Massachusetts Institute of Technology HHMI

StarGenetics

Name: _____

Mendel's Peas Exercise 1 - Part 2

GENOTYPE AND PHENOTYPE RELATIONSHIPS

Goal

In this exercise you will use StarGenetics, a genetics experiment simulator, to explore the relationship between phenotype and genotype by following the inheritance of a specific genetic trait, flower color, in pea plants.

Learning objectives

After completing this exercise, you will be able to:

1. Explain important genetic terms including: allele, genotype, phenotype, dominant, recessive, homozygous, and heterozygous.
2. Implement genetics experiments in the genetics cross simulator, StarGenetics.
3. Determine whether a phenotype is dominant or recessive relative to another phenotype.
4. Use Punnett Squares to predict and confirm expected phenotypic ratios given possible genotypes.
5. Infer and assign genotypes of individual organisms using proper nomenclature of alleles.

Getting started with StarGenetics

- To access StarGenetics, please navigate to: **http://star.mit.edu/genetics/**.
- Click on the **Start** button to launch the application.
- Click **Trust** when a prompt appears asking if you trust the certificate.
- Click on **File** → **New** in the drop-down menu in the upper left hand corner.
- Click on the **Mendel's Peas Exercise 1 – Part 2** file.

You are working in a company that produces strains of pea plants and ships them out all over the world to research labs. Your company prides itself on supplying only true-breeding pea plants that produce the identical pea plant offspring for many generations. You and your co-worker have successfully identified two new true-breeding strains of pea plants: one with white flowers and one with purple flowers. These are named "***White Parent 1***" and "***Purple Parent 1***", and can be found in the **Strains** box in StarGenetics. Your supervisor wants you to examine the properties of these strains, in particular the genetics of their flower colors.

1 You are curious whether the white flower phenotype is dominant or recessive to the purple flower phenotype. To answer this question, cross the true-breeding ***White Parent 1*** strain with the true-breeding ***Purple Parent 1*** strain.

- Set up a cross by dragging the ***White Parent 1*** and ***Purple Parent 1*** pea plants to the **Mating site** and click **Mate**.
- Each resulting offspring can be viewed within the **Individual** tab or a summary of the results is available in the **Summary** tab.
- The flower color of individual offspring can be visually observed or obtained by selecting an offspring of interest and looking in the **Properties** window.

Answer

Number of F1 pea plants that look like *White Parent 1*:

Number of F1 pea plants that look like *Purple Parent 1*:

Total number of pea plants generated:

Circle the ratio that best fits the progeny you observe:

All Purple **3 Purple : 1 White** **1 Purple : 1 White** **1 Purple : 3 White** **All White**

2 Based on the results you obtained in Question 1, is the purple flower color phenotype dominant or recessive to the white flower color phenotype? Explain what it means for this phenotype to be dominant to the other the phenotype?

Answer

Which flower color is dominant relative to the other? (Circle one) **Purple** **White**

Explain:

3 What are the likely genotypes for the **true-breeding** ***Purple Parent 1*** and **true-breeding** ***White Parent 1*** pea plants with respect to flower color? Assign genotypes to ***Purple Parent 1*** and ***White Parent 1*** and explain your answer. Assume that a **single gene** encodes the flower color trait.

A Note on Nomenclature and Assigning Alleles:

- Each allele in question is assigned a single letter. Use the **UPPERCASE** version of the letter to denote the allele that confers the dominant phenotype and the **lowercase** version of the letter to denote the allele that confers the recessive phenotype. For example, a plant that is homozygous dominant for a trait we will call *G* will have the genotype *GG*. A plant that is homozygous recessive for trait *G* will have the genotype *gg*.
- Usually the letter chosen describes the phenotype you observe. In this instance you may choose to use a "*W*" (for white) or a "*P*" (for purple) as the letter for the flower color trait, depending on your preference.
- Make sure to use the SAME letter for both the allele that confers the dominant and the allele that confers the recessive phenotype; just use different cases!

Answer

***Purple Parent 1*'s genotype:**

***White Parent 1*'s genotype:**

Explain:

4 Now we're going to investigate the process that enables offspring to inherit alleles from their parents. In the parents, one germ cell (a cell that gives rise to sperm or eggs) containing two alleles for flower color

divides into 4 gametes through the process of meiosis. The resulting gametes could be either 4 eggs (ovum) or 4 sperm (pollen) depending on the type of germ cell that undergoes meiosis. Half of the gametes will have one allele and the other half will have the other allele. This is **Mendel's Law of Segregation**.

Note: Refer to **Worksheet: Meiosis and Mendel's Law of Segregation** available on the StarGenetics website (star.mit.edu/genetics/problemsets) for more information about the process of meiosis.

Write in the genotype for the flower color gene in the appropriate spaces using the same nomenclature that you defined in Question 3. Copy the genotypes of the parents you determined in Question 3.

Answer

Purple Parent 1's genotype (diploid):

Gamete genotypes (haploid):

Gamete 1:

Gamete 2:

Gamete 3:

Gamete 4:

White Parent 1's genotype (diploid):

Gamete genotypes (haploid):

Gamete 1:

Gamete 2:

Gamete 3:

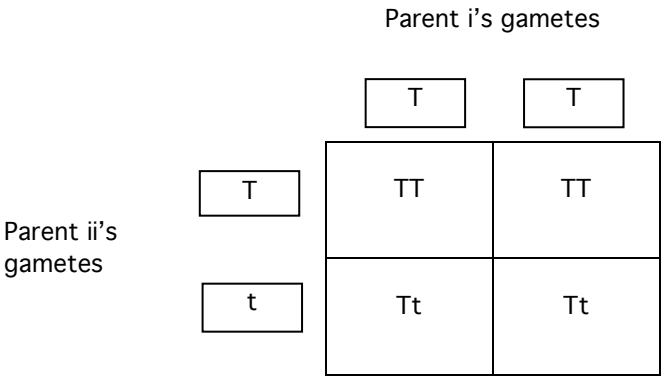
Gamete 4:

5 We will now use Punnett Squares to determine the potential genotypes and infer the phenotypes of the offspring from individual crosses.

Below is an example Punnett Square for a cross between two tall plants with different genotypes:

Trait: Plant Height
Alleles: T (tall plants), t (short plants)
Parent i:
- Genotype: TT
- Phenotype: Tall
- Gametes from Parent i: all T

Parent ii:
- Genotype: Tt
- Phenotype: Tall
- Gametes from Parent ii: ½ T, ½ t

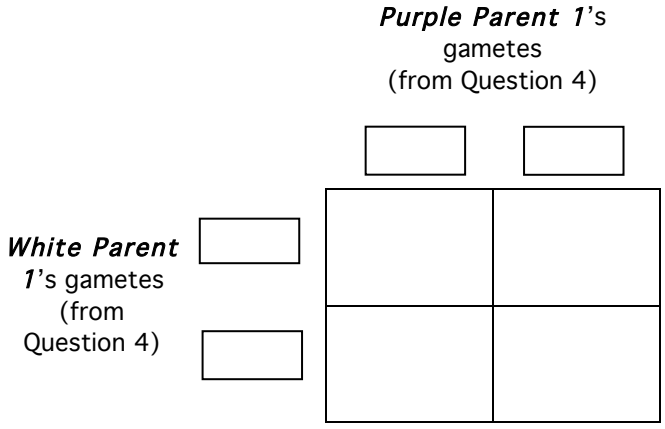


Genotypic Ratio: 1 TT : 1 Tt

Phenotypic Ratio: All Tall

a) What are the expected genotypes of the offspring resulting from a cross between ***Purple Parent 1*** and ***White Parent 1***? Fill in the Punnett Square below with the expected genotypes of the F1 offspring using the same nomenclature that you used in Questions 3 and 4.

Answer



6 Based on your Punnett Square predictions in Question 5a, what are the **expected** genotypic and phenotypic ratios for the F1 offspring of the ***Purple Parent 1*** x ***White Parent 1*** cross with respect to flower color?

Answer

Genotypic Ratio:

Phenotypic Ratio:

7 How does your observed phenotypic ratio from the ***Purple Parent 1*** x ***White Parent 1*** cross in Question 1 compare to your prediction of the expected phenotypic ratio in Question 6?

Answer

8 Given your answer to Question 5a, are the resulting F1 pea plants from the cross in Question 1 homozygous or heterozygous for the flower color trait?

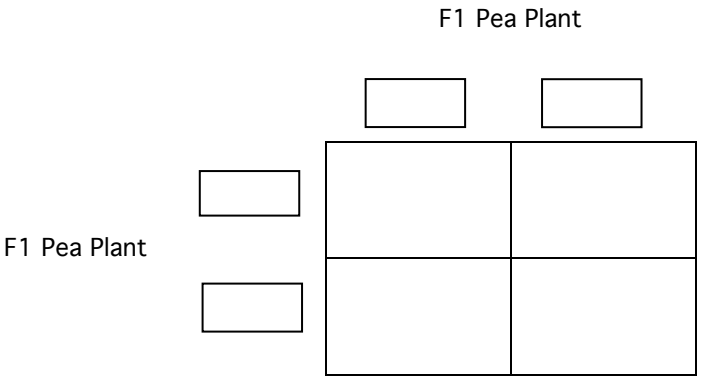
Answer

F1 plants are (circle one): Homozygous Heterozygous Both

9 Now we will determine the **expected** genotype(s) and phenotypes of the F2 offspring resulting from a cross of two different F1 pea plants.

a) Fill in the Punnett Square below with the genotypes of the possible gametes of the F1 pea plants and the expected genotypes of the F2 offspring.

Answer



b) Using the Punnett Square in Question 9a, indicate the **expected** genotypic and phenotypic ratios for the F2 offspring.

Answer

Genotypic ratio:

Phenotypic ratio:

10 Now cross two different F1 pea plants and produce 80 progeny (10 matings). What do you observe?

- To begin a new experiment, click **New experiment**. Your previous experiment will be automatically saved for you, and accessible in the **Saved experiments** window.
- To add additional offspring in the same cross, click on the **Add more matings** button and select the appropriate number of matings you would like to perform in the pop-up window to add the appropriate number of additional offspring.

Answer

Number of purple flowered plants:

Number of white flowered plants:

Total number of pea plants generated:

% of plants with purple flowers:

% of plants with white flowers:

Observed phenotypic ratio:

11 If any 2 purple flowered F2 plants from Question 10 are crossed, what are the possible genotypic and phenotypic ratios of the resulting F3 progeny with respect to flower color?

There are 3 possible types of crosses between purple F2 plants. Fill in one Punnett Square below for each possible cross type. For each cross indicate the genotypes of the F2 parents above the Punnett Square. The order of the parents in a single cross doesn't matter.

Answer

Note: Since the male and female gametes are not specified, the assignment of the gametes at the top and left side of the Punnett Square may be reversed. The possibilities may be listed in any order, as long as the numbering remains consistent in all future questions.

Possibility 1: ___ ___ x ___ ___ (Parents' genotypes)

Genotypic ratio:

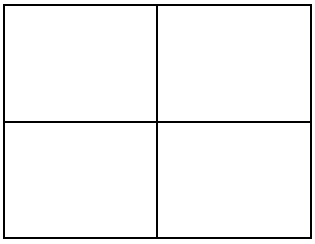
Phenotypic ratio:

Possibility 2: ___ ___ x ___ ___ (Parents' genotypes)

Genotypic ratio:

Phenotypic ratio:

Possibility 3: ___ ___ x ___ _ _ (Parents' genotypes)



Genotypic ratio:

Phenotypic ratio:

12 "***Purple F2-A***" and "***Purple F2-B***" found within your **Strains** box represent two individual F2 purple flowered plants picked at random from the potential progeny that you would have generated in Question 11. Cross these two plants to produce 80 progeny (10 matings) and record the number of plants in each phenotypic category observed in the resulting offspring. Based on your results, what are the genotypes of the ***Purple F2-A*** and ***Purple F2-B*** pea plants with respect to the flower color gene? Explain how you formed your conclusion.

Answer

Number of purple flowered plants:

Number of white flowered plants:

Purple F2-A genotype:

Purple F2-B genotype:

How did you form your conclusion?

Advanced

13 In the **Strains** box, you will find an additional 8 representative F2 offspring with purple flowers that arose from the cross in Question 10. They are called: "***Purple F2-C***" through "***Purple F2-J***".

a) Pick any two of these plants and cross them together to produce 80 F3 individuals. What is the phenotypic ratio in the F3 generation for the flower color trait?

Answer

Parent 1: Purple F2-___ (write in the name of the plant)

Parent 2: Purple F2-___ (write in the name of the plant)

Phenotypic ratio in the F3 generation:

b) From the 3 possibilities you listed Question 11, put a check mark next to all of the possibilities that would produce the phenotypic ratio you listed above.

Answer

□ Possibility 1

□ Possibility 2

□ Possibility 3

c) Can you determine the genotypes of the F2 parents from this single cross? If so, write them down. If not, explain why there is an ambiguity / are ambiguities in determining their genotypes.

Answer

Purple F2-___ (write in the name of the plant) Genotype: _____

Purple F2-___ (write in the name of the plant) Genotype: _____

If ambiguity, why?

If you were not able to conclusively determine the genotypes of your F2 parents in question 13c, answer Questions 14 and 15: (DO NOT COMPLETE IF RESULTS WERE NOT AMBIGUOUS)

14 a) Outline the crosses you could perform to determine the genotypes of these F2 plants unambiguously. Use Punnett Squares to help you explain your strategy.

Answer

b) Perform the crosses you proposed in 14a in StarGenetics. Infer the genotypes of the two F2 pea plants you chose in Question 13a and explain how you arrived at your conclusion.

Answer	
Purple F2-___ (write in the name of the plant)	Genotype: _____
Purple F2-___ (write in the name of the plant)	Genotype: _____
Explain:	