

Lab Report Template: Genetics Lab

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Introduction:

In this experiment, we aim to understand the genetic rules governing the passing of traits from one generation to the next, in particular the chromosomal theory of inheritance and Mendelian genetics. In Mendelian genetics, traits are passed down in their original form from one generation to the next through genes, meaning that the possibility of a phenotype, or an expressed trait of the offspring, can be predicted by the genotype, or the gene combination, of the parents. The chromosome theory of inheritance tells us that these genes are located on chromosomes and that the patterns observed in Mendelian genetics, in particular the law of segregation and the law of independent assortment, can be explained by the meiotic divisions of germ cells. We are showing that our test organisms conform to this rule by examining parent and offspring genotypes and phenotypes through three generations and seeing if Mendel's predicted ratios match the results in terms of dominance and recessiveness.

We used a large number of seeds of three generations of *Brassica rapa* or field mustard as test organisms, looking at their visually distinctive phenotypes from generation to generation to determine parent and offspring genotypes, especially which alleles are dominant and recessive (since dominant traits are visible in phenotype while recessive traits are not). Specifically, we aim to answer the question of whether *Brassica rapa* seeds follow traditional Mendelian genetic laws in terms of dominance and recessiveness by looking at their phenotypes, in particular their height (standard height versus Rosette-dwarf height) and their stem coloring (non-purple versus purple). Our hypothesis is that *Brassica* follows Mendelian inheritance laws, and we seek to support this claim through our experiment. Through making inquiries about the genetic patterns of *Brassica rapa*, we can understand its inheritance laws better and use this knowledge to inquire about *Brassica*'s other genotypes and phenotypes, and perhaps even *Brassica*'s genetic relatives.

Materials & Methods:

Materials:

- *Brassica rapa* P1 seeds
- *Brassica rapa* F1 seeds
- *Brassica rapa* F2 seeds
- Petri dishes
- Paper towel or similar absorbent paper
- Pipette
- Fluorescent lamp and bulb
- Dechlorinated Tap Water

Procedure:

1. Preparing seeds for germination
 - a. Label the edge of the bottom side of the petri dishes: “P1”, “F1” and “F2”.
 - b. Place the paper towel in the lid of the petri dish and add water until it is completely soaked. Pour off any excess water not absorbed by the filter paper.
 - c. Place seeds on the paper, taking care of spreading them evenly.
 - d. Place the bottom of the petri dish and label—make sure to match seeds and labels.
 - e. Place the petri dish in a germination cup and add water until the water level reaches the edge of the paper towel (approx 1 cm) (Figure 1).
 - f. Place the cup approximately 7 inches below the lamp and place a “DO NOT TURN OFF LIGHT” sign.
 - g. Keep the cup at room temperature (22°C).



Figure 1. Petri dishes are placed in the cup with water.

2. Germinating seed and Data collection
 - a. Maintain the dishes under constant light and temperature (optional: monitor temperature in the room).
 - b. Every 12 hours inspect the water level in the cup and check the filter paper for moisture—add water to the cup as needed. Do not let the paper dry out.
 - c. Every 12 hours inspect the seedlings and record observations in the Data Collection Sheet. Take a picture of each dish.
3. Clean up
 - a. Discard paper and seedlings as compostable.
 - b. Discard dishes and cup as Recyclable waste.
 - c. Lamp and bulb should be returned to the instructor.

Results:

In Zhang’s version of this experiment, we noted that the entire P1 generation exhibited the non-purple phenotype and mostly exhibited the standard height phenotype, with very few exhibiting the Rosette-dwarf phenotype. Furthermore, in the F1 generation, we noted that 9 out of the 10 sprouts exhibited the purple phenotype, while only one exhibited the non-purple phenotype. The F1 generation also almost exhibited the standard height phenotype (only one exhibited Rosette-Dwarf), as there were two late-germinating seeds that could not exhibit a height phenotype. The two generations at the end of the experiment (96 hours in) can be seen below in Figures 2 and 3, respectively.

In the F2 generation, we noted that all plants exhibited the purple phenotype after the 96 hours of the experiment were finished. We also noted in this generation that 2 of the 10 plants observed were of the

Rosette-Dwarf phenotype, with the other eight being of a standard height. The picture of this generation can be seen in Figure 4 below.

Figure 2: P1 Generation after 96 Hours of Germination

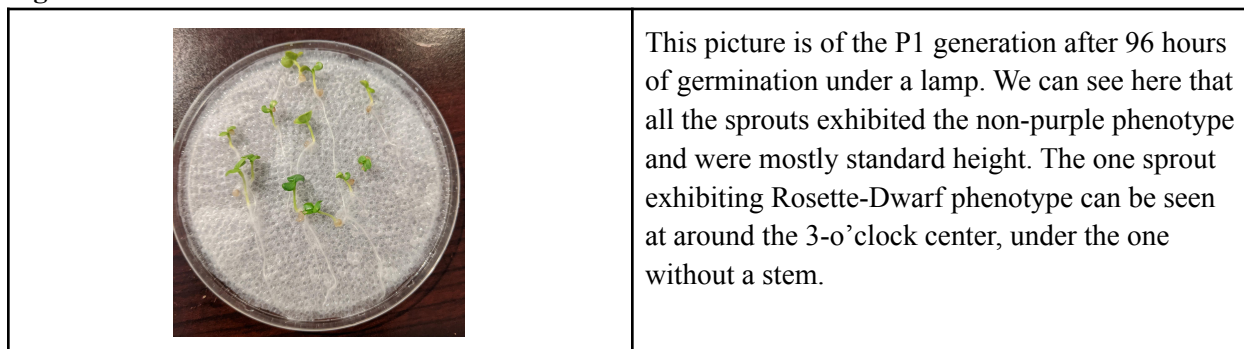


Figure 3: F1 Generation after 96 Hours of Germination

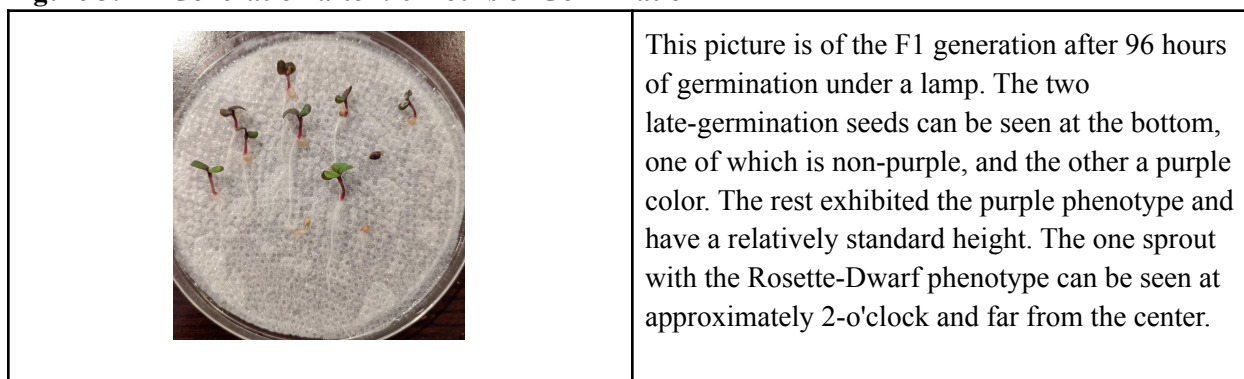
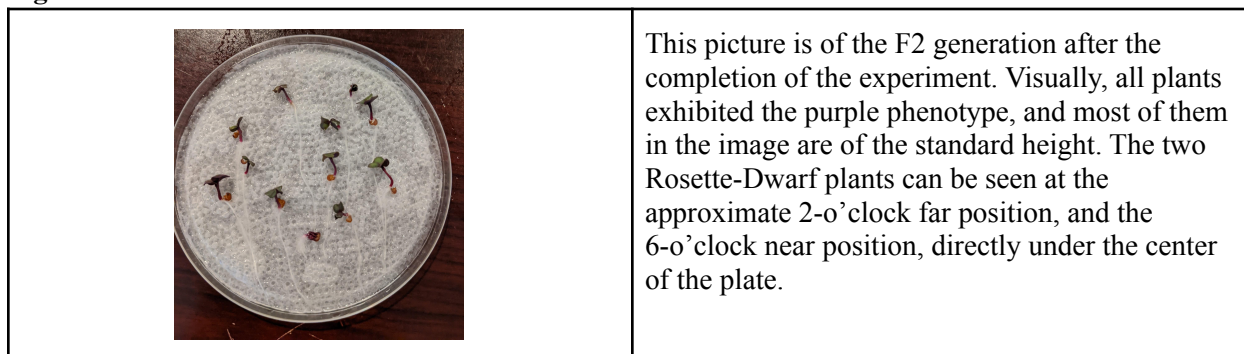


Figure 4: F2 Generation after 96 Hours of Germination



These results were generally consistent with the class data for this experiment. In the whole-class data, we found that the P1 generation all had a green phenotype (Table 1, Figure 5), and that very few of the P1 generation exhibited the Rosette-Dwarf phenotype, having a 1:9 ratio of Rosette-Dwarf to standard height (Table 1, Figure 5). In the F1 generation, we observed that most of the stems were purple, as there was an approximate 1:10 ratio of non-purple phenotypes to purple ones (Figure 6, Table 2). The stem heights for this generation were also similar to the results observed in Zhang's experiment, given that the class observed an approximate 1:4 ratio for dwarf stems to standard height stems (Figure 6). The major

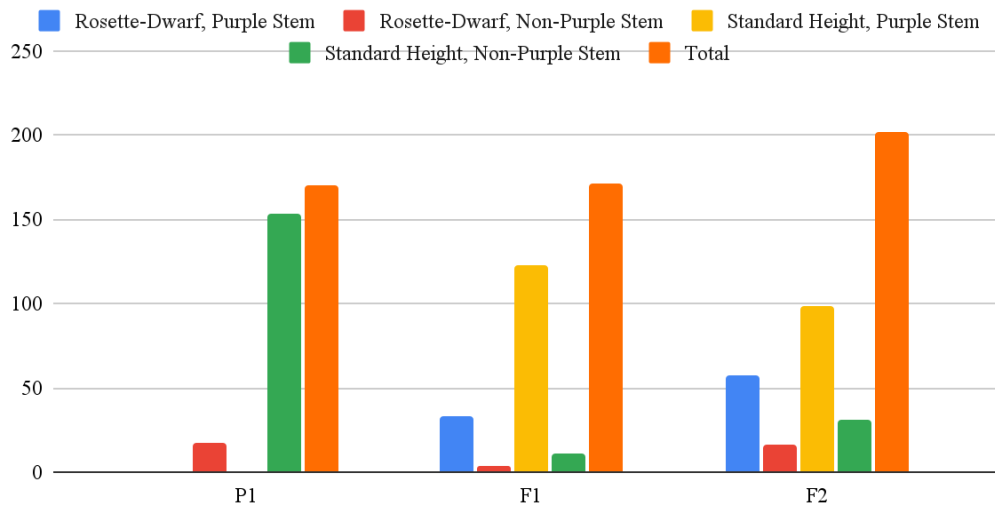
difference in results came with the F2 generation since the class data showed a 1:3 ratio of non-purple stems to purple stems, which was not observed in Zhang's data. For the heights of the F2 generation, the class observed a 1:2 ratio of dwarf stems to standard stems overall (Figure 6, Table 2).

Table 1: Number of *Brassica rapa* Plants per Phenotype In P1, F1, F2 Generations

	P1	F1	F2
Rosette-Dwarf, Purple Stem	0	33	57
Rosette-Dwarf, Non-Purple Stem	17	4	16
Standard Height, Purple Stem	0	123	98
Standard Height, Non-Purple Stem	153	11	31
Total	170	171	202

This table shows the number of *Brassica rapa* with each phenotype combination in the P1, F1, and F2 generations. The data was taken 96 hours after planting the seeds at the start of the experiment.

Figure 5: Number of *Brassicca rapa* Plants per Phenotype in Each Generation

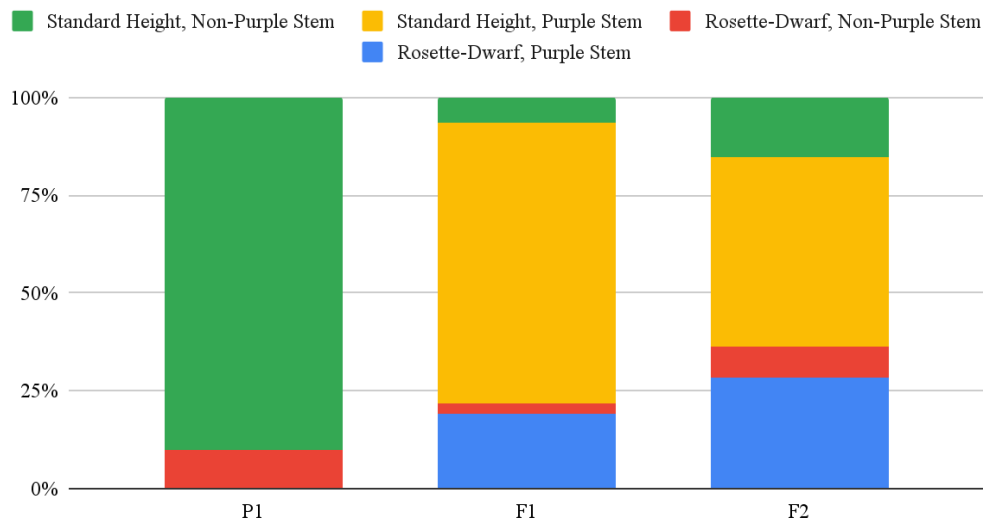


This chart is a visual representation of how many plants in the P1, F1 and F2 generations had each phenotype combination after 96 hours of germination.

Table 2: Percentage of Total Population for Each Phenotype in P1, F1, F2 Generations

	P1	F1	F2
Rosette-Dwarf, Purple Stem	0.0%	19.3%	28.2%
Rosette-Dwarf, Non-Purple Stem	10.0%	2.3%	7.9%
Standard Height, Purple Stem	0.0%	71.9%	48.5%
Standard Height, Non-Purple Stem	90.0%	6.4%	15.3%
Approximate Ratios of Phenotypes (Rosette-Dwarf Purple Stem : Rosette-Dwarf Non-Purple Stem : Standard Height Purple Stem : Standard Height Non-Purple Stem)	0:1:0:9	8:1:29:3	7:2:12:4
Total	170	171	202

This table shows the percentage of each generation (P1, F1, and F2) expressing each phenotype combination, and also gives the approximate phenotype ratios of each of the three generations.

Figure 6: Ratios of Phenotypes in Each Generation

This chart is a visual representation of the phenotype combination ratios of each generation, using the percentages calculated in Table 5.

Discussion:

To summarize, we conducted this experiment in order to answer the question of whether the offspring of *Brassica rapa* plants inherit and express their parent's traits following classical Mendelian genetics laws and the chromosomal theory of inheritance. In other words, we are investigating whether

the laws of dominance, segregation, and independent assortment can approximate the phenotype ratios of each of the offspring generations. By doing so, we can understand the inheritance patterns of *Brassica rapa* better by being able to predict which phenotypes its offspring are most likely to express given the genotypes of the parents. We also can understand genetic inheritance as a whole better as a result of this experiment, as most of the observations and predictions made for *Brassica rapa* plants extend in similar ways to all organisms, all sharing the fundamental similarities of carrying genes on chromosomes that undergo meiosis when reproducing, meaning we can apply the observations in this experiment to predict the phenotypes of the offspring of any species, an extremely powerful tool.

From the results of this experiment, it is logical to conclude that the *Brassica rapa* traits that we observed are autosomal and on different genes. This is because the F1 generation was bred with itself and produced a wide variety of results shown in the F2 generation. Because it was bred with itself, we can assume that the reciprocal cross had no effect on the F2 generation (as it would have produced more skewed results), so the gene is autosomal. We also know that these genes must independently assort. If these genes were on the same chromosome, we would observe the two phenotypes always being present with each other (standard height purple, Rosette-Dwarf non-purple, etc.), something that was not observed in the class data. As such, we are observing an autosomal mode of inheritance for two independently assorted genes.

We can also use the phenotype ratios of the F1 and F2 generations to predict the genotype of the P1 and P2 generations. Because the F2 generation had a (approximate) 1:3 ratio of non-purple stems to purple stems, this is indicative that the parents of the F2 generation (the F1 generation) were all heterozygous, as shown in Table 3 below.

Table 3: F1 Generation Punnett square

	P	p
P	PP	Pp
p	Pp	pp

This table is a Punnett square that represents the predicted offspring genotypes of the F1 breeding for the plants in this experiment. It shows the 3:1 phenotype ratio (as P is dominant to p) of this crossing, which helps prove that the F1 generation must have been heterozygous in this experiment.

As we can see, a heterozygous cross at the F1 generation would produce a 3:1 ratio of the dominant trait to the recessive trait. We can therefore determine that the purple stem allele is dominant to the green stem, since it was the phenotype that was observed about three times more often than the non-purple. We will call the purple allele P and the non-purple allele p. This is also supported by the data collected for the F1 generation. Because all of these plants must be heterozygous for the gene in question, we would only observe the dominant trait in the phenotypes of these plants. In this case, we only observed Purple plants, so that means that purple would be dominant to non-purple.

This then allows us to determine the genotypes of both the P1 and P2 parent generations. Because the purple allele is dominant to the non-purple, then the P1 generation, having all non-purple stems observed, must be homozygous recessive (pp), as that is the only way the recessive phenotype could be expressed. This then means that in order for the F1 generation to be all heterozygous, the P2 generation must have a homozygous dominant genotype, creating the cross seen in Table 4 below.

Table 4: Parent Generation Crossing Punnett Square

	P	P
p	Pp	Pp
p	Pp	Pp

This table is a Punnett square that represents the predicted offspring genotypes between the two parent generations for these plants. The P1 generation (the one germinated in this experiment) can be seen on the left, with the P2 generation on the top.

This mating produces an entirely heterozygous F1 generation, like the one we observed, and thus the P1 generation must have a genotype of pp and the P2 generation must have a genotype of PP to create the data observed in this experiment.

We can use a similar line of thinking to determine the genotypes of the P1 and P2 generations for the other trait, trait for height. Looking again at the class data, we can see that there is an approximate 1:3 ratio of Rosette-Dwarfs to standard height plants in the F2 generation. This, according to the same logic as above, means that the F1 generation must all have had heterozygous genotypes.

Since the standard height phenotype was more common in the F2 generation than the Rosette-dwarf phenotype, the standard height allele (H) must be dominant to the Rosette-dwarf allele (h). We then know that the P1 and P2 generations must have both been homozygous for different alleles, as that is the only crossing that produces an entirely heterozygous offspring generation. Since the P1 generation which was observed was almost entirely of the standard height phenotype, we thus know that P1 must have been homozygous dominant (and must have had genotype HH), and P2 must have been homozygous recessive (and must have had genotype hh).

Combining these two genotypes, we then know that the P1 generation had a genotype of ppHH and the P2 generation had a genotype of PPhh. This means the first cross in this experiment would be represented in the Punnett squares in table 5, and the second would be in table 6. They would have produced a ratio of phenotypes like the one seen in table 7, which approximately match the observed data.

Table 5: Punnett Square of P1 x P2

	pH
Ph	PpHh

This table shows our predicted genotypes for both parents and how it logically leads to the F1 genotype PpHh. The P1 generation can be seen on the top, while the P2 is on the left.

Table 6: Punnett Square of F1 x F1

	PH	Ph	pH	ph
PH	PPHH	PPHh	PpHH	PpHh
Ph	PPHh	PPhh	PpHh	Pphh

pH	PpHH	PpHh	ppHH	ppHh
ph	PpHh	Pphh	ppHh	pphh

This table shows our predicted genotype ratios for the F2 generation. Since the F1 generation was self-pollinated or bred with itself, the PpHh genotype belongs to both parents.

Table 7: Ratios of Phenotypes of F2

Purple & standard height	9:16
Purple & Rosette-dwarf	3:16
Non-purple & standard height	3:16
Non-purple & Rosette-dwarf	1:16

This table shows our predicted phenotype ratio for F2 if the PpHh plant in F1 is bred with itself. In the F2 generation, we have a 9:3:3:1 phenotype ratio, which resembles the experimental results we achieved.

Conclusion:

In conclusion, the experiment supports our hypothesis that *Brassica* seeds follow traditional Mendelian inheritance laws. The P1, F1, and F2 phenotype ratios resemble typical cross patterns of the simple dominant/recessive inheritance pattern. The results do not provide conclusive evidence, proving this claim, as the phenotype ratios exhibited are not perfectly balanced or matched to standard ratios (like 3:1). However, based on our current knowledge, they show a strong enough correspondence to lend solid evidence to our claim.

The knowledge and conclusions we have gained from this experiment are enlightening in understanding *Brassica*'s inheritance patterns. However, there is still much to learn.

After this experiment, we have support for the sub-hypothesis that for the height trait, the "standard height" allele is dominant, while the "Rosette-dwarf" allele is recessive. We can conclusively prove this by breeding pure lines of *Brassica* plants that exhibit the standard height allele, as well as pure lines of *Brassica* plants that exhibit the Rosette-dwarf allele. The standard height population would all be heterozygous dominant, whereas the Rosette-dwarf population would be entirely recessive. Then, we can test this sub-hypothesis by using a controlled environment to cross the offspring from these two pure lines, then crossing their respective offspring.

Table 8: Punnett Square of Cross of Pure Line Standard Height and Pure Line Rosette-dwarf *Brassica*

	H	H
h	Hh	Hh
h	Hh	Hh

This Punnett square shows the result of the first generation of offspring from crossing these pure lines (assuming standard height is dominant and Rosette-dwarf is recessive). According to this Punnett square, all plants should exhibit standard height in the first generation.

Table 9: Punnett Square of Second Cross of Pureline Standard Height and Pureline Rosette-dwarf *Brassica*:

	H	h
H	HH	Hh
h	Hh	hh

This Punnett square shows the result of the second generation of offspring from crossing the offspring of the pure lines (assuming standard height is dominant and Rosette-dwarf is recessive). According to this Punnett square, around 3/4ths of the plants should exhibit standard height and around 1/4th of the plants should exhibit Rosette-dwarf height in the second generation.

If we achieve results that resemble the ratio seen in the Punnett squares above, we have much stronger evidence for this sub-hypothesis. Thus, we can effectively claim that the standard height phenotype and the Rosette-dwarf phenotype are dominant and recessive, respectively.

We can apply the same principles to an experiment observing the stem color trait, or breeding two pure lines and crossing them for two generations.

Through this experiment, we can understand *Brassica*'s inheritance patterns better and use this knowledge to inquire about *Brassica*'s other genotypes and phenotypes, and perhaps even *Brassica*'s genetic relatives.