Genetics in the Garden

Overview:

Students will learn who Gregor Mendel was and his contribution to genetics. They will learn to fill out a Punnet Square using real examples from the garden in order to determine the possible genotypes and phenotypes of a plant's offspring.

Objectives:

At the end of the lesson students will be able to:

- **Describe** Gregor Mendel's contributions to genetics.
- **Explain** what dominant traits and recessive traits are.
- **Use** a Punnet Square to determine phenotype and genotype.
- **Complete** a Punnet Square using a plant observed in the garden.

Preparation:

- Prior to the lesson, review the handouts.

Materials:

- Handout 1: "Punnet Squares"
- Handout 2: "Create Your Own Punnet Square"
- Plants in the garden that can be picked for observation
- Garden gloves and clippers

On the Board:

- A blank Punnet Square form
- Vocabulary
- Student Reflection Questions

Suggested Snack:

- Snap peas and hummus

Vocabulary:

- genetics
- genes
- genotype
- phenotype
- hybrid
- heredity
- allele
- Punnet Square
- trait
- dominant trait
- recessive trait
- probability

Learning Activities:

1. Presentation: Review what students have learned in their Science class about genetics and Punnet Squares. (25 min.)
   A. Ask students to recall what they know about *genetics:* the science of *heredity* (the passing on of characteristics through one's genes from one generation to another).

- Ask students: What are some physical characteristics we inherit from our parents? (height, hair color, eye color, skin color)
- Ask students: What are some physical characteristics that are inherited from plant parents? (size, shape, color)
- Ask students: What are these characteristic called? (traits)

B. Tell students that Gregor Mendel was an Austrian Monk who is known as the "father of genetics." He grew peas in his monastery's garden.
   - He noticed that different pea plants had different traits. Some were tall, some were short. Some pods were wrinkled, some were smooth. Some flowers were purple, some were white.
   - He wanted to find out how *traits (*genetically determined characteristics*)* were passed from generation to generation.
   - Ask students: How are these traits inherited/passed down between generations? Have students think, pair, share. (Traits are determined by genes, which are inherited from the parents. In sexual reproduction, half of an individual's genetic makeup (genes) comes from one parent and half from the other parent.)
   - Define *gene:* set of "instructions" for a particular trait.
   - Define *allele:* offspring have two different versions of the same gene for each characteristic. For example, tall and short are both alleles of the gene that determines height. Every person has two alleles for every trait.

C. Mendel knew that plants bred and reproduced using pollen, so he controlled which plants were pollinated by other plants (i.e., which plants were available to pollinators such as bees, birds, butterflies and the wind).

D. He discovered that how a plant looks and its genetic code do not always match up.
   Define:
   - p*henotype:* gene that affects an organism's appearance (e.g, purple or white petals, long or short stems)
   - g*enotype:* the entire genetic make-up of an organism or combination of genes for one or more traits (both inherited alleles form an organism)

E. Traits that show up more often are called **dominant** traits and traits that show up less frequently are called **recessive** traits.
   Define:
   - d*ominant trait:* the trait that is always present in the first generation when parents who have different traits are bred (e.g., when you cross purple flowers with white flowers, all flowers in the first generation of offspring will be purple because it is the dominant trait). A dominant trait is 'seen' when one or two dominant alleles are present.
   - r*ecessive trait:* a trait that reappears in the 2nd generation after disappearing in the first generation of offspring, when parents with

different traits are bred (e.g., for every three plants that have purple flowers, one will have white flowers). A recessive trait can only be 'seen' when two recessive alleles are present.
- If a plant with dominant traits breeds with a plant with recessive traits, this can result in *hybrid* offspring. A hybrid plant could be carrying a recessive allele even though you cannot see it. Another word to describe one recessive allele and one dominant allele is heterozygous.

F. Mendel created the Punnet Square, a chart/table, to track genotype and phenotype between generations.
- On the board, walk students through how to label dominant (represented with an upper case letter) and recessive (represented with a lower case letter) traits. If the offspring has at least one dominant allele, its phenotype will reflect the dominant trait. If the offspring has two recessive alleles, its phenotype will reflect the recessive trait.
- Give students the phenotype for two parents and have them collectively fill in the Punnet Square.
- Tell students that a Punnet Square helps you to determine the *probability,* mathematical chance, that something will happen, sometimes expressed as a percentage. In this case, it determines the probability that an offspring of two parents will have a particular trait.
- Ask students:
  - For each possible result, what is the genotype? What is the phenotype? Remind students that **genotypes** are the genes present and **phenotypes** are the physical characteristics.
  - In which cases will the dominant trait be reflected in the physical appearance? (In all cases where at least one dominant allele is present.)
  - In which cases will the recessive trait be reflected in the physical appearance? (In any case where two recessive alleles (and no dominant alleles) are present.)
  - If there are four options, what is the probability of each occurring? (25%)

G. Distribute Handout 1: "Punnet Squares."
- Give students five minutes to complete the handout.
- Review the correct answers.

2. Garden Activity (20 min.)

A. In pairs, send students into the garden and give them five minutes to pick a plant to observe.

B. Distribute the handout: "Creating Your Own Punnet Square," and have students work with their partners to complete the sheet.

3. Snack: Serve snap peas and hummus. (5 min.)

4. Have students answer the Reflection Questions in their garden journals. (5 min.)

Student Reflection Questions:

1. Why do you think it is important to distinguish between genotype and phenotype?
2. How do you think scientists might use knowledge of genetics when breeding plants?

Assessment Questions:

1. Explain the difference between genotype and phenotype.
   - ***Phenotype* is the gene that affects an organism's appearance (e.g., purple or white petals, long or short stem). *Genotype* is the entire genetic make-up of an organism based on the combination of genes for one or more traits (both inherited alleles form an organism).**

	T	**t**
T	TT	Tt
t	Tt	tt

2. You have two parents both with hybrid genotypes for height (Tt). T= tall and t= short. Fill in the Punnet Square accordingly and determine the probability that the offspring will be tall.
   - **75% of offspring will be tall.**

Standards:

Next Generation Science Standards

NGSS-DCI Disciplinary Core Idea

- 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.

Growth, Development, and Reproduction of Organisms

- MS-LS1-4.

Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

- MS-LS1-5.
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Punnet Squares

Name: Teacher: Date:

Punnet squares show the two alleles of each parent and four possible ways they might cross with each other when producing offspring. T = tall and t = short.

TT = dominant tall (genotype tall, phenotype tall)
Tt = mixed hybrid (genotype hybrid, phenotype tall)
tt = recessive short (genotype short, phenotype short)

Below, you are given four different sets of genotypes. Complete Punnet Squares one to four to determine the possible genotypes of their offspring. Then list the expected ratio of offspring **phenotype.**

1	T	T
T		
T		

Expected ratio of offspring phenotype:
____ tall ; ____ short

2	T	t
T		
t		

Expected ratio of offspring phenotype:
____ tall ; ____ short

3	T	T
T		
t		

Expected ratio of offspring phenotype:
____ tall ; ____ short

4	t	t
t		
t		

Expected ratio of offspring phenotype:
____ tall ; ____ short

Create Your Own Punnet Square

Name: Teacher: Date:

Venture out into the garden and pick a small fruit, vegetable, or flower.

1. Describe the physical characteristics (traits) of your plant. Talk about its size, shape, color of petals, etc.

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2. Pick one trait. If this is the dominant trait, what do you think the recessive version of the trait might be? For example, if you picked a pea pod and the shell is smooth, perhaps the recessive allele would produce a wrinkled pod.

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3. Assign a capital letter that represents your dominant allele: _____

4. Assign a lower case letter that represents your recessive allele: _____

5. Now, you have two parents that are both mixed hybrids (one dominant allele, one hybrid allele) for this trait. Fill in the Punnet Square to determine the potential genotypes of their offspring.

6. What is the probability that the phenotype of this offspring will reflect the recessive trait? (Express your answer as a percentage.) _____%