Inheritance and Evolution

Originally developed for Phipps Conservatory and Botanical Gardens in Pittsburgh, PA

GRADE LEVEL: 4-12
TIME: 20-35 minutes
SUBJECT: Biology/ Genetics
CONCEPTS: DNA, DNA, inheritance, genetics, evolution, plant reproduction

LEARNING OBJECTIVES

- Inheritance: Passing of DNA from one generation (the parents) to the next generation (offspring)
- Self-fertilization: a plant can fertilize itself and produce offspring that are very similar to itself
- Cross-fertilization: when a plant fertilizes another and produces offspring that combine the characteristics of both parents
- Cross-Fertilization leads to greater genetic variation (and thus, is a driving force for evolution)

MATERIALS

- Poster or information about Flower Reproduction (should specifically include a visual for self- and cross-fertilization)
- Poster or information about Darwin, Mendel, and Punnett
- Clear Cups
- Food Coloring (yellow)
- Permanent Marker
- Diagrammed Place Mat
- Water and Pitchers
- Bucket for waste water

SET-UP

- Prepare one pitcher of water dyed yellow
- Prepare one pitcher of clear water (un-dyed)

- Label 2 cups "Plant A"
- Label 2 cups "Plant B"
- Label 1 cup "Offspring from Self-Fertilization of Plant A"
- Label 1 cup "Offspring from Self-Fertilization of Plant B"
- Label 2 cups "Offspring from Cross-Fertilization of Plants A and B"
    - Drop a few drops of yellow food coloring in the bottom of this empty cup and let dry overnight.

INTRODUCTION

(Note: This introduction provides background information for those leading this activity.)

Inheritance occurs when traits are passed from parents to offspring. Some traits are dominant over others, which can explain why you look more like one of your parents than the other! Traits are essentially made up of DNA; DNA (Deoxyribonucleic Acid) contains all of the instructions for an organism's development and characteristics.

When flowers reproduce – that is, when they combine their DNA in order to create new offspring– it is called fertilization. During fertilization, the pollen from a flower's anther is transferred to the stigma of either the same flower or a different flower. These two mechanisms are called self-fertilization and cross-fertilization. When a plant reproduces with itself, its offspring will look very much like the plant. This is self-fertilization. Specifically, self-fertilization is when the pollen from a flower is transferred to the stigma of the same flower. Cross-fertilization is when the pollen from a flower is transferred to the stigma of a different flower. These offspring will therefore have traits from both parents.

Cross-fertilization can lead to greater genetic variability, as there are more traits in the "gene pool" for the new offspring to "choose" from. Charles Darwin studied self- and cross-fertilization and hypothesized that cross-fertilization propels evolution by increasing genetic variability.

ACTIVITY

<u>Note:</u> in these instructions the dye used was yellow, please adapt to the food dye that is convenient.

1. Set-Up:
    a. Place two cups of water on the table. Cup 1, previously labeled as Plant A, has yellow water; Cup 2, previously labeled as Plant B, has clean water and is considered "white".
    b. Place "Offspring of Self-Fertilization of Plant A" and "Offspring of Cross-Fertilization of Plants A and B" on the table.
2. Begin by asking the student: "In what ways do you look like your parents?" "Do you know why you share this characteristic?"
    a. Talk about inheritance; Inheritance occurs when traits are passed from parents to offspring. Some traits are dominant over others, which can explain why you

look more like one of your parents than the other! Traits are essentially made up of DNA; DNA (Deoxyribonucleic Acid) contains all of the instructions for an organism's development and characteristics.

   b. While talking, perform a general example:
      i. Identify two cups as "parents" – Plant A and Plant B. Pour clear water into one and yellow water into the other.
      ii. Mix a cup of yellow water and a cup of clear water into a third cup (previously empty). Explain how the "offspring" now has traits from both parents.

3. Ask if the students know how plants reproduce? Explain that there are some similarities and differences between plant reproduction and human reproductions.
   a. Ask "How do you think they are similar?"
      i. *Plants, like people, also have parents.*
   b. Ask "How do you think they are different?"
      i. *Plants have many methods of reproduction – for example, they can either have one parent or two parents.*
4. Using the poster, discuss flower reproduction in more detail. Explain to the students that the water represents the pollen of the plant. Genetic information is found in the nucleus of the pollen, where it is transferred during reproduction. In this experiment, the water acts like the pollen and therefore, "contains the genetic information." Explain briefly that plants can reproduce with each other (sexual reproduction and cross-fertilization) or by themselves (asexual reproduction and self-fertilization).
5. What do you think will happen when a plant reproduces with itself? This is self-fertilization. Self-fertilization is when the pollen from a flower is transferred to the stigma of the same flower.
   a. Demonstrate self-fertilization: *(or ask for a volunteer to help you)*
      i. Identify the "parent" cup as Plant A.
      ii. Pour 1/3 of the water from the Plant A cup into the empty cup labeled "Offspring of Self-Fertilization of Plant A"
      iii. Pour 1/3 of the water from the cup labeled Plant A into the same cup. (This means that you will essentially be pouring 2/3 of the water from the Plant A cup.)
      iv. Ask the students to compare the offspring to Plant A: lead the students to understand that the offspring looks just like Plant A because it has the same genetic material.
      v. "Offspring of Self-fertilization" will be now be yellow to show that the offspring of a flower that undergoes self-fertilization has the same phenotypes as its one parent.
   b. Repeat this experiment with the water in the white cup, labeled Plant B, in order to compare the offspring of self-fertilization from Plant A with Plant B.
      i. Pour 1/3 of the water from the Plant B cup into the empty cup labeled "Offspring of Self-Fertilization of Plant B". Pour 1/3 of the water from the Plant B cup into the same cup. "Offspring of Self-Fertilization of Plant B" will now be clear.

c. Discuss what happened in each situation.
    i. Re-define inheritance as the process of passing traits from a generation to the next, from the parent passed on to the child.
    ii. In self-fertilization, the child received all characteristics from the parent, so the resulting "plant" (cup of water) looks like the parent "plant".
    iii. Ask the students what the water stands for? (genetic information)

6. Cross-fertilization is when the pollen from a flower is transferred to the stigma of a different flower. These offspring will therefore have traits from both parents.
    a. Demonstrate cross-fertilization: *(or ask for a volunteer to help you)*
        i. Ask "what do you think the offspring of BOTH of these parents will look like?"
            1. *The student will most likely assume that the colors will blend together to produce a lighter yellow color. Since the importance of this exercise is to show that one trait (yellow) is dominant over another trait (white), the yellow drop of food coloring already placed in the bottom of the cup will help the students to understand that these traits do NOT blend. The extra food coloring will help the "offspring" to show more yellow than white. Additionally, you could pour more of the yellow parent into the offspring cup, to achieve a more yellow color.*
        ii. Identify the parent cups "Plant A" and "Plant B" and the offspring cup labeled "Offspring of Cross-Fertilization of Plants A and B".
        iii. Pour 1/3 of the water from Plant A into the empty cup labeled "Offspring of Cross-Fertilization of Plants A and B"
        iv. Pour 1/3 of the water from Plant B into the same cup labeled "Offspring of Cross-Fertilization of Plants A and B"
    b. "Offspring of Cross-Fertilization of Plants A and B" will now contain yellow water, just as the "Offspring of Self-Fertilization of Plant A" does. (Note: Use the Punnett squares during this segment to help explain the conclusions!)
    c. Ask your students what happened? (Inheritance has occurred here: the offspring has received characteristics from both parents.). How is this different from self-fertilization? *(Plant received genetic material from both parents.)*Why is the offspring plant yellow? *(Only the characteristics from one parent can be seen; this is called dominance. Here, blending did not occur. In cases of dominance, some traits are dominant over others – this helps to explain why you look more like one of your parents than the other!)*
    d. Does the offspring plant have genetic information for the clear color? (Yes, and it can be passed on to the next generation. It is just hidden).
7. Discuss: What do you think would be the offspring of two plants where one is white and short, and the other is tall and yellow? Conclude that in sexual reproduction, the traits of the parents are combined in new ways.
8. Ask your students if they can think of any advantage of using sexual reproduction instead of asexual? Cross-fertilization can lead to greater genetic variability, as there are more traits in the "gene pool" for the new offspring to "choose" from. In fact, some

flowers have mechanisms to prevent self-fertilization, in order to increase their genetic variation.

a. Explain:
    i. Charles Darwin was a naturalist that studied plants. He was amazed at the variation he found within species and between species. This was one of the clues that led him to propose the principle of evolution. In his time, no one actually knew the methods of flower reproduction. Gregor Mendel finally figured out the Laws of Inheritance, which were observed today.
    ii. Charles Darwin studied self- and cross-fertilization and hypothesized that cross-fertilization propels evolution by increasing genetic variability.
    iii. Darwin also knew that for evolution to occur, traits must be passed between generations, but he didn't know how! Now *you* know that DNA is passed between parents and offspring.

OPTIONAL DISCUSSION/WRAP-UP

Propose various situations of self- and cross-fertilization and ask what the offspring will most likely look like? Which type of fertilization is "used"? Use different potted flowers as a visual representation.

1. Yellow + Itself (Yellow) = Yellow (Self-Fertilization)
2. White + Itself (White) = White (Self-Fertilization)
3. Yellow + Yellow = Yellow (Cross-Fertilization)
4. White + White = White (Cross-Fertilization)
5. Yellow + White = Yellow or White