Bean There Done That

Genetic Backcrossing of the American Chestnut

Science SOL. LS.1 (using models), LS.12

LS.1 a) models and simulations are constructed and used to illustrate and explain phenomena
LS.12
a) the function of genes and chromosomes;
b) genotypes and phenotypes;
d) genetic engineering and its applications; and
e) historical contributions and significance of discoveries related to genetics.

Background Information:

Genotype is the set of genes, genetic information, that an organism has. An organism's **phenotype** consists of the physical characteristics that result from the genes. For example, dimples would be the phenotype, but the genotype would be DD or Dd, the two possible gene forms that can result in a dimple phenotype. The American Chestnut has many different genotypes than the Chinese Chestnut and thus, many different phenotypes. The Chinese Chestnut has blight resistance due to its genes, but the American Chestnut does not have these blight resistant genes (blight resistance is a phenotype). Research into the genes that infer blight resistant has revealed that at least seven different genes are involved in providing the Chinese Chestnut with resistance to the blight fungus. The goal of The American Chestnut Foundation (TACF) is to reestablish the once flourishing American Chestnut tree in forests. In order to do this, scientists are inter-breeding American and Chinese Chestnuts. They are using a process called **genetic backcrossing** to try to insert blight resistant genes into our American Chestnut. This activity simulates the backcross process.

Materials

- Two different types of beans (pinto, black, or kidney); several beakers full of each type
- Paper plates (for pouring the beans out of the beakers)
- 50 mL beakers (or small measuring cups or small drinking cups)
- Paper strips (about 2" wide and 10" long); cardboard stock works well
- American Chestnut Foundation backcross chart (1 per group of students)

Instructional Strategy:

Part 1. Independent Reading. Read the background information paragraph to review genetic concepts pertinent to this investigation.

Developed by Carroll County Public Schools, MD.
Modified & revised by Blandy Experimental Farm, 2018 & 2019.

Part 2. Hybrid & backcrossing simulation

1. Identify and label one set of beans as American Chestnut (kidney beans) and the other as Chinese Chestnut (black beans).
2. Pour a full beaker of the "American" beans and a full beaker of "Chinese" beans and mix them on the paper plate—this represents the F_1 generation. Record the proportion of beans (genetic information) that is American Chestnut and that is Chinese Chestnut.
3. Remove a beaker full of the mixed F_1 generation and put them into a separate container.
4. Add another beaker of American Chestnut beans (kidney beans) to the F_1 generation on the paper plate and mix. This represents the BC_1 generation (BC stands for Back Cross). Record the proportion of beans (genetic information) that is American Chestnut and that is Chinese Chestnut.
5. Remove a beaker of the mixed BC_1 generation and put them into a separate container.
6. Add another beaker of American Chestnut beans (kidney beans) to the BC_1 generation on the paper plate. This represents the BC_2 generation. Record the proportion of beans (genetic information) that is American Chestnut and that is Chinese Chestnut.
7. Remove a beaker of the mixed BC_2 generation and put them into a separate container.
8. Add another beaker of American Chestnut beans (kidney beans) to the BC_2 generation on the paper plate. This represents the BC_3 generation. Record the proportion of beans (genetic information) that is American Chestnut and that is Chinese Chestnut.
9. Now… Remove a beaker of the mixed BC_3 generation and mix them with another group's beaker of BC_3 generation. This is the first intercross generation; it is labeled BC_3F_1. Record the proportion of beans (genetic information) that is American Chestnut and that is Chinese Chestnut in the data table.
10. Look at the TACF backcross diagram: What percentage of American Chestnut and what percentage of Chinese Chestnut is the intercross generation?

Part 3. Using a manipulative to understand the genetic backcross

Use the strips of paper to model what happens to the genetics of the American chestnut each time a genetic cross or backcross is performed.Write 100% on one end of the paper. This represents the proportion of genetics that is American Chestnut.

1. Fold the paper in half. Write 50% on one side of the folded paper. This represents the proportion of genetics that is Chinese Chestnut. What is the ratio of Chinese Chestnut to American Chestnut genes? ½:½
2. Fold the 50% half in half again. Write 25% on one side of the folded paper. This represents the proportion of genetics that is Chinese Chestnut. What is the ratio of Chinese Chestnut to American Chestnut genes? ¼:¾
3. Fold the 25% portion in half. Write 12.5% on one side of the folded paper. This represents the proportion of genetics that is Chinese Chestnut. What is the ratio of Chinese Chestnut to American Chestnut genes? ⅛:⅞
4. Fold the 12.5% portion in half. Write 6.25% on one side of the folded paper. This represents the proportion of genetics that is Chinese Chestnut. What is the ratio of Chinese Chestnut to American Chestnut genes? 1/16:15/16

Part 4. Review & Synthesize.

1. Look at the The American Chestnut Foundation hybrid cross and backcross chart for another visual representation of the genetic engineering that TACF has been doing since the 1980's. What percentage of American Chestnut and what percentage of Chinese Chestnut is the intercross generation?
2. Answer the Analysis and Conclusion questions.

Lesson Plan

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Genetic Backcrossing of the American Chestnut

1. Identify Desired Results **What should students know and/or be able to do as a result of this lesson?**	
Big Idea: American chestnut research by TACF involves genetic backcrossing.	**Investigation Essential Questions** ● What is a backcross? How is a backcross done? ● What are the desired genes associated with the American Chestnut & Chinese Chestnut backcross and why are scientists attempting to add them to the American chestnut?

Learning Objectives

- Students demonstrate understanding of the concepts genotype, phenotype, and genetic backcross.
- Students illustrate backcrossing and use vocabulary: (Genotype, Phenotype, Backcross, Hybrid, Resistance) to explain the reasons for the process.

2. Assessing Student Learning

What evidence or artifact will you accept as proof that the Learning Objectives have been met?

Formative: Access students' prior knowledge of (a) what genetic information is, where it is stored, and how it is shared with successive generations; (b) the relationship between genotype and phenotype; (c) examples of genetic engineering/genetic biotechnology and types of genetic engineering processes

Summative: The students complete the BLIGHT conclusion questions.

3. Lesson Elements

Process:

I. **Warm-up:** Ask for students take-aways from the chestnut investigation at Blandy. Record these on a whiteboard or post it notes.
II. **Independent Practice (You do):** Read background information on backcrossing.
III. **Guided Instruction (We do):** (a) Small groups perform the backcross activity using manipulatives. Encourage healthy dialogue regarding genetics and use of the appropriate terms.
(b) Use the manipulative (paper strip) to demonstrate the proportion of American Chestnut to Chinese Chestnut genes after genetic cross.
IV. **Assessment:** The students will complete the BLIGHT conclusion questions.

Closure: Give each student AN EXIT PASS which asks them to relate the following 5 words and explain them: genotype, phenotype, hybrid, backcross, resistance

Reflections

Student Learning Expectations:
Did students achieve the stated objective?
How do you know?
If not, why not?

Implementation
How effective was the lesson?
What went really well?
What would you differently?

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Name:_____ Date:_____

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Hybrid and Backcross Data Table

Step	Generation	Proportion of American to Chinese chestnut genes	Genetic engineering process (choose from hybridization, backcross, or intercross)
1			
2			
3			
4			
5			

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Analysis and Conclusions Questions

1. Based on this investigation and what you already know, define the term *hybrid.*

2. What characteristic is the American Chestnut Foundation trying to obtain in the American Chestnut with each cross?

3. Why was each successive generation backcrossed with the American Chestnut?

4. Based on what you have observed (with this simulation and your visit to the Blandy chestnut plot), do you think there ever will be a pure American Chestnut (100% American Chestnut genes) that is resistant to the fungal blight? Explain your answer (why or why not?)

5. Brainstorm some other genetic engineering or genetic biotechnology techniques that could be used to add blight resistance to the American chestnut genetic information.