Wisconsin Fast Plants® Monohybrid Crosses Inquiry

A Carolina Essentials™ Investigation

Overview

In this scientific inquiry activity, students germinate F_2 generation Wisconsin Fast Plants® seeds and identify the phenotypes and possible genotypes of the F_2 generation plants. Based on phenotypic ratios, the genotype may be refined. Monohybrid crosses are performed using Punnett squares to test possible genotypes for the parental and F_1 generations of plants. Students design an investigation based on Mendelian monohybrid crosses to test predicted genotypes. If time permits, students can germinate the F_1 and parent generation seeds for comparison to their predictions. They may also perform actual plant crosses of the parent seeds and determine if the predicted phenotypes and genotypes from the Punnett squares are accurate.

Life Science—Mendelian Genetics, Variation of Traits
Grades: 9–12

Essential Question

How can monohybrid crosses be used to predict the genotypes and phenotypes of the parent generation?

Investigation Objectives

1. Observe phenotypes for the F_2 generation of Wisconsin Fast Plants®.
2. Identify the genotypes of the F_2 generation plants.
3. Use monohybrid crosses to predict the genotypes and phenotypes of the F_1 generation, and then of both parents, P_1 and P_2.

Next Generation Science Standards* (NGSS)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Students will develop a model of variation in traits for Wisconsin Fast Plants®. They will use their model to predict the phenotypes of F_1 generation plants.	**LS3: Heredity: Inheritance and Variation of Traits** • **LS3.B:** Variation of traits among Wisconsin Fast Plants® will be determined through seed germination investigations.	**Patterns** • Observed patterns of traits in Wisconsin Fast Plants® guide organization and classification of trait variation. Relationships among inherited traits can be traced.

Safety Procedures and Precautions

Ensure that students understand and adhere to safe laboratory practices when performing any activity in the classroom or lab. Use personal protective equipment such as safety glasses or goggles, gloves, and aprons when appropriate. Require students to adhere to all laboratory safety rules.

Disposal

Dry plants out completely, place them in a resealable bag, and dispose of them in the trash. Plants may be allowed to continue to grow for additional investigations.

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TIME REQUIREMENTS

PREP	ACTIVITY
30 min	About 1 hr

Teacher Prep: 30 min
(**Note:** *Seeds take 2 to 3 days to germinate.*)

Student Activity: 30 min for germination setup on day 1; 10 min for days 2 to 4 for observation; 30 min on day 5 for observation and conclusions

SAFETY REQUIREMENTS

MATERIALS

10 Wisconsin Fast Plants® F_2 seeds

1 filter paper, 9 cm or paper towel disk

1 petri dish, 100 × 15 mm

1 spray bottle, 500 mL

Plant light bank or plant light

OPTIONAL MATERIALS (for student-designed experiments)

1 Wisconsin Fast Plants® F_1 seed pack (heterozygous)

1 Wisconsin Fast Plants® P_1 seed pack (homozygous dominant)

1 Wisconsin Fast Plants® P_2 seed pack (homozygous recessive)

1 filter paper, 9 cm or paper towel disk

1 petri dish, 100 × 15 mm

1 spray bottle, 500 mL

Plant light bank or plant light

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Student Procedure

1. Place a filter paper or paper towel disk in the bottom of a petri dish. The paper should cover the dish's bottom.
2. Space the 10 seeds out evenly on the filter paper.
3. Use the spray bottle to moisten the seeds and paper. The paper should be damp, but not sitting in a puddle.
4. Cover the petri dish and place it under a fluorescent lamp.
5. Observe the seeds daily for 4 or 5 days, or as directed by your teacher. Record your observations on the data sheet.
6. Use the spray bottle to mist the seeds as needed. They should be kept moist, but not wet.

Teacher Preparation and Tips

If you are using paper towels, cut them into disks to fit the bottom of the petri dishes prior to the activity. If the paper towels are thin, 2 layers may be necessary to keep the seeds moist.

To save time, count out 10 seeds for each student or group before the activity.

Check the petri dishes. Make sure seeds are separated and moist, but not standing in water.

Place all seeds under intense fluorescent light for the duration of the investigation.

Seeds should germinate in 2 to 3 days.

Remind students to observe the seedlings carefully. They need to look at stem and leaf color. Color may change in intensity over time.

If students wish to perform the experiment they designed, have the additional seed packets available. The same germination technique may be used.

An alternative is to grow the parent generation through maturity and manually pollinate the parent plants, collect those seeds, and repeat the procedure for the F_1 generation.

Data and Observations

Record the number of seeds germinated each day for 4 or 5 days, or as your teacher instructs. Identify the color of the stem for each seed germinated.

Fast Plants® Seed Germination Data F_2 Generation

Day	Number of Seeds Germinated	Purple Stems	Green Stems
1			
2			
3			
4			
5			
Total			

Data will vary by group but should produce 75% purple stems and 25% green stems.

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Seed Stock (item number)	Genotype	Phenotype	Notes
Purple Stem, Hairy (158810)	*ANL/ANL* (dominant) *YGR/YGR* *ROS/ROS* *EIN/EIN* DWF_1/DWF_1	purple stem, sometimes extending to midribs of leaves; color varies from purple to dark pink	hairy trait is quantitative and therefore best ignored in introductory activities
Non-Purple Stem, Hairless (158812)	*anl/anl* (recessive)	green stem	cross with 158810 for a monhybrid F_1
Yellow-Green leaf (158818)	*ygr/ygr* (recessive)	yellow-green leaves, purple stems	cross with 158810 for a monohybrid F_1 or with 158812 for a dihybrid F_1
Non-Purple Stem, Yellow-Green leaf (158843)	*anl/anl, ygr/ygr* (double recessive)	yellow-green leaves, green stems	cross with 158810 for a dihybrid F_1
Rosette-Dwarf (158815)	*ros/ros* (recessive)	very short plant	internodes do not elongate
Tall Plant (158825)	*ein/ein* (recessive)	tall, spindly plant	abnormally tall due to elongation of internodes
Petite (158833)	dwf_1/dwf_1 (recessive)	reduced height	mature at 5–15 cm; normal is 17–20+
Varigated (158820)	Var (non-Mendelian)	irregular leaf areas are devoid of chlorophyll	trait is part of the chloroplast genome, which is transmitted through the cytoplasm of the ovule; trait is not transmitted by pollen

Analysis and Discussion

1. What are the 2 possible stem phenotypes?

   Purple, hairy
   Non-purple, hairless

2. Calculate the ratio and percentage for each phenotype.

   75% purple and 25% green

3. Given your data, which phenotype appears to be dominant? Why?

   Purple, because of the greater percentage

4. For each stem phenotype, identify the possible genotypes.

   Purple dominant, homozygous ANL/ANL and heterozygous ANL/anl
   Green recessive, homozygous anl/anl

5. Using a monohybrid cross, predict the phenotypes and genotypes of the F_1 generation plants.

   ANL/anl × ANL/anl

	ANL	anl
ANL	ANL/ANL	ANL/anl
anl	ANL/anl	anl/anl

Ratio of 3:1 purple to green given by the data, so both F_1 parents were heterozygous purple, ANL/anl.

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6. Using a monohybrid cross, predict the phenotypes and genotypes of the parent (P_1 and P_2) generation plants.

   To produce heterozygous offspring, one parent must be homozygous dominant, ANL/ANL and the other must be homozygous recessive, anl/anl.

	ANL	ANL
anl	ANL/anl	ANL/anl
anl	ANL/anl	ANL/anl

7. Design an experiment to test your predictions. (Check with your teacher about performing your experiment.)

   Student answers will vary, but should include comparing phenotype counts for each generation of seeds. The specific phenotypes from each seed packet should be counted and compared to the ratios predicted by Punnett square crosses. The chi-square statistic may be introduced as an analysis tool now, since students will have actual seed phenotype data.

   If time permits, you may begin with the P_1 and P_2 seeds and cross-pollinate the plants in class, harvest the seeds (F_1 generation), and germinate those seeds. The same procedure can be used to test the crossing of F_1 plants to identify F_2 phenotypes and genotypes. This procedure will take several weeks.

HELPFUL LINKS

www.carolina.com

32 Standards Met with Wisconsin Fast Plants®

Carolina™ CareSheet: Plants

Carolina™ Living Plants Care

Carolina™ CareSheet: Geminating Seeds

Exploring with Wisconsin Fast Plants® Manual

Teaching with Fast Plants® Manual

Wisconsin Fast Plants® Poster

REFERENCE KITS

Wisconsin Fast Plants® 72-Hour Monohybrid Genetics Kit

TEACHER NOTES