NEBRASKA AGRICULTURE IN THE CLASSROOM
NEBRASKA FARM BUREAU FOUNDATION

DIRT DETECTIVES

Choices

Activity Level: 4-6 Grade | Time: 60 minutes

PURPOSE

Using wheat as an example, students will explore how DNA determines the genetic traits of a plant and how plant breeders change the DNA of a plant to produce desired characteristics.

NEBRASKA STATE STANDARD CONNECTION

- SC.4.6.3.B Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- SC.6.9.3.B Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- SC.6.9.3.C Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

ACTIVITY SNAPSHOT

1. Organize and Prepare Supplies
2. Read Background Information
3. Dirt Detectives: Choices PowerPoint
   a. Wheat DNA Necklace
   b. GM Soybean Test

MATERIALS

- Dirt Detectives: Choices PowerPoint
- Fresh or vacuum-packed wheat germ
- Warm Water
- Dish soap
- Rubbing Alcohol
- Test tubes, 1 per student*
- Stir Sticks, 1 per student*
- Pipettes, 1 per student*
- Microcentrifuge tubes, 1 per student*
- Yarn, 1 necklace length piece, 1 per student*
- Safety glasses, 1 per student
- 1 teaspoon measuring spoon, 1 per group

DIRT DETECTIVES

- 1 tablespoon measuring spoon, 1 per group
  *These items are included in the Wheat Germ DNA Kit *agclassroomstore.com/wheat-germ-dna-necklace*
- GM Soybean Seed Kit, 1 per class, or 1 per group to allow students to preform test
  agclassroomstore.com/gm-soybean-seed
- Distilled water, 1 mL per test
- Access to tweezers, paper towels, hammer/mallet, and 50-70% rubbing alcohol

WHAT'S THE CONNECTION TO AGRICULTURE?

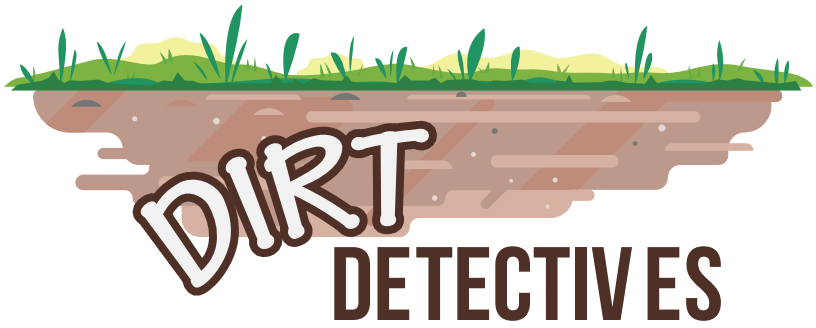
Plant genetics help farmers make choices when they plant their fields. Farmers can pick and choose the best seeds that will grow with their soil while producing the highest quality crop. Scientists and bioengineers continue to research in order to develop new products for crop production.

PROCEDURES:

1. Organize and Prepare Supplies
   See "Materials" on cover page.
   Prepare supplies and set up PowerPoint.
2. Background Information
   Sources: Kansas Foundation for Agriculture and National Center for Agriculture for Literacy

   When farmers make decisions about which varieties of a crop to plant, they are thinking about genetics. For example, each variety of wheat has DNA (deoxyribonucleic acid) that gives it certain genetic traits. In the wheat kernel, the DNA is located in the germ, which is the embryo or sprouting section of the seed. Some varieties of wheat grow better in drought conditions while others are better at resisting certain pests. Some wheat varieties have a higher moisture content or contain higher percentages of protein. These traits are important when considering the types of products that can best be produced by the flour of different classes of wheat.

   American farmers grow six main classes of wheat—Hard Red Winter, Hard Red Spring, Soft Red Winter, Soft White, Hard White, and Durum. In addition to the time of year in which they are harvested, wheat classes are also determined by the hardness, shape, and color of the kernels. Hard wheats contain high levels of protein. Protein develops gluten which gives elasticity, structure, and strength to dough and creates a chewy texture in the finished product. These characteristics are important to the bread-making process. Soft wheat flour is ideal for making cakes, pastries, cookies, and crackers. The low protein levels create a flaky texture in the finished product. Durum wheat is a botanically separate species from the hard and soft wheat varieties. Its high protein content and gluten strength make it ideal for making pasta. The gluten levels make the dough firm and allows the pasta to hold its shape until it dries. Spring wheat is planted in the spring and harvested in the late summer or early fall. Winter wheat is planted in the fall and harvested in the spring.



Farmers decide which varieties to grow based on growing conditions in their area. They consider factors such as rainfall, temperature, soil condition, and customer preferences. Soft wheats grow best in humid areas where temperatures remain elevated throughout the night. Hard wheats require low humidity, hot daytime temperatures, and cool temperatures at night.

Norman Borlaug was a plant breeder who developed wheat varieties to help people get more food from their land. Borlaug's research was instrumental in the creation of faster-growing wheat varieties and other grains that withstood disease and drought. He introduced these varieties to people all over the world and taught them how to implement farming practices. Norman Borlaug received the Nobel Peace Prize in 1970 for his work that saved over a billion people from starvation in developing countries like Mexico, India, and Pakistan. Borlaug used traditional plant selection methods in his breeding programs. He was ahead of his time in creating varieties that caused the Green Revolution. His leading research achievement was the development of Dwarf Spring Wheat. Borlaug found that plants with stalks that were short and of equal length would receive equal amounts of sunlight when they did not have to compete with taller-stalked plants. Nature favors genes for tall stalks because, in nature, plants must compete for sunlight. Borlaug's dwarf wheat uses its energy to grow valuable grain rather than usingits energy to grow tall stalks with no food value. Stout, short stalks also support wheat kernels better. Tall-stalked wheat may bend over at maturity, making it difficult to harvest. Modern technology allows plant breeders to make precise genetic changes in order to address disease, insect, or environmental challenges more rapidly. Agricultural biotechnology is an advanced technology that allows plant breeders to identify the specific genes responsible for individual traits and transfer only the desired traits between plants. Currently, there is no genetically modified wheat seed available to farmers in the US.

There are many ways to modify the genes or genome of plants and other living things. These genetic modification tools vary based on which method is needed for acquiring specific traits. This lesson introduces various methods of plant modification and demonstrates the scientific process used to create a genetically modified organism (GMO). While GMOs are a topic of socioscientific debate, this lesson focuses solely on the scientific method and biological processes involved in the development of a transgenic plant.

There are many terms and acronyms used to describe genetically modified organisms or biotechnologies applied in plant science. Genetically engineered (GE), genetically modified (GM), and transgenic are three adjectives used to describe an organism that has a copy of a gene not previously found in the species.

Every living organism is made from the instructions encoded in strands of DNA contained in its cells. Changes in this genetic code distinguish one species from another (a cow from a corn plant), as well as one trait from another within a species (a cow with a black coat verses a cow with a red coat). Found within the genome of every species is a series of traits and characteristics. Traits manifested through an organism's phenotype include colors, sizes, and other observable characteristics. Other characteristics such as drought tolerance, resistance to disease, or resistance to chemicals (such as herbicides) are also found within the genotype of an organism. These genetic characteristics are passed from parent to offspring following the basic rules of inheritance originally discovered by Gregor Mendel.

3. PowerPoint
   Slide 1: Dirt Detectives Lesson 4: Choices

   Slide 2:
   - Lesson 1: *Our World and Soil* – Technology Advances
   - Lesson 2: Soil Types – Sand, silt, and clay; which is ideal for growing crops? *A mixture of all three which is called loam. All have their advantages and disadvantages*
   - Lesson 3: Traits – Why are traits important? *They provide a variety and different choices when selecting plants and animal genetics.*

   Slide 3:
   - Review that Mendel discovered that traits determine characteristics in our DNA that are passed down from parents to offspring. Farmers want the best genes possible when they plant their crops and raise their livestock animals.

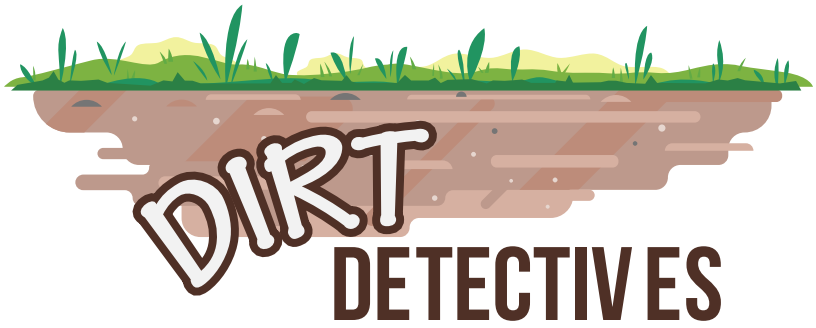
   Slide 4:
   - I have a short game to play with you. Can you identify the difference between these plants, seeds, and fruit?

   Slide 5:
   - Why are the corn plants on the left healthier that the ones on the right?
     - *The healthy corn is tolerant to drought conditions, meaning its genetics allow it to survive with less water and can with stand high temperatures for a longer amount of time than the corn on the right.*
     - *Genetics can be altered through research to create drought tolerant crops.*

   Slide 6:
   - Why is the strawberry on the left larger than the one on the right?
     - *It has more than one set of chromosomes making it larger.*
     - *Scientists have researched ways for crops and fruits to be larger by adding an extra chromosome through breeding plants over many years.*

   Slide 7:
   - Why is the corn on the left infested with European Corn Borer and the one on the right is not?
     - *The corn on the right produced a protein that kills the corn borer, so it doesn't infest the crop.*

   Slide 8:
   - What is the difference between these two samples of soybean seeds?
     - *The "B" seeds have a gene not previously found in soy.*
     - *Making the soybean insect resistant and herbicide tolerant.*



Slide 9:

- DNA is located in the germ, which is the embryo or sprouting section of the seed. Some varieties of wheat grow better in drought conditions while others are better at resisting certain pests. Some wheat varieties have a higher moisture content or contain higher percentages of protein. These traits are important when considering the types of products that can best be produced by the flour of different classes of wheat.

Slide 10:

- There are six different types of wheat. All have different DNA.
- Farmers decide which varieties to grow based on growing conditions in their area. They consider factors such as rainfall, temperature, soil condition, and customer preferences. Soft wheats grow best in humid areas where temperatures remain elevated throughout the night. Hard wheats require low humidity, hot daytime temperatures, and cool temperatures at night.

Slide 11:

- Norman Borlaug was a plant breeder who developed wheat varieties to help people get more food from their land. This video shows he used science to grow wheat and save many lives.
- What did Norman Borlaug do for people all over the world.

Slide 12:

- Every living organism is made from the instructions encoded in strands of DNA contained in its cells. Changes in this genetic code distinguish one species from another (a cow from a corn plant), as well as one trait from another within a species (a cow with a black coat verses a cow with a red coat). Found within the genome of every species is a series of traits and characteristics. Traits manifested through an organism's phenotype include colors, sizes, and other observable characteristics. Other characteristics such as drought tolerance, resistance to disease, or resistance to chemicals (such as herbicides) are also found within the genotype of an organism. These genetic characteristics are passed from parent to offspring following the basic rules of inheritance originally discovered by Gregor Mendel.
- Reference the pictures, these soybeans have the same observable characteristics, the genes can be altered to resist chemicals which are used to prevent weeds.

Slide 13:

- Scientistand researchers complete many experiments to create disease and pest resistance as well as chemical and drought tolerant genes in certain crops. These experiments take years to test and must be approved by the United States Department of Agriculture, Food and Drug Administration, and Environmental Protection Agency before they can sell seeds that carry these genetics.

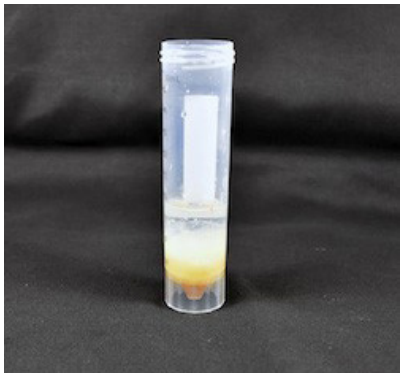
Slide 14:

- These are the only crops on the market that are approved by the United State Department of Agriculture and labeled as genetically modified (GMO).
- GMOs are safe and help produce a higher yield product. It helps farmers use less resources such as

pesticides and herbicides. Drought tolerant plants use less water over the growing season. These genetic traits help farmers be more efficient in the fields each year.

Slide 15: Wheat Germ DNA Extraction & GM Soybean Test.

- Wheat Germ DNA Activity:
  1. The germ of the wheat kernel, which is the embryo or sprouting section of the seed, contains the DNA. When the embryo sprouts and grows into a plant, the specific traits will be expressed in the plant.
  2. We are going to extract (remove) DNA from wheat germ so that we can observe the DNA strands that contain the traits of the wheat.
  3. Organize students into small groups. Provide each student with one test tube, one stir stick, one pipette, one microcentrifuge tube, one necklace-length piece of yarn, and a pair of safety glasses. Provide each group with warm water, dish soap, rubbing alcohol, a teaspoon measuring spoon, and a tablespoon measuring spoon.

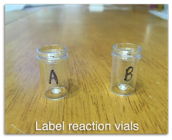


  4. Guide the students through the following instructions:
     a. Pour 1/4 teaspoon of wheat germ into the test tube.
     b. Add 2 teaspoons of warm water and mix with the stir stick.
     c. Add 4 drops of dish soap and mix.
     d. Let the solution stand for 5 minutes. Use this time for students to discuss their predictions within their groups.
     e. After the 5 minutes are up, put safety glasses on, tip the test tube slightly and slowly run 1 tablespoon of rubbing alcohol down the side of the tube until it is half full. It is important that the alcohol is slowly added to the solution to avoid stirring up the wheat germ flakes. The rubbing alcohol will precipitate the DNA (cause the DNA to come out of the wheat germ solution).
     f. Observe the line between the wheat germ solution and the alcohol. You will notice a white, thread-like cloud appearing above this line. This is the wheat germ DNA.
     g. Use the pipette to carefully collect the cloudy clumps of DNA strands and transfer them to the microcentrifuge tube.

h. Close the cap of the microcentrifuge tube tightly around a piece of yarn and tie the ends of the yarn to make a DNA necklace.

5. Ask the students to make observations about the wheat germ DNA. Use the following questions to guide the discussion:
6. What does DNA look like? Did it match your prediction?
7. Why is it useful for scientists to be able to extract DNA from an organism?
8. Why is it important for farmers to understand the genetic traits of the crops they grow and the animals they raise?

- GM Soybean Activity:
  1. Using the seeds in the *GM Soybean Seed Kit*, allow students to observe and compare the seeds. Let them know they are the same type of seeds pictured in question #4 slide 8. Ask students to examine the seeds and look for observable differences in size, shape, and color. Little or no difference will be found in the seeds.
     - Note: As students observe the seeds, be sure the two varieties are kept separate. Place seeds in Ziploc bags for observation to help avoid cross contaminating the seeds during observation.
  2. Explain to the class that although the two seeds look the same, there is a difference between them, and you are going to do an experiment to discover it.
  3. Complete the following lab test for the class to see:

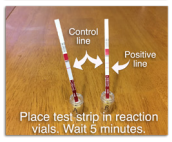


a. Label the reaction vials for identification of the seed that will be tested by labeling one vial "A" and the other vial "B".

b. Break the seed by placing one Roundup Ready® soybean seed between two small weigh boats and tapping it with a hammer. The seed should break into two to three pieces to allow enough surface area to be exposed for extraction. Do not crush the seed. Crushing can cause issues recovering all the pieces for extraction and may cause cross contamination of the testing area. Repeat this step with the conventional soybean, using separate weigh boats to avoid cross-contamination.

c. Remove the top weigh boats and place the seed pieces into the correct reaction vial. If the seed is stuck to the boat, use tweezers to gently release it. Do not touch the seeds with your hands (clean tweezers with 50-70% alcohol to prevent cross contamination).

It's important to understand that GM seeds are perfectly safe to touch. The only reason you shouldn't in this experiment is to avoid altering the test results by cross contaminating the seed samples or contaminating the experiment with human microbiome.



d. Use pipette to fill reaction vial with 1% PBS buffer or distilled water (approximately 0.5 mL). Using the pipette as a pestle and the reaction vial as a mortar, stir the seed pieces and distilled water together for 20-30 seconds. Be sure to stir with separate pipettes to avoid cross-contamination.

e. Let the vial with the seed/distilled water mixture stand for three to five minutes.
f. Place one QuickStix test strip inside each reaction vial, with the arrow pointing down.
g. Allow the test to incubate in the reaction vial at room temp for five minutes. Conclude with students that the test will show a "positive" line if an additional protein is found in one or both of the soybeans. Both test strips should have a "control" line indicating that the test is functioning.
    - Note: You may see positive results in less than five minutes, however the full incubation time will allow for the negative control to fully develop.
h. Interpreting Results: If the sample contains the extra protein, a second line will develop between the control line and the tape with the arrow on it. If the sample does not contain the extra protein, a second line will NOT be present on the test strip.

4. Ask students, Is there a difference between these two varieties of soybean? Guide a class discussion for students to conclude that these two varieties of soybean are fundamentally the same. They are both soybeans. However, one variety has a protein that the other does not which gives the plant resistance to the herbicide glyphosate.
5. Plant genetics help farmers make choices when they plant their fields. They can pick and choose the best seeds that will grow with their soil and produce the highest quality crop. Scientist and bioengineers continuously research to develop new products for crop production.

Slide 16: Next Lesson

- We will classify seeds and observe how a seed sprouts through the investigation of the conditions necessary for germination to occur.

Review:

- Ask students to get out their scientific journal.
- What have you learned from today's lesson? Write down key concepts and ideas that will help us solve our problem: how we grow more food with less land?
- Brainstorm new ideas and ways to solve this problem and write it in the ideas box.