Plant Breeding Genetics

Skill Level: Intermediate (11-13 years old)

Learner Outcomes:
Understands the connection between physical traits and their genetic control.

Understands the concept of probability and the role it plays in genetics.

Education Standard(s):
NSES: Life Science

Sunshine State Standards: HE.6.C.1.4; HE.7.C.1.4; HE.8.C.1.4; SC.7.L.16.1: SC.7.L.16.2

Success Indicator:
Can explain how plant breeders use the science of genetics to address real world issues.

Life Skill(s): teamwork, communication, contributions to a group effort

Tags: traits, DNA, probability, allele, chromosome

Time Needed: 90-120 minutes

Materials List: Pencils, Favorable Plant Traits Worksheet, Coins (1 for every two youth), 5 lunch bag, 6 pipe cleaners in each of the following colors: green, blue, yellow, red, orange, pink, white, black, purple, and brown.

What do you know about genetics?

Genetics is what makes each of us different, but it is also what makes us similar. Each of us inherited *traits* from our parents that determined our eye color, skin color, height, and other characteristics. Traits are notable features or qualities that can be physical, behavioral, or a predisposition to a disease or health problem (such as high blood pressure or diabetes). Our traits are encoded in genes. *Genes* are parts of *DNA* (deoxyribonucleic acid) molecules. There could be thousands of genes in one strand of DNA and if you unraveled a strand of DNA, it would be almost 9 feet long!

DNA molecules are organized and stored in *chromosomes* in the nucleus of each cell in every living being. The number of chromosomes contained in each cell depends on the type of living organism the cell is part of. Goldfish have 94 chromosomes, humans have 46 chromosomes, peanuts have 40, and mosquitos only have 6. In humans, we receive half of our chromosomes from our mother, and the other half from our father. This is how your parent's genes are passed down to you. *Heredity* refers to the passing down of genetically controlled traits from the parent to the offspring. Ever wonder why you have your mom's eyes instead of your dad's? Plant breeders can predict which genes will be passed down from parent to offspring using mathematical probability.

Individual genes are often expressed as *alleles*, or *genotypes*. Alleles are slightly different codes on the same location of the chromosome. For example, you inherit

Learn More

Learn much more about genetics and DNA through the Massachusetts 4-H Green Genes Project at: http://www.mass4h.org/index.php/programs/set/green-genes.

Virtual Fun

Animated tour of the basics about genetics and DNA http://learn.genetics.utah.edu/content/begin/tour/.

Interactive game about Mendel's Peas http://www2.edc.org/weblabs/Mendel/mendel.html.

eye color from both parents. If your father has brown eyes, then that trait's genotype can be either BB or Bb. If you mother has blue eyes, that traits genotype is bb. Because brown eyes are dominant (B) and blue eyes are recessive (b), there is a good chance that if your dad has brown eyes and your mom has blue eyes, you have brown eyes if you inherit Bb. You will only have blue eyes if you inherit bb.

Plant breeders use the concept of mathematical probability to help predict or hypothesize plant traits. If you examine a coin, it has 2 sides (heads and tails) so there are 2 possible outcomes when the coin is tossed. It will land either with its head up or its tail up. When you toss the coin, the probability of getting a heads up is ½ or 50%. Next, let's do an experiment to learn more about the concept of heredity, probability and alleles.

Favorable Food Traits-

1. Divide the group up into four or six youth per group.
2. Ask each group to decide on a particular species of fruit or vegetables (could be apples, peas, carrots, tomatoes, watermelon, etc).
3. Ask each group to make a list of the physical traits of that fruit or vegetable (color, shape, size, sweet taste, sour taste, etc).
4. Ask each group to select 5 traits and decide which genes are dominate and write alleles for each trait. Encourage them to be creative! *Tomatoes for example:*
    a. Bright pink color- PP, Pp, pp
    b. Oblong shape- OO, Oo, oo
    c. Sweet taste- SS, Ss, ss
    d. Smooth Skin texture- TT, Tt, tt
    e. Hairy leaves- HH, Hh, hh
5. Ask each youth to create their own fruit or vegetable using the alleles their group decided upon.
6. Have the group pair up and "breed" their plant with another member of their group. Use a coin toss to determine which allele will be used for the offspring. Ask youth to record their results on the worksheet included in this lesson.

Breed the Perfect Plant- As you learned in the first lesson, "History of Plant Breeding," scientists learned in the late 20th century how to take DNA from one plant's genes and insert it into another to create a genetically modified crop. In order to do this, plant breeders need to know how to read the "language" of DNA to figure out the "instructions" for favorable plant traits such as plant color, height, drought tolerance, or resistance to disease. This next activity will help youth explore heredity and requires some preparation ahead of time. Make sure you have at least 6 of each of the following colors of pipe cleaners (green, blue, yellow, red, orange, pink, white, black, and brown). Cut each of the pipe cleaners into four-inch pieces. Label five paper bags with the following: Plant Height, Leaf Size, Fruit or Seed Size, Germination Rate, and Drought Tolerance.

Twist the pieces of pipe cleaner together to create the following chromosome pairs:

- Six green pairs (two green pieces twisted to form an x)
- Six green and blue pairs (one green and one blue piece twisted to form an x)

Did You Know?
Genetically, humans are 99.9% alike. It is the 0.01% of our DNA that makes each of us unique and different!

Glossary Words
Traits
Genes
DNA
Chromosome
Allele
Genotype
Heredity
Probability

Related Activities

News
Science Daily features news articles about plant and animal genetics at: www.sciencedaily.com/news/plants_animals/genetics.

- Six blue pairs (two blue pieces twisted to form an x)
- Six yellow pairs (two yellow pieces twisted to form an x)
- Six yellow and red pairs (one yellow and one red piece twisted to form an x)
- Six red pairs (2 red pieces twisted to form an x)
- Six orange pairs (2 orange pieces twisted to form an x)
- Six orange and pink pairs
- Six pink pairs (2 pink pieces twisted to form an x)
- Six white pairs (2 white pieces twisted to form an x)
- Six white and black pairs
- Six black pairs (2 black pieces twisted to form an x)
- Six purple pairs (2 purple pieces twisted to form an x)
- Six purple and brown pairs
- Six brown pairs (2 brown pieces twisted to form an x)

Place all of the green, blue, and blue/green chromosome pairs in the bag labeled "Plant Height." Place all of the yellow, red, and yellow/red chromosome pairs in the bag labeled "Leaf Size." Place all of the orange, pink, and orange/pink chromosome pairs in the bag labeled "Fruit or Seed Size." Place all of the white, black, and white/black pairs in the bag labeled "Germination Rate." Place all of the brown, purple, and brown/purple chromosome pairs in the bag labeled "Drought Tolerance."

Explain to the youth that they will be building a plant that has 5 pairs of chromosomes (10 total). They will need to randomly select a pair of chromosomes from each paper sack and then use the key to determine what their plant characteristics are. Once they have correctly determined their plant's traits, then they can select a partner. Tell them that the government has asked them to develop the "Perfect Plant" to help end world hunger. The plant needs to have large fruit and large leaves because both the fruit and the leaves are tasty sources of nutrients. The plant also needs to have a fast germination rate and be drought tolerant. Working together, each set of partners can untwist their chromosomes and trade one leg (pipe cleaner) with their partner to breed the perfect plant. Once each set of partners is finished, ask them to share their creation with the rest of the group and explain why they made the choices they did.

TALK IT OVER:

Share. . . .

- What were some of the things that were hard to understand when you started learning about genetics?
- What surprised you about genetics?

Reflect. . .

- How was this a fun way to learn about genetics?
- What was the most challenging part of this activity?

Generalize. . . .

- How will learning about plant genetics help you in the future?
- Why was this lesson important?

Apply. .

- How would you teach someone else about plant genetics?
- What are some ways that you think learning about plant genetics can help your community?

References

Fehr, Walter R. Principles of Cultivar Development Volume 2. 1987 Macmillan Publishing Company, New York, NY.

Favorable Plant Traits Probability Data Sheet

Start by listing the traits your group decided upon in the first column and the choices in the second column. List all possible alleles in the third column. Then list the preferred traits that your plant has in the fourth column. Once you have selected a partner, list his or her plant traits in the fifth column. To determine which traits your offspring will have, you will be using a coin toss. Decide which of you will be "heads" and which of you will be "tails." For example, if you are heads and your partner is tails, and the coin landed on tails, then the offspring will have your partner's allele for that trait.

Trait	**Choices**	**Alleles**	**Your Plant**	**Partner's Plant**	**Offspring**
Fruit Color	*Bright pink or dull pink*	*PP, Pp, or pp*	*PP*	*Pp*	*Pp*

Make a sketch of the two parent plants and their offspring below.

Breed the Perfect Plant Data Sheet

Begin by record the alleles that you randomly selected from each paper bag. Using the chromosome key, determine which traits each allele represent and record them in column three. Next, record your partner's alleles and traits. Finally, record your offspring's alleles and traits.

Color Chromosome Key:

- Green= Tall plant
- Blue= Short plant
- Blue + Green= either short or tall
- Yellow= Large leaves
- Red= Small leaves
- Yellow +Red= Either large or small
- Orange= Small fruit or seed
- Pink= Large fruit or seed
- Orange + pink= Either large or small
- White= Slow germination rate
- Black= Fast germination rate
- White + Black= Either fast or slow
- Brown= Low drought tolerance
- Purple= High drought tolerance
- Brown + Purple= Either low or high drought tolerance

	Alleles You Selected	**Traits**	**Partner's Alleles**	**Partner's Traits**	**Offspring Alleles**	**Offspring Traits**
Height						
Fruit Size						
Leaf Size						
Germination Rate						
Drought Tolerance						

How many of the desired plant traits were you and your partner able to incorporate?

In the space below, draw a picture of your "perfect plant."