Guided Exercise - Mendel's Peas

Goal

To become familiar with using the StarGenetics application, a genetics experiment simulator, to determine the inheritance of traits by performing and analyzing the results of crosses between garden pea plants.

Learning Objectives

After completing this exercise, you will be able to:

1. Identify the phenotype of a pea plant within StarGenetics.
2. Perform genetic crosses in StarGenetics, by crossing two pea plants together or self-crossing one pea plant, to generate progeny in a series of generations.
3. Determine whether a plant is true breeding for a specific trait through the analysis of results from genetic crosses.
4. Determine if a phenotype is dominant or recessive relative to another phenotype through the analysis of results from genetic crosses.

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 main menu.
• Click on the Mendel's Peas Guided Exercise file.

In the Strains box, you will find three different pea plants, named *Plant A*, *Plant B*, and *Plant C*. First, examine the physical characteristics of the three plants. The parts of the pea plant illustrated in StarGenetics are labeled below.
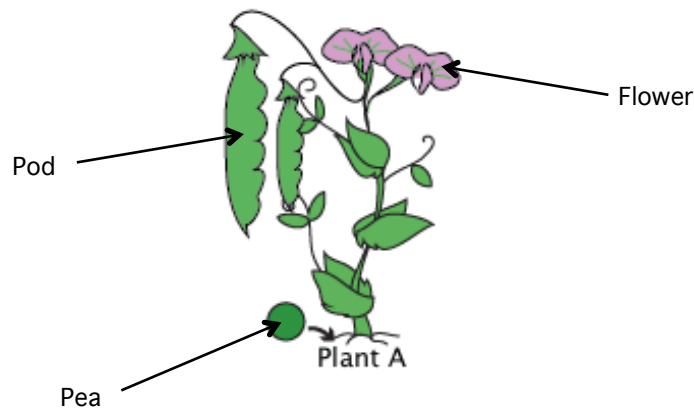

Gregor Mendel, the "Father of Genetics", studied the variation in phenotypes in garden peas and characterized various phenotypes corresponding to their flowers, peas, pods, and also plant height:

	Phenotype 1	**Phenotype 2**
Pod Shape	Inflated: The pea pod is smooth	Pinched: The pea pod is indented (pinched) along one side
Plant Height	Tall	Short
Flower Color	Purple	White
Pea Color	Yellow	Green
Pea Shape	Round	Wrinkled
Flower & Pod position	Axial: The flowers and pods are located at the branch points	Terminal: The flowers and pods are located at the tips of the branches
Pod Color	Yellow	Green

How do we identify the phenotype of an organism in StarGenetics?

1 What are the phenotypes of *Plant A* and *Plant B*, with respect to pod shape, plant height, flower color, pea color, pea shape, pod color, and flower & pod position? Fill out the table below with the phenotypic information.
  • Examine the phenotypes of the plants by selecting each plant in the **Strains** box and looking at their phenotype in the **Properties** box.
  • Below is what you should see in the properties box for *Plant A*:
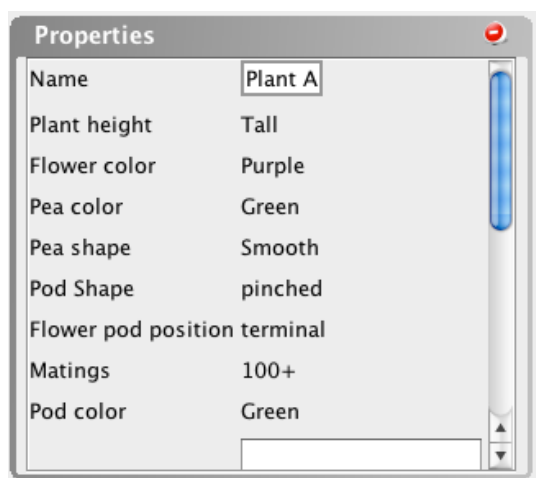
Answer

	Phenotype	
	Plant A	Plant B
Plant Height		
Flower Color		
Pea Color		
Pea Shape		
Pod Shape		
Pod Color		
Flower & Pod position		

## How do we know if a plant is true breeding for a specific phenotype?

A plant is true breeding if all the progeny generated through generations of self-crosses look exactly the same as the original parent. When an organism is true breeding, we can conclude that the organism is homozygous for ALL of its alleles. When an organism is true breeding for a *certain trait*, it means that it is homozygous for *that specific trait*.

2 Is *Plant A* true breeding for the flower color or pod color phenotypes?
- Self-cross *Plant A* by dragging *Plant A* to BOTH boxes in the **Mating site** to act as the ovum donor **and** sperm donor.
- Click on the **Mate** button to produce the first generation of progeny.

What do you see?

Let's take a look. You can see all the plants resulting from this self-cross of *Plant A* x *Plant A* within the **Individual** tab.

Name: _____
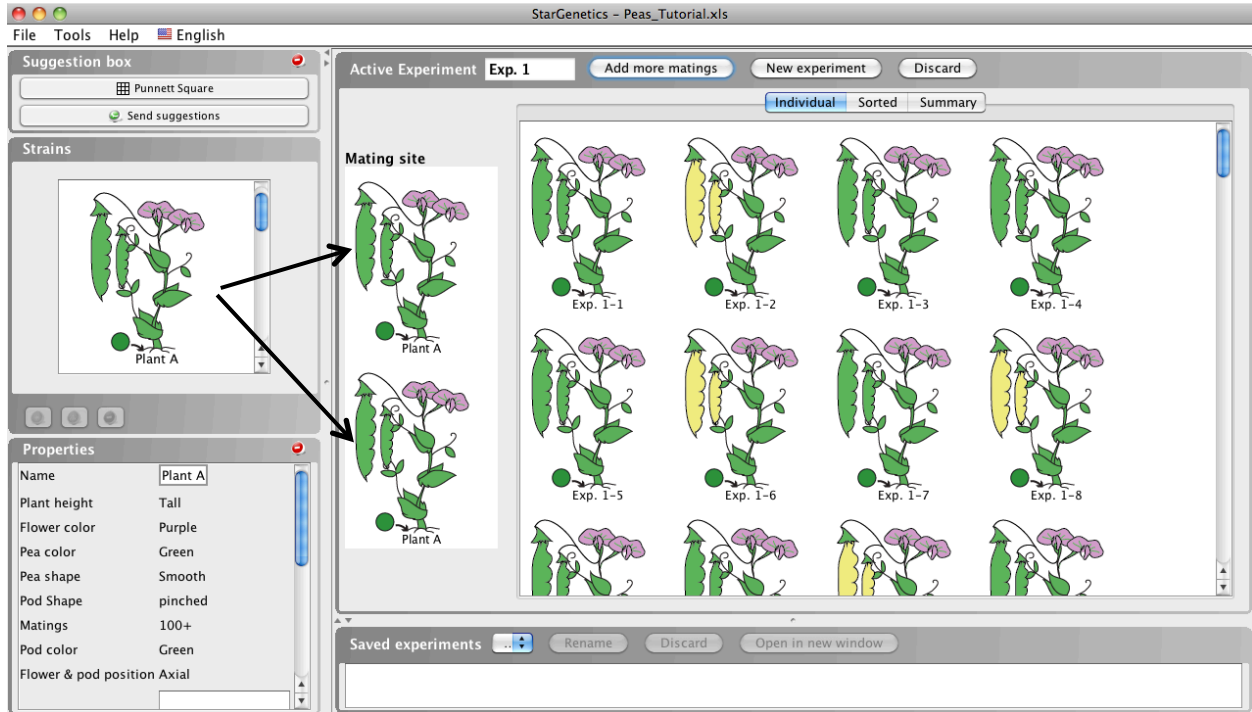
a) How many progeny did you obtain?

Answer

b) How many different phenotypic categories do you observe in the resulting progeny? Which phenotype(s) is/are **different** between these categories?
   • View a summary of the experiment by clicking on the **Summary** tab.
   • Within the **Summary** tab, all of the progeny are organized by <u>phenotype</u>.
   • Click the **Show** button next to **Phenotype description** to see a list of phenotypes for each phenotypic category.
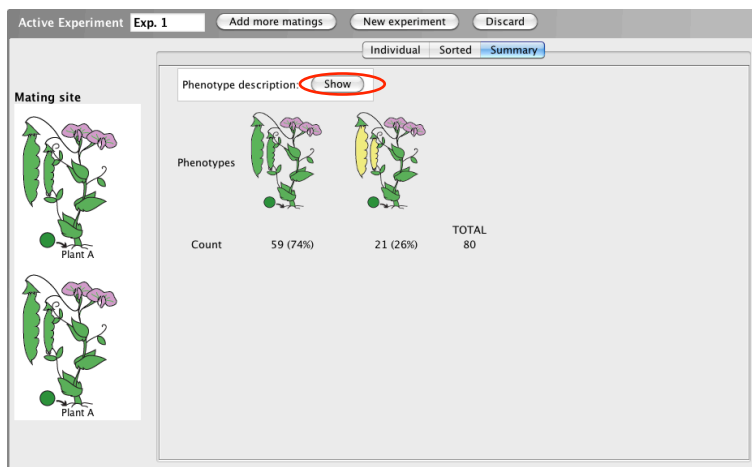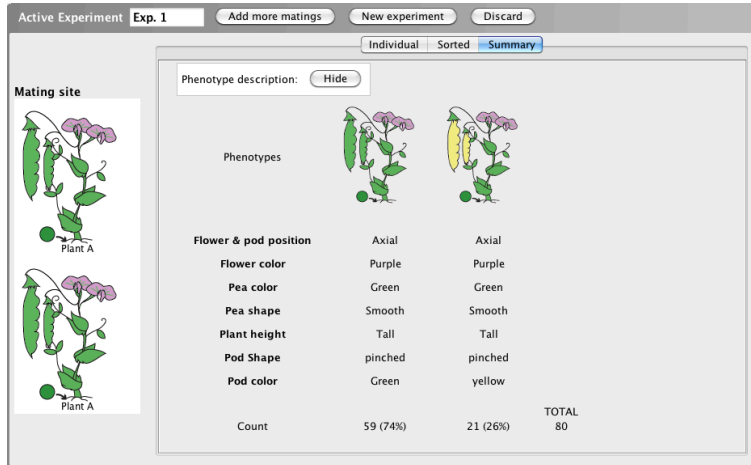
Answer

c) What are the phenotypic ratios for these 80 plants with respect to flower color and pod color? Record the ratios in terms of numbers and percentages, and select the phenotypic ratio that best fits the results you generated.

Answer

Flower Color: ___ Purple Flowers : ___ White Flowers

% with Purple flowers:

% with White Flowers:

| All Purple | 3 Purple:1 White | 1 Purple:1 White | 1 Purple:3 White | All White |

Pod Color: ___ Green Pods: ___ Yellow Pods

% with Green Pods:

% with Yellow Pods:

| All Green | 3 Green:1 Yellow | 1 Green:1 Yellow | 1 Green:3 Yellow | All Yellow |

d) Let's now increase the number of progeny from this self-cross from 80 to 240. How many categories of progeny do you observe with 240 progeny? Which phenotypes are **different** between these categories?
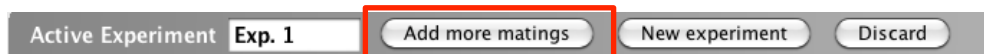
- To increase the number of progeny from any mating, click the **Add more matings** button at the top of the **Active Experiment** window.
- Select the number of matings you want to add to the cross, and click **OK**. Add additional matings to your cross to produce a total of 240 plants (2 additional matings).

• Click on the **Summary** tab to view the phenotypic categories of progeny, then click **Show** next to **Phenotype description** to examine the phenotypes within each category.

Answer

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e) What are the phenotypic ratios for these 240 plants with respect to flower color and pod color? Record the ratios in terms of numbers and percentages, and select the phenotypic ratio that best fits the results you generated.

Answer

Flower Color: ___ Purple Flowers : ___ White Flowers

% with Purple flowers:

% with White Flowers:

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

Pod Color: ___ Green Pods: ___ Yellow Pods

% with Green Pods:
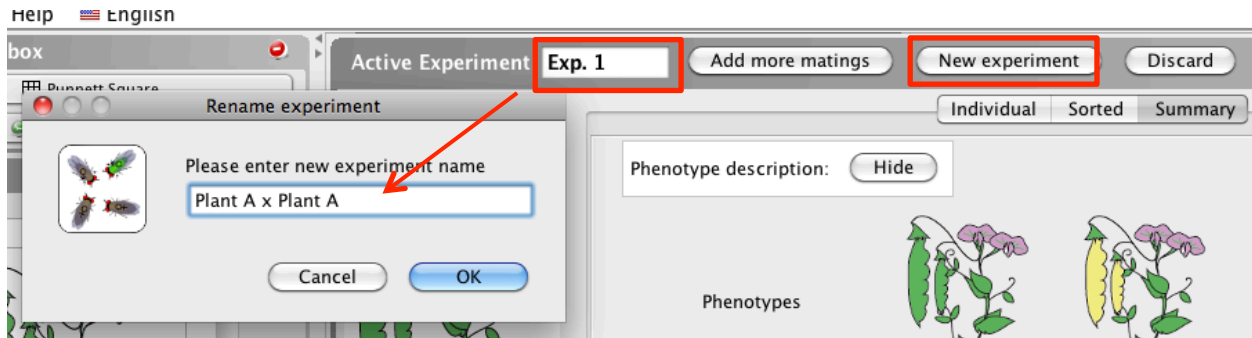
% with Yellow Pods:

All Green   3 Green:1 Yellow   1 Green:1 Yellow   1 Green:3 Yellow   All Yellow

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f) Based on your answers above, is *Plant A* true breeding for flower color? Is *Plant A* true breeding for pod color? Explain.

Answer

Rename your experiment by clicking the text box containing the current experiment name (Exp. 1) and typing "*Plant A x Plant A*".

Click **New experiment**. Your previous experiment will be automatically saved for you and can be accessed in the dropdown menu in the **Saved experiments** window.

As previously stated, in a true-breeding plant, all progeny will have the same phenotype when the plant is self-crossed for successive generations. Let's self-cross an F1 progeny plant that resulted from the *Plant A x Plant A* cross to determine whether the resulting F2 progeny all have the same phenotype as *Plant A* for the true-breeding trait(s).

g) How many different phenotypic categories do you observe in the resulting F2 progeny? Which phenotypes are **different** between these categories?

Let's first set up a self-cross of an F1 pea plant from the saved *Plant A* x *Plant A* cross.
- Drag a green-pod F1 plant to the **Mating site** twice to act as both the ovum and sperm donor.
- Click **Mate**.
- Produce a total of 80 F2 plants using the **Add more matings** button.
- Click on the **Summary** tab to view the resulting phenotypic categories, and click **Show** to see the phenotypes associated with each category.

Answer

i) Do the results of the F1 self-cross in Question 2g support your answer to Question 2f? Explain.

Answer

Rename your experiment as "*Plant A F1 x F1*" and start a **New experiment**.

How do we know if a phenotype is dominant or recessive?

When you cross two true-breeding organisms, the F1 generation is heterozygous having one copy of each allele.
- A phenotype is <u>dominant</u> if this phenotype is observed in an organism that is heterozygous for the alleles encoding this trait.
- A phenotype is <u>recessive</u> if this phenotype is not observed in an organism that is heterozygous for the alleles encoding this trait.

For the following questions, assume that both *Plant B* and *Plant C* have previously been determined to be **homozygous** for pea shape (true breeding for the pea shape trait).

3 Let's cross *Plant B* with *Plant C* to determine if the wrinkled pea phenotype is recessive or dominant to the smooth pea phenotype.
- Mate *Plant B* with *Plant C* by dragging both plants to the **Mating site**. In this cross, one plant will act as the ovum donor, and a different plant will act as the sperm donor, therefore this <u>IS NOT</u> a self-cross.
- Click on the **Mate** button.

What do you see?

Let's take a look at the plants you generated within the **Individual** and **Summary** tabs.

a) How many progeny did you obtain? What phenotype(s) do you observe in the resulting progeny with respect to pea shape?

Answer

b) Can you conclude whether the round pea phenotype is dominant or recessive to the wrinkled pea phenotype after analyzing the progeny that you obtained? Explain.

Answer