



Mendel's Peas Exercise 4 – Part 2 (Advanced)

Non-Mendelian Inheritance: Biochemical Pathways

Goal

In this exercise you will use StarGenetics, genetics experiment simulator, to explore the non-Mendelian inheritance of a trait and to explain, using biochemical pathways, how a genotype a specific phenotype.

Prerequisite knowledge

Before completing this exercise, students should be able to:

1. Infer and assign genotypes of individual organisms using proper nomenclature of alleles.
2. Determine if an organism is true breeding.
3. Explain how alleles are passed down from parents to progeny and how traits are inherited according to Mendel's laws of segregation and independent assortment.
4. Design experiments to distinguish between dominant versus recessive phenotypes.

Note: Please complete **Exercise 4 – Part 1** prior to beginning this exercise. This is necessary background information for the following questions.

Learning objectives

After completing this exercise, you will be able to:

1. Predict genotypes of individuals based on phenotype in cases of incomplete dominance.
2. Explain how a mutation in a gene can cause different phenotypes on within individual cells and in the organism on the whole.
3. Describe how a mutation in an enzyme can alter the products of a biochemical pathway.
4. Interpret and draw graphs correlating the level of protein in cells with the phenotype of cells.

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 4** file.

As a fearless explorer and geneticist, you decide to take a trip to the Near East to look for new species of popular crops, particularly plants related to the common/domesticated garden pea plant, in honor of your favorite gardening enthusiast/bee keeper/Austrian monk, Gregor Mendel, the “Father of Modern Genetics”. During an expedition to the Nile Delta in Egypt, one of few the places where wild pea plants grow, you discover what appears to be a new, uncharacterized species of pea plant, perhaps related to the pea plant species that Mendel studied (*Pisum sativum*). You decide to creatively name this new species *Pisum niledeltus*. Even though this new species of pea plant resembles Mendel's peas and exhibits similar variations in flower color, this phenotype may be inherited in different ways in the two species. Previously, in Exercise 4 – Part 1, you characterized this new species of pea plant by performing a series of crosses with two plants that you had brought back from Egypt (**Plant A** and **Plant B**) to determine the inheritance pattern of flower color.

In this exercise, we will investigate the biochemical pathways underlying flower color to better understand how genotype affects phenotype.

- 1** Based on your answers from **Exercise 4 – Part 1**, what are the genotypes of **Plant A** and **Plant B**? List the phenotypes corresponding with ALL of the possible flower color genotypes.
- Use the letters 'R' and 'r' to represent the possible alleles for flower color.

Let 'R' represent the red allele and 'r' represent the white allele:

Strain A

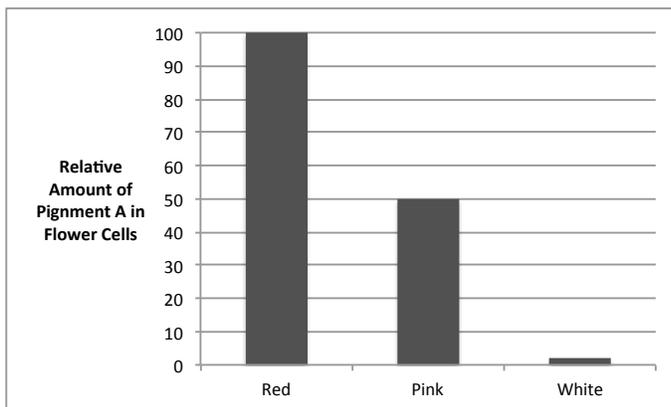
Genotype:

Strain B

Genotype:

Flower colors for each possible genotype:

- 2** To better understand the biological mechanism that underlies flower color, you quantify the amount of a red pigment, named Pigment A, in *Pisum niledeltus* plants producing red, pink and white flowers. To do this, you gather the same amount, in weight, of petals from red, pink, and white flowers and crush them to make an extract that contains Pigment A. You then measure the relative amount of Pigment A in each extract. The results of your experiment are shown in the graph below. The bars indicate the relative amount of Pigment A after adjusting for the amount of extract (volume) isolated from each phenotypic flower color type.



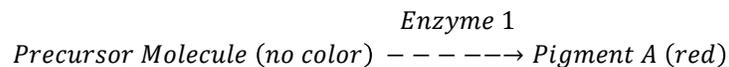
- a)** Compare the amount of Pigment A in red and pink flowers. Approximately how much pigment is in red flowers relative to pink flowers? How is pigment concentration related to flowers being red or pink?

Answer

b) How much Pigment A is found in white flowers relative to red flowers? Why might these white flowers appear white instead of pink or red?

Answer

3 Below is a proposed pathway for pigment production in the flowers of *Pisum niledeltus*.



In this biochemical pathway, Enzyme 1 catalyzes a reaction in which a colorless precursor molecule is converted to a red pigment molecule, Pigment A. The arrow connecting the precursor molecule to the product indicates the direction of the reaction. A buildup of the red Pigment A in flower cells makes the flower appear red. The **amount** of Pigment A in cells determines the observed flower color of the pea plant. As the amount of Enzyme 1 decreases, the amount of red Pigment A produced from the precursor decreases as well.

Using the information and answers to Question 2, propose a theory that explains how both the pink and white flower color phenotypes you observed in this pea species can result from a single mutation in the gene encoding Enzyme 1. Make sure to include:

- whether the mutation increases the activity of Enzyme 1 (gain of function) or decreases/inactivates Enzyme 1 (loss of function mutation).
- a description of how changes in the activity of Enzyme 1 relate to the amount of colorless precursor molecule and Pigment A present, and the resulting flower color for each of all the possible flower color genotypes.

Answer

4 In the graph below, draw bars representing the relative amount of the colorless precursor molecule you would expect to find in the red, pink, and white flowers (from 0 to 100%) if you were to measure it in the same way as previously described. The bars should represent the relative amount of precursor molecule present in red, pink and white petals if the same amount, by weight, of petals are used for each flower type and the amount of extract isolated from these petals is equal for all three preparations.

Answer