



Assessing Student Understanding of Genetic Principles

Students will observe Mendel's Laws of Segregation and Independent Assortment through a series of monohybrid crosses with *Brassica rapa* plants. Students will make inferences supporting Mendel's Laws on the basis of their interpretations of the results of these crosses.

Problem: In what way do parental traits get passed down to progeny?

Primary Learning Outcomes

By the end of this lesson the student should be able to:

- State Mendel's Law of Segregation.
- State Mendel's Law of Independent Assortment.
- Apply both of the above concepts to the inheritance of two plant traits.
- Explain how genotypes influence phenotypes.
- Use scientific inquiry to apply Mendel's Laws, analyze data and interpret evidence.

Assessed GPS

Habits of Mind

SCSh2, SCSh3, SCSh4, SCSh5, SCSh6, SCSh7

Content

SB2C

Assessed QCC's

General Agriculture: 106, 119, 120

Horticulture: 106, 119, 121

Duration

Parts of 3 days

Materials

- Cool white fluorescent light source (for plants to grow under).
- 9 clear covered Petri dishes (or film canisters)
- 9 filter papers (or cut pieces of paper towel)
- The following Fast Plants Seed stocks:
 1. Non-purple stem hairless
 2. Rosette-Dwarf
 3. F1 Rosette-Dwarf
 4. F2 Rosette-Dwarf
- Pencil and Data Sheets

Background

Terminology

1. P1-Maternal parent or “mother”.
2. P2-Paternal parent or “father”.
3. F1-first generation offspring, the result of crossing P1 and p2 plants.
4. F2-second generation offspring, the result of intermating the F1 plants.

Anthocyanin is a common purple pigment found in brassicas. You have all seen purple cabbage. This color is caused by the pigment anthocyanin. It is best observed in the hypocotyls (embryonic stems) of seedlings that germinate in the presence of light. A single gene anthocyaninless (anl) regulates the expression of anthocyanin in *B. rapa*. In the homozygous recessive form (anl/anl) no anthocyanin is expressed and the whole plant will be a bright green color. In the heterozygous (anl/ANL) and homozygous dominant (ANL/ANL) the anthocyanin is seen and the plants will have purple hypocotyls or purple stems.

Gibberellic acid (GA) is a plant hormone that stimulates growth. A single gene in *B. Rapa*, rosette-dwarf (ros) regulates GA production. In the homozygous recessive form (ros/ros) the plant produces 4 to ten times less GA than in standard *B. rapa*. This prevents the hypocotyls from elongating properly resulting in dwarf plants. If the genotype is heterozygous (ros/ROS) or homozygous dominant (ROS/ROS) then the plant grows normally because GA is produced at normal concentrations.

The purpose of this experiment is to assess whether students understand basic genetic principles and whether they can apply these principles to living organisms. Students must solve a paternity puzzle involving the inheritance of the two traits of *B. rapa*.

First they will observe seedlings of the P1 and F1 generations. Based on their observations they must generate a hypothesis that explains how the inheritance worked. They use this to predict the phenotypes of the P2 and F2 generations. When they observe the F2 offspring will see a new genotype (rosette-dwarf) which will require them to reevaluate their model of inheritance. Their final observations of P2 seedlings will be used to validate the accuracy of their model.

Common Misconceptions:

- Students may think the traits blend when parental gametes are united.
- Students may not understand that genes are inherited as discrete units from each parent that are randomly assorted during meiosis.

Procedure I

1. 3 days prior to day one of the experiment, germinate P1, F1, P1 and F2 seeds on moist paper in closed Petri dishes. Check moisture levels regularly.
2. Give students the 3-day seedlings of P1 and F1 to observe. Have them take notes and record data about these plants.
3. Have students make their predictions about Phenotypes and genotypes of the P2 and F2 seedlings.

Assessment I

1. What are the characteristics of the P1 plants?
2. What are the characteristics of the F1 plants?
3. Why do you think these plants are not all alike? Why are some of the F1 plants different from the P1 plants?
4. What do you already know that could help explain why this is so?
5. Predict the phenotype of the P2 plants.
6. How did the P2 plants contribute to the traits of the offspring?
7. Design and experiment to test your prediction. Be sure to include a problem statement, hypothesis and a brief description of what you plan to do.
8. Predict the phenotypes and genotypes of an F2 generation made from an F1 cross.

Procedure II

1. Obtain F2 plants from your instructor.
2. Observe the results of the F2 cross that has been made for you.
3. Write your observations in your data table.

Assessment II

1. What did you observe about the offspring of the F1xF1 cross?
2. Were they different than you expected?
3. How did they differ from your prediction?
4. What type of statement would you now make about the P1 generation?
5. What type experiment would you conduct to prove or disprove your prediction?
4. What information or evidence do you need to determine the phenotype of the father?
5. How could you design an experiment to test this using the materials we have in class?
6. What will you measure or quantify?
7. What evidence do you need to gather to test your hypothesis? How does your prediction about the F2 seedling phenotypes support your hypothesis about inheritance?
8. The F2 generation is the result of intermating F1 plants. Describe how you would do your experiment if we grew these plants through their entire life cycle.

Procedure III

1. Obtain P1 sample plants from our instructor.
2. Observe these and put your observations in your data table.

Assessment III

1. Did your prediction match the reality of the P1 generation?
2. Does your evidence support your hypothesis about inherited traits? If so, explain how. If not, what other information do you need to know, or what experiment could you do?
3. Based on your evidence, what is the Phenotype of the P1 generation? What is the genotype?
4. How would you quantify a trait that varies in its expression?
5. Do you think that such a trait is regulated by a single gene or more than one?
6. Describe an experiment to test your hypothesis.
7. What evolutionary advantage might anthocyanin production have for a plant in nature?
8. What evolutionary advantage might GA production have for a plant in nature?