seeds.

The new seeds were hybrids, with one white and one purple parent. But surprisingly, the plants that grew from these hybrid seeds *all* had purple flowers.

What happened to the white?

Looks Like Grandma

Mendel noticed something else interesting: for every three purple-flowered plants, he saw one white. The ratio, or relationship, between purple and white was 3 to 1, or 3:1.

Would that always be true? Mendel had to know. He started again. He pollinated more plants. He planted more seeds. He counted. He kept at it for eight years, until he knew his numbers were right.

Every hybrid plant had purple flowers. Of the "grandchildren," three out of four had purple flowers; one out of four had white. He got the same results whether he put white-flower pollen into purple flowers or purple-flower pollen into white flowers. And

Mendel kept experimenting. For his next crop, he brushed the hybrids' own pollen on their blossoms. Would this make all purple plants again? No! This time, even though the hybrids (the "children") had only purple flowers, the plants that grew from their seeds (the "grandchildren") were NOT all purple. White showed up!

the same pattern showed up when he crossed plants with green and yellow pods or smooth and wrinkly peas.

What caused these regular, predictable results?

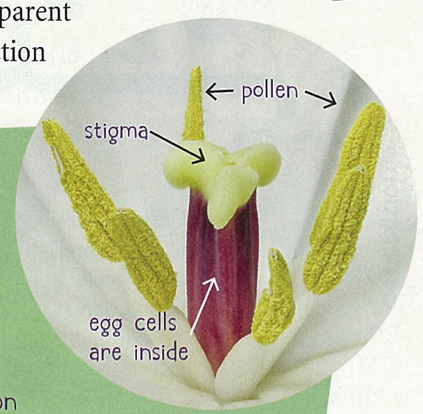
Mendel knew that seeds hold instructions about what kind of plant to grow into. That's why a pea seed grows into a pea plant, while a sunflower seed sprouts into a sunflower plant. He also knew that for a seed to develop, a grain of pollen has to combine with an egg cell inside the flower. That must mean that both the egg cell and the pollen pass instructions to the seed. The combined instructions tell the new plant how to grow.

Double Up

Then Mendel had a great idea. What if each plant has *two* instructions for flower color, not one? Then each seed would inherit one color instruction from each parent!

Pure-bred plants have two purple or two white instructions. Their children, the hybrids, get one purple instruction from one parent and one white instruction from the other.

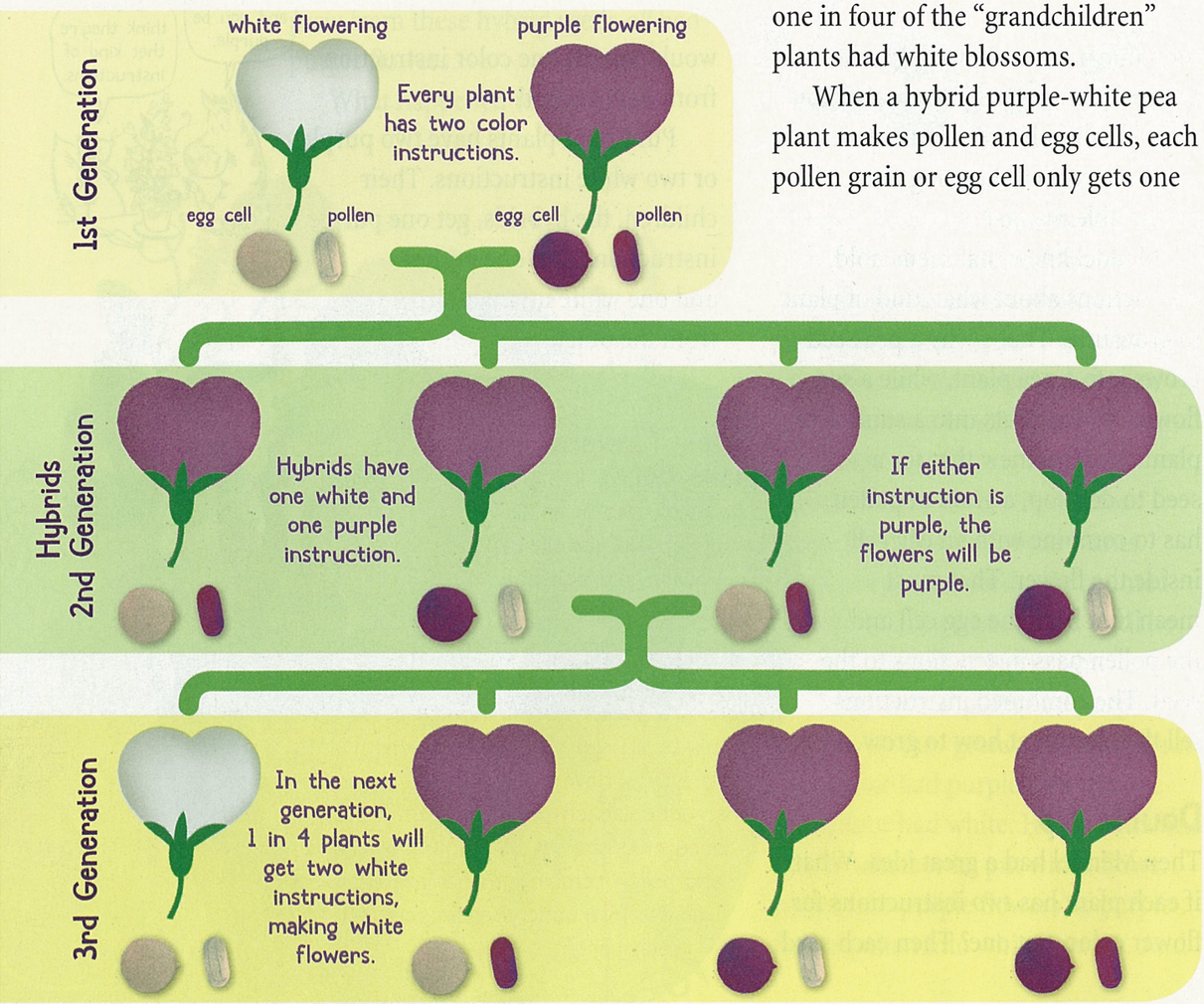
How Flowers Make Seeds



If you look closely at a flower, you will see dusty yellow pollen and also a sticky stalk called a stigma. When a pollen grain lands on the stigma, it sends a long tube down to a pocket containing egg cells. When pollen joins with an egg cell, a seed forms. Plants, like most living things, have two copies of every plant-making instruction. Each pollen grain and each egg cell carry only one set of instructions. When egg and pollen combine, they make a seed with double instructions again—one set from each parent.

But if all the hybrid seeds get a "white-flower" instruction from one parent, why do they all make purple flowers? Why not lavender, or striped?

Mendel thought he could explain this too. The "white" and "purple" instructions don't blend like paint. If a plant gets two different color instructions, it only obeys the "louder" one—in this case, purple.



Mendel called these stronger instructions "dominant."

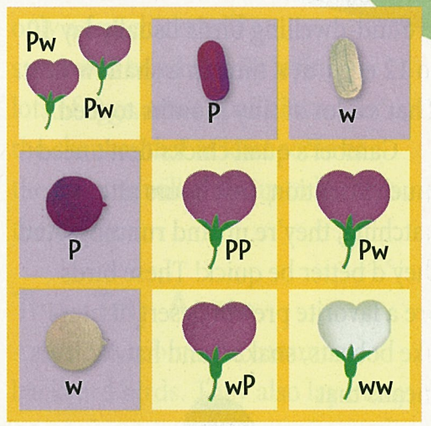
The weaker, "white-flower" instructions are silent in the hybrids. But they are still there, in the plant's pollen and eggs. To make white flowers show up, you just need to get two "white" instructions again.

The Magic Square

The double instructions, plus the laws of chance, solved the puzzle of why one in four of the "grandchildren" plants had white blossoms.

When a hybrid purple-white pea plant makes pollen and egg cells, each pollen grain or egg cell only gets one color instruction—about half get "white" and half get "purple."

These single-color pollen grains and egg cells can combine in four possible ways to make a new seed with two color instructions: purple-purple (PP), purple-white (Pw), white-purple (wP), and white-white (ww). Capital letters show dominant traits. Written in a box, it looks like this:



Of these four possibilities, only white-white makes white flowers. So the "grandchildren" plants have a one-in-four chance of being white flowered. This explains the 3:1 ratio.

Eureka! By counting his peas, Mendel had discovered the key to one of nature's greatest mysteries.

Not Just Peas

The double instructions that Mendel discovered don't just happen in peas. All animals and plants pass along traits in the same way—children inherit one set of instructions from each parent. Humans have about 20,000 of these little instructions, or genes. These determine everything from hair color to the shape of your toes. Some traits, such as skin color, are controlled by several instructions acting together. Since no one color instruction dominates, the skin tone of a child is often somewhere between the two parents—but the genes themselves don't actually blend. In later experiments, Mendel also proved that sets of traits don't "travel" together—the collection we get from each parent is pretty much random. And that's a good thing. Variety keeps a species healthy.

The chunks of DNA inside seeds that carry the instructions are what we now call genes. They weren't discovered until much later—Mendel didn't know genes exist. But his work explained how traits pass from one generation to the next, and why children sometimes look like their grandparents. He began the modern science of genetics.

DONG! DONG! DONG! When the abbey's dinner bell rang, what do you think was the probability of pea soup on the menu?