Genetic Inheritance: Modeling Corn Trait Expression

Principal concept:

This lesson introduces the concept of genetic inheritance. Through a genotype/phenotype modeling activity, students explore corn reproduction and the expression of dominant and recessive traits.

Grade levels:

This activity is most appropriate for grades 6 – 8.

Performance standards:

MS-LS3-2: 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.

LS3.A: Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

Summary:

Chromosomes are found in pairs in every organism's cells. Special reproductive cells are an exception because they contain single copies of each of a cell's chromosomes. Genes encode (produce) proteins and are found at specific locations along the chromosomes. Human beings have 23 pairs of chromosomes and at least 20,000 genes. Corn plants, by contrast, have 32,000 genes crammed on only 10 pairs of chromosomes.

Many sexually reproducing plants (including corn) have two copies of each gene (genotypes). These two copies, called alleles, can be different from each other, producing different characteristics (phenotypes) in offspring. Alleles are either dominant or recessive. A dominant allele from either parent will result in the expression of that characteristic in the offspring (dominant phenotype). The only way a recessive allele can appear in offspring is if both parents contribute the recessive trait or if one parent has the trait and the other does not have the trait. Offspring with one dominant allele and one recessive allele will still have the dominant phenotype, but will be considered a carrier of the recessive phenotype. Such a genotype can produce a recessive phenotype in future generations.

This activity models how offspring inherit genetic traits from each parent. In a corn plant the tassel and the ears are the reproductive structures. The tassel is the male part of the plant. The male flowers on the tassel release pollen grains which contain male reproductive cells (sperm). The female flowers develop into the corn's ears which contain the female eggs. These eggs are arranged in rows on the corn cob. Silks—long threadlike strands—grow from each egg and emerge from the top of the ear. Pollination occurs when wind-driven pollen is carried from the tassels to the exposed silks resulting, ultimately, in fertilized eggs on the cob. A corn plant can self-pollinate or it can cross with another corn plant. In cross-pollination, the resulting kernel contains the full number of chromosomes, half of them contributed by each parent plant. The appearance (phenotype) of the offspring plant is driven by the genotype (DNA) of the parent plant(s).

In early human history, people gathered food that nature produced. With the advent of agriculture, new techniques and tools improved the quality of plant production. Seeds from the best plant varieties were saved for future plantings. Conventional breeding techniques continue today and, in fact, still comprise the majority of Monsanto's budget commitments. But today, technological advances such as the seed chipper dramatically increase the efficiency of plant breeding. Scientists can analyze the DNA of a seed before it is planted and accurately identify the mature plant's traits.

Vocabulary:
allele, phenotypes, genotype, chromosome, gene, reproductive cells, heredity, trait, genetics, fertilization, dominant, recessive, carrier, kernel, DNA, pollination

Prior knowledge:
Students need no specific prior knowledge.

Class time required:
45 minutes

Materials for class

- 4 trait boxes containing colored paper clips—purple for height, green and silver for leaf color, yellow and white for seed color, and red for seed texture

- 1 box of ovule and pollen tags
- Laminated Cross-pollination sheets
- Laminated Trait Code sheets
- Traits in Corn worksheet
- 6-16 card decks of corn plant phenotype cards

Materials (per allele group of 2-3 students)

- 1 laminated Cross-pollination sheet for ovule group only
- 1 laminated Procedure sheet
- 1 laminated Trait Code sheet
- 1 Traits in Corn worksheet **per student**
- 1 small Dixie cup
- 4 randomly selected corn trait paper clips and 1 reproductive cell tag (see **Teacher Notes)**

Materials (per pollination group of 4 – 6 students)

- 1-16 card deck of corn plant phenotype cards

Procedure for students:

Part 1: Decoding Genetic Traits (view PowerPoint slides 1-19)

1. Randomly select 1 paper clip from each of the four trait bags (height, leaf color, seed color, seed texture) and one tag from the reproductive cell bag (ovule or pollen). Place the clips in the Dixie cup, and return to the group. (Only one student from each group will draw the clips and tag.)
2. Create a chain of the tag and the paper clips in the following order:
    - Ovule or pollen tag
    - Height (large purple or small purple clip)
    - Leaf color (green or silver clip)
    - Seed color (yellow or white clip)
    - Seed texture (red or twisted red clip)
3. Refer to the laminated Trait Code Sheet to decode the trait represented by the purple paper clip (tall or short stalk?)
4. Circle that trait on the Genetic Traits worksheet. Be sure to circle the trait in the **correct** table. For example, if you have an ovule tag at the top of your chain, use the ovule table.
5. Repeat steps 4 and 5 for the other three traits.

Part 2: Modeling Pollination (view PowerPoint slides 20-24)

1. Each pollen group will join an ovule group with its trait chain and worksheets.
2. Place the chains on the matching cornstalks on the Cross-pollination Sheet.
3. Complete the top 2 tables of the worksheet.
4. Compare responses for accuracy.

Part 3: Analysis of trait expression (view PowerPoint slides 25-29)

1. Read the Trait Expression bullets at the bottom of the laminated Trait Code sheet to guide you in deciding which traits will be expressed in the offspring plant.
2. Start with the purple height clips and decide whether the new plant will have a tall or a short stalk.
3. In Table 3, circle the height trait (phenotype) that will be expressed in the new offspring plant.
4. Repeat steps 2 and 3 for the other three traits.

Part 4: Phenotype identification (view PowerPoint slide 30)

1. View and compare the 16-phenotype cards.
2. Select the **ONE-phenotype** card that exactly matches the traits from Table 3.
3. Ask your teacher for the key to check your choice for accuracy.
4. Be prepared to present a justification of your phenotype choice.

Assessment:

Performance: Check for phenotype identification accuracy.

Written: Complete the 3 tables and answer the short answer questions found on the Genetic Traits worksheet.

Teacher/Presenter notes:

1. Be aware that the PowerPoint starts and stops throughout the lesson. Slides 1-30 correspond to Parts 1-4 of the lesson. See the lesson procedure above for specific slides. The lesson concludes with slides 31-36.
2. The Dixie cups, the four trait bags with paper clips, and the one bag with ovule and pollen tags should be placed side-by-side at a single table in order for students to make their selections assembly-line style. Monitor closely so that the students are taking only one clip and one tag from each bag. (Let the students know that the twisted red paper clips need to remain twisted. Untwisted red paper clips should not be twisted.)
3. Distribute the paper packets to each allele group as soon as the traits are selected. The ovule groups get the packets with the cross-pollination sheet on top.

4. Although the deck of phenotype cards could be distributed with the packet of materials at the beginning of class, it might be best to wait until Part 4 to pass them out.
5. After groups determine their phenotypes, the teacher will need to use the key to check for accuracy.