

# Genetic improvement method: selective breeding

<b>Focus questions</b>	How are breeding techniques being used in agriculture to solve problems? What are the advantages of selective breeding (artificial selection)? How does selective breeding differ from genetic modification?
<b>Vocabulary</b>	Genetics, trait, artificial selection, genetic modification, antibiosis, antixenosis, tolerance

The purpose of this activity is to model selective or artificial breeding in soybeans for aphid resistance.

The soybean aphid is a pest that damages soybeans by piercing plant tissues and feeding on sap, causing yield losses of up to 25 percent or more if left untreated. During outbreaks producers typically rely on timely insecticide applications to prevent yield loss. However, host plant resistance can reduce the need for insecticide use and increase producer profitability. A single soybean plant may express one or more of these resistance types.

- **Antibiosis** (plant produces a toxin or unpleasant substance when attacked) suppresses aphid growth and reproduction (*Rag1*)
- **Antixenosis** (i.e., a hairy leaf surface) deters aphid feeding or colonization (*Rag2*)
- **Tolerance** allows the plant to maintain yield despite aphid injury (*Rag3*)

Since the soybean aphid invasion in 2000, researchers have developed soybean varieties with natural resistance genes called *Rag* genes. This is the direct result of increased resistance of aphids to traditional insecticides which can be harmful to the environment. Five *Rag* genes have been identified, and varieties with *Rag1*, *Rag2*, or both are commercially available and can keep aphid populations below the level of economic loss. Continued development of high-yielding resistant soybeans may further reduce the need for insecticides, saving time and money for producers.

## Materials

- Starburst candies in pink, yellow, red, and orange (these have no allergens and are individually wrapped): 3 of random combination per student
- Opaque cups (foam cups or colored plastic that students cannot see through): 1 per every 2 students

## Procedure

1. The Starburst candies in the cup represent different traits that are/are not desirable in soybeans to provide aphid resistance. Which characteristics does your soybean plant have? Circle the combination of traits you have.

Color	Soybean trait expression
Red ( <i>Rag1</i> )	Suppresses aphid growth and reproduction
Pink ( <i>Rag2</i> )	Deters aphid feeding or colonization
Yellow ( <i>Rag3</i> )	Yield tolerance to aphid injury
Orange	Non- <i>Rag</i> gene

2. Combine your Starburst with those of someone else at your table. Place your six traits in the cup.
3. Shake the cup.
4. Draw out three Starburst (traits). This represents the offspring from your cross.
5. Which characteristics does your new soybean plant have? Circle the combination of traits you have.

Color	Soybean trait expression
Red ( <i>Rag1</i> )	Suppresses aphid growth and reproduction
Pink ( <i>Rag2</i> )	Deters aphid feeding or colonization
Yellow ( <i>Rag3</i> )	Yield tolerance to aphid injury
Orange	Non- <i>Rag</i> gene

6. Select another soybean plant at your table that has some or all of the desired traits. Cross your plant with that plant by repeating steps 2–4. How many offspring in the class have all three of the desired traits? (Report as the number that have all three out of the total possible pairings.)

## Reflection

1. Why didn't choosing the parents result in all of the offspring having the desired traits?
  
  
  
  
  
  
  
  
  
  
2. How does meiosis affect the outcome? What are the limitations of this model?

3. How might plant breeders overcome these obstacles using genetic modification?

4. How much might it cost (in dollars and time) to genetically modify a plant gene? What are the environmental costs and benefits?

### Rubric for self-assessment

Skill	Yes	No	Unsure
I constructed an explanation of the selective breeding process and the obstacles to it.			
I can identify insecticide use as a human activity that impacts natural systems.			
I can list the costs (both economic and time) and benefits of genetic modification.			
I can consider unintended consequences (virulent biotypes, genetic diversity loss) of selective breeding techniques.			
I can explain how structure and function of genes and chromosomes impacts selective breeding.			
I can explain how selective breeding and genetic modification may have an impact on natural systems.			
I understand the difference between natural and induced mutagenesis.			