Demonstration of Genetic Transmission Through the Growth of Wild Turnip

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Research Question

How can plants with the anthocyaninless (non-purple stem) and purple stem gene be used to demonstrate the laws of genetics?

Abstract

Context: Mendel's dihybrid cross experiment was a historical breakthrough on the subject of trait transmission from parent to offspring. He planted pea plants of the same breed with different traits and crossbred them to create generations of plants with a combination of traits from the previous generations.
Methods: Similar to Mendel's experiment, this experiment is done by planting a plant with anthocyaninless and hairless genes through several generations. The dominant trait is purple stem and recessive trait is non-purple stem. Three pots of plants are planted for the first generation under cool white fluorescent light and new generations will be planted using seeds harvested and crossbred from previous generations.
Results: A plant from 2 parent plants is grown with a 75% possibility for dominant traits (purple stem), and a 25% possibility for recessive traits (non-purple stem). In the plants planted, all three plants showed the non-purple stem trait, demonstrating a 100% recessive turnout.
Conclusion: The planting of the seeds with parents of different traits demonstrates heredity and the inheritance of parental traits. Using the observation of a few simple traits in the plant, human heredity could also be connected and understood to a greater extent. If more time and resources are given, possible further experiments could include crossbreeding and multi-generational planting.

Introduction

Evolution, the explanation for how life came to be and the relation of all organisms, is a concept proposed by Charles Darwin in 1859. From then on, more and more evidence validating evolution was discovered. One of the most important pieces of evidence is genetic transmission. Genetic transmission is the driving principle of evolution and genetic variation, and accounts for the relation of all organisms on earth (Stearns). Genetic traits are transmitted from the parent to its offspring through fertilization (Rye, 2015). This discovery was made by Gregor Mendel, which changed the future of the study of genetics.

In 1856, Gregor Mendel began his crossbreeding experiments using garden peas to study trait transmission and inheritance. For 7 years, Mendel continued to conduct experiments and eventually, he established the Laws of Mendelian Inheritance (Miko, 2008). Through his experiments, he discovered that genes are transmitted in distinct units, a pair from each parent, by tracking the appearance of parental genes shown in their offsprings and segregating certain parent genes to observe the presence of dominant and recessive traits (Delp). For generations, people had noticed the resemblance between parent and offspring in most organisms and Mendel's experiments explained the process of this heredity.

There are three parts to Mendel's Law of Inheritance (dnaftb.org):

1. The Law of Segregation: a pair of parental alleles are randomly segregated from each other during meiosis so that there would only be one allele in each gamete while performing the monohybrid cross.
2. The Law of Independent Assortment: two or more segregated alleles independently sorted into gametes.
3. The Law of Dominance: the dominant trait will be expressed in a phenotype with different traits.

In my experiment, a plant with two parents will be planted and the trait which appears will be observed. The plant that is used is called Wisconsin Fast Plants (Brassica rapa), also known as wild turnips; the image below shows its structure after 8 days of growth:

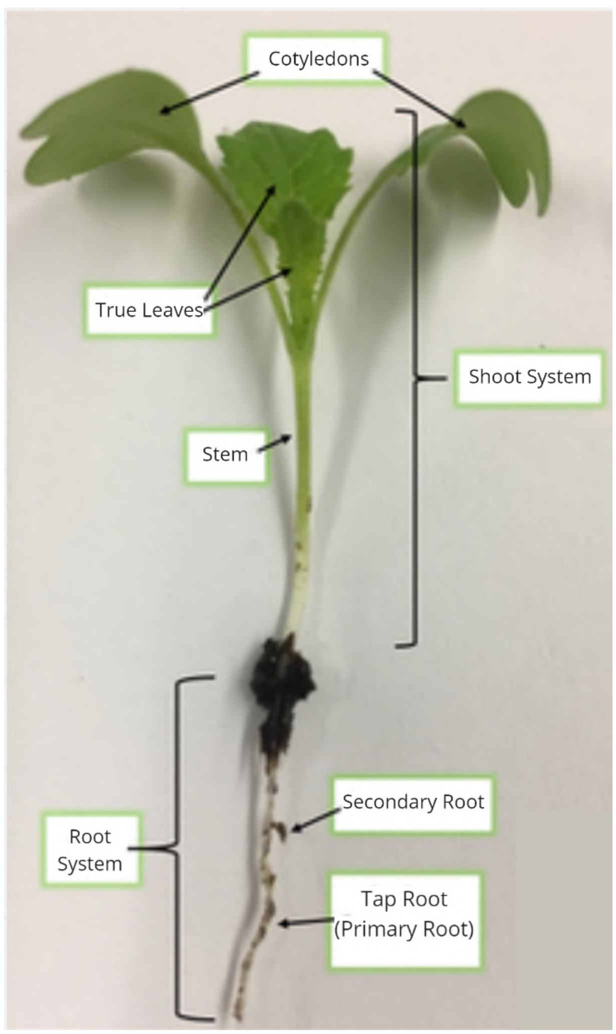


Figure 1

There are two traits that could be produced by the first generation of the plant, the purple stem trait and the anthocyaninless trait. Demonstrating the anthocyaninless trait (anl) means that Brassica rapa, Wisconsin Fast Plants, wasn't able to produce anthocyanin (purple) pigments (Burdzinski & Wendell, 2007). It is also called non-purple stem trait and is the recessive trait of the plant.

The plant on the right demonstrates the anthocyaninless trait
Figure 2

When the seed with the anthocyaninless and the purple stem traits is planted, there are two ways that the traits from its parents could have crossed:

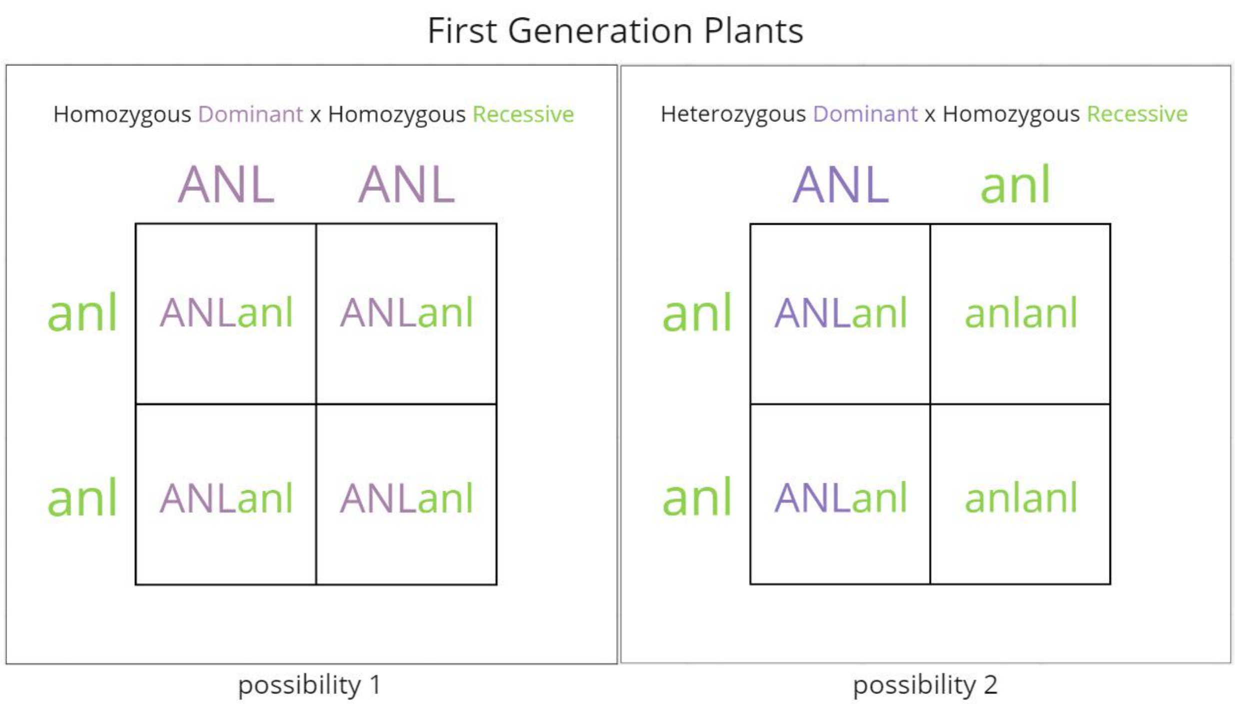


Figure 3

ANLANL ~ Homozygous Dominant (Purple Stem trait)

ANLanl ~ Heterozygous Dominant (Purple Stem trait)

anlanl ~ Heterozygous Recessive (Anthocyaninless trait)

The first possibility is that one of the parents is homozygous dominant while the other is homozygous recessive. With this pairing, there is only one possibility for the first generation plant: heterozygous dominant.
The second possibility is that one of the parents is heterozygous dominant while the other is homozygous recessive. With this pairing, there are two possibilities for the first generation plants: heterozygous dominant and homozygous recessive.

When the first generation plants are crossed, the second generation also has a few different possibilities for its traits:

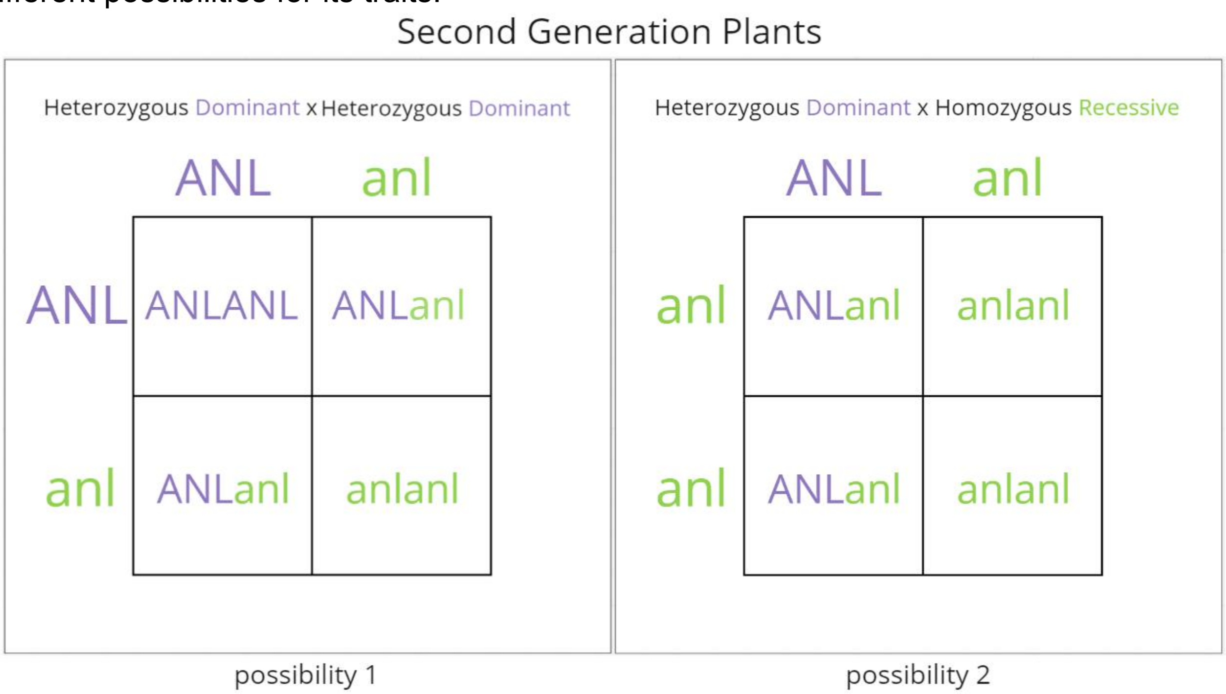


Figure 4

ANLANL ~ Homozygous Dominant (Purple Stem trait)

ANLanl ~ Heterozygous Dominant (Purple Stem trait)

anlanl ~ Heterozygous Recessive (Anthocyaninless trait)

The first possibility is that a heterozygous dominant trait is crossed with another heterozygous dominant trait. With this pairing, there are three possibilities for the

second generation plants: homozygous dominant, heterozygous dominant and homozygous recessive.
The second possibility is that a heterozygous dominant trait is crossed with a homozygous recessive trait. With this pairing, there are two possibilities for the second generation plants: heterozygous dominant and homozygous recessive.

In this experiment, a plant with the anthocyaninless and hairless gene will be planted for one generation and traits shown by the plants will be observed. My hypothesis is that the first generation plants will have the Purple Stem trait because it has a higher probability than the anthocyaninless trait with a 100% chance in possibility 1 and 50% in possibility 2 (refer to figure 1).

Method
Materials:

- Wisconsin Fast Plants Seeds
- Potting mix
- Small Flower Pots
- Fertilizer Pellets
- Fluorescent white light system

Independent variable	Wisconsin fast plants
Dependent variable	Traits of the plant
Control	Type of soil, water, fluorescent lights

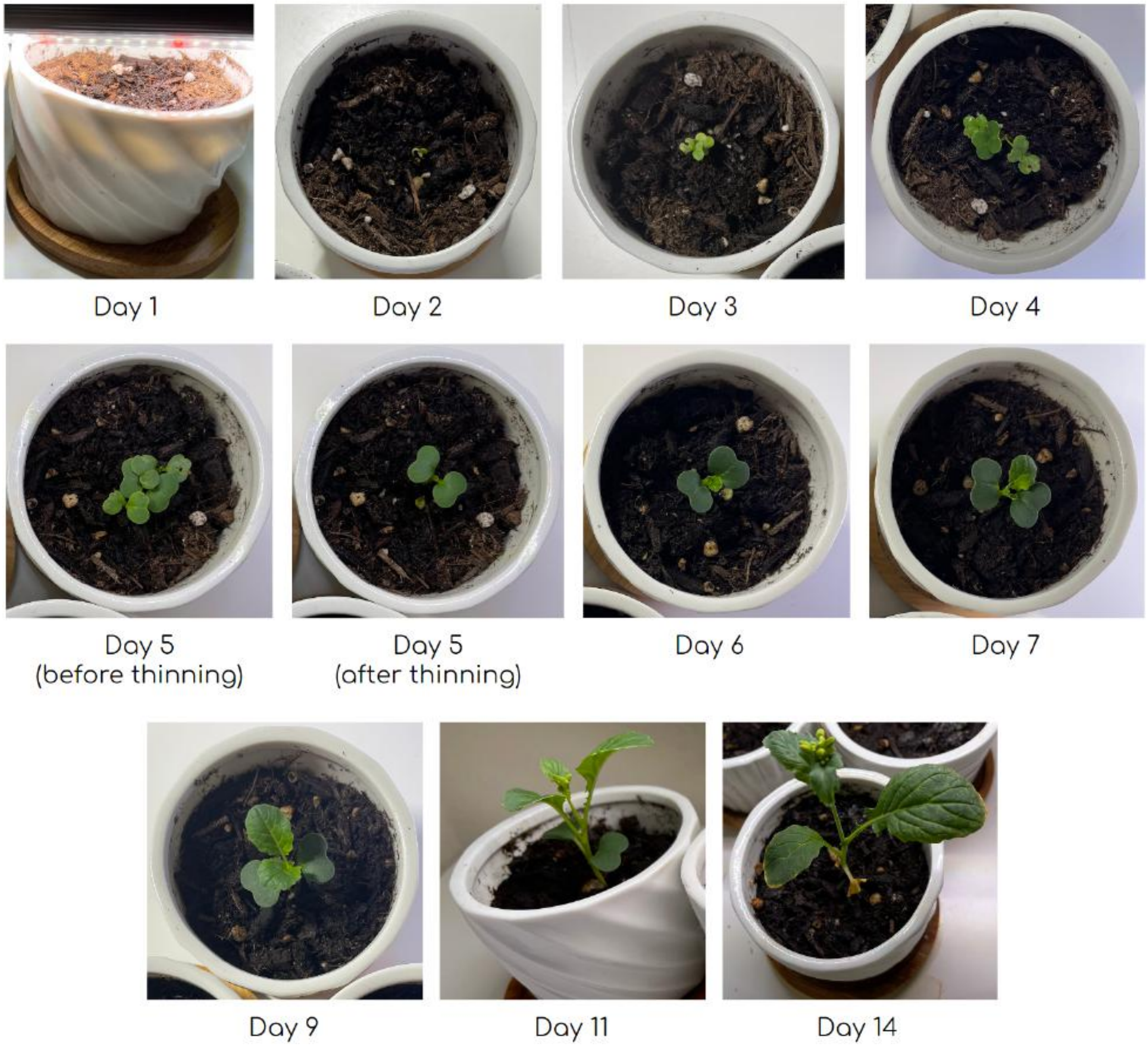
After half the flower pot was filled with slightly moist potting mix, 3 fertilizer pellets were placed in the soil. Then, the pot was filled to the top with moistened potting mix. A small depression was made on top of the soil and 2-3 seeds were dropped in each depression. Potting mix was sprinkled enough to cover the seeds and a few drops of water were drizzled on top of the soil. The fluorescent light was positioned 5-10 cm above the plant and the plant was watered gently from the top for the first 3 days. On day 5, pots were thinned to one plant in each pot if more than one plant grew. The plants were watered regularly to keep the soil moist. If there were no signs of growth by day 4, the plants were discarded and the steps above were repeated.

Results

Total seeds planted	31
Successful plant growth	3
Unsuccessful plant growth (<10 days*)	11
Unsuccessful plant growth (0 days)	17

*number of days the plant grew for

Example of successful plant growth:



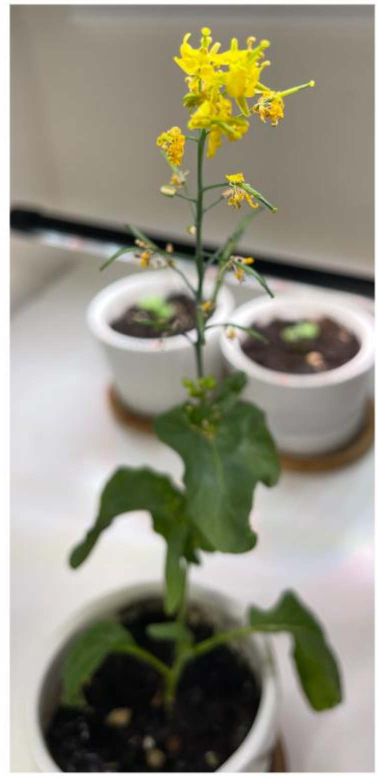
Day 15

Day 17

Day 19


Day 20


Day 21

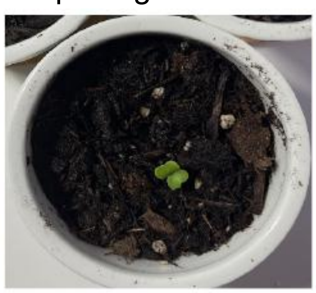

Day 25

Day 34

Day 41

Example of unsuccessful plant growth:

Day 1



Day 3

Day 5

Day 7

Day 11

Day 15

A total of 31 seeds were planted, with 3 successful growths, 10 unsuccessful growths that lasted for less than 11 days which include ones picked out during the thinning on day 5, and 17 unsuccessful growths that had no growths at all. From the successful growth, it was observed that the plant started to grow right after planting and emerged from the soil the day after planting. The latest emergence for a seed is on day 4. The cotyledons enlarge until day 6 (Figure 1), which is when the leaves start to grow. Flower buds begin growing on day 11 and the flowers bloom on day 17. The flowers bloom for around 10 days; seeds begin to grow on day 28 and finish developing on day 36. On around day 45, seeds will turn yellow and be ready to harvest. On the various pictures from day 15 to the end, it could be seen that the roots are green which means the plant in the pictures has the Anthocyaninless trait. The other two plants which were successfully grown also ended up becoming plants with anthocyaninless traits.

Discussion

Based on the raw data, there was a 9.7% success rate for the plants to complete its life cycle, a 35.4% chance for them to grow but not for longer than 10 days and 54.8% chance for them to not grow at all. 14 out of the 18 unsuccessful growths are the first attempts at growing the plants. As the attempts increased, the chance of success increased. The last attempts were almost all successful. The changes made for the increase in success include two adjustments in the details of the method. The first is the amount of water used in the first 4 days; previous attempts used too little water. Only a few drops of water were dripped onto the top of the soil with a pipet each day as instructed, but it was far from enough. For the later attempts, water was poured from a water source and drenched all of the soil but not too much is used either. The second is the depth of the seed buried in the soil. The seed was buried too deep into the soil and the white light could not reach it and the seeds were not able to develop. For later attempts, the soil barely covered the seed, but also provided enough coverage for a developing environment.

A total of 3 plants grew successfully. The anthocyaninless trait is shown on the plants with a non-purple and green stem. The trait is a recessive trait which in the first generation, must have been the result of possibility 2 (Figure 3) since possibility 1 has a 100% chance of the plant being purple stemmed. In possibility 2, there’s a 50% chance of the plant being anthocyaninless and 50% of the plant having purple stems. The experiment did not follow the genetic probabilities of the calculated traits as 100% of them have been anthocyaninless. Therefore, the hypothesis was not supported since it stated that “the first generation plants will have the Purple Stem trait” which was refuted by the results of this experiment.

Further experiments for this subject includes planting another generation as well as planting other species of plants. Planting another generation involves repeating the process of planting Wisconsin Fast Plants, except the seeds would be obtained from previous generations after it reaches day 40 and the seed pods are ready to be harvested. This would allow the further examination of the genetic transmission of the traits of its previous generations to answer questions such as whether or not seeds from a plant with a certain trait would result in higher probability of a second generation of plants with the same traits or would their traits be based on the chances of the crossing of the genes. Another potential experiment is to plant other species of plant with crossed genes and compare them to the results of Wisconsin Fast Plants. It would also be interesting to see plants with crossed physical traits, such as shape, height, or texture.

References

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